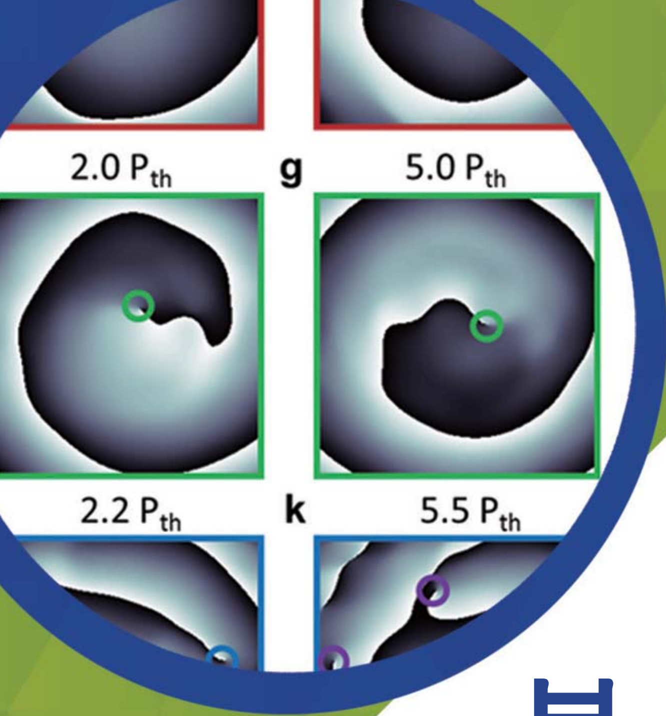

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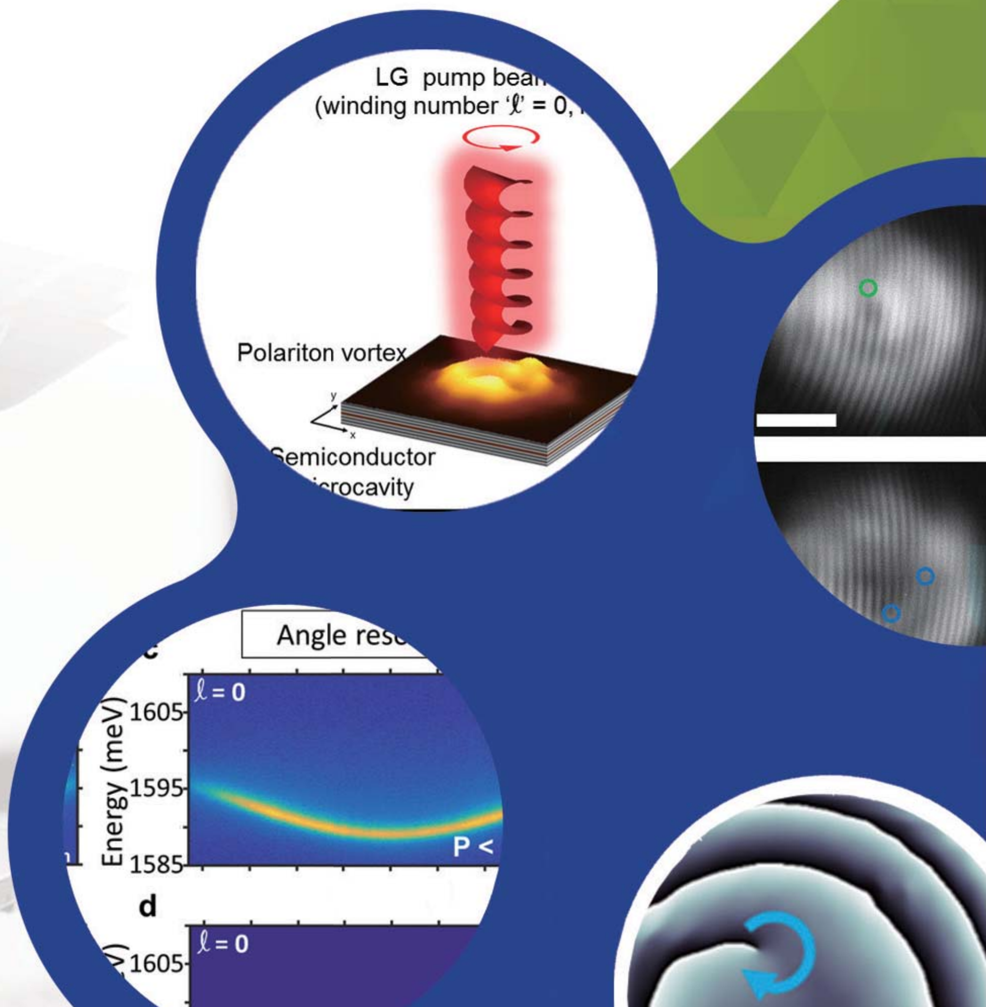
한국물리학회 **초록집**

2019년
봄 학술논문발표회 및 제95회정기총회

2019 KPS Spring Meeting

2019년 4월 24일(수)-26일(금)
대전컨벤션센터



구두발표논문

Oral session abstracts

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Where is the stable Pentaquark

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Abstract:
We systematically analyze the flavor color spin structure of the pentaquark $q^4\bar{Q}$ system in a constituent quark model based on the chromomagnetic interaction in both the SU(3) flavor symmetric and SU(3) flavor broken case with and without charm quarks. We show that the originally proposed pentaquark state $\bar{Q}sqqq$ by Gignoux et al and by Lipkin indeed belongs to the most stable pentaquark configuration, but that when charm quark mass correction based on recent experiments are taken into account, a doubly charmed antistrange pentaquark configuration $P_{cc}\,(udcc\bar{s})$ is perhaps the only flavor exotic configuration that could be stable and realistically searched for at present through the $P_{cc} \to \Lambda_c K^+ K^- \pi^+$ final states. The proposed final state is just reconstructing K^+ instead of π^+ in the measurement of $\Xi_{cc}^{++} \to \Lambda_c K^- \pi^+ \pi^+$ reported by LHCb collaboration and hence measurable immediately.

Keywords:
Quark model, pentaquark

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A1.02

Electromagentic form factors of singly heavy baryons

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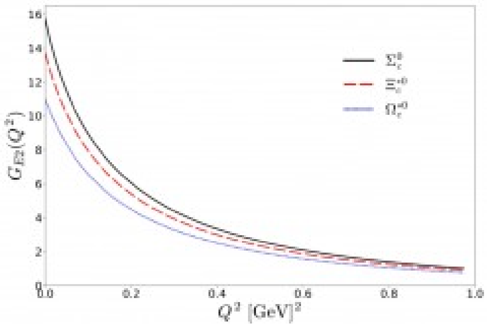
Abstract:

We present a series of recent works on the electromagnetic form factors of singly heavy baryons in a pion mean-field approach. Considering the rotational $1/N_c$ corrections and linear-order m_s corrections, we compute the electromagnetic form factors of both the spin 1/2 and 3/2 heavy baryons, including the electric monopole, magnetic dipole, and electric quadrupoole form factors. The results are discussed, compared with those from lattice QCD. we also present the sum rules of the electric quadrupole form factors. We also discuss the electromagnetic transition form factors of the spin 3/2 to 1/2 heavy baryons.



Keywords:

Singly heavy baryons, Electromagnetic form factors, chiral quark-soliton model, pion mean fields

A1.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Theoretical studies on the Λc^+ hadronic weak decays

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Abstract:

In this presentation, we report our recnt progrees on the Λc^+ hadronic weak decays, i.e., $\Lambda c^+ \to \pi^+ K^- p$ and $\Lambda c^+ \to \pi^0 \underline{K}^0 p$, from theoretical point of views. As a machinary to investigate the decay process, we employ the effective Lagrangian approaches and a parallel computation method mumerically using OpenMP. We provide numerical results of Dalitz plots, invariant-mass line shpapes, and possible existence of new hyperon resonances.

Keywords:
Λc+ , hadron weak decay, Dalitz process, interference, hyperon resonances.

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2019-04-24 - 2019-04-26

A1.04

Study on ϕ(1020) photoproduction at full scattering angles with an effective Lagrangian approach

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Abstract:
We suggest a possible explanation for the ϕ(1020) photoproduction mechanism in the W = 2.0−2.8 GeV region covering the full scattering angles. We have found that, with the universally accepted Pomeron exchange, the Odderon and three PDG N^* resonances play a crucial to describe the cross sections and spin-density matrix elements data from CLAS collaboration.

Keywords:
phi photoproduction, effective Lagrangians, nucleon resonances

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Simulation Study for “K⁻p → Λη” Scattering Experiment (J-PARC E72) at J-PARC

양성배*[1], TANIDA Kiyoshi[2], 안정근[1]
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Abstract:

"**K^-**(p, Λ)η” 반응을 통한 새로운 Λ^* 탐색 실험이 J-PARC 하드론 실험 시설에서 준비 중이다[1]. 이 실험에서 목표로 하고 있는 Λ^*는 Belle의 “$\Lambda_c^+ \to pK^-\pi^+$” 붕괴 Dalitz 분석과 “**$K^-p$** → Λη” 산란 실험 데이터에 대한 partial wave 분석들에서 증거를 찾을 수 있다 [2-5]. 실제 실험 환경과 GEANT4를 기반으로 하는 시뮬레이션 프로그램을 이용해 예상되는 결과와 오차를 계산 하였다. 새로운 시뮬레이션 결과 뿐만 아니라 실험의 준비 상황도 발표할 예정이다.

[1] K. Tanida et al., J-PARC P72 Proposal ('Search for a Narrow Λ* Resonance using the p(K-, Λ)η Reaction with the hypTPC Detector').
[2] S.B. Yang et al. (Belle Collaboration), Phys. Rev. Lett. 117, 011801 (2016).
[3] A. Starostin et al. (Crystal Ball Collaboration), Phys. Rev. C 64, 055205 (2001).
[4] Bo-Chao Liu and Ju-Jun Xie, Phys. Rev. C 85, 038201 (2012).
[5] H. Kamano et al., Phys. Rev. C 92, 025205 (2015).

Keywords:
J-PARC, Hadron, GEANT4, Simulation, J-PARC E72

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Studies on photon polarizations for Λ(1405) electromagnetic production

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Abstract:

We study the photo- and electro-productions of the vector kaon off the proton with the vector kaon K^*, and investigate the line shape of the invariant mass in an effective Lagrangian approach with the inclusion of a $K^*N\Lambda(1405)$ interaction. Relevant electromagnetic form factors for the neutral hyperons and charged strange mesons are constructed by considering experimental and theoretical information. We suggest a photon-polarization asymmetry Σ to extract information of the K*NΛ(1405) interaction. It turns out that Σ near the Λ(1405) peak region becomes negative with a finite K*NΛ(1405) interaction while positive without it for $Q^2 = 0$, due to the different naturalities of K and K^* exchanges. For $Q^2 > 0$, we observe more obvious signals in the peak region due to the additional contribution of the longitudinal virtual photon for Λ(1405) .

Keywords:
Λ(1405), three-body phase space, vector kaon, polarization, interferecen

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A1.07*

Electromagnetic structures of the baryon decuplet

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Abstract:

In this talk, we will present the electromagnetic form factors of the baryon decuplet as well as the transition form factors from the decuplet to the octet baryons within the SU(3) chiral quark-soliton model in a self-consistent way. In the present approach, a baryon can be viewed as Nc valence quarks, which are bounded by the pion mean fields in the limit of large Nc. The results of the Delta+ and Omega electromagnetic form factors-E0, M1, E2 and M3 will be presented in comparison with those from the lattice QCD. We also discuss the corresponding electromagnetic properties, the magnetic moments, the electric quadrupole moments and charge radii, compared with those from other models. We find the sum rule of the electric quadrupole moments within the present model. Finally we discuss the results of the electromagnetic transition form factors in comparison with the experimental data.

Keywords:

Chiral quark-soliton model, Electromagnetic form factor, Flavor SU(3) symmetry breaking

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A1.08

Nucleon and Delta isobar in a strong magnetic field

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Abstract:

We investigate the static properties of the nucleon in the presence of strong magnetic fields and discuss the consequent changes of the nucleon structure, based on the Skyrme model. The results show that at large values of the magnetic field ($\sim 10^{17}$ to 10^{18} G), which is supposed to appear in heavy-ion collision experiments at RHIC energies, the soliton starts to deviate from the spherically symmetric form and its size starts to change. At extremely large values of the magnetic field ($\sim 10^{19}$ G), which may be found at the LHC experiments, the soliton becomes more compact than in free space. The results also show that in the presence of the external magnetic field, the mass of the nucleon tends to increase in general and the mass degeneracy of the Δ isobars from isospin symmetry will be lifted. We also discuss the changes in the mass difference between the Δ and the nucleon, $\Delta m_{\Delta \mathrm{N}}$, due to the influence of the external magnetic field. We find that $\Delta m_{\Delta \mathrm{N}}$ increases as the strength of the magnetic field grows.

Keywords:

Soliton, nucleon, strong magnetic field

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A1.09*

Nuclear mass table in deformed Relativistic Continuum Hartree-Bogoliubov theory

인은진[1], 김영만[3], 박태선[2], 송영호[3], PAPAKONSTANTINOU Panagiota[3], 홍승우*[2], CDFT Collaboration[4]
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Abstract:

In exotic nuclei, particularly those close to neutron drip lines, pairing correlations between the bound states and the continuum should be treated carefully.

We have studied the properties of even-even nuclei in a deformed Relativistic Continuum Hartree-Bogoliubov (DRHB) theory for deformed nuclei which provides a proper treatment of paring correlations. With the relativistic density functional PC-PK1, the deformed RHB equations are solved in a Woods-Saxon basis. We study the deformation effect on the position of the neutron drip line and compare with Relativistic Continuum Hartree-Bogoliubov (RCHB) theory. Also, a nuclear mass table under construction will be presented.

Keywords:
DRHB, deformed nuclei, paring correlation, continuum, drip line, RCHB

A2.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Optical characteristics of lateral width controlled InGaN quantum wires grown on c-axis GaN template by MOCVD

여환섭[1], 이관재[1], 심영출[1], 조용훈*[1]
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Abstract:

기존 디스플레이에서는 높은 대비값을 얻기 위해 편광판을 사용하므로 편광된 빛을 내는 광원은 밝기 손실을 줄일 수 있는 장점을 가지고 있다. 일반적으로 상용화 되어있는 질화물 반도체 기반 발광체는 c-plane 사파이어 기판 위에 성장하기 때문에 평면방향으로 결정 대칭성을 가지고 있어 편광 특성을 가지고 있지 않다. 이를 해결하기 위해 off-axis 기판을 사용하거나 평면방향 응력 제어를 통해 편광도를 높이는 연구가 진행되고 있으나, off-axis 기판의 경우 기존 c-plane 기판 대비 가격이 비싼 측면과 고품질 결정성을 가지며 성장하는데 어려움이 있다. 따라서 c-plane 기판에서 발광층의 편광도를 제어할 수 있는 연구가 필요하다. 본 연구는 금속유기화학증착법(MOCVD)으로 c-plane 기판에서 삼차원 나노구조체를 이용해 InGaN 발광층의 가로 길이를 조절하는 방법론과 그로 인한 편광도 변화에 관한 내용을 다룬다. 전자빔 식각으로 선형 오프닝 구조를 만든 후 선택영역성장기법으로 GaN 삼각 피라미드 선형 구조를 제작한다. 이때 GaN 삼각 피라미드에 존재하는 반극성면과 극성면의 성장률 차이를 제어하면 수직방향 성장률이 동일해지면서 수~수십 나노미터 사이즈의 c-plane 면이 드러나게 된다. 성장온도, V/III 몰 비율 등 성장조건을 조절하면서 c-plane 면의 너비를 제어하였고, 그 위에 InGaN 양자우물을 형성하고 구조적 및 광학적으로 분석하였다. 투과전자현미경으로 구조체의 단면을 측정하여 InGaN 양자우물이 형성됨을 확인하였다. Cathodoluminescence를 측정하여 구조체의 위치에 따른 발광스펙트럼을 측정하여, 극성면의 발광파장 및 발광위치가 반극성면과 확실히 구분되는 것을 확인하였다. 편광특성을 측정하기 위해 micro-photoluminescence를 측정하였으며, 20 nm 수준의 가로너비를 갖는 InGaN 발광층에 대하여 높은 편광도를 측정하였다. 또한 가로너비의 증가에 따라 편광도가 어떻게 달라지는지 확인하였다. 결론적으로 본 연구는 일반적으로 편광특성을 갖지 않는 c-plane 방향의 기판에서 삼차원 구조체를 이용하여 나노구조체를 제작하였고, 가로너비에 따라 InGaN 양자우물의 특성을 변화시켜 편광도를 제어할 수 있음을 확인하였다.

Keywords:

MOCVD, selective area growth, quantum wire, lateral size, polarization anisotropy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A2.02*

Optical properties of InAs / GaAsSb submonolayer quantum dots with diffrent Sb composition

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Abstract:

본 연구는 InAs/GaAsSb Submonolayer Quantumdot (SML-QD)의 Sb조성변화에 따른 광학적 특성을 광 발광(Photoluminescence; PL)과 광분광법(Photoreflectance; PR)을 통하여 조사했다. SML-QD 시료는 Molecular beam epitaxy (MBE)를 통해 반 절연성 GaAs(100) 기판상에 성장되었고, 0.5 ML InAs 위에 GaAs1-xSbx 의 X를 각각 0%, 7.5%, 11.6%, 15.8%, 19.4%로 다르게 하여 40층의 SML-QD를 형성했다. 여기 광 세기가 8.3mW/cm^{2}일 때 13 K에서 측정된 PL실험결과 Sb이 0%일 때 1.42 eV에서 PL 신호가 관측되었으며, Sb조성비가 증가할수록 적색편이가 관측되었다. 이 적색편이는 Sb의 조성비율의 증가로 인한 가전자대의 감소 때문이다. 또한 Sb조성이 11.6%에서 15.8%로 변할 때 전이에너지의 변화가 확연히 적은 것을 확인 할 수 있는데, 이는 Sb의 조성비가 15%일 때 Type-I 이종구조에서 Type-II 이종구조로 변하기 때문이다. Sb조성비가 15% 이하인 Type-I의 경우 InAs 내부의 전자와 정공간의 전이가 발생하고, Sb조성비가 15% 이상일 경우 InAs의 전자와 GaAsSb 정공간의 전이인 Type-II 전이가 발생한다. 또 FWHM(Full Width at Half Maximum)의 변화는 Sb조성이 증가할수록 증가하는 경향을 보이는데 이는 Sb의 계면활성효과에 의한 크기 다양성의 증가에 기인한다. 이 샘플들의 PR 실험결과를 통하여 다양한 전이의 근원이 분석될 예정이다.

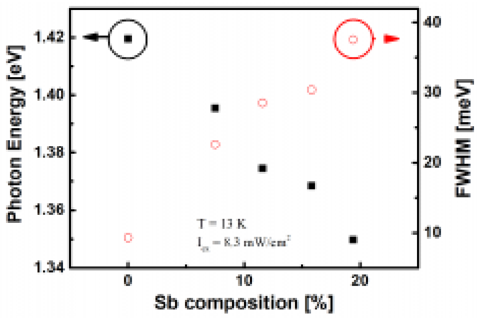

Fig 1. PL transition energy and FWHM of SML-QD with diffrent Sb composition.

Keywords:
semiconductor, III-V, quantum dot, submonolayer, InAs, GaAsSb, surfactante effect

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2019-04-24 - 2019-04-26

A2.03

Optical properties of InGaAsSb and InAsSb nbn detectors using photoluminescence and photoreflectance

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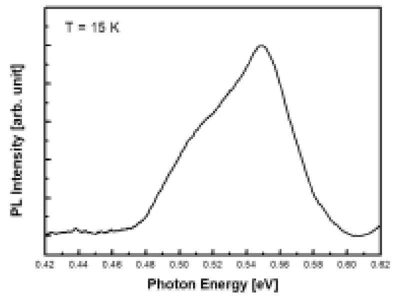
Abstract:

Photoluminescence (PL) and photoreflectance (PR) measurements for InGaAsSb and InAsSb nbn detector have been performed. The samples were grown using molecular beam epitaxy (MBE) method. Figure 1 shows PL spectra at 15 K. The PL emission of InGaAsSb shows 0.55 eV at 15 K. To investigate optical properties of InGaAsSb and InAsSb nbn detectors, excitation intensity and temperature dependent PL were measured. Also we measured internal electric fields of InGaAsSb and InAsSb nbn detectors using excitation intensity and temperature dependent PR and the results are discussed.



Keywords:
InGaAsSb, InAsSb

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Merging topological insulators and accompanied charge conservation revealed by ultrafast terahertz field

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Abstract:

Topological insulator (TI) exhibits interesting physical phenomena originating from the interplay between its electronic states including topological surface state (TSS) and bulk state. Especially, heterostructures of TI and normal insulator are optimal for exploring the inter-TSS coupling and the associated change in the TSS-bulk interplay. Despite its importance, the interlayer coupling effect of the TI heterostructure has not been demonstrated systematically in experiments. To address the issue, we fabricated a series of Bi_2Se_3 heterostructures, namely, $[Bi_2Se_3]$-$[Al_2O_3]$-$[Bi_2Se_3]$ with varying thickness of Al_2O_3 layer. We measured THz spectra of our TI heterostructures to investigate the low-energy electrodynamics and its evolution due to the interlayer coupling. To track the interlayer coupling effect on the charge carriers, we analyzed the THz conductance spectra with a Drude-Lorentz model. We also observed a noticeable change in the high-energy optical spectra over 0.7-4 eV. As *d* decreases down to 2 nm, we found that the energies of the interband transitions are upshifted by ~90 meV, indicating an increase of the doping level by that amount. Importantly, we found that the total carrier density is definitely conserved for all the samples. We explained the charge conservation of the TI heterostructures with two steps: charge transfer due to the interlayer coupling and charge redistribution over the reconstructed band. Our work proved that the charge conservation should be carefully considered whenever TIs are mechanically tailored for practical applications.

Keywords:

Topological insulator heterostructure, terahertz spectroscopy, merging topological insulators, charge conservation

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A2.05

Photoreflectance를 이용한 GaSb 박막의 굴절률 해석

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Abstract:

GaSb 박막의 광반사 변조 분광법 (photoreflectance; PR)을 이용한 굴절율 해석을 위하여 분자선 박막 성장법 (molecular beam epitaxy; MBE)으로 n-GaSb (~10^{18} cm^{-3}) 기판에 undoped-GaSb을 성장하였다. 시료의 굴절율 해석을 위해 온도에 따른 PR 스펙트럼을 측정하였다. 측정 된 PR 신호는 GaSb띠간격 에너지 (E_g) 보다 낮은 영역에서는 간섭 진동 (low energetic interference oscillations; LEIO) 형태를 나타내었다. LEIO는 단층의 표면과 기판에서 반사되는 두 빔의 간섭현상으로 나타나며 단층의 두께와 GaSb의 파장에 따른 굴절률 정보를 포함하고 있다. 따라서, 본 연구에서는 온도 의존성 PR신호의LEIO 영역을 해석하여, updoped-GaSb의 온도변화에 따른 굴절률 변화를 구하였다. 측정된 단층 매질의PR 스펙트럼을 이용하면 온도변화에 따른 굴절률 변화를 측정하고 해석할 수 있음을 보였다.

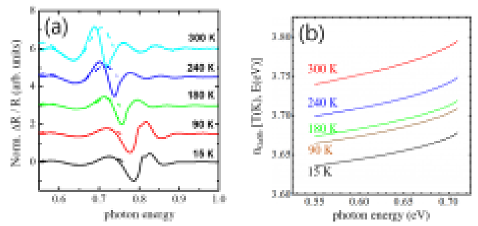

Fig. 1. 단층 박막GaSb에서 측정한 PR 스펙트럼 (a)과 Eg 보다 낮은 에너지 영역에서 측정된 LEIO PR영역에서 PR 스펙트럼의 해석해 (점선)를 이용하여 실험 값으로 얻은 undoped-GaSb 단층 박막의 온도에 따른 굴절률 변화 (b).

[1] J. P. Estrera, W. M. Duncan, and R. Glosser, "Complex Airy analysis of photoreflectance spectra for III-V semiconductors," Phys. Rev. B **49**, 7281 (1994).
[2] Sadao Adachi, "Model dielectric constants of GaP, GaAs, GaSb, InP, InAs, and InSn," Phys. Rev. B **35**, 7454 (1987).

Keywords:
Photoreflectance, refractive index, GaSb

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A2.06*

2차원 단층 WS_2 결정의 CVD 성장 메커니즘 연구

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Abstract:
2차원 반도체 물질 전이금속 디칼코제나이드(Transition metal dichalcogenides)는 층수에 따른 에너지 밴드 구조의 변화 및 K(-K) 밸리에 부여되는 밸리 자유도 등의 흥미로운 물리적 성질로 인해 차세대 정보/광전자 물질로써 각광을 받고 있다. 하지만, 이러한 2차원 물질 기반 소자의 개발 및 응용은 2차원 물질의 성장 메커니즘에 대한 이해 부족 및 이에 따른 성장 기술의 한계로 인해 제한되고 있다. 본 연구에서는 열화학기상증착법을 이용하여 2차원 반도체 물질 단층 WS_2의 결정 성장 과정을 탐구하였다. 투과전자현미경 분석으로부터, WS_2 결정 성장의 nucleation site로 작용하는 WO_3-WS_2 core-shell 나노 입자 구조를 관찰하였다. 또한, 성장 온도와 시간에 따른 결정 구조 분석을 통해 WO_3-WS_2 core-shell 나노 입자로부터 3차원 구조의 WS_2 island가 성장된 후에, 기판 표면에 존재하는 W-S molecular cluster의 표면 확산에 의해 단층 WS_2의 2차원 측면 성장이 일어남을 확인하였다. 이러한 연구 결과는 다른 2차원 물질의 성장 메커니즘에 대한 물리적 이해를 제공하며, 이는 2차원 물질의 두께 제어 및 대면적화 성장에 응용될 수 있을 것으로 기대된다.

Keywords:
전이금속 디칼코제나이드, 단층 WS2, 표면 확산, 성장 메커니즘

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Parameter extension to compound semiconductor for density-functional-based tight-binding method

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Abstract:
Material parameter files of InP for density-functional-based tight-binding (DFTB) method have been generated and validated. The DFTB method has been reported as a successful approximation of the quantum mechanical calculations for atomistic structure and also electronic structures of semiconductors, surfaces, and nanostructures. The bottle neck of the wide usage of this method has been the limited numbers of material parameters, i.e. Slater-Koster files. In this presentation, the extension of parameter file from pre-existing set will be shown. The new parameter of In to mio set enabled us to investigate the compound semiconductor InP with DFTB. The comparative benchmark calculations by DFTB and density functional theory (DFT) methods will show the validity of this new parameters.

Keywords:
DFTB, DFT, InP

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A3.02*

금속 나노 홀 어레이의 광대역 광 투과를 위한 유전율 엔지니어링 연구

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Abstract:

유전율 및 투자율 엔지니어링이 가능한 광 메타물질은 빛의 투과 및 반사와 같은 광학적 특성을 원하는 파장 영역에서 선택적으로 제어할 수 있다는 점에서 큰 잠재성을 갖는다. 본 발표에서는 금속 나노 홀 어레이 물질의 구조적 설계를 통해 유효 유전율 및 투자율을 엔지니어링함으로써 광대역에서 일어나는 특이한 광 투과 현상에 대한 연구 결과를 소개하고자 한다. 금속 나노 홀 어레이의 주기에 따라 높은 광 투과 밴드를 가시광/근적외선 영역 내에서 제어할 수 있음을 확인하였다. 관찰된 높은 광 투과 밴드는 금속 나노 홀 어레이와 주변 유전체 간의 유효 인덱스 매칭에 기인한 결과임을 알 수 있었다. 이러한 연구 결과는 금속 나노 홀 어레이 기반 투명 전극 기술에 활용될 수 있을 것으로 기대한다.

Keywords:

메타물질, 유전율 엔지니어링, 투명 전극, 금속 나노 홀 어레이

A3.03*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Resonantly Enhanced Free Exciton Feature in Pristine and Defective WSe_2 Monolayer

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Abstract:

Atomically thin transition metal dichalcogenide (TMDC) monolayer have a large exciton binding energy, a few hundreds of meV, due to strong confinement effect and dielectric screening. These large binding energy enables the observation of high order excitonic states such as excitons, trions and excited excitons. However, because defects have a greater influence on optical properties of monolayer material, photoluminescence (PL) shapes vary in reported papers. For this reason, the origin of variation on PL spectrums need to be considered precisely.

We perform Photoluminescence Excitation Spectroscopy (PLE) on WSe_2 monolayer at 80 K. Excited exciton states of A and B exciton are clearly identified in PLE spectrum. Interestingly, A:n=2 exciton resonant excitation laser enhances the free exciton (FX) PL intensity compare of the PL emission from trion. In contrast, localized exciton (LX) emission in defective sample is not enhanced by A:n=2 exciton resonant excitation. In spatially resolved PL experiment, LX emission is dominant in the region without top h-BN capping layer, indicating that this LX is originated from bounded exciton which might be formed by top Se vacancy. Additionally, PL mapping data clearly shows that the top h-BN layers make free exaction energy red shift and free exciton emission enhancement.

Keywords:
TMDC, photoluminescence excitation spectroscopy, exciton, spatially resolved photoluminescence, defect, localized exciton.

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Single crystal α-MoO_3 nanosheeets grown on 2D growth templates via van der Waals epitaxy and characterization

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Abstract:

Here, we report that the epitaxial growth of α-MoO_3 (molybdenum triple oxide) nanosheets on various 2D growth templates such as on hexagonal boron nitride (hBN), graphene, mica, and transition metal dichalcogenides (TMDs). Atomic force microscopy and transmission electron microscopy studies revealed that additional layers are continuously grown after the formation of the first monolayer α-MoO_3 which works as a kind of buffer layer to relax strain at the hetero-interface. Local friction, work function, and current properties of single-crystal α-MoO_3 nanosheets grown on ML-graphene was also investigated by atomic force microscopy. The observed thickness-insensitive friction reflects the negligible change of crystal structures with short interlayer separation, which results in the thickness-independent orbital overlapping and electronic band structure like work function. Local current spectroscopy shows that α-MoO_3 has the n-type behavior, that is associated with the oxygen vacancy. Also, local dielectric constant of MoO_3 was also quantitatively analyzed. The value was high enough in comparison with that of SiO_2, which indicates that that the possibility of dual roles of MoO_3 as tunneling barrier and dielectric insulator. Plus, the local I/V spectroscopy reveals that it has n-type property, which is associated with the oxygen vacancy. Finally, we demonstrated that the grown α-MoO_3 layers can be directly converted into MoS_2 nanosheets. Our work presents a platform for an alternative way toward 2D-oxide-based electronics.

Keywords:

2D materials, MoO3, transition metal oxide, van der waal epitaxy, AFM

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A3.05*

Thermoelectric property of 2D-$As_{1-x}P_x$ binary compounds

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Abstract:

Using the electronic band structure of the optimized monolayer and bilayer $As_{1-x}P_x$ structure calculated through the DFT calculation a comprehensive study on the electronic transport properties based on the Boltzmann transport theory are investigated within the respect of the constant relaxation time approximation τ. The Seebeck coefficient of the monolayer As_xP_{1-x} system has a larger value than the bilayer system and shows no anisotropic behavior along the armchair and zigzag directions while we found a higher electrical conductivity along the armchair direction in both mono and bilayer structures. A similar behavior was found in the electronic contribution to the thermal conductivity and this was understood from the Weidmann-Franz law. We also found that the power factor had a larger value along the armchair direction than the zigzag direction. Besides, in monolayer system, the p-type $As_{0.75}P_{0.25}$ alloy showed a highest power factor while the n-type bilayer $As_{0.75}P_{0.25}$ alloy system displayed a highest power factor. Thus, we suggest that the thermoelectric property can be improved in alloy system compared with the pristine phosphorene and arsenene layer.

ACKNOWLEDGMENT

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Keywords:

As1-xPx 2D-materials, DFT calculation, Boltzmann approach, Transport properties

A3.06*

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Encapsulation of monolayer WSe_2 phototransistor with hydrothermally grown ZnO nanorods

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Abstract:

Transition metal dichalcogenides (TMDCs) are promising two-dimensional (2D) materials for realizing next-generation electronics and optoelectronics with attractive physical properties. However, monolayer TMDCs (^{1L}TMDCs) have various serious issues, such as instability under ambient conditions and a low optical quantum yield from their extremely thin thickness of ~0.7 nm. To overcome these issues, we constructed a hybrid structure (HS) by growing zinc oxide nanorods (ZnO NRs) on the monolayer tungsten diselenide ($^{1L}WSe_2$) using the hydrothermal method. Consequently, we confirmed not only enhanced photoluminescence of the $^{1L}WSe_2$ but also improved optoelectronic properties by fabricating the HS-phototransistor. Through various investigations, we found that these phenomena were due to the p-doping effect and antenna effect attributed to the ZnO NRs. In addition, we verified that the optoelectronic properties of ^{1L}TMDCs are maintained for 3 weeks in the ambient condition through the sustainable encapsulation effect induced from our HS. This encapsulation method with inorganic materials is expected to be applied to improve the stability and performance in various 2D material-based emerging devices.

Keywords:

encapsulation, tungsten diselenide, zinc oxide, p-doping, antenna effect, charge transfer

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Twisted multi-layered graphene through decoupling of layers by electride-based electron injection

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Abstract:

After interesting phenomena like superconductivity and quantum spin liquids have been reported in twisted bi-layer graphene, unrevealed characteristics, novel physics and fabrication methods of twisted multi-layer (ML) graphene have attracted much attention. Since randomly deposited mechanical exfoliation and dry transfer are the only way to fabricate twisted bi-layer graphene, to apply further various application, another controllable fabrication method is needed.

Here, we report contact-driven charge transfer phenomena in ML graphene by building an interface between two-dimensional electride Ca_2N. Because of electrons from the Ca_2N, well stacked ML graphene layers with strong van der Waals force are decoupled and twisted about 13° without formation of defects and atomic intercalation of Ca or N atoms. In Raman spectrum, we observed dramatically changed P1 and P2 components of 2D peak and new peak generation of R peak after making a contact between graphene and the Ca_2N. It means interaction between stacked graphene layers became weaker and graphene layers are twisted. We also observed metallic contact resistance between electrode and ML-graphene/Ca_2N decreased ~500 Ω·um at room temperature which is comparable with edge contact method.

Keywords:

twisted graphene, contact resistance, Raman, doping, electron diffusion, electride

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A3.08*

양이온 교환과정을 통한 $Cd_{1-x}Zn_xSe$ 콜로이드 양자점의 파장 제어

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Abstract:
양자점은 높은 색순도와 밴드갭 제어를 통해 다파장 영역대에서 발광할 수 있는 물질로서 향후 태양전지와 디스플레이에 활용될 수 있는 높은 가치를 가진다. 하지만 가시광선 영역대에서는 장파장 영역대의 벌크 밴드갭을 가진 물질들은 여전히 청록색 파장 영역대를 포함한 다파장 영역대에서 높은 안정성과 색순도를 가진 물질로 구현하기에는 어려움을 겪고 있다. 이러한 물질들을 구현하기 위해 주로 밴드갭이 큰 물질을 사용하여 장파장 영역대에서의 발광을 위해서는 쉘을 이용한 다층구조가 연구되어 왔지만 복잡한 공정 과정과 격자 불일치로 인한 격자 변형 현상으로 인해 양자효율이 떨어지는 문제가 발생되어 최근에는 다원소계 물질을 이용하여 이러한 문제점들을 해결하는 연구가 진행되고 있다. 본 연구에서는 초기 핵 생성 유도과정과 단일 고온 주입법을 이용한 열처리 과정을 통해 양이온 교환 과정을 유도하여 $Cd_{1-x}Zn_xSe$ 콜로이드 양자점을 제작하였다. 제작된 $Cd_{1-x}Zn_xSe$ 콜로이드 양자점은 양이온 교환 과정에 있어서 발생되는 조성비 불균일 현상을 열처리 과정을 통해 해결하고 높은 안정성과 색순도를 가진 $Cd_{1-x}Zn_xSe$ 콜로이드 양자점을 다양한 파장 영역대에서 제작하고 광학적 특성을 분석하였다. 제작된 높은 안정성과 색순도를 가진 $Cd_{1-x}Zn_xSe$ 콜로이드 양자점은 향후 광전자소자로서의 높은 응용 가능성을 보여준다.

Keywords:
콜로이드 양자점, Cd1-xZnxSe, 혼합물 구조, 양이온 교환과정, 광학적 특성

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A3.09*

Surface Potential Mapping of Exfoliated MoS_2 Flakes on Au Nano-gratings

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Abstract:

Surface plasmon polariton (SPP) is propagating, dispersive electromagnetic waves coupled to the electrons of conductor at a dielectric interface. Momentum mismatch between surface plasmon and light can be overcome by using periodic grating structures. In this work, exfoliated flakes of MoS_2, one of the most popular 2D semiconductor materials, were transferred on Au nano-gratings to investigate the influences of SPP excitation on the physical properties of MoS_2. The nano-gratings were fabricated by e-beam lithography and lift-off processes. The number of MoS_2 layers was identified by micro Raman spectroscopy and atomic force microscopy. We carried out optical characterizations of the MoS_2/Au grating samples and compared them with finite difference time domain calculation results. We also studied spatial distributions of the surface potential of the MoS_2 flakes in dark and under illumination of light using Kelvin probe force microscopy. We have considered the strain and interface dipole effects as well as the SPP effect to explain all the results. This work can help us to propose new kinds of MoS_2-based plasmonic devices.

Keywords:

MoS2 surface plasmon polariton nanograting Kelvin probe force microscopy strain

A4.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

In-situ Local Phase Transition of $MoSe_2$ in Perovskite Oxide Heterostructure and Excellent Overall Water Electrolysis over 1000 hours

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Abstract:

Developing efficient bifunctional catalysts for overall water splitting that are earth-abundant, cost-effective, and durable is of considerable importance from the practical perspective to mitigate the issues associated with precious metal-based catalysts. In the present study, we introduce a heterostructure comprising perovskite oxides ($La_{0.5}Sr_{0.5}CoO_{3-\delta}$ (LSC)) and transition metal dichalcogenides (TMDs, $MoSe_2$) as an electrochemical catalyst for overall water electrolysis. Interestingly, formation of the heterostructure of LSC and $MoSe_2$ (LSC&$MoSe_2$) induces a local phase transition in $MoSe_2$, 2H to 1T phase, owing to electron transfer from Co to Mo, and the semiconducting $MoSe_2$ transforms to the metallic phase. In addition, LSC becomes more electrophilic, and Co-O and Co-OH bonds are favored owing to partial oxidation of the Co cation due to the electron transfer. Together with the electrochemically active nature of 1T $MoSe_2$ and the increased amount of Co-O and Co-OH bonds in LSC, the electrochemical activities are significantly improved for both hydrogen evolution reaction and oxygen evolution reaction. In the overall water splitting operation, LSC&$MoSe_2$ showed excellent stability at the high current density of 100 mA cm^{-2} over 1,000 h, which is exceptionally better than the stability of the state-of-the-art Pt/C || IrO_2 couple.

Keywords:

bifunctional catalyst, local phase transition, molybdenum diselenide, overall water splitting, perovskite oxides, stability

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A4.02*

Nano-Scale Stray Field Imaging of Magnetic Structure with a Single Spin Magnetometer

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Abstract:
Magnetic field imaging has been developed for tools to study not only in basic sciences but also in spintronic engineering. These imaging requires high spatial resolution in nanoscale with high sensitivity. In this talk, We will introduce scanning magnetometers based on diamond Nitrogen-Vacancy (NV) centers. NV center is an atomic scale defects center in diamond crystal lattice satisfying high spatial resolution and high magnetic sensitivity.
We will discuss basic concepts of scanning magnetometer and show examples of stray field image of magnetic samples and devices at room temperature including magnetic hard disk, magnetic vortices, and current devices.

Keywords:
Scanning probe microscopy, diamond NV centers, magnetic imaging

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A4.03*

Microwave-welded single-walled carbon nanotubes as suitable electrodes for triboelectric energy harvesting

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Abstract:
Biomaterials and bioproducts have unique characteristics of being renewable, abundant, biodegradable, and having rough surfaces. In order to implement them into highly efficient triboelectric nanogenerator (TENG) applications, the contact electrode should be cheap, flexible, able to withstand outdoor environments, and have a rough surface. Here, microwave-welded single-walled carbon nanotubes (SWCNTs) are shown to effectively harvest the mechanical vibrational energy from biomaterials and bioproducts. Selective and flash microwave heating provides firm welding of SWCNTs to a polycarbonate substrate without significant losses in flexibility, transparency, and electrical conductivity. Microwave-welded SWCNT electrodes were successfully deployed as single-electrode TENGs to harvest energy from cellulose film, hanji paper, and cherry leaf. The cellulose- and paper-based TENGs showed the quite stable triboelectric outputs even after excessive contacts and a long period of time. In summary, we have fabricated and utilized a microwave-welded SWCNT electrode for the mechanical energy harvesting in bio-TENGs. Without any physical or chemical treatments, the microwave-welded SWCNT has a rough surface with nano-sized pored structure. Considering the high flexibility, high conductivity, and resistance against environmental shocks, the SWCNT electrode could be used in efficient and portable bio-TENG applications.

Keywords:
Microwave welding; Single-walled carbon nanotube; Rough and pored surface morphology; Outdoor biomaterial; Indoor bioproduct; Triboelectric nanogenerator

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A4.04

Vanadium based two-dimensional materials

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Abstract:

Two-dimensional (2D) transition metal oxides and dichalcogenides have garnered much interest due to distinctive physical properties from their bulk counterparts. Herein, we report the V_2O_5 nanosheets for an effective selector devices and VSe_2 nanosheet as a candidate of intrinsic ferromagnetic 2D materials. V_2O_5 nanosheets synthesized by facile chemical vapor deposition show highly stable and low threshold voltages, which have not been previously reported on the threshold switching properties. The electrons occupying trap sites in poly-crystalline V_2O_5 nanosheet contribute to the perfectly symmetric threshold switching feature at the bias polarity and low threshold voltages in V_2O_5, confirmed by high-resolution transmission electron microscopy measurements. Furthermore, we find an additional PdO interlayer in V_2O_5 nanodevices connected with a Pd/Au electrode after thermal annealing treatment. The PdO interlayer decreases the threshold voltages, and the I_{on}/I_{off} ratio increases because of the increased trap density of V_2O_5. These studies provide insight into V_2O_5 switching characteristics, which can support low power consumption in non-volatile memory devices. For VSe_2 nanosheet, we report for the first time the atomistic real-space observation of van der Waals layered structure of VSe_2 by using HAADF-STEM images. Furthermore, simply by controlling the carrier gas flow rate, a morphological variation of surface area and thickness of VSe_2 nanosheets was observed. The room temperature ferromagnetic feature of single VSe_2 nanosheet was also revealed by magnetic force microscopy measurements. Our findings will play a significant role in the research of intrinsic 2D ferromagnetic materials.

Keywords:

V2O5, VSe2, VS2, van der Waals materials, nanosheets

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A4.05*

Tailoring Physical Properties of 2D MoS_2 Monolayers on 3D Nanostructures

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Abstract:
2D MoS_2 layers have a sizable band gap in the energy region of visible light and there have been intensive research efforts to realize MoS_2-based novel optoelectronic devices. In addition, recent research works have shown that hybrid heterostructures consisting of 2D and 3D materials can modulate the physical properties of 2D materials. In this work, we prepared 2D MoS_2 monolayers on 3D Si and SiO_2 nanocone (NC) arrays. Finite difference time domain calculations showed that the optical absorption in the MoS_2 monolayer on SiO_2 NC was much larger than that on Si NC. Measured photoluminescence and Raman spectra of the MoS_2/NC samples well agreed with the calculated absorption spectra. High refractive index Si 3D nanostructures strongly concentrated incoming light near the surface due to the Mie resonance. Weak light confinement in the SiO_2 NC with small refractive index resulted in large electric field intensity at the surface, leading to the enhanced absorption in the MoS_2 layers. In addition, we studied the local surface potential distribution in MoS_2 monolayers coated on the SiO_2 nanostructures by virtue of Kelvin probe force microscopy, which clearly revealed strain-induced bandgap modulation in the MoS_2 monolayers. All these results suggest that the 2D MoS_2 and 3D Si hybrid nanostructures can provide a useful means to realize high-performance van der Waals devices with the help of improved physical properties of the 2D MoS_2 layers and the well-established 3D Si-based device technology.

Keywords:
MoS2 optoelectronic Si nanostructure Mie resonance Kelvin probe force microscopy

A4.06*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Optoelectronic characteristics of two-dimensional *n-p* hetero-structures

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Abstract:

An organic semiconducting *p*-type tetracene thin film was partially hybridized with two-dimensional (2D) *n*-type MoS_2 monolayer grown by chemical vapor deposition method. The photoluminescence (PL) intensity in the hetero-junction region of the MoS_2/tetracene hybrid structure was lower than that of pristine tetracene, it was confirmed by the decrease in exciton lifetimes due to the charge transfer from tetracene to MoS_2. With decreasing temperature, the PL peak position of MoS_2 layers blue-shifted and the PL intensities of both MoS_2 and tetracene increased due to the reduction of phonon interaction. Decreasing temperature, the PL spectra of bound excitons in the hetero-junction region was observed, indicating the formation of trap states at interface. We fabricated the lateral-type *n-p* heterojunction field-effect transistors (FETs) using the MoS_2/tetracene hetero-structure. It were observed that anti-ambipolar field-effect characteristics with hysteresis effect and gate-tunable rectification *I-V*. The charge transport characteristics in the *n-p* hetero-junction transistor can be explained in terms of the Coulomb recombination mechanisms and trap-intermediated tunneling. We observed the decrease in the hysteresis effect and threshold voltage of the h-BN/MoS_2/tetracene-based FETs due to the decrease in the number of traps at the interface through the insertion of h-BN dielectric layer. The performance of h-BN/MoS_2/tetracene FET device was also enhanced after the annealing process. Another lateral *n-p* hetero-junction FET was fabricated using the exfoliated $MoSe_2$/WSe_2 flake. We have performed the photo-responsive charge transport measurements for $MoSe_2$/WSe_2 hetero-structural device. It was observed that the output and transfer characteristics varied with illumination conditions.

Keywords:

TMDC, organic, anti-ambipolar, n-p heterojunction

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Selective patterning of graphene surface by oxidation and chemical modification using conductive AFM manipulation

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Abstract:

Graphene has been extensively studied due to its superior electrical and mechanical properties and number of graphene based electronic and electromechanical devices were introduced to investigate its properties. Among these devices, graphene have been studied to use nanoscale lithography for fabricating desired nanostructure such as graphene nanoribbons.

In this presentation, we investigated the oxidation condition of graphene surface using electrochemical method with conductive atomic force microscope (AFM) and studied its application for selective patterning. We prepared our devices using transfer method of graphene on the SiO_2/Si substrate and adjusted relative humidity of the surroundings before the measurement of conductive AFM. The AFM lithography was performed taking into account the sample bias voltage, scan speed and set point by a contact-mode. The oxidation of graphene surface was observed by AFM topography and Raman spectroscopy.

We found out the optimum condition of oxidation and patterned oxidized graphene surface. The oxidized graphene was soaked in chloroform for etching method. Also, we will introduce our plan to estimate the amount of oxygen out of measuring the mechanical frequency of the oxidized graphene. This work can help us to utilize desirable devices in electronic and mechanical applications.

Keywords:

graphene oxidation, nanoscale lithography, atomic force microscope, Raman spectroscopy

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2019-04-24 - 2019-04-26

A4.08*

Fabrication of Flexible UV Photodetector Array Using ZnO nanotubes Grown on Graphene Films

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Abstract:
We report the fabrication of flexible and individually addressable ultraviolet photodetector array using zinc oxide (ZnO) nanotubes grown on graphene layers. To fabricate the ZnO nanotube arrays, both position- and morphology-controlled ZnO nanotubes were grown on a chemical vapor deposited (CVD) graphene layers using metal organic chemical vapor deposition. After preparing 9-μm-long ZnO nanotubes on CVD graphene layers, 5-μm-thick polyimide(PI) layers were coated on the nanorods and then they were peeled off from the substrate by simple mechanical exfoliation technique, which yielded free-standing and ultrathin layers consisted of ZnO nanorods and graphene. Then, top and bottom electrodes were made depositing Au on ZnO nanorod tips and Cr/Au on graphene, respectively. We will discuss the photodetector characteristics including photoresponse and flexibility

Keywords:
flexible, UV sensor, zinc oxide nanotube, graphene

A5.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

2018년 노벨물리학상에 대한 소개(Introduction to the Nobel Prize in Physics 2018)

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Abstract:

지난 2018년 노벨물리학상은 레이저 물리학 분야에서 혁신적인 발명을 통해 기초과학 및 응용 분야에 새로운 지평을 연 세 명의 과학자에게 수여되었다. 광학집게(Optical Tweezer)의 발명과 그 응용을 제시한 아서 애쉬킨(Arthur Ashikin) 박사와, 극초단 레이저 펄스를 아주 높은 출력으로 증폭할 수 있는 처프펄스 증폭(Chirped Pulse Amplification; CPA) 기술을 발명한 제라드 무루(Gérard Mourou) 교수와 도나 스트리클랜드(Donna Strickland) 교수가 그 주인공들이다.
본 강연에서는 각각의 기술 및 그 응용에 대한 세부적인 내용을 소개하기 전에 2018년 노벨물리학상 전반에 대해 간략히 이야기하고자 한다.

Keywords:

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A5.02

Practical challenges and solutions of petawatt-class laser

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Abstract:

1985년 도나 스트리클랜드(Donna Strickland) 교수와 제라드 무르(Gerard Mourou) 교수가 처프 펄스 증폭(Chirped Pulse Amplification) 기술을 발표하였다. 지난 한 세대 동안 지속적인 발전을 거듭하여 2010년부터 펨토초 페타와트급의 레이저가 발표되었고, 이 도구를 이용하여 새로운 발견과 혁신적인 과학기술들이 나오고 있다. 이제는 한 단계 더 나아가 페타와트급의 레이저기술과 융합한 신산업 출현을 기대하는 시대가 열리고 있다.
본 발표에서는 페타와트급 레이저 기반으로 출현 가능한 신산업을 소개하고, 현재 페타와트급 레이저가 신산업분야 적용하는 과정에서 직면한 실제적인 문제와 기술적 해결방안에 관해 소개한다.

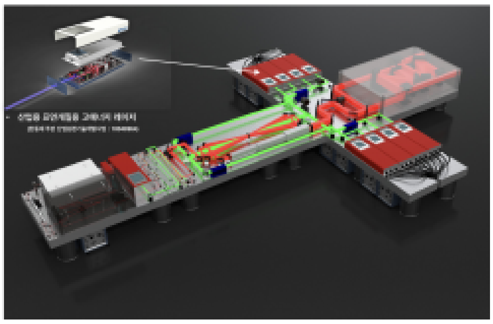

그림 1. 초고출력 레이저기반 신산업 창출을 위한 탁상형 펨토초 고반복율 페타와트급 레이저 상상도

Keywords:

처프펄스증폭(Chirped pulse amplification), 페타와트급 레이저(Petawatt-class laser)

Relativistic Laser Plasma Interactions and Strong-field Quantum Electrodynamics: Novel Interaction Regimes the CPA Technique Has Enabled

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Abstract:
The CPA technique developed by Mourou and Strickland has skyrocketed the light intensity since its inception in 1985. As a consequence, previously inaccessible physical conditions have become subject to experimental investigations, and novel regimes of light-matter interactions have been observed and studied, especially the regimes in which relativity plays the crucial role. At intensities above 10^{18} W/cm^2 (for the laser wavelength of 1 μm), the matter under such an intense radiation is immediately ionized, and the light field drives electrons to the speed of light. The consequent dynamics is dominated by the relativistic collective motion of charged particles, and it is dubbed relativistic laser-plasma interactions. Recently, much higher intensities above 10^{22} W/cm^2 have been realized so that not only radiation reaction effects become substantial, but also non-perturbatively nonlinear quantum electrodynamic phenomena can occur in the collision of high-energy electrons and an intense laser pulse. In this talk, we introduce these novel regimes of light-matter interactions, i.e., relativistic laser-plasma interactions and strong-field quantum electrodynamics, with research results mainly from Center for Relativistic Laser Science, IBS and also from other research groups.

Keywords:
Relativistic laser plasma interactions, strong-field quantum electrodynamics

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A5.04

Coherent extreme ultraviolet emission generated through strong-field excitation

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Abstract:

We report the observation of coherent extreme ultraviolet (EUV) emission from He atoms exposed to a strong laser field. The atoms are coherently excited through strong field excitation which is also known as frustrated tunneling ionization. The coherent EUV radiation is emitted from the excited atoms through free induction decay. The intensity of the radiation is strongly modulated depending on the carrier-envelope-phase and ellipticity of the driving laser pulse. The propagation direction of the radiation can be controlled using a spatially-chirped laser beam. The coherent EUV radiation can be used as a light source for the applications such as EUV imaging and ultrafast pump-probe spectroscopy.

Keywords:

Extreme ultraviolet, frustrated tunneling ionization, strong field excitation, CPA, laser

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A5.05

Trapping of single quantum dot via photon squeezing

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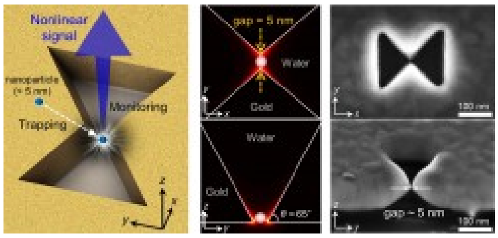
Abstract:

We propose and demonstrate a non-fluorescent nanoscopic trapping and monitoring platform implemented with a three-dimensional plasmonic nanoantenna. It can trap a single sub-5-nm particle and detect the fine movement of the trapped nanoparticle with a pair of floating nonlinear point sources.



Keywords:

Optical trapping, nano-antennas, plasmonics, nanoscopes

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Emergent Localization in Twisted Dodecagonal Bilayer Quasicrystals

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Abstract:

A new type of long-range ordering in the absence of translational symmetry gives rise to drastic revolution of our common knowledge in condensed matter physics. Quasicrystal, as such unconventional system, became a plethora to test our insights and to find exotic states of matter. In particular, electronic properties in quasicrystal have gotten lots of attention along with their experimental realization and controllability in twisted bilayer systems. In this talk, we present how quasicrystalline order in bilayer systems can induce unique localization of electrons without any extrinsic disorders. We focus on dodecagonal quasicrystal that has been demonstrated in twisted bilayer graphene system in recent experiments. In the presence of small gap, we show the localization generically occurs due to non-periodic nature of quasicrystal, which is evidenced by the inverse participation ratio and the energy level statistics. We understand the origin of such localization by approximating the dodecagonal quasicrystals as an impurity scattering problem.

Keywords:

Twisted bilayer graphene, localization, quasicrystal

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A6.02

Unconventional Bloch-Gruneisen scattering in hybrid Bose-Fermi Systems

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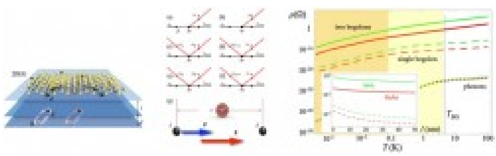
khvillegas@gmail.com

Abstract:



Hybrid Bose-Fermi systems essentially consist of a layer of fermions, usually two-dimensional electron gas (2DEG), coupled to another layer of bosons, such as excitons, exciton polaritons, or Cooper pairs. The interplay between Bose and Fermi particles leads to various novel fascinating phenomena, interesting from both the technological and fundamental physics perspectives [1-4]. In this work [5], we report a novel mechanism of electron scattering in hybrid Bose-Fermi systems consisting of a two-dimensional electron gas in the vicinity of an exciton condensate. We show that a pair-of-bogolons-mediated scattering has a dominant contribution to the electron resistivity over the conventional acoustic phonon channel and over the single-bogolon scattering, even if the screening is taken into account. We develop a microscopic theory of this effect, focusing on GaAs and MoS_2 materials, and find the principal temperature dependence of resistivity, distinct from the conventional phonon-mediated processes. Further, we scrutinize parameters and suggest a way to design composite samples with predefined electron mobilities and propose a mechanism of electron pairing for superconductivity.

References

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Keywords:
Bose-fermi mixtures; hybrid quantum systems; exciton BEC; two-dimensional electron gas

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2019-04-24 - 2019-04-26

A6.03*

Doping-method dependence of magnetism in two-dimensional $PdSe_2$

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Abstract:
Doping induced magnetism in two-dimensional materials has drawn great interest. Previous density functional theory (DFT) calculations showed that decrease of the total number of electrons can induce Stoner-type ferromagnetism in $PdSe_2$ monolayer (ML) due to very high density of states near the valence band maximum. In our present work, we perform DFT calculations using virtual crystal approximations and supercell calculations to study dependence of magnetism in $PdSe_2$ ML on doping methods. We consider different atomic species of dopants and different spatial distributions of dopant atoms and analyze their effects on induced magnetic properties in $PdSe_2$ ML. We discuss Stoner-type ferromagnetism and localized magnetic moments to understand magnetic properties in hole-doped $PdSe_2$ ML. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (KSC-2018-CRE-0097).

Keywords:
PdSe2, doping, DFT

A6.04

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2019-04-24 - 2019-04-26

Inevitability of the Aharonov-Bohm effect without an Aharonov-Bohm loop

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Abstract:
On the basis of the duality in the charge - magnetic dipole interaction, we show that there should be a `loop-free' Aharonov-Bohm effect. Brief discussions are added how this effect can be realized in superconducting hybrid devices.

Keywords:
Aharonov-Bohm effect, charge-magnetic dipole duality, superconducting hybrid devices

A6.05*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Vertex corrections to the dc conductivity in anisotropic multiband systems

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Abstract:
For an isotropic single-band system, it is well known that the semiclassical Boltzmann transport theory within the relaxation time approximation and the Kubo formula with the vertex corrections provide the same result with the $(1 - \cos\theta)$ factor in the inverse transport relaxation time. In anisotropic multiband systems, the semiclassical Boltzmann transport equation is generalized to coupled integral equations relating transport relaxation times at different angles in different bands. Using the Kubo formula, we study the vertex corrections to the dc conductivity in anisotropic multiband systems and derive the relation satisfied by the transport relaxation time for both elastic and inelastic scatterings, verifying that the result is consistent with the semiclassical approach.

Keywords:
Boltzmann transport equation, vertex correction, anisotropy, multiband

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Topological flatbands in twisted gapped Dirac materials

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Abstract:

Twisted bilayers offer an attractive avenue to tailor the electronic structure through their moire superlattices. Here we obtain the phase diagram of the bandwidth and the valley resolved Chern numbers in twisted gapped Dirac material heterostructures in search of topological flatbands as a function of system parameters such as twist angle, Fermi velocity, band gap, interlayer coupling, and interlayer potential difference. The presence of an inherent band gap is found to facilitate the formation of narrow bandwidth flatbands giving rise to a continuous range of twist angles where the bandwidths are much smaller than the Coulomb repulsion strength estimated from the moire period. We find the phase diagram maps of valley resolved topological Chern flatbands in a variety of hybrid gapped Dirac materials such as gapped G/G, TMDC/TMDC, SiC/SiC, BN/BN structures, where interaction driven spontaneous quantum Hall phases in the absence of a magnetic field could be triggered.

Acknowledgment: This work was supported by Samsung Science and Technology Foundation under project no. SSTF-BA1802-06

Keywords:
Flatbands, gapped Dirac materials, topological bands

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The Korean Physical Society

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2019-04-24 - 2019-04-26

A6.07*

Pathway for Acoustic to Optical Phonon Conversion in GaN Pyramid Arrays

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Abstract:
Up-conversion of low to high energy phonon is always in the attention of the researchers due to its potential application in efficient heat dissipation. Though in some of the organic materials such phenomena have been reported [1], in pragmatic semiconductor materials like GaN this process isn't much clear yet. Here we studied the role of such up-conversion process in enhancement of Anti-Stokes photoluminescence (ASPL). Though ASPL detection has been reported in numerous GaN structures, while describing the contribution of phonons in such events low energy acoustic (AC) phonons were always ignored as the focus was always on higher energy longitudinal optical (LO) phonons due to their higher interaction tendency with electrons [2-3]. We have observed the enhanced ASPL at room temperature by the below bandgap excitation in nanoscale GaN pyramids fabricated on InGaN/GaN MQWs possibly through up-conversion of AC to LO phonons. From the excitation power dependent measurement, it has been confirmed that the dominating mechanism for measured ASPL is phonon-assisted absorption, rather than multi-photon absorption [4]. Furthermore, propagating phonons' attribution in ASPL have been investigated via time-resolved PL measurement, which depicts a delay in TRPL signal peak appearance. This delay has been interpreted as the propagation time for AC phonons generated in GaN/InGaN MQWs to reach phonon accumulating point in nanopyramids and consequence in enhanced ASPL due to the high density of phonons resulting in up-conversion of low energy AC phonons to optical phonon. Blocking the lower energy phonon propagation by geometrical pathway change at the GaN pyramids and the presence of hybrid phonons due to trap levels facilitates this phonon up-conversion process [1]. Optical phonon generation surely leads to the PL at the pyramid due to coupling with the localized electron in the defect states, so the PL energy, in this case, is slightly higher than the defect state energy. This work proposes a promising way for efficient cooling in LEDs by altering acoustic to optical phonons.

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Acknowledgments: This work was supported by the GIST-Caltech Research Collaborations in 2018 and by Basic Science Research Program through National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning(2018R1A2B6008101).

Keywords:
GaN pyramid, acoustic phonon, photoluminescence, time-resolved spectroscopy, up-conversion.

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A6.08

Bogolon-mediated electron scattering in graphene in hybrid Bose-Fermi systems

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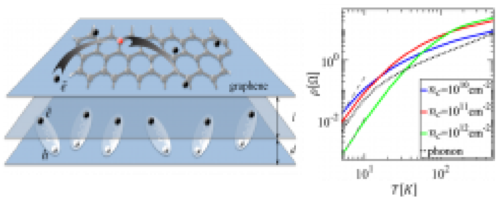
Abstract:

We report on an unconventional mechanism for electron scattering in hybrid Bose-Fermi systems [1] (Fig.1 left panel) by considering the coupling of electrons in graphene layer with condensed excitons. The energy-dependent electron relaxation time here is determined by the processes of emission and absorption of Bogoliubov excitations (bogolons). With the Bloch-Grüneisen approach, we get the finite-temperature resistivity of graphene and show that its principal behaviour is ~T^4 at low temperatures and linear at high temperatures (Fig.1 right panel).



As shown in Fig.1 right panel, the bogolon-mediated scattering can surpass the acoustic phonon-assisted relaxation [2]. The distance between layers and the condensate density provide additional degrees of freedom which can be used to control the electron mobility by the sample design and an external pump. Such extra degrees of freedom can be also used for the study of alternative mechanisms of superconductivity.

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Keywords:
Hybrid Bose-Fermi systems; Graphene

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A6.09

그래핀 준결정의 물리

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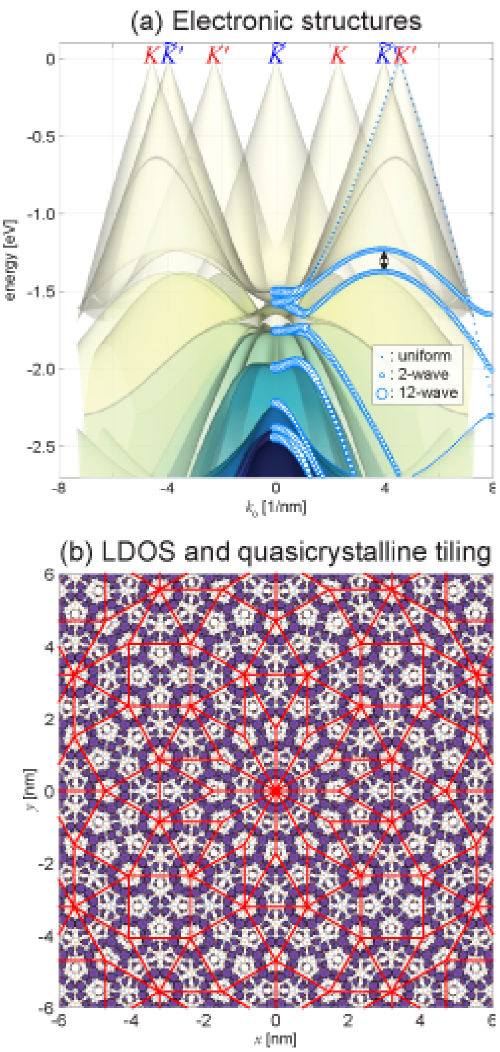
Abstract:

준결정(quasicrystal)은 결정(crystal)과 달리 구성 원자들이 주기적인 배열을 이루지 않지만, 비정질(amorphous)과 달리 원자들이 질서있게 배치된 매우 독특한 고체 구조이다. 고체 속 전자의 양자상태는 고체가 갖는 대칭성의 영향을 크게 받기 때문에, 규칙적인 결정과 비규칙적인 비정질의 경계에 있는 준결정에 대한 연구는 고체 물리의 발전에 중요한 기여를 해왔다.
이번 발표에서는 두장의 그래핀을 30도 어긋나게 적층함으로써 만든, 인공적으로 설계된 준결정 구조("그래핀 준결정")에 대해 발표하고자 한다. 먼저, 이 구조를 처음으로 구현하고, 투과전자현미경(TEM)과 각도분해 광전자 분광법(ARPES)를 통해 이 구조가 가진 준결정의 독특한 특성을 보인 성균관대 안종렬교수님 연구실과의 공동 연구 결과를 소개한다 [1]. 그후, 이 그래핀 준결정의 전자구조를 정확하고 매우 간결하게 기술할 수 있는 model Hamiltonian을 소개하고, 이로부터 12회전 angular momentum으로 기술되는 준결정 상태의 존재와, 준결정 tiling의 fractal inflation과 일치하는 전자확률분포 및 flat band dispersion등, 매우 독특한 물성이 발현됨을 보인다 [2].
모든 구성 원자들이 준주기적(quasi-periodically)으로 배치된 기존의 준결정은 내재적인 준결정(intrinsic quasicrystal)으로 볼 수 있는 반면, 그래핀 준결정은 그 준주기성이 서로 독립적으로 완벽한 주기를 갖는 두 원자층들간의 상호작용으로부터 나타난다는 점에서 외재적인 준결정(extrinsic quasicrystal)이라 할 수 있다. 이번에 그래핀 준결정의 model Hamiltonian을 만들기 위해 개발한 방법은, 보다 일반적인 2차원 원자층들을 특정한 배치로 적층함으로써 만들어지는, 모든 종류의 외재적인 준결정들에 적용 가능한 매우 높은 범용성을 갖는다.



Reference:

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M. Koshino, Y.-W. Son†, C.-W. Yang†, J. R. Ahn†, Science **361**, 782 (2018).
[2] P. Moon*,†, M. Koshino*, and Y.-W. Son (submitted, arXiv:1901.04701)

Keywords:
그래핀, 준결정, 유효이론, twisted bilayer graphene

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A7.01

Artificial Lead Molecules Assembled on the $IrTe_2$ Surface

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Abstract:
We demonstrate the fabrication of artificial Pb molecules on a honeycomb charge order structure of $IrTe_2$ as a template. Scanning tunneling microscopy shows the Pb adatoms to form clusters from monomer to heptamers including benzene-rings hexamers. Tunneling spectroscopy and electronic structure calculations reveal the molecular orbital formation within these clusters. Spin-orbit coupling is a driving force for the stabilization of these molecules and their unusual electronic states. The current approach would be a mass producible alternatives for atom manipulation in fabricating artificial metal clusters and initiates the use of novel electronic orderings in templated growth.

Keywords:
artificial molecules, spin-orbit coupling, charge-order template, STM, DFT

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Epitaxial van der Waals double heterostructure of topological insulators and hBN for tunneling spectroscopy between topological surface states

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Abstract:

Van der Waals (vdW) heterostructures composed of various two-dimensional (2D) materials serve as novel platforms to explore a wide variety of interesting physical properties and device applications. One of the most intriguing systems is a highly crystalline and atomically thin insulating barrier sandwiched between 2D vdW layered materials since tunneling spectroscopy applied to the heterostructure provides a powerful tool to probe the density of states of the materials and vertical transport across the vdW interface. For example, precisely aligned two graphene layers separated by a hexagonal boron nitride (hBN) barrier layer made it possible to detect and manipulate energy-, momentum-, and chirality-conserved tunneling of Dirac fermions in graphene. On the other hand, $(Bi, Sb)_2(Te, Se)_3$ topological insulators (TIs), which have vdW layered structures with topologically non-trivial surface states, possess great potential for applications in spintronics and topological quantum computing. In this regard, it would be crucial to explore TIs that are in a close proximity with each other across only a few atomic barriers and to further carry out tunneling spectroscopy on this system. Here, we present the fabrication and measurement of vertical tunnel junctions in which two epitaxially aligned TIs are separated by an a-few-atom-thick hBN tunnel barrier. Ultrathin hBN layers were transferred using micromanipulation to pre-patterned sub-micrometer holes in SiN_x membranes to expose both surfaces. Subsequently, Bi_2Se_3 and Sb_2Te_3, which are *n*- and *p*-type TIs, respectively, were grown on both sides of the suspended hBN using molecular beam epitaxy, naturally forming TI/hBN/TI vertical tunnel junctions whose interfaces were sealed under ultrahigh vacuum. High-resolution transmission electron microscopy revealed that an atomically abrupt and epitaxial interface was formed between the hBN substrate and the top- and bottom-TIs. We performed magneto-tunneling spectroscopy of Sb_2Te_3/hBN/Bi_2Se_3 (*p*-TI/hBN/*n*-TI) and Bi_2Se_3/hBN/Bi_2Se_3 (*n*-TI/hBN/*n*-TI) junctions under in-plane and out-of-plane magnetic fields to investigate energy-momentum-spin resonance between the topological surface states (TSSs). We believe the results presented in this work have paved a new way to investigate intrinsic momentum-space tunneling selection of electrons in the TSSs and to design new topological devices.

Keywords:

Topological insulator, Tunnel junction, Molecular beam epitaxy, Van der Waals heterostructure

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A7.03*

Angle-resolved photoemission study on Bi intercalated graphene on SiC(0001)

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Abstract:

It has been well known that epitaxial graphene can be fabricated on the surface of silicon carbide by thermal decomposition at high temperature. It has also well studied that intercalating foreign atoms in between graphene and the substrate can not only effectively decouple epitaxial graphene from the substrate but also modify graphene band structures. We have modified the band structure of graphene by intercalating Bi in between epitaxial graphene and SiC(0001). By means of angle-resolved photoemission spectroscopy (ARPES), we have studied how the band structure changes with the density of Bi atoms. After intercalation of Bi atoms, we found two phases with a clear signature of π bands. On the other hand, the doping level of graphene continuously changes with the Bi coverage, which is different from the case of Au-intercalated graphene on SiC.

Keywords:

ARPES, epitaxial graphene

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Curvature effects on two-dimensional materials

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Abstract:
In this work, we consider curved two-dimensional materials and study how electronic band structures are altered by curvature. A single-particle Green function which contains the information of single-particle density of states is a relatively accessible object that is affected by the curvature. Based on the work of Bunch and Parker, we calculate the Green function in momentum space where first-order perturbation correction is proportional to the curvature. A tunneling spectroscopy experiment can be employed to verify the change in the density of states since the differential conductance dI/dV is proportional to the density of states at low temperatures.

Keywords:
curved surface, Green function, density of states

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Valley magnetic domain as a pathway to valleytronic current processing

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Abstract:
Interplay between an applied strain and the Berry curvature reconstruction in the uniaxially strained monolayer MoS_2 is explored, which leads to the unbalanced Berry curvatures centered at **K** and **-K** points and eventually the valley magnetization under an external electric field. This finding of the valley magnetoelectric effect (VME) is shown to explain a recent experimental observation of the valley magnetoelectricity and develop the valley magnetic domain (VMD), i.e., a real-space homogeneous distribution of the valley magnetization. It is discovered that one can achieve a manipulation of the anomalous transverse current perpendicular to the electric field, directly accessible to the signal processing through the VMD moving or the VMD switching, for instance, the current modulation by the VMD (i.e., the VMD wall) moving and the current rectification attained under the electric field oscillation accompanying the VMD switching. This suggests a concept of VMD to provide new physical insight to the valleytronic functionality and its manipulation to be a key ingredient of potential device applications.

Keywords:
Valley magnetization, Berry curvature, valley degrees of freedom, transition metal dichalcogenides, anomalous Hall effect.

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A7.06*

Optical mapping of carrier density depth-profile in a graphene-based field effect transistor

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Abstract:

To measure depth-dependent density profile of charge carrier confined at surface or interface is a challenging experimental task. Here we demonstrate one method of depth-profiling measurment by constructing ionic liquid gated multilayer (i=2,3,4,5) graphene transistor, and performing broadband optical transmission spectroscopy on it. The optical absorption spectrum is characterised by a series of absorption edges appearing in the frequency domain, which represent the interband excitations of Dirac electrons occurring in the gated graphene multistack. We analyze the energies and strengths of the absorption edges, obtaining the carrier densities for the individual graphenes and thus revealing the field-induced charge density (*q*) as function of layer (*i*). The *q(i)* profile shows that vertical carrier distribution of multilayer graphene system. The knowledge of *q(i)* obtained in this work provides invaluable insight into understanding of the novel electronic phase-superconductivity, insulator-metal transition, etc- found in carious EDL transistor.

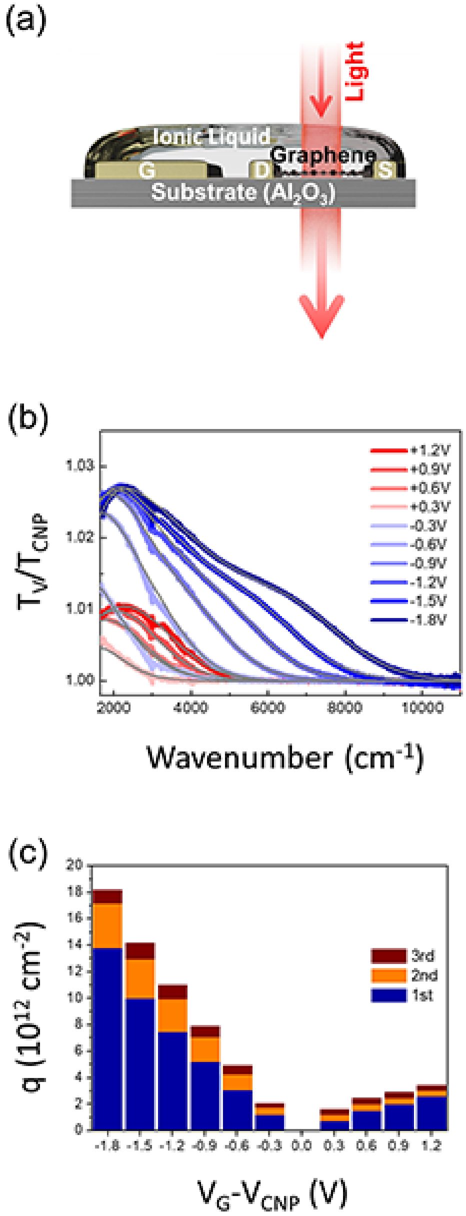

Figure description
(a) 3D Illustration of an ionic-liquid gated graphene device and optical transmission measurement. (b) Normalized optical transmission data T(Vg)/T(Vcnp) (blue and red line) and fitting lines (grey line) of 3-layer graphene. (c) Vertical carrier distribution of ionic liquid gated multi-layer graphene devices with various voltages (Vg-Vcnp)

Keywords:
Multilayer graphene, Ionic liquid, FET, IR spectroscopy, Vertical carrier distribution

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A7.07*

Toward mass production of graphene using CVD

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Abstract:

Graphene is monolayer material with a two-dimensional honeycomb lattice. It has excellent electrical, optical, mechanical and thermal properties and is called a new material of dream at the future.

To extend graphene research to the industrial application, mass production of graphene is necessary. But it's still expensive, environmental destructive. Although a number of previous research results have been reported, each research has its own problems.

Therefore, we have developed a process that can produce graphene with high speed and low price. We succeeded in high speed synthesis of graphene for 1 min at 900℃ using liquid precursor and tried to synthesize it continuously. On the other hand, in actual continuous synthesis, tension and vibration-related issues affecting the catalytic metal should not be overlooked. In addition, the continuous supply of the hydrocarbon gas during movement of catalytic substrate can form carbon black on the sample.

Solving these problems, we invented new CVD equipment. We got an idea from semiconductor process. Our CVD can produce 12samples for 3 hours by different condition. We evaluated graphene with Raman spectra and electrical property.

Keywords:
Graphene, CVD, Liquid precursor

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Atomistic Study on the Electronic Structure of Twisted Double Bilayer Graphene

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Abstract:
Flat bands in two dimensional van der Waals moiré superlattices are attracting enormous interests, intensified by the recent observations of correlated insulators and superconductivity in the magic-angle twisted bilayer graphene (MA-TBG). Furthermore, it has been recently noticed that twisted double bilayer graphene (TDBG), consisting of two sets of Bernal-stacked bilayer graphene with a twist, also hosts intriguing correlated electron phases. However, its atomic and electronic structures have not yet been fully investigated. In this work, we present atomistic calculations on the atomic and electronic structure of twisted double bilayer graphene. First, we obtain the equilibrium atomic structures of TDBG and compare the electronic structure of TDBG with TBG. Then, we show that a vertical electric field can be used to tune the low-energy flat bands of TDBG. As a result, we find that extremely narrow bands can be obtained for a wide range of twist angle, rather than at certain specific magic angles. Our results serve as a theoretical guide for exploring correlated electron physics in TDBG, and illustrate the importance of the layer-number degree of freedom in the moiré superlattices.
This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2018-CRE-0097). Y.W.C. acknowledges support from NRF of Korea (Global Ph.D. Fellowship Program NRF-2017H1A2A1042152).

Keywords:
moiré superlattice, twisted bilayer graphene

A8.01

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Magnetic fragmentation for planar spins on kagome lattice

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Abstract:

Frustration is known to give rise to many interesting physical phenomena. One such example is magnetic fragmentation when original spins decompose into new elementary degrees of freedom. Inspired by Jospehson junctions arrays we propose a model of magnetic fragmentation on kagome lattice for
classical planar spins with isotropic nearest-neighbor Heisenberg interactions and broken sublattice symmetry. As couplings are varied, the groundstate exhibits a transition from plain ferromagnet to a highly degenerate manifold of states that retain non-zero magnetisation. Importantly this behavior, i.e. fragmentation, persists for a range of couplings. We analyse the properties of these groundstates, like correlations and long-wavelength behaviour. As a simpler version we also consider the d=1 version of the model, that also exhibits highly degenerate groundstates in part of the phase diagram, but does not show any magnetic ordering. Finally we discuss how this model can be extended to different types of spins and other 2D and 3D lattices.

Keywords:

josephson junctions, kagome, degeneracy

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각분해 광전자 분광법을 이용한 뫼비우스 콘도 절연체 후보 물질의 전자 구조 연구

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Abstract:

위상 절연체는 스핀트로닉스나 양자 컴퓨터에 응용 할 수 있을 것으로 기대되어, 최근 위상 절연체에 대한 연구가 활발하다. 통상적인 위상 절연체는 위상 불변량을 가져서 하나의 Dirac cone이 형성된다. 그런데 최근 한 이론 연구에 의하면 nonsymmorphic 대칭 구조를 이루는 콘도 절연체가 위상 불변량을 가질 수 있게 되어, 복잡한 뫼비우스 띠 모양의 면이 생길 것으로 예측하고 있다 [1]. 이 이론 연구에서는 nonsymmorphic 대칭 구조를 가지고 있는 $Ce_3Bi_4Pt_3$, CeNiSn, CeRhSb, CeIrSb 등의 콘도 절연체를 뫼비우스 콘도 절연체 (Möbius Kondo Insulator) 라 하고 있다. 본 연구에서는 뫼비우스 콘도 절연체 후보에 속하는 CeNiSn과 CeRhSb에 대하여 각분해 광전자 분광법 (angle-resolved photoemission spectroscopy: ARPES) 실험을 수행함으로써 이 물질들의 전자 구조를 연구하였다. 빛 에너지를 변화시키면서 두 물질의 세 개의 직교면에 대한 페르미 면과 띠 구조를 각각 측정함으로써, Ni 3d 띠와 Rh 4d 띠의 유사점과 차이점 및 Ce 4f 전자 상태를 관찰하였다. 이 연구를 통하여 뫼비우스 콘도 절연체의 존재 여부와 그 원인을 규명하고자 한다.

[1] Po-Yao Chang, et al., Nature physics, **13**, 794 (2017).

Keywords:
위상절연체, 뫼비우스 콘도 절연체, 각분해 광전자 분광법

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A8.03

Gapless Kitaev Spin Liquid to Classical String Gas through Tensor Networks

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Abstract:

We provide a framework for understanding the gapless Kitaev spin liquid(KSL) in the language of tensor network(TN). Without introducing Majorana fermion, most of the features of the KSL including the symmetries, gauge structure, criticality and vortex-freeness are explained in a compact TN representation. Our construction reveals a hidden string gas structure of the KSL. With only two variational parameters to adjust, we obtain an accurate KSL ansatz with the bond dimension D=8 in a compact form, where the energy is about 0.007% higher than the exact one. In addition, the opening of gap and non-Abelian phase driven by a magnetic field are naturally understood in our construction.

Keywords:

Kitaev Spin Liquid, Tensor Network, Topological Order

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A8.04*

Chemical-pressure effects of the Kitaev candidate materials α-Ru(Br,Cl)$_3$

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Abstract:

α-$RuCl_3$ is the most intensively studied Kitaev material. In spite of the dominant Kitaev interaction, unwanted non-Kitaev terms are known to stabilize the zigzag magnetic order at 7 K. Applying hydrostatic pressure above 0.24 GPa, the zigzag order is driven to valence bond solid, while the strong spin-orbit assisted Mott insulator is turned into a band insulator. In hydrostatic pressure environments, however, diverse characterization tools cannot be employed towards an in-depth understanding of a quantum phase transition. To overcome this drawback, we adopt a chemical-pressure route by substituting Cl with Br. The ionic radius of Br, 1.82 Å, is larger than of that of Cl, 1.67 Å. The large difference of the ionic size between the Br and Cl atoms is anticipated to create huge anisotropy of the Ru-Ru interaction. To this end, we successfully synthesized a whole series of α-$Ru(Cl_{1-x}Br_x)$ crystals. In analogy to the hydrostatic pressure, we observe a quantum phase transition from the zigzag to the spin dimer phase through x_c~0.5-0.6. In this presentation, we provide a detailed comparison between the x-T and the p-T phase diagram. In addition, at the quantum critical point x_c, we elucidate a coexistence of the zigzag and dimerized spin chain phase as well as a nature of quantum critical fluctuations.

Keywords:

Kitaev honeycomb lattice, quantum criticality, chemical pressure

A8.05

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Spin-transfer torques for domain walls in antiferromagnetically coupled ferrimagnets

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Abstract:

Antiferromagnetic materials are outstanding candidates for next generation spintronic applications, because their ultrafast spin dynamics makes it possible to realize several orders of magnitude higher-speed devices than conventional ferromagnetic materials. Though spin-transfer torque (STT) is a key for electrical control of spins as successfully demonstrated in ferromagnetic spintronics, experimental understanding of STT in antiferromagnets has been still lacking despite a number of pertinent theoretical studies. Here, we report experimental results on the effects of STT on domain-wall (DW) motion in antiferromagnetically-coupled ferrimagnets. We find that non-adiabatic STT acts like a staggered magnetic field and thus can drive DWs effectively. Moreover, the non-adiabaticity parameter β of STT is found to be significantly larger than the Gilbert damping parameter α, challenging our conventional understanding of the non-adiabatic STT based on ferromagnets as well as leading to fast current-induced antiferromagnetic DW motion. Our study will lead to further vigorous exploration of STT for antiferromagnetic spin textures for fundamental physics on spin-charge interaction as wells for efficient electrical control of antiferromagnetic devices.

Keywords:

Antiferromagnet, Ferrimagnet, domain-wall motion, Spin-transfer torque, angular momentum compensation termperature

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A8.06*

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Study on the Magnetic Structure of Triangular Antiferromagnet $CePtAl_4Ge_2$

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Abstract:

$CePtAl_4Ge_2$ adopts trigonal structure (R3m, 166) and exhibits a Kondo metallic behavior. An antiferromagnetic (AFM) long range ordered state appears below 2.3 K and anisotropic spin interactions exist due to geometrical frustration in the Ce-triangular lattice [1]. In this presentation, we discuss neutron scattering study that reveals the collinear incommensurate structure with ordering wave vector (***k***) of (1.39, 0, 0.09) in the AFM state, which persists down to the lowest measuring temperature of 70 mK. When the magnetic field is applied along [100], the neutron scattering intensity shows a sharp peak around 1 tesla with the same ***k***. On the other hand, a sudden change of ***k*** is induced near 1.2 tesla for the field applied along [001]. This anisotropic field dependence of magnetic ordering wave vector is consistent with that of electrical resistivity and magnetization. The origin and mechanism of the unusual magnetic structure and field dependence in $CePtAl_4Ge_2$ will be discussed in connection with the crystal field analysis.

Keywords:

metallic spin frustrated lattice, CePtAl4Ge2, antiferromagnet, Kondo metal, RKKY interaction

A8.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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머신러닝을 이용한 자성체의 상호작용 매개변수 추정

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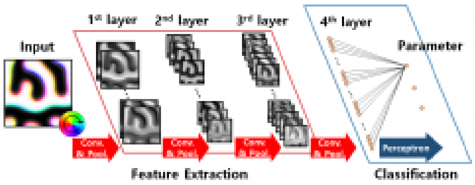
Abstract:

교환 상호작용 외에도 쌍극자 상호작용, DM 상호작용 등의 다양한 상호작용이 존재할 때 나타나는 복잡한 자성구조들을 연구하기 위해 전산모사 방법이 널리 사용되고 있다. 실험결과의 분석을 위해 전산모사 방법을 사용하는 경우, 자성물질에서 나타나는 상호작용의 매개변수 값을 알아야 한다. 우리는 머신러닝 알고리즘을 도입하여 상호작용 매개변수를 구하는 방법에 대해 연구하였다. 학습과 검증에 필요한 데이터 셋을 몬테카를로 전산모사를 통해 만들었고, Fully Connected Neural Network(FCNN)와 Convolutional Neural Network(CNN)를 이용하여 이 데이터 셋을 학습시켰다. 그 후, 학습된 머신에 전산모사 결과와 SPLEEM을 통해 관측된 실험 데이터를 넣어 학습 정도를 평가하였다. FCNN을 이용할 경우 간단한 모델임에도 불구하고 추정된 데이터가 정답과 유사함을 보았고, 이미지 분석에 더 최적화 된 CNN을 사용하면 정확도가 개선되는 것을 확인하였다. <그림>은 CNN을 통해 자성구조에서 나타나는 특징들이 성공적으로 추출되었음을 보여준다.



<그림> Convolutional Neural Network의 구조

Keywords:
Magnetism, Monte-Carlo simulation, Machine learning, Magnetic parameter estimation, Convolutional neural network

A8.08*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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강자성 이중층 시스템의 지역적으로 층간 결합이 뒤집힌 구역에서 발견되는 자기 구조들

이찬기[1], 권희영[1], 김남준[1], 윤한규[1], 송치호[1], 원창연*[1]
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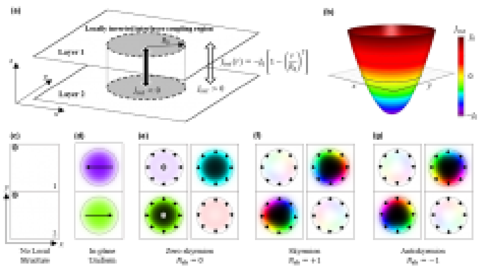
Abstract:



자기 스커미온(Skyrmion) 및 자기 소용돌이(Vortex)와 같이 스커미온 수를 가지는 자기 구조는 안정적이다. 또한 스핀 토크와 외부 자기장으로 제어할 수 있기 때문에 광범위하게 연구되고 있다. 우리는 전산모사를 이용하여 지역적으로 뒤집힌 층간 상호 작용을 가지는 자기 이중층 시스템에서 나타나는 자성 구조들을 조사하였다. 지역적으로 뒤집힌 층간 결합 영역에서는 스커미온, 반스커미온, 면내 균일 자성 상태, 비스커미온 상태 등의 다양한 안정된 구조가 나타났다. 안정적인 구조들의 크기는 영역의 면적, 이방성, 층간 결합 강도 및 교환 상호 작용 강도와 같은 다양한 요인에 의존한다. 우리는 그들의 안정화 조건 및 그 구조들 사이에서 나타나는 구조적 전이 조건을 조사하였다. 그리고 쌍극자 상호 작용, Dzyaloshinskii-Moriya (DM) 상호 작용이 그 스핀 배열과 안정성에 어떠한 영향을 미치는지를 연구하였다. 또한 자기 구조가 하나의 층에서만 생성되고 균일한 자화를 가지는 다른 층과 상호 작용 할 때 반전 대칭이 자발적으로 파괴되는데, 이때 쌍극자 상호 작용에 의해 카이랄성을 가지는 자성 구조가 DM 상호 작용이 없는 경우에도 나타날 수 있음을 확인하였다.

Keywords:

Skyrmion, Ferromagnetic Bilayer System, Locally Inverted Interlayer Coupling, Spontaneously Broken Inversion Symmetry, Monte-Carlo Simulation

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A8.09*

Dynamics of Bloch point in an asymmetric patterned permalloy disk

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Abstract:

A Bloch point is a magnetic singularity in ferromagnetic materials, where the local magnetization vanishes [1, 2]. Bloch point shows intriguing physical behaviors as a discrete spin texture - pinning and depinning at atomic lattices, and the spin-Cherenkov effect [3, 4]. Furthermore, it has been known that the Bloch point plays a critical role in the switching of 2D magnetic textures such as magnetic vortex core and skyrmions with changes of their local topological numbers [5]. However, it has been challenging to study the physical behavior of a Bloch point including its static and dynamic motion experimentally. First, it is very difficult to secure the stabilized Bloch point in ferromagnetic materials. Second, it is necessary to observe internal magnetic structures surrounding the Bloch point on nanometer scale, which requires a state-of-the-art imaging technique with high spatial resolution.

In this presentation, we report the Bloch point in the middle of vortex core structure and its dynamics directly observed by the time-resolved magnetic full-field transmission soft X-ray microscopy (MTXM) [6]. From the measurement of the Bloch-point motion and its effects on the magnetic vortex-core dynamics, we successively addressed the atomic nature of the Bloch point. We will discuss detailed structures of Bloch points according to its type and topological numbers and fundamental understandings on the role of the atomic nature of the Bloch point in magnetic textures' dynamic motion and switching.

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Keywords:

Bloch point, magnetic singularity, Time-resolved X-ray imaging, spin dynamics, magnetic vortex

A10.01*

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Individual and collective activity in GitHub

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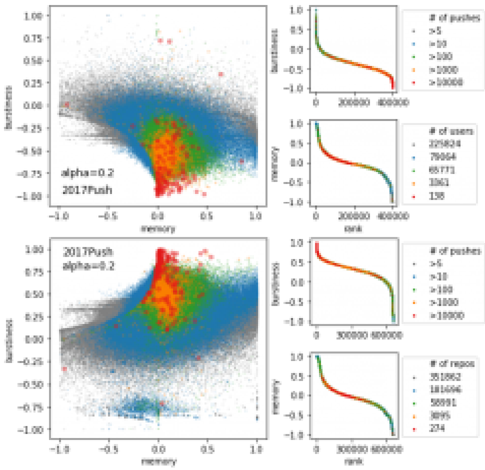
Abstract:

GitHub is a representative online code-repository and community of millions of developers. The GitHub has 28 million users and 85 million repositories from its onset in 2008. Not only an open source project but also a private enterprise project have been based in the GitHub. In this study, we perform the analysis of the activities in the GitHub. Our all analysis is executed two-way parallelly: user-based and repository-based - individual and collective activity. We investigate from simple statistics about activities to more complex statistical formulas: Gini index as inequality [1], burstiness and memory as inter-event time distribution [2]. All activity distributions follow a fat-tailed distribution. Using the clustering method, we categorize the type of users and repositories. We find a mirror symmetry between an individual and collective activity in memory and burstiness (MB) phase diagram.



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Keywords:
github, activity, burstiness, open soruce,

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A10.02

Universality and non-universality of the international trade networks of individual countries

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Abstract:
While recent studies have led to a basic understanding of the global organization of the international trade networks, the local network properties and their fluctuation remain to be investigated. To understand how individual countries distribute their export volume over importer countries and export products, here we investigate the country-country network connecting exporter and importer countries by links weighted by trade volumes and the country-product network with the same weighted links between exporter countries and product categories.We find that the distribution of export volume over importers takes a universal form independent of exporters while that over products takes different forms, classifiable into two depending on the out-degree of exporters in the country-country network.

Towards a better understanding, we investigate the relation between the export volumes and the in-degrees of importers and products, and find their significant positive correlation characterized by the scaling exponents not universal but varying with the out-degree of exporters.
More importantly, significant disassortativity is present in both networks such that only exporters of large out-degrees are linked to importers and products of small in-degrees. We show that the volume-degree correlations and the degree-degree disassortativity underlie the universality and non-universality of the export volume distributions. More implications of our findings are discussed.

Keywords:
International trade network, Econophysics

A10.03*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

부호와 단방향성을 가진 네트워크에서의 확장 네트워크 모티프 분석

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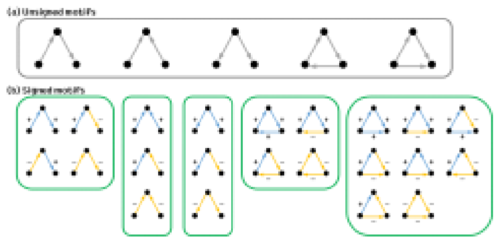
Abstract:



사회 연결망이나 생태계와 같은 복잡계는 노드(구성요소)와 링크(두 구성요소 사이의 연결관계) 로 표현되는 네트워크로 나타낼 수 있다. 특히, 이러한 네트워크들은 링크의 방향과 부호가 있고 크기가 시간에 따라 변화한다. 링크의 부호는 각 노드가 표적 노드에게 긍정 또는 부정적인 영향을 끼침을 의미하며, 방향은 링크의 나감이나 들어옴을 나타낸다. 네트워크의 부분 그래프인 모티프 중, 우리는 3개의 노드로 구성되는 22가지 종류의 모티프에 집중한다 (그림 b). 우리는 각 노드로 들어오는 링크의 가중치 합으로 정의된 적합도를 가진 네트워크 모델과 실제 네덜란드의 대학교 신입생을 대상으로 서로의 우정 정도를 조사한 네트워크를 이용하여, 시간에 따라 변화하는 네트워크에서 모티프 수의 변화를 관찰한다. 네트워크에서 특정 모티프들은 네트워크 크기 변화의 안정성과 관련이 있음을 보여준다. 부호와 방향을 고려한 모티프 분석은 기존의 방향만 고려한 경우에 비해 더 다양한 모티프 경우를 생각할 수 있고, 방향만 고려했을 때 같은 모티프인 경우에서도, 링크의 부호에 따라 네트워크에서의 역할과 그 의미가 다름을 확인한다.

Keywords:

부호가 있는 단방향 네트워크, 성장 네트워크, 모티프, 모티프 분석

A10.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Probabilistic Reference Networks and Information-Theoretic Measure of Novelty and Influence in Creative Works

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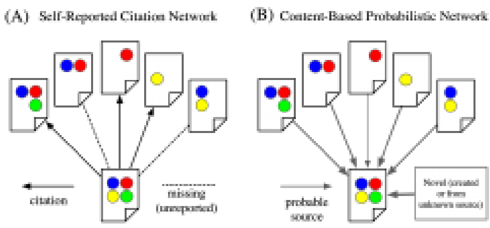
Abstract:

Amid the surging interest in scientific understanding of human behavior and intelligence, advanced methods and high-quality data of intellectual and creative achievements are enabling deep investigations into how creativity, an essential human faculty, crystalizes into novel knowledge and culture. To understand how they form and evolve, we characterize the interconnected nature of creativity using the concepts of novelty and influence that differentiate and connect creative achievements. Our general framework starts from the *probabilistic reference network* that compares the content of two creative works to estimate the likelihood that one referenced the other.



This overcomes the following problems of classical citation networks (Figure A): First, with the exception of research publications, references are not seldom explicitly given, especially in cultural creations. Second, since citations are self-reported, it is subject to incompleteness due to human bias or misinformation. Our content-based reference/influence network between creative works (Figure B) considers all known data of older works and also accounts for the possibility that each element of a work could have been invented or originated from unknown sources by introducing a general prior. We define information-theoretic measures of novelty and influence based on the probabilities, and apply them to a comprehensive midi data of western classical piano music that have high scientific as cultural value. We find that a continual innovation against oneself as well as the entire field helps become an influential figure, and show that the developmental history of a creative enterprise can be visualized as a series of paradigmatic shifts in creative styles featuring novelty against conventions.

Keywords:

Citation networks, probabilistic citation networks, classical music, statistical inference, novelty

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A10.05

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Threshold cascade model in signed networks and hidden complexity

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Abstract:
We investigate a threshold cascade model on signed network. In signed networks, there are two types of link, positive and negative. The model incorporates the effect of negative links and is used to apply various network-theoretical concepts and tools to quantitatively understand the signed network dynamics. In the model, an inactive node gets activated if i) the fraction of active nodes among its neighbors connected by the positive link exceeds the prescribed threshold *r*, and at the same time, ii) there is no active neighboring node connected by the negative link. From numerical simulations, the presence of the negative interactions (encoded by the negative-link mean degree z_-) is found very effective in suppressing global cascade. As the negative links are introduced in the network, the cascade size ρ decreases promptly. While the cascade covers lesser fraction, it takes longer time to proceed, up to the point by which the depletion effect gets saturated at around $z_- \approx z_+$. We will discuss interesting nontrivial effects of the existence of negative interactions to show the additional facets of complexity such as degenerate stationary states. For a given z_- and seed conguration, some stationary states are occurred. And interestingly, such occurrence of the degenerated stationary states is kept for increasing z_-. We anticipate this work could prompt the community to the study of dynamic processes on signed networks at large, which we believe will prove itself a fertile ground for yet another layer of complexity in networked complex systems.

Keywords:
signed network, cascade dynamics, complexity

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A10.06*

K-selective percolation: Modeling enzymatic degradation of polymer networks

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Abstract:

Enzymatic degradation of polymer networks is emerging as an important future industry. We approach the substrate specificity, an essential characteristic of enzymes, from the percolation perspective and develop a new percolation model, called the *K*-selective percolation. Our model has following rules: On the network, which corresponds to the polymer network architecture, if a randomly-chosen node has degree exactly *K*, then we delete the node. This process continues iteratively until there remain no nodes with degree *K* left in the network. Nodes with degree *K* corresponds to the specific substrates that the enzyme reacts with. We derive numerical solutions using generating function method, and verified them by Monte Carlo simulations. We obtain, among others, the optimal value K_{opt} that can degrade the substrate network most efficiently. In most cases three phases and double phase transitions are observed in the *K*-selective percolation. The first phase transitions are continuous and the second ones are hybrid. We hope this study to be a stepping stone in understanding the enzymatic degradation of polymer networks with percolation perspective and the fundamental physics of multiple phase transitions.

Keywords:

Percolation, K-selective percolation, Polymer networks, Enzymatic degradation, Multiple phase transition

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A10.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Hybrid percolation transitions of scale-free networks

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Abstract:

Recently it was proposed that the global suppression (GS) protocol changes the type of percolation transition (PT) to a discontinuous transition. Along this spirit, recently the Erdős-Rényi (ER) random graph model was extended to a so-called restricted ER model, in which clusters are classified into two sets according to their sizes and cluster coalescence occurs in dichotomous cluster merging processes, which generates the global suppression effect implicitly. Here we extend the r-ER model further into the scale-free (SF) network case. We find that as long as the degree exponent λ is larger than two, a hybrid PT occurs at a finite transition point with continuously varying exponents. However, in the region $2 < \lambda < 3$, finite-size scalings of the order parameter and transition point appear in an abnormal form, distinct from those in the explosive percolation model.

Keywords:

hybrid percolation transition, scale-free network, critical phenomena

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A novel critical phenomenon of the restricted ER model : interevent time distribution

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Abstract:

The restricted ER model is a dichotomous cluster merging process which exhibits a hybrid phase transition. In this model, clusters are ranked by their size and partitioned accordingly into two sets. A giant cluster emerges in a discontinuous fashion and the cluster size distribution exhibits power law after the jump. In this talk we present another critical phenomenon of this model; a power law in the intervals of set switching. The inter-set crossing events occur in a self-organized critical and bursty manner, which is however distinct from the conventional Bak-Tang-Wiesenfeld dynamics. This novel feature in the subcritical regime has not been reported before. Moreover, we find that the exponent of this interevent time distribution is independent of the partition parameter.

Keywords:

Hybrid percolation transition, discontinuous transition, self-organized criticality, bursts, restricted random graph

A10.09*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Profile of effective free energy for a hybrid synchronization transition in the Kuramoto model

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Abstract:

It is well known that the Kuramoto model exhibits different types of phase transition according to the choice of the natural frequency distribution. As one of the analytic approach to describe synchronization transition, Kuramoto's self-consistency argument has played a role of explaning the collective behavior of the system. We present an extended self-consistency approach by introducing the potential which corresponds to the free energy of the Landau theory. The landscape of this effective free energy displays a plateau across the order parameter region at the criticality for the system with uniform frequency distribution where it is reported that the hybrid synchronization transition occurs. The presented scheme can be applied to any systems with symmetric distribution and is confirmed by the numerical simulations for finite size of the system. It yields cogent interpretation for the evolution of the order parameter and metastability. These results provide a suggestion that the effective free energy can be regarded as the reference of the synchronization transition.

Keywords:

Hybrid phase transition, Synchronization, Kuramoto model

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A11.01

Role of zinc ion during enzyme catalysis

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Abstract:

Carbonic anhydrases are mostly zinc metalloenzymes that catalyze the reversible hydration/dehydration of CO_2/HCO_3. Until now, the role of zinc in carbonic anhydrase II (CA II) has been studied as a Lewis acid, stabilizing a hydroxyl ion in the active site. In this presentation, we show multiple crystallographic structures of CA II at seven differnt CO_2 (substrate) pressurized conditions to explore the role of the metal on the active site solvent organization. Our results reveal that the zinc ion plays a critical role beyond the ionization of the zinc-bound water.

Keywords:

carbonic anhydrase II zinc ion water dynamics

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A11.02

Superb single molecule technique DNA curtain reveals the damage search mechanism of XPC in human NER

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Abstract:
DNA damage repair is critical for the genomic stability and integrity. In particular, searching for DNA lesions is important because it initiates the entire repair process. In nucleotide excision repair (NER) that is a conserved and versatile repair mechanism, Xeroderma pigmentosum complementation group C protein (XPC) finds DNA lesions and recruits downstream NER components. Structural studies revealed the molecular features of damage identification by XPC, and single-molecule approach reported the diffusion of XPC on DNA. However, how XPC can recognize the defects on DNA while it scans genome via diffusion and what factors influence the diffusive motions of XPC still remain elusive. We investigated the detailed mechanism underlying damage search by human XPC by visualizing its motion on either undamaged or lesion-containing DNA, using a high-throughput single-molecule imaging technique, DNA curtain. Human XPC-Rad23B (hXPC-Rad23B) moves along DNA with one-dimensional diffusion with three distinct motions: diffusive motion, constrained motion, and immobile state. This heterogeneity of motion results from the interaction between XPC-RAD23B and DNA breathing on consecutive AT-tracks. We also found that the diffusion coefficient dramatically increases according to ionic strength, suggesting that hXPC-Rad23B diffuse along DNA via hopping. Based on the collision experiments, we demonstrated that the hopping facilitates bypassing protein obstacles. Furthermore, hXPC-Rad23B preferentially binds to the cyclobutene pyrimidine dimers (CPDs). During diffusion, nevertheless, hXPC-Rad23B does not identify the lesions at one time.

Keywords:
NER, single molecule, XPC, DNA repair, DNA curtain

A11.03*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

The molecular function of AboI in the biophysical perspectives

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Abstract:

Chromatin assembly following DNA-based processes is required for the maintenance of genomic stability and epigenetic information. Nucleosomes can be assembled via ATP-dependent pathway by chromatin assembler proteins. In *Saccharomyces cerevisiae*, Yta7, a bromodomain-containing AAA-ATPase, is known to disrupt chromatin organization to facilitate transcriptions. Meanwhile, it was recently reported that AboI, a fission yeast homolog of Yta7, contributes to chromatin assembly. However, the biological role and molecular features of AboI remain poorly understood yet. Here we characterize the molecular function of AboI in the structural and biophysical perspectives. The cryo-EM structures of AboI reveal that ADP-bound state shows a symmetric hexameric ring structure whereas ATP-bound state shows open spiral structure. Using a novel single-molecule imaging technique, DNA curtain, we demonstrate that AboI does not dislodge H3-H4 histones from DNA but deposits the histones onto DNA in the presence of ATP. In the presence of no ATP or non-hydrolysable ATP analogues, AboI does not load the histones on DNA. Our results manifest that AboI loads H3-H4 histones only when ATP hydrolysis is permitted.

Keywords:

AboI, Cryo-EM, Single-molecule imaging, DNA curtain

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A11.04

Nanostructure of intercellular nanotubes reveals its formation mechanism

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Abstract:
Intercellular nanotubes (INTs) are an actin-based cell-to-cell connecting structure, which grow between the cells and transport mRNA, proteins, viruses, and even mitochondria from one cell to another. Interestingly, INTs are very stable even though they have a long and thin structure. Recently, we discovered that the helical deformation of the filopodial connection (filopodial bridge) between cells triggers the INT formation and cell adhesion molecules (cadherin) strongly links the INT to the paired cell. However, the conventional fluorescence microscopy couldn’t reveal the nanostructure of INTs. We will introduce how we use super-resolution radial fluctuations microscopy to reveal temporal fine structures of the INT formation and super-resolution localization microscopy to visualize the helical structure of the filopodial bridge and the junction of the INT and the cell body.

Keywords:
intercellular nanotubes, super-resolution

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A11.05*

Diffusion mechanics of PCNA-p15 on DNA

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Abstract:

Proliferating cell nuclear antigen (PCNA) regulates various life processes by the physical interaction with around 50 different proteins. Its ring-shaped trimer encircles DNA and its internal interface associates with the DNA backbone. The continuous binding between PCNA and DNA can allow the helical motion of PCNA on the DNA backbone. Single-molecule studies have proposed that the PCNA diffusion on DNA combines the helical diffusion with a hopping motion. PCNA-associated factor 15 (p15), an intrinsically disordered protein, regulates the exchange of DNA polymerases associated with PCNA in translesion DNA synthesis by binding PCNA on DNA. We found that p15 changes the diffusion mechanics of PCNA using a novel single-molecule tracking platform called DNA skybridge. We will introduce a physical model of the p15-PCNA interaction for the polymerase exchange.

Keywords:

PCNA, p15, paf15, long DNA, diffusion, DNA Sky Bridge

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A11.06*

Strand excision in *E. coli* DNA mismatch repair

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Abstract:

UvrD helicase that unwinds double stranded DNA plays an important role in strand excision in *E.coli* mismatch repair (MMR). However, UvrD alone spontaneously dissociates from DNA after unwinding 50 ~ 60 bp, which indicates that exonuclease is required to prevent the unwound DNA from being rezipped because the distance between the initiation site of UvrD and a mismatch is several hundred nucleotides. We used a novel single-molecule technique based on a hydrodynamic force to monitor the activities of UvrD helicase and ExoI exonuclease. We found that ATP-bound MutL sliding clamp that is formed on mismatched DNA can enhance the UvrD unwinding activity. Interestingly, the unwinding by a UvrD/MutL complex is controlled by single strand binding protein (SSB). Contrary to previous biochemical ensemble studies, our results strongly suggest that the single-strand DNA excision of exonuclease is not critical during the course of UvrD helicase.

Keywords:
UvrD helicase, Flow-stretching, Single-molecule, DNA mismatch repair

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2019-04-24 - 2019-04-26

A11.07*

Protonation of amine headgroup controlled by its occupied area

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Abstract:

Langmuir monolayer is a monomolecular layer formed on water surface and has been widely investigated as a model two-dimensional system or simplified system to resemble bio-membranes. Protonation/deprotonation state of headgroups in monolayer system is the main factor which affect to the property of monolayer, especially the interaction between lipid - protein. The amine headgroups which are the functional groups of the amino acids have biological importance because the amino acid is the elementary particle of proteins. As the latest addition to investigate the Langmuir monolayer, sum-frequency vibrational spectroscopy (SFVS) has been widely accepted to be one of the most capable techniques to investigate this interfacial system where inversion symmetry is broken.

Charge status of the headgroups of the molecules consisting monolayer at different area per molecules is studied by SFVS. Langmuir monolayers consisting of mixtures of 1-hexadecanol (HD) and octadecylamine (ODA) molecules at different molar ratios were prepared to investigate the effect of surface area/molecule on the charge status of the amine headgroup. Here the fatty alcohol molecules worked as mere spacers to widen the distance between the amine groups. Sum-frequency vibrational spectra in the OH range was larger for the monolayers having intermediate area/molecule, which indicated the surface is more charged even when there are less amine groups in the monolayer. To compare with the above systems, 1,2-dipalmitoyl-3-trimethylammonium-propane (DPTAP), a surfactant molecule having quaternary amine headgroup was then mixed with 1-hexadecanol (HD) at different molar ratios and investigated by SFVS. Comparison of the OH spectral areas of HD/ODA and HD/DPTAP systems allowed quantitative estimation of the protonation fraction of amine headgroups in the ODA mixture monolayers. It was found that the amine headgroup protonated at larger area per molecule. Additionally, the surface potential calculated from Gouy-Chapman theory that took into account the area change followed the intensity of the OH bands in SFG spectra in HD/DPTAP mixtures. However, the theory overestimated the ionized fraction of the amine headgroup.

Keywords:

Langmuir monolayer, sum-frequency generation, protonation

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2019-04-24 - 2019-04-26

A11.08

Catalytic enzymes are active matter

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Abstract:
Recent studies suggest that the enhanced diffusion of catalytically-active enzymes is promoted by super-diffusive "kicks" generated by the catalytic events. Pursuing this idea, we have explored methods to vary systematically the turnover frequency, k_{cat}, which defines how many substrate molecules are consumed in a given time. Our measurements using fluorescence correlation spectroscopy in super-resolution mode (FCS-STED) enable us to illuminate this matter. The contrast between motions in the presence of inhibitor and of substrate is especially interesting.

Keywords:
Enzyme, diffusion, STED-FCS

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A11.09

Lateral diffusion of membrane protein-antibody complexes in a lipid membrane: beyond the Saffman-Delbrück description

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Abstract:

The Saffman-Delbrück model, since its introduction in 1975, has been employed to explain the lateral dynamics of membrane proteins diffusing in a cellular lipid membrane. The model describes lateral diffusion of a protein as a quasi two-dimensional diffusion of a cylindrical object embedded in a viscous fluid of lipid membrane surrounded by water. In spite of its wide applicability and prediction power of the model, it neglects the interactions among the proteins in the membrane, which may play a crucial role in in vivo lateral protein dynamics [1, 2], and the effect of attachment of a macromolecule to the protein outside the membrane. In this work, we carefully explore this issue based on both experimental and theoretical approaches. Using the membrane protein Syntaxin 1A, we scrutinize lateral diffusion of the Syntaxin 1A at varying lipid-to-protein ratio with and without attachment of antibodies of various size. Our experiment shows that the diffusivity of the membrane protein can be significantly reduced beyond the Saffman-Delbrück theory by the attachment of big antibodies and their crowding effect. We explain the observed diffusion dynamics in terms of two-body collisions and their excess entropy. We also perform the corresponding coarse-grained simulation of our membrane system and quantitatively explains the experimental data. Our study finds that the reduction of the protein diffusivity as a function of the protein area fraction follows the universal scaling law, originally found in the dense hard particle systems. Possible effect of softness of the proteins is shortly discussed.

[1] D.-H. Kim et al., Angew. Chem. Int. Ed. 24, 7028 (2015).
[2] J.-H. Jeon et al., Phys. Rev. X. 6, 021006 (2016).

Keywords:
Saffman-Delbrück model, Lateral diffusion, Membrane protein, Molecular crowding, Coarse-grained simulation, Single particle tracking

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A12.01

한국원자력연구원 DIAC 중이온빔 조사시험시설 구축 현황 및 활용 계획

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Abstract:

한국원자력연구원에서는 일본 고에너지가속기 연구기구 (KEK)로부터 전자사이클로트론공명 이온원, radio-frequency quadrupole 선형가속기, rebuncher, interdigital H-type 선형가속기를 이전받아 중이온빔 조사시험시설, Daejeon Ion Accelerator Complex (DIAC)을 구축하였다. DIAC 가속 장치는 전하 대 질량 비 (charge-to-mass ratio)가 1/9 이상인 중이온을 1 MeV/nucleon까지 가속하여 표적에 조사시킬 수 있도록 설계되었다. 구축 기간 동안 (1) 가속기 공동, 전자석, 전원장치 등 시스템에 대한 건전성 시험 및 가속기 정렬 작업을 완료하였고, (2) 빔 표적 챔버를 제작하였으며, (3) 운전자와 이용자 안전을 위하여 인터락 시스템을 구축, 방사선발생장치 인허가 획득 및 시설 검사를 완수하였다. 최근 He 이온을 이용한 첫 빔 가속 실험을 수행하였고, 실험 결과, 4 MeV, 최대 18 μA 전류의 He^+ 빔을 확인하였다. 현재 빔 성능 개선을 위해 빔 조정, 최적화 작업을 진행 중이며, 시설 활용 확대 및 이용자 편의성 제고 방안을 모색 중이다. 본 발표에서는 가속기 구축 현황·시험 결과와 함께 DIAC의 핵융합·원자력 재료시험 분야 활용 계획에 대하여 보고한다.

Keywords:

중이온, 이온빔, 가속기, 빔조사시험, DIAC

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A12.02

머신러닝을 이용한 전자빔의 longitudinal Phase Space 예측

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Abstract:

2010년대가 되면서 인공지능분야는 여러 분야에서 큰 발전을 이루었고 그 결과 현실의 여러 분야에 적용될 수 있을 정도에 이르렀다. 특히 데이터 학습 기반 예측과, 이미지 분석 등은 산업과 과학에서 인간을 도울 수 있을 정도로 발전했다. 이를 바탕으로 2016년부터 가속기 분야에 인공지능을 적용하려는 시도들이 있었고, dynamic aperture 계산 및 pulse property를 예측하는데 성과를 거두었고 2018년에는 Longitudinal Phase space를 예측하는 연구 결과가 나왔다. 본 연구에선 PAL-XFEL에 머신러닝을 적용하기 위한 기반 연구로 EUV-FEL에서 머신러닝을 이용해 전자 빔의 Longitudinal Phase Space를 예측하기 위한 연구를 진행했다. 그를 위해 Single-Turn ERL에서 10000번의 시뮬레이션을 통해 undulator 입구에서의 Longitudinal Phase Space 데이터를 얻었고 CNN 기반으로 훈련시킨 결과 같은 위치에서 전자 빔의 에너지 분포와 밀도를 예측하는데 성공했다. 이러한 연구를 통해 PAL-XFEL에서 빔의 정보를 더 정확하고 안정적으로 제공해 유저들이 더 좋은 연구를 하는데 이바지 할 수 있을 것이다

Keywords:
Machine Learning,CNN,Longitudinal Phase Space

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A12.03

On a sextupole-free electron storage ring

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Abstract:
원형 전자 가속기의 구조를 획기적으로 변모, 발전 시키기 위해, chromaticity를 교정하고 또 될수록 큰 dynamic aperture를 확보하기 위한 6극자석들을 모두 없애거나 그 수를 대폭 줄이는 것을 제안한다. Chromaticity교정 없이 head-tail instability를 제어하기 위해 두 가지 방법을 제안한다. 첫째는 가속기 vacuum chamber 물질로 세라믹, 유리등을 사용하여 broadband impedance를 획기적으로 낮추는 것이고, 둘째는 이렇게 해서 약해진 head-tail instability를 bunch-by-bunch feedback system으로 억제하는 것이다. 본 발표에서는 이에 대한 이론적 근거 및 방법을 설명한다.

Keywords:
Electron accelerator, storage ring, sextupole magnet, head-tail instability

A12.05*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Warm electron waves driven by time-dependent flows in magnetized plasma

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Abstract:

Kinetic aspects of warm waves in magnetized plasma have been analyzed to study the effect of finite flows on cyclotron harmonic waves. For the constant flow velocity, the growth rates of the harmonic waves in Doppler-shifted frequencies do not change compared to the stationary plasma. However, the time-dependent or shear flow, which is expected in the fast transport events such as solar flares and bursts of fusion plasma instabilities, can drive the wave instabilities. The analysis is confirmed by the particle-in-cell simulations with prescribed flows, demonstrating the increase of EM wave intensity in the presence of transient plasma flow. The temporarily generated stream induces a perpendicular flow by the Lorentz force. The two perpendicular streams are coupled to each other and develop the harmonic waves in the vicinity of the cyclotron harmonics. A detailed examination is presented for the $\mathbf{E} \times \mathbf{B}$ shear flow produced by the radial electric field in the edge transport barrier region of tokamak plasma. The enhanced EM wave emission is reproduced with the electric field reduction at the collapse of the edge transport barrier.

* This work was supported by the National Research Foundation of Korea under BK21+ program, Grant No. NRF-2017M1A7A1A03064231, and Grant No. NRF-2017M1A7A1A03064242.

Keywords:

time-dependent shear flow, cyclotron harmonic waves, plasma disruption, radial electric field, PIC simulation

A12.06

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Stark broadening을 이용한 헬륨 저온 플라즈마의 물성 진단 연구

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Abstract:

Stark broadening은 플라즈마내 전자나 이온에 의하여 플라즈마 방출광의 선폭이 증가하는 현상으로, 주로 천체 플라즈마나 대기압 플라즈마의 물성 진단에 사용되고 있다. 일반적으로 Stark broadening의 측정 한계는 Doppler broadening에 의하여 결정되며, 아직까지 저온 플라즈마의 물성 진단에는 활용되지 못하고 있다. 본 연구에서는 헬륨 저온 플라즈마의 Stark broadening을 측정하기 위하여 ICP 플라즈마 발생장치를 구성하였으며, 396.5nm(2^1S-4^1P) 파장과 1MHz 미만의 주파수 선폭을 가지는 고분해능 레이저를 이용한 saturated absorption spectroscopy 실험 장치를 구성하였다. 이를 이용하여 Doppler broadening이 제거된 Stark broadening을 측정하였고, 헬륨 플라즈마의 전자밀도를 결정하였다.

본 연구는 핵융합기초연구사업(과기정통부)의 연구비 지원으로 수행되었음.
(No. NRF-2017M1A7A1A02016145)

Keywords:

Helium plasma, Stark broadening, Saturated absorption spectroscopy

A13.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Constraining dark matter-neutrino interactions with IceCube-170922A

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Abstract:

Astrophysical neutrinos travel long distances from their sources to the Earth traversing dark matter halos of clusters of galaxies and that of our own Milky Way. The interaction of neutrinos with dark matter may affect the flux of neutrinos. The recent multi-messenger observation of a high energy neutrino, IceCube-170922A, can give a robust upper bound ₩sigma/Mdm < 5.1*10^23 cm2= GeV on the interaction between neutrino and dark matter at a neutrino energy of 290TeV allowing 90% suppression. Combining the constraints from CMB and LSS at different neutrino energies, we can constrain models of dark matter-neutrino interactions.

Keywords:

IceCube-170922A, dark matter, neutrino

A13.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Energetic Dark Matter Search via Dark-strahlung

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Abstract:

We propose *dark-strahlung* processes, a new channel for exploring dark sectors via scattering between dark matter and standard model particles. Dark-strahlung processes efficiently occur in situations where energetic dark matter particles are produced, e.g. beam dump experiments and boosted dark matter scenarios. We find that the dark-strahlung process can be comparable and even better than leading order simple elastic scattering of dark matter depending on energy and mass of dark matter, mass of dark gauge boson and dark gauge coupling. In addition, we discuss advantages of cosmic frontier approaches over intensity frontier approaches when utilizing the dark-strahlung process to search for dark matter signals.

Keywords:

dark matter, dark-strahlung, dark matter scattering, cosmic frontier

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A13.03

A new model for vector SIMP dark matter

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Abstract:

Strongly Interacting Massive Particles (SIMPs) have recently been proposed as light thermal dark matter relics. Here we consider an explicit realization of the SIMP mechanism in the form of vector SIMPs arising from SU(2)_X ₩times U(1)_{Z'} hidden gauge theory. In this model, we considered both cases that the degenerated and non-degenerated dark gauge bosons of SU(2)_X as a dark matter candidate. For the degenerated case, there is a Chern-Simons coupling to get a kinetic equilibrium between dark matter and SM particles. On the other hand, for the non-degenerated case, dark-charged gauge bosons of SU(2)_X can be dark matter candidates while neutral gauge bosons of SU(2)_X play a role as mediators for achieving the correct relic density and kinetic equilibrium. We showed that renormalizable interactions for the neutral gauge bosons can mediate between dark matter and SM particles, being compatible with experimental constraints.

Keywords:
Dark Matter, SIMP

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A13.04

Gravity-mediated dark matter beyond minimal couplings

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Abstract:

We consider a gravity-mediated dark matter model where dark matter of arbitrary spin interacts with Standard Model particles through their energy-momentum tensors, mediated by a massive graviton. In the case of a light graviton, dark matter can annihilate into two massive gravitons, so there is a need of going beyond the minimal gravity couplings and include the self-interactions for the massive graviton. We discuss the implications of new graviton interactions in the benchmark models with extra dimensions.

Keywords:

dark matter, gravity-mediated model, extra dimension, a massive graviton

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A13.05

Searching for Axino-Like Particle at Fixed Target Experiments

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Abstract:
We investigate the detectability of axino-like particle, which is defined as a supersymmetric partner of axion-like particle and can be a good candidate for dark matter in our Universe. Especially we consider the fixed target experiments to search for the light axino-like particle with neutralino as the next-to-lightest supersymmetric particle. We calculate the production and decay rates of neutralinos and the consequent number of events (such as photons and charged leptons) that are produced when the neutralinos decay to the axino-like particles.

Keywords:
Axino-like particle, Fixed target experiment, Cosmology

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A13.06

Letoquark models for B-meson anomalies and constraints (focus on muon g-2 and electron EDM)

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Abstract:
We consider the extension of the Standard Model with scalar leptoquarks, proposed to explain recent anomalies in semi-leptonic B-meson decays. We determine the flavor structure of leptoquark couplings from phenomenological constraints and discuss various implications of scalar leptoquarks for muon g-2, electron EDM as well as a portal to dark matter physics.

Keywords:
Lepton Flavor Universality B-meson anomalies Leptoquark Dark matter

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A13.07

Testing exotic vector-like quark decays at the LHC

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Abstract:

Many standard model extensions that address the hierarchy problem contain Dirac-fermion partners of the top quark, which are typically expected around the TeV scale. LHC searches for these vector-like quarks mostly focus on their decay into electroweak gauge bosons and Higgs plus a standard model quark. However, many underlying models predict ``exotic'' decays of vector-like quarks into a standard model quark and light BSM scalars. We determine bounds on exotic vector-like quark decays from existing LHC searches.

Keywords:

BSM, LHC, vector-like quarks, composite Higgs models

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A13.08

Unitarizing Higgs inflation in general sigma models

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Abstract:
We consider the extension of the Standard Model with a real scalar or sigma field to unitarize the Higgs inflation with a general form of the sigma field couplings. In particular, a linear non-minimal coupling to gravity plays a crucial role to restore unitarity up to the Planck scale while maintaining the sigma field inflaton light enough accessible at terrestrial experiments or cosmological observations. We also discuss the implications of our setup for dark matter, electroweak phase transition and Higgs precision physics.

Keywords:
Inflation, Non-minimal coupling, Unitarity, Light inflaton, Dark matter, Electroweak phase transition, Higgs physics

A14.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Korean contributions towards the CMS phase-2 endcap GEM upgrades for the HL-LHC

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Abstract:
As luminosity upgrade of large hadron collider (LHC) is scheduled, the upgrade of the CMS is also planned. As parts of the upgrades, the new detector stations based on the gas electron multiplier (GEM) will installed at the CMS endcap muon system. The Korean CMS group (KCMS) is carrying out important responsibilities for the CMS GEM detector upgrade. KCMS is supplying large size GEM foils, the most important detector parts. Also KCMS researchers are performing detector R&D, detector assembly, and quality control for the CMS GEM upgrade. Brief introduction to the upgrade and KCMS constributions will be presented.

Keywords:
GEM, CMS phase-2 upgrade, HL-LHC

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A14.02*

The results of large size Korean GEM foil validation for the CMS phase-2 upgrade

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Abstract:
The High Luminosity LHC (HL-LHC), with the aim of increasing potential discoveries, is planned to be in operation by 2025. An upgrade of the CMS detector technologies is needed to cope with the increased luminosity and pileup conditions of the HL-LHC. Since the flux of particles is the highest near the beam line, the installation of detectors that can operate efficiently in such harsh environments is necessary. In part of the endcap region of the CMS detector, a new sub-detector using gas electron multiplier's (GEM) technologies will be installed. A key component of the GEM detectors are the GEM foils. The KCMS group have been collaborating with MECARO to produce GEM foils as a part of the CMS detector upgrade. Korean GEM foil production capabilities have been established through the production of several previous batches. We present the performance of a chamber using Korean GEM foils.

Keywords:
CMS, GEM, detector

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A14.03*

Background study for triple GEM detector in CMS

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Abstract:

As part of the CMS muon system upgrade preparing for the high luminosity LHC, the installation of triple GEM detector is planned. They will be located at forward region of CMS, giving us higher rate capability and improve the triggering and physics potential. The area that GEM will be located is in a very heavy radiation environment, requiring us to know the effects from these background particles.

Keywords:

GEM, CMS, LHC, Muon, detector

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A14.04*

Impact of EM showers on energetic muons at CMS

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Abstract:

One of the major obstacles in the precise momentum measurement of an energetic muon is electromagnetic (EM) showers introduced by the interaction between the muon and material of the CMS muon system. In 2016 and 2017 the CMS detector collected 78 /fb of proton-proton collisions at center-of-mass energy $\sqrt{s}$=13 TeV. These data contain a large number of sufficiently energetic muons allowing us to better understand their performance. In this talk, we will present the recently developed methods to identify EM showers in the CMS muon system. Moreover, the impact of the showers on muon momentum measurement, reconstruction, and identification will be shown.

Keywords:
CMS, Muon

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A14.05*

CMS GE1/1 chamber assembly, quality control and aging test

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Abstract:
During the Long Shutdown 2 (LS2) of LHC at CERN, the triple Gas Electron Multiplier (GEM) detector called GE 1/1, will be installed in CMS endcap. The Korea CMS group have been participating in the GE1/1 chamber production and quality control (QC) at GEM QC/Prodcution lab in the CERN Prevessin site during Run II.
In this talk, we present the activities of Korea group on GE1/1 production and quality control.
We also present the most current result of aging test of GE1/1 chamber.

Keywords:
Compact Muon Solenoid (CMS), Gas Electron Multiplier (GEM), Quality Control (QC), Aging test

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A14.06*

Neutron Detector using Gas Electron Multipier

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Abstract:

We plan to produce a neutron detector using gadolinium as absorber. Gadolinium has a very high neutron absroption rate and emits gamma rays of 8 to 9MeV when absorbing neturon. This gamma ray produce electron and positron pairs , that electrons accelerated by GEM make avalanche and we can get the signal. We will check the possibility of GEM as neutron detector.

Keywords:

Neutron, GEM, Gadolinium

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A14.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Study on the performance of CEPC detector with dual-readout calorimetry

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Abstract:

The dual-readout calorimeter offers high quality energy measurement for both electromagnetic particles and hadrons. In the dual-readout calorimetry, the poor energy resolution of hadron calorimeters is improved by measuring the electromagnetic shower fraction of hadron showers and correcting the measured energy event-by-event. Application of the dual-readout calorimeter with the 4π projective geometry to the circular electron positron collider (CEPC) is being discussed significantly in the conceptual design report (CDR). In this talk, we introduce the basic concept of the dual-readout calorimeter, and present the electromagnetic and hadronic performances of it described in CDR.

Keywords:

Dual-readout, Calorimeter, CEPC, Circular Electron Positron Collider, 4π projective geometry, Shower

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A14.08

CMS RPC system in Level-1 Muon Trigger

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Abstract:
The CMS experiment implements a two-level triggering system composed of Level-1, instrumented by custom-design hardware boards, and a software High Level Trigger. To cope with the more challenging luminosity conditions, a new Level-1 architecture has been deployed during run II. This new architecture exploits in a better way the redundancy and complementarity of the three muon subsystems: Cathode Strip Chambers (CSC), Drift Tubes (DT) and Resistive Plate Chambers (RPC). In this talk, the role of each subsystem in Level-1 muon trigger will be described, with highlight on the contribution from the RPC system. Challenges brought by the HL-LHC environment and new possibilities coming from detector and trigger upgrades will also be discussed.

Keywords:
CMS, Level-1 Trigger, Muon Detectors, RPC

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A14.09

Construction of CMS iRPCs and the quality assurance

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On behalf of the CMS Muon Collaboration

Abstract:

In the future PHASE-2 high luminosity runs, the LHC will be operated with an instantaneous luminosity of maximum 7.5×10^{34} cm^{-2} s^{-1}. The CMS muon system in the PHASE-2 LHC runs will be extended up to η region of 2.4 where only the cathode strip chambers are currently present for the muon measurement. The Korea university group is in charge of construction of and quality assurance for core detector components of the iRPCs. In view of the high background conditions in the HL-LHC runs, the new CMS iRPCs should be designed and constructed so as to compromise with ample radiation hardness as well as guarantee the desired rate capability of exceeding 2 kHz cm^{-2}. The present CMS iRPC upgrade project will be completed with the installation of the chambers during the Technical Stops at the end of 2021 and 2022.

Keywords:
CMS experiment, Phase-2 HL LHC runs, iRPCs, Rate capability

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Magnetic properties of bulk and monolayer FeSe : A DFT+DMFT study

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Abstract:
FeSe is unique among other iron-based superconductors, as it has no magnetically ordered phase and becomes superconducting below 8 K in the undoped bulk form while the superconducting transition temperature soars by an order of magnitude for a monolayer FeSe on $SrTiO_3$ substrate.
Using a DFT+DMFT method, which combines the conventional first-principles electronic structure calculation scheme based on the density-functional theory (DFT) with the dynamical mean-field theory (DMFT) to include the time-dependent local electronic Coulomb correlation, we perform a comparative study on the magnetic properties of FeSe systems and LaFeAsO, another representative iron-based superconducting material. Calculated magnetic moment in the typical stripe-type magnetic ordering pattern is finite for LaFeAsO while negligible for bulk FeSe, consistently with experiments, and is also finite for expanded monolayer FeSe which is lattice matched to SrTiO3 suggesting the magnetic order is restored in expanded monolayer FeSe. We suggest a mechanism explaining why the systems with the similar magnitudes of fluctuating spin ($\langle S^2 \rangle$) have very different magnitude of ordered moment ($\langle S_z \rangle$) focusing on the different aspects of local charge fluctuation, in the context of so-called Hund's metal physics. Our work provides a comprehensive understanding of magnetic order in iron-based superconducting materials, and also suggests the proximity of magnetic ordered phase to the high temperature superconductivity of monolayer FeSe on $SrTiO_3$ substrate.

Keywords:
iron-based superconductor, FeSe, magnetic order, DFT+DMFT

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A15.02

Isostructural Metal-insulator Transition in VO_2: First Principles Design

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Abstract:
In correlated materials, electron and lattice distortion is coupled, therefore metal-insulator transition (MIT) of correlated materials must accompany the structural phase transition (SPT). We focus on the near room temperature phase transition process, i.e. insulating monoclinic to metallic rutile phase transition of the vanadium dioxide (VO_2), a representative correlated materials. By the first principles density functional theory calculation, we designed the rutile/monoclinic heterogeneous interface that electron-electron interaction of monoclinic VO_2 region is successfully reduced without crystal structure changing.[1] This interface design can stabilize unstable metallic monoclinic phase which was reported under high pressure or by photo excitation. The MIT without SPT of VO_2 is also confirmed by combination with experimental approaches like thin-film growth, structural and electrical characterizations. Our results clarify the long-time controversy about the origin of phase transition in VO_2.

References:

[1] Daesu Lee et al., *Science* **362**, 1037 (2018).

Keywords:
Metal-insulator transition, structural phase transition

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A15.03

Subtle electron-lattice interplay in the insulator-metal transition of NiS2-xSex: a structural study combined with x-ray diffraction and Raman scattering

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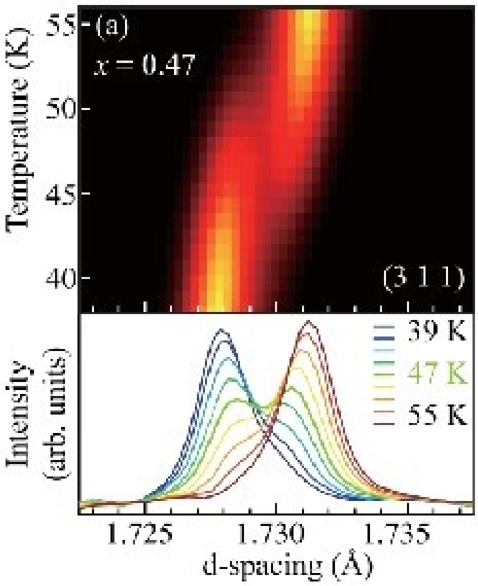
Abstract:

The insulator-metal transition is inevitably one of the most fundamental phenomena in the strongly correlated system. Although this has been found decades ago, it is still actively being studied owing to its complex nature and various possible applications such as ultrafast resistive switching using an electronic-driven transition. However, almost all candidate materials turn out to have a structural transition concomitantly occurring at the insulator-metal transition, making an in-depth investigation on the transition challenging. In this regard, NiS2-xSex is a rare prototypical material absent of a structural transition at the electronic transition, suggesting a pure electronic-driven transition in a bandwidth-controlled way. However, a recent experiment and theory on this compound propose that the transition is triggered by the chalcogen dimer, which thus needs to be examined in detail.



To investigate the electron-lattice interplay in NiS2-xSex at the transition in a structural point of view, we carefully performed a combined measurement of high-resolution x-ray diffraction on powder and Raman scattering on single crystalline NiS2-xSex samples that exhibit the insulator-metal transition with Se doping, by comparing with the counterpart doping absent of the transition. Via x rays, an abrupt change in the bond length between Ni and S (Se) ions is observed at the transition temperature, in sharp contrast to the almost constant bond length between chalcogen ions. Raman scattering, a complementary technique with the unique sensitivity to the vibrations of chalcogen bonds, reveals no anomalies in the phonon spectrum, consistent with the x-ray diffraction results. This indicates the important role of the interaction between Ni and S (Se) in the insulator-metal transition. The potential implication of this interpretation will be discussed in terms of current theoretical models.

Reference: Garam Han, Sungkyun Choi, Hwanbeom Cho, Byungmin Sohn, Je-Geun Park, and Changyoung Kim, Phys. Rev. B 98, 125114 (2018).

Keywords:

the insulator-metal transition, the charge transfer insulator, NiS2-xSex, x-ray diffraction, Raman scattering

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A15.04

$LaMnO_3$의 라만 스펙트럼에서 나타나는 611 cm^{-1} 공진신호에 대한 해석

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Abstract:

우리는 2001년에 van den Brink가 제안한 해밀토니안을 풀어서 A 타입 강자성 정렬 온도 이하의 온도에서 $LaMnO_3$가 보이는 편광 의존적 라만 산란 단면 스펙트럼을 계산했다. 이미 발표된 여러 실험 결과들과 유사하게 우리의 계산에서도 라만 스펙트럼 상에서 두 개의 강한 공진신호가 MnO6 팔면체 stretching phonon 주파수 주위에 나타난다. 하나의 모드는 Ag 대칭을 나타내지만 다른 모드는 Bg 대칭을 나타낸다. 우리는 Ag 대칭 신호는 오비탈 정렬과 결합된 Jahn-Teller phonon으로 판단했고, Bg 대칭 신호는 Jahn-Teller 전자-phonon 결합 방식으로 격자의 Q_2형 진동과 결합된 오비탈 파동 모드라고 해석했다.

Keywords:

LaMnO3, 오비탈 파동

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A15.05*

Emergence of robust 2D skyrmions in $SrRuO_3$ ultrathin film

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Abstract:

Magnetic skyrmions have fast evolved from a novelty, as a realization of topologically protected structure with particle-like character, into a promising platform for new types of magnetic storage. Significant engineering progress was achieved in the synthesis of compounds hosting room-temperature skyrmions in magnetic heterostructures, with the interfacial Dzyaloshinskii-Moriya interactions (DMI) conducive to the skyrmion formation. Here we report findings of ultrathin skyrmion formation in a few layers of $SrRuO_3$ grown on $SrTiO_3$ substrate without the heavy-metal capping layer. Measurement of the topological Hall effect (THE) reveals
a robust stability of skyrmions in this platform, judging from the high value of the critical field ~ 1.57 Tesla (T) at low temperature. THE survives as the field is tilted by as much as 85 degree at 10 K, with the in-plane magnetic field reaching up to 6.5 T. Atomically precise structural determination of the ultrathin film by the Coherent Bragg Rod Analysis (COBRA) method reveals the nontrivial atomic rumpling of the Ru-O lattice plane to be the source of inversion symmetry breaking and DMI. First-principles calculations based on the structure obtained from COBRA find significant magnetic anisotropy in the $SrRuO_3$ film to be the main source of skyrmion robustness. These features promise a few-layer $SrRuO_3$ to be an important new platform for skyrmionics, without the necessity of introducing the capping layer to boost the spin-orbit coupling strength
artificially.

Keywords:
SrRuO3, ultrathin film, perovskite oxide, Topological Hall effect

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A15.06

Pomeranchuk instability in the antiferromagnetism in RuO_2

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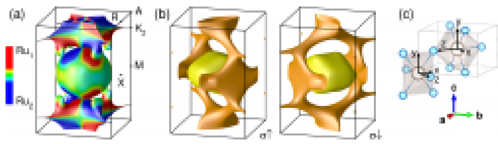
Abstract:

There are not many examples of metallic antiferromagnets (AFMs) like doped cuprates, CuMnAs, TiAu, and so on. Due to the unique coupling of magnetism and electric current as well as such rarity, metallic AFMs have been intensively studied, in particular, in spintronics. Recently, the rutile RuO_2 has been observed as a metallic AFM at room temperature,[1,2] but the origin of the AFM remains unclear.



In this presentation, we will address the origin through two approaches of static Hartree-Fock (HF) and density functional + dynamical mean-field theory (DFT+DMFT), which show similar results. In this system, the AFM order does not change the translational symmetry, since the two anti-parallel Ru sites fit into the rutile unit cell. However, the 4_2 screw rotation connecting the two Ru sites requires spin-inversion, to belong to the symmetry group. Thus, the AFM electronic structure is spin-polarized: the two spin channels are $\pi/2$-rotated to each other, classified as a d-wave Pomeranchuk instability.[3] To investigate the origin of the AFM instability, the energy difference of paramagnetic (PM) and AFM was calculated for the entire Brillouin zone (BZ). We found a hot spot at the point K_2, where the nodal-line 1 (NDL1) of Ref. [4] meets the BZ edge. The hot spot occurs on the PM Fermi surface where the Ru_1 and Ru_2 characters touch each other. By constructing a model Hamiltonian for the K_2 point, we show that the applied staggered potential splits the NDL1, and this is the origin of the AFM instability.

Figure 1. (a) Fermi surface of the paramagnetic RuO_2 (red: Ru_1, blue: Ru_2). (b) Spin-polarized Fermi surface of the AFM state. (c) Crystal structure of RuO_2 with the global and local coordinates.

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[3] C. Wu et al., Phys. Rev. B 75, 115103 (2007).
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Keywords:
Rutile RuO2, Hartree-Fock, DFT+DMFT, Pomeranchuk instability

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A very neutron-rich nuclear matter at RAON

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Abstract:
Using the quantum molecular dynamics (QMD) model, we investigate the very asymmetric nuclear matter which may be formed at RAON. RAON which is under construction in Daejeon will be a unique facility which has two different rare isotope generator, isotope separator on-line (ISOL) and in-flight fragmentation (IF), both. We expect that the combination of ISOL and IF would make more neutron-rich beam. We calculate the fragmentation cross-sections of the very neutron-rich nuclei with neutron-rich beams and discuss the effect of N/Z ratio of the incident beam on the fragmentation cross-section. Also, we study the isospin ratio of the collision center when the incident beam is neutron-rich and discuss the way to study nuclear matter with an extreme condition.

Keywords:
Nuclear matter, Asymmetric, Isospin, Neutron-rich, RAON

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B1.02*

Directed flow of parity doublet model in a new transport simulation

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Abstract:
핵자의 대부분의 질량은 양자색역학의 관점에서 손지기 대칭의 깨짐 (chiral symmetry breaking) 으로 인해 쿼크들과 글루온의 상호작용에서 온다. Parity doublet model (PDM)은 핵자의 손지기 (chiral) 파트너를 도입하여 양자색역학의 손지기 자발붕괴를 유효이론에서 구현하며, 대칭성이 복원 될 경우 핵자와 그 파트너의 질량은 손지기 불변 질량 (chiral invariant mass, m0) 값에 수렴하게 된다. 본 발표에서는 중이온 충돌 수치모사 코드 (DJBUU)를 이용하여 Au + Au @ 400A MeV에서 나타나는 directed flow 및 rapidity 분포를 PDM모델의 손지기 불변 질량에 따라 살펴 보고 FOPI 실험 결과와 비교하여 적합한 불변 질량을 제안하고자 한다.

Keywords:
Transport theory, directed flow, effective theory, dense matter

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B1.03

Effective range expansion and elastic $₩₩alpha$-^{12}C scattering at low energies

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Abstract:

The phase shift data of the elastic $₩alpha$-^{12}C scattering for $l=0,1,2,3$ at low energies are studied by using the scattering amplitudes represented in the effective range expansion where four effective range terms are included for $l=0,1,2$ and five ones for $l=3$. The first effective range terms are fixed by using the binding energies of 0_2^+, 1_1^-, 2_1^+, and 3_1^- ($l_{i-th}^₩pi$) states of ^{16}O, and the other parameters are fitted to the phase shift data. After fitting the paramters to the data, we find that the broad resonance 1_2^- and 3_2^- states of ^{16}O are well incorporated in the amplitudes represented in terms of the effective range parameters while the sharp resonance 0_3^+ and 2_2^+ states are not. We also study the asymptotic normalization coefficients for the bound states of ^{16}O comparing them with the previous results in the other works.

Keywords:

Effective range expansion, elastic alpha-carbon-12 scattering, asymptotic normalization coefficients, resonance states

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B1.04*

THERMAL NEUTRON CAPTURE OF $^{163}Dy(n,g)^{164}Dy$ AT DALAT REACTOR

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Abstract:

The decay of the 2^+ state from E_x = 1716 keV level in the ^{164}Dy is still controversial. It is predicted that there may exist two gamma rays decaying to ground and gamma bands from this state. However, in the previous study of Fohl et al., only the branch to the ground-state band was observed. In addition, the ^{164}Dy lifetime study of Lemann et al. suggested that the gamma line of 888 keV should be observed in the decays of ^{164}Dy. Notice that this gamma transition has not been detected in the previous (n,n) measurements. Therefore, the thermal neutron capture of ^{163}Dy was measured by the g-g coincidence spectrometer at Dalat Reactor (in Vietnam) to search for new gamma transitions to reveal the mentioned problem. The level density and the radiative strength of the ^{164}Dy in the energies below the neutron binding, E_b = 7.657 MeV are also objected since these quantities are very important for reaction models and nuclear astrophysics. The ^{163}Dy target (Dy_2O_3) was irradiated by the thermal neutron beam with a flux of the 2×10^5 ($n.cm^{-2}.s^{-1}$) in about 600 hrs. The experiment and the gamma transitions as the preliminary results of this work will be presented.

Keywords:
neutron capture, gamma transition, reaction models, thermal neutron beam, gamma coincidence, cascade gamma rays.

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B1.05

The viability of 3+1 neutrino scenario on the supernova neutrino process

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Abstract:
We investigate the sterile-active neutrino oscillation effects on the supernova (SN) neutrino process. Although the sterile neutrino is a hypothetical particle which do not interact with particles via standard interactions, through mixing or non-standard interactions, it can play a crucial role in astrophysics. In particular, the resonance effect of sterile-active neutrino oscillation significantly changes the behavior of neutrino propagting in the SN environment. This behavior affects the thermal neutrino induced reactions, which are important to determine the elements abundance produced by the neutrino process. Adopting sterile-active oscillation parameters of the IceCube and shortbase line experiments, we found the significant influence of varied reactions on the SN neutrino process. We also show the possible mass hierarchy in 3+1 neutrino scenario from the meteorite observation.

Keywords:
sterile neutrino, neutrino process, supernova

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B1.06

An EFT calculation with dibaryon fields for the equation of state of nuclear matter

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Abstract:

Equation of state of nuclear matter has a long history of investigation, but the convergence region of a naive EFT calculation is very narrow due to the huge size of the NN scattering length.
We will report an EFT calculation for the equation of state of nuclear matter by adopting dibaryon fields, which naturally provide us a consistent and convenient resummation scheme of NN interactions that is needed to cure the convergence issue. Our results will be compared with experiments as well as previous calculations.

Keywords:

Equation of state, nuclear matter, EFT, dibaryon

B1.07*

$^{16}O(^{6}Li,\mathit{t})^{19}Ne$ transfer reaction study for the future use at KOBRA

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Abstract:

Observation of 511 keV ɣ-ray flux from galactic centre gives a good insight on the structure of galaxy. Possible sources of 511 keV ɣ-ray flux include , ^{13}N, ^{18}F, and ^{22}Na. Model calculations indicate that during the first day after the nova explosion, the 511 keV ɣ-ray emission is dominated by the decay of ^{18}F. It is, therefore, important to estimate the final abundance of ^{18}F directly related to the yield of 511 keV ɣ-ray flux. It has been known that the $^{18}F(\mathit{p,g})^{19}Ne$ and the $^{18}F(\mathit{p,a})^{15}O$ reactions are the main mechanisms of the destruction of ^{18}F. Since the reaction rates of $^{18}F(\mathit{p,g})^{19}Ne$, $^{18}F(\mathit{p},a)^{15}O$ are determined by the properties of resonances in the $^{18}F+\mathit{p}$ system, ^{19}Ne, the reaction rates could be constrained to some extent by performing the $^{16}O(^{6}Li,\mathit{t})^{19}Ne$ multi-nucleon transfer reaction measurement. The $^{16}O(^{6}Li,\mathit{t})^{19}Ne$ measurement will be conducted using a ^{6}Li beam from the tandem accelerator of Kyushu university. Results of relativistic kinematics calculations for detector geometry, beam energy determination, and Monte-Carlo simulation for energy resolution consideration will be presented.

Keywords:

Transfer reaction, nuclear reaction, g-ray flux, reaction rate, resonant strength

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B1.08

Astrophysical (a,p) reaction measurements using solenoid

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Abstract:

Nucleon transfer reaction is a very powerful tool in nuclear spectroscopy. Since the state populated through a transfer reaction shows a structure that can be expressed as the core with the transferred nucleon orbiting around it, the energies of shell model orbitals can be well probed by performing transfer reaction measurements. Although the transfer reaction experiment in normal kinematics provide better quality data, using radioactive heavy ion beams in inverse kinematics becomes more important in modern nuclear structure studies since the particle of interest is usually far from stability in most cases.
When transfer reaction is measured in inverse kinematics using radioactive ion beam, the beam intensity is usually very low and recoiling light charged particles are ejected over a wide range of angles. Moreover, since the resolutions in energy and angle are significantly degraded than those of normal kinematics measurements, a pioneering detector system covering large solid angle and showing very good angular and energy resolutions is required. Modern detector systems for transfer reaction measurements include HELIOS (Helical Orbit Spectrometer) at Argonne National Laboratory, ORRUBA (Oak Ridge Rutgers University Barrel Array), and SuperORRUBA.
In a similar way to the HELIOS that utilizes a superconducting solenoid for uniform axial magnetic field at 3 Tesla and a position sensitive silicon detector array, a new solenoid-based detector system has been developed at the University of Notre Dame by using one of two superconducting solenoid used for TWIONSOL. Although the system was originally built for transfer reaction measurements, we used the system to measure the ^{24}Mg(a,p)^{27}Al reaction in order to demonstrate the feasibility of compound nucleus reaction measurements.
By using alpha beams and a ^{24}Mg solid target located in a 5 Tesla superconducting solenoid, the excitation function of the ^{24}Mg(a,p)^{27}Al reaction was measured at the energy range of $E_{c.m.}$ = 3 - 4.4 MeV for the first time. The reaction affects on the final abundances of ^{34}S and ^{30}Si, and the total nuclear energy of x-ray bursts. Details of the experiment and the preliminary result will be presented.

Keywords:
24Mg(a,p) reaction, solenoid

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B1.09*

^{24}Mg(α,p)^{27}Al reaction measurement for development of astrophysical (α,p) reaction studies at KoBRA

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Abstract:

The ^{24}Mg(α,p)^{27}Al reaction rate is very important to understand the total nuclear energy of x-ray burst and the final abundances of ^{30}Si and ^{34}S nuclei during the explosion through the αp-process [1]. The reaction rate depends on the properties of resonances located above the proton threshold at E_x = 11.6 MeV in ^{28}Si nucleus. Measuring those resonances are extremely difficult by using standard energy loss technique, since the kinetic energies of protons (≤ ~ 2 MeV) after reaction are too low for the particle identification. In order to overcome the limitation, the excitation function of the ^{24}Mg(α,p)^{27}Al reaction was measured by using a solenoid-based new detection system and α beams from a tandem accelerator at University of Notre Dame. Details of experimental setup and preliminary result will be presented.

[1] A. Parikh *et al.*, ApJS, **178**, 110 (2008).

Keywords:
x-ray burst, reaction rate, αp-process, solenoid-based detection system, KoBRA recoil spectrometer, RAON

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Magnetic and Hybrid Nanostructures for Biomedicine: Synthesis, Colloidal Stability and Photo/Magnetic Heating

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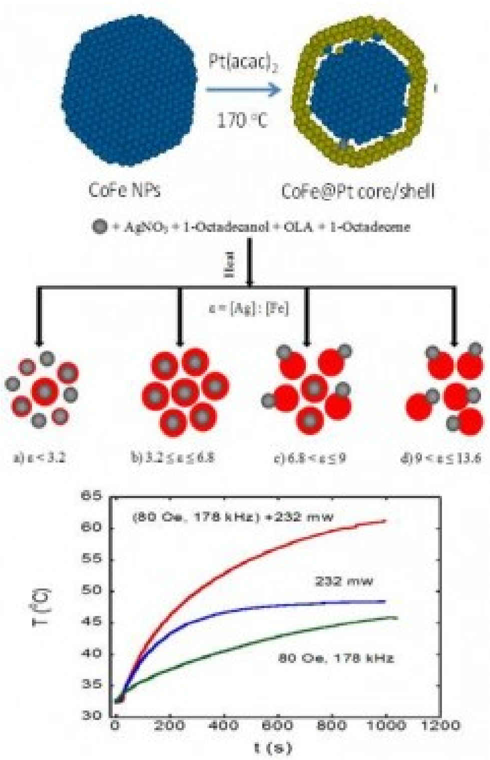
Abstract:

Magnetic and complex hybrid nanostructures are potential for cancer therapy and imaging diagnosis due to their novel physical properties. In the current work, we will present our preparations and studies of variety of magnetic nanostructures with the tunable morphology (size and shape), chemical composition ($CoFe_2O_4$, Fe_3O_4, CoFe, Fe_3O_4-Ag..) and structures (core/ shell, dumbbell-like, yolk-shell..).
Hydrophobic nanostructures were rendered water-dispersible by encapsulating with poly(maleic anhydride-alt1-octadecene) (PMAO). Magnetic/photo induced nanoheating effects of some complex hybrid nanostructures, such as Fe_3O_4-Ag and yolk-shell Fe_3O_4@Au, were investigated to provide mechanisms such as magnetic hysteresis and photothermal effect, contributing additionally to the heat power generated by relaxation losses observed for Fe_3O_4 MNPs. The polymer encapsulated hybrid nanostructures exhibited a stable suspension in aqueous solution and a high ability of transferring of magneto-optical energies into the heat. ***Fig.*** shows an illustration for the formation and dual mode heating of Fe_2O_4-Ag hybrid nanostructures.



Keywords:

hybrid nanostructures, magnetic nanoparticles, photothermal, dual nanoheating

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B2.02

Anomalous optical properties of halide perovskites as probed by wavelength-dependent nonlinear optical spectroscopy

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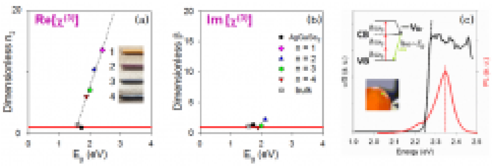
Abstract:



Although emerged from the field of photovoltaics, halide perovskites have also shown great promise for other optoelectronic applications such as light-emitting diodes, radiation detectors, lasing, thermoelectricity, nonlinear optics, etc. While device architecture is a critical factor in terms of technology evolution, the basic understanding of light-matter interaction in the perovskites is unarguably important for furthering their optoelectronic performance. In this talk, I will talk about two anomalous properties recently observed from this emerging material class as probed by wavelength-dependent nonlinear optical spectroscopy. Specifically, I will present intriguing results on 1) selective enhancement of third-order optical nonlinearity in two-dimensional layered lead iodide perovskites and 2) the bandgap anomaly associated with above-bandgap emission in three-dimensional all-inorganic lead bromide perovskites. The observed anomaly may be universal to the halide perovskites, which can be utilized for realizing novel optoelectronic applications with high efficiency and high selectivity.

Keywords:
halide perovskites, optical properties, above-bandgap emission, optical nonlinearity

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B2.03

Theoretical Approach to Understanding of Chemical Reactions

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Abstract:

In this talk, we present our recent results obtained using both high accuracy molecular orbital and density functional methods to determine geometrical structures, potential energy surfaces, and kinetics and mechanisms of a series of gas phase reaction involving small organic species and related to the atmospheric chemistry and combustion processes.

Our calculated results also point out that some transition metal clusters, such as Rh_5, Ag_7, Ag_7^+, Cu_7, turn out to be potential catalysts for the NO_x decomposition directly and indirectly into N_2 and H_2O.

Keywords:

molecular orbital and density function, catalysts, transition metal cluster

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B2.04

Optical coupling procedures and asymmetric states in a single coupled quantum dot

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Abstract:

Recent advances in droplet epitaxy (DE) methods have enable the growth of laterally coupled quantum dot (CQD) structures. The vertically CQDs have been investigated in terms of optical coupling and entangling states. When the interdot distance between two quantum dots is short enough to result in a wave function overlap between the two quantum dots via the tunneling effect, the optical coupling is controlled by the interdot distance and external DC electric fields along the coupling direction. However, when the eigenstates of CQDs are measured by the photoluminescence of an electron-hole pair in the presence of an external electric fields, indirect electron-hole pairs can also be involved, where the electrons and the holes belong to different QDs. As a result, the indirect electron-hole pairs of a CQD structure give rise to both symmetric and antisymmetric eigenstates.

We found that the exciton dipole-dipole interaction in a single laterally CQD structure can be controlled by the linear polarization of optical excitation [1-2]. As the excitation intensity is increased with the linearly polarized light parallel to the lateral coupling direction, excitons (X1 and X2) and local biexcitons (X1X1 and X2X2) show a redshift along with coupled biexciton (X1X2), while neither coupled biexcitons nor a redshift are observed when the direction of excitation beam is perpendicular to the coupling direction. The polarized dependence and power dependent redshift are attributed to an optical nonlinearity in the exciton Forster resonant energy transfer interaction. This interaction becomes significant with increasing the excitation parallel to the coupling direction, where redshifts, an exciton population transfer, and a coupled biexciton appear. We have also distinguished the coupled biexciton from local biexcitons by the large diamagnetic coefficient. In addition, we observed strongly polarized exciton states with coupling directions based on polarization dependent PL measurements.

Keywords:

Reference(s) [1] T. Unold et al., Phys. Rev. Lett. 94, 137404 (2005). [2] J. R. Lakowicz, Principle of Fluorescence Spectroscopy, 3rd; Springer, New York, (2006).

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B2.05

Photocatalytic application of TiO_2

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Abstract:

TiO_2 has always been of great interest due to its high stability, low cost, relatively low toxicity, and excellent photocatalytic performances in the oxidation of organic pollutants. However, the large band gap and high rate of electrons-holes pairs recombination has limited a photocatalytic application of TiO_2. This research aims to synthesize TiO_2 metal doped or nonmetal doped, composites of the metal or non-metal doped TiO_2 with some materials such as CNTs, graphene, or 2D materials like In_2Se_3, GaSe, SnS, MoS_2 with enhanced photocatalytic activities. The hybrids TiO_2/2D mateirals not only reduces the band gap but also lowers the rate of electrons-holes pairs recombination, enhancing photocatalytic performances of TiO_2 materials. Technically, the research focuses on successfully synthesizing the materials. Physically, it aims to investigate the energy band structure and electron transfer mechanism between substances involved. In addition, the density functional-theory (DFT) calculations of the electronic band structures and density of states (DOS) to understand the bonding states between TiO_2 and 2D materials like graphene, MoS_2, proved that the TiO_2/2D system is stable. Hopefully, this work can help promote better understanding of the role of 2D materials interface in increasing the efficiency of using the solar energy, by enhancing the photocatalytic performance in the visible region.

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S. B. Kim, J. Y. Park, C. S. Kim, K. Okuyama, S. E. Lee, H. D. Jang and T. O. Kim, *J. Phys. Chem. C* **119**, 16552 (2015).
H. Liu, T. Lv, C. Zhu, X. Su and Z. Zhu, *Journal of Mol. Catal. A: Chem.* **396**, 136 (2015)

Keywords:
Photocatalyst, TiO2/2D-materials heterostructures, carrier transfer

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B3.01*

Excitation of multiple spin-wave modes and their critical angles in a photon-magnon coupled system

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Abstract:

Magnons, as quanta of collective dynamic modes of individual magnetization vectors, represent the eigenstates of spin-wave (SW) modes excited in ordered magnets such as ferro-, ferri-, and anti-ferromagnets. In particular, spin-waves of wavelengths lying within the micrometer-to-millimeter range, the so-called magnetostatic spin-waves (MSWs) [1], can propagate over long distances in low-damping magnets e.g. yttrium iron garnets (YIG). Therefore, magnonics has been attracting significant interest owing both to novel underlying physics of MSWs and their potential applications to information processing technologies. When the external magnetic field is applied with a particular angle respect to the film plane and the wave vector, only the uniform mode resonance peak appears as a single resonance, referred as the critical angle effect [1,2]. Despite many theoretical and experimental studies of the critical angle for in-plane magnetized film, the critical angle effect for the external magnetic field changed from parallel to perpendicular to the film has been inconclusive. Also, the search is still ongoing for an alternative and easy method to excite and probe higher-order SW modes with arbitrary magnetic-field configurations due to the limitation in experimental arrangement and detection of low intensity of spin-waves.

In the present work, we explored multiple spin-wave modes excitation for different magnetic-field directions spanning all of the solid angles with enhanced gains due to photon-magnon interaction [3] in an YIG film coupled to the inverted split-ring resonator (ISRR) at room temperature. An effective and convenient method of the simple scattering parameter measurement of a planar YIG/ISRR hybrid sample with rotatable electromagnets was used for observation of multiple spin-wave modes to be excited in the YIG film. The coherent photon-magnon coupling gives rise to a strongly modified spectrum when spin-waves are near the ISRR resonance, as indicated by the anti-crossing features in the measured transmittance spectra. Representative pure spin-wave modes and their mixture, as well as a phase diagram of the multiple spin-wave mode excitations on solid angles were explored. The critical angles at which zero group velocity was obtained were analytical derived, which agreed with the experimental observations. The results provide understanding of the critical angle in the spin-wave transition with varying the external magnetic field angle and show its application to the quantum computing devices as well as spin-wave devices.

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[3] B. Bhoi, B. Kim, J. Kim, Y.-J. Cho, and S.-K. Kim, Sci. Rep., 7, 11930 (2017).

Keywords:
spin-wave, photon-magnon coupling, critical angle

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B3.02*

Wide field magnetic distribution imaging based on diamond defect centers

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Abstract:
Among many kinds of magnetic sensors, a quantum sensor based on diamond Nitrogen-Vacancy(NV) center is one of the promising candidates to realize nano-scale Magnetic Resonance Imaging(MRI) because of its high spatial resolution (e.g. ~ 10 nm) with high magnetic field sensitivity (e.g. ~ nT/Hz^1/2). In this talk, we introduce the basic concepts of magnetic distribution imaging technique and discuss our current efforts on building an experimental setup and future plans for bio-imaging applications.

Keywords:
magnetism

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B3.03

Exchange bias by molecular spinterface

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Abstract:

Molecular spins as individual are promising quantum states for coming computation technology. The "on surface" configuration of molecules in proximity to a magnetic film allows control over the orientations of molecular spins and interfacial coupling between them. The stacking of planar molecular spins could favor antiferromagnetic interlayer coupling and induce exchange bias. Here, we show tunable molecular exchange bias and its asymmetrical magnetotransport features by varying composition of ferromagnet/metalloporphyrin bilayers. The systems exhibit a wide range of exchange bias at both magnetization and magnetotransport of anisotropic and angle-dependent magnetoresistance. Theoretical calculations suggest the origin of molecular exchange bias in detail. Finally, we briefly introduce the result of molecular multi-spinterface demonstrated by exchange bias.

Keywords:

molecular spinterface, exchange bias

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B3.04*

Pressure-induced ferromagnetism and enhanced perpendicular magnetic anisotropy of bilayer CrI_3

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Abstract:

Using the first-principles calculations, we explored the pressure dependent magnetic properties of CrI_3 bilayer CrI_3 for AB and AA type stacking. We found an anti-ferromagnetic ground state in both pristine bilayer systems with indirect band gaps of 1.71 and 1.68 eV for AB and AA type system. However, the transition from anti-ferromagnetic to ferromagnetic state was achieved with the pressure and the band gap was decreased although the indirect bandgap nature remains unchanged. We obtained a substantially enhanced perpendicular magnetic anisotropy with pressure. In the pristine anti-ferromagnetic bilayer, both Cr and iodine atoms almost equally contributed to the perpendicular magnetic anisotropy. However, the contribution from the iodine atoms was almost four times larger than the Cr contribution with increasing the pressure. Particularly, the interface iodine atoms played a major role in the enhancement of the perpendicular magnetic anisotropy. We found that both AB and AA type bilayer displayed the same tendency.

ACKNOWLEDGMENTS
This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and Future Planning (2016R1A2B4006406) and by the Supercomputing Center/Korea Institute of Science and Technology Information with supercomputing resources including technical support (KSC-2017-C3-0062).

Keywords:

Chromium (III) iodide, stacking, pressure, magnetic semiconductor, magnetic anisotropy.

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B3.05

Unidirectional Magnetoresistance in CoGd-Ferrimagnet/Pt Bilayers

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Abstract:

Recently, the rare earth-transition metal ferrimagnet (RE-TM FIM) alloy has much attention because it is considered for a good platform to explore the antiferromagnet (AFM) spintronics. FIM consists of antiferromagnetically coupled magnetic sublattices as same as AFM whereas the finite magnetization appears on FIM owing to uncompensated magnetization between two sublattices. Indeed, the many interesting physics related to antiferromagnetic coupling were discovered in FIM. For example, the ultrafast domain wall motion and inhibition of skyrmion Hall effect were observed in RE-TM FIMs. These observations are closely related to the magnetization dynamics of FIM rather than the electrical transport of that. Even though the electrical reading and writing the magnetic state are the heart of spintronic applications, there is less research on the electrical transport of FIM. Thus, we study on the electrical transport in the GdCo-FIM/Pt-heavy-metal (HM) bilayer, since various important and unique spin-current-induced magnetoresistances (MRs) are observed from the magnetic/nonmagnetic heterostructure. Those MRs reflect the interaction between magnetic materials and the injected spin current from HM generated by the spin Hall effect, hence exploration of them in FRM/HM bilayers can give crucial clues for how to electrically read and control the magnetic state of AFM. In this study, we especially concentrate the unidirectional MR of FIM/HM bilayers. This recently discovered MR has great potential for applications because it is possible to read and control the magnetic state with a simple two terminal geometry by the electrical current.

Keywords:

ferrimagnet, unidirectional magnetoresistance, antiferromagnet spintronics

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B3.06

Abnormal anti-crossing dispersion in photon-magnon coupling

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Abstract:

Understanding and exploiting the interactions of excited modes in hybrid quantum systems are the keys to achieve the ambitious goal of quantum information processing [1-2]. Therefore, collectively excited modes (i.e., magnons) in ferromagnets, being coupled to elementary excitations of electromagnetic waves (photons), have increasingly been studied in a variety of hybrid structures of two or more different systems [3-5]. The interaction (coupling) between the magnon and photon modes usually demonstrated by showing the modes' splitting near their common resonant frequency within the so-called anti-crossing region or the level repulsion, as described well by a classical model for coupled oscillators [4] and also by a two-level quantum model [5].
Here, we report the experimental demonstration of an abnormal, opposite anti-crossing dispersion (or level attraction) in a photon-magnon-coupled system that consists of an Yttrium Iron Garnet film and an inverted pattern of split-ring resonator structure (noted as ISRR) in a planar geometry. It is found that the normal shape of anti-crossing dispersion typically observed in photon-magnon coupling is changed to its opposite anti-crossing shape just by changing the position/orientation of the ISRR's split gap with respect to the microstrip line axis along which ac microwave currents are applied. Characteristic features of the opposite anti-crossing dispersion and its linewidth evolution are analyzed with the help of analytical derivations based on electromagnetic interactions. The observed opposite anti-crossing dispersion is ascribed to the compensation of both intrinsic damping and coupling-induced damping in the magnon modes. This compensation is achievable by controlling the relative strength and phase of oscillating magnetic fields generated from the ISRR's split gap and the microstrip feeding line. We provided a phase diagram of the dispersion type in the photon-magnon coupling region according to the strength and phase of microwave magnetic fields acting on the hybrid system. The position/orientation of an ISRR's split gap provides a robust means of controlling the dispersion shape of anti-crossing and its damping in a photon-magnon coupling, thereby offering more opportunity for advanced designs of microwave devices.

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Keywords:
YIG, photon-magnon coupling, anti-crossing

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B4.01

High-Sensitivity Pressure Sensor Using Chemically Etched Si Nanorods Array

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Abstract:

We present the fabrication of high sensitivity pressure sensors using Si nanorods (NRs) array and their characteristics. The Si nanorod arrays were fabricated using metal assisted chemical etching method using Ag as noble metal catalyst and HF/H_2O_2 as the etchant. Mesoporous, high aspect ratio Si NRs with length ~11 mm and diameter ~20-150 nm are obtained, which are mechanically robust but flexible enough to show significant piezoelectric properties. The pressure sensor is fabricated simply evaporating Au (100 nm) on either side of the Si NRs array. The pressure sensing characteristics of the device were investigated by applying pressure with various tools such as voice coil motor, mechanical load and precise flow of inert gases including a weak air flow. A high sensitivity of 0.79 kPa^{-1} is achieved the ultra-low range of pressure (0.4-1.2 Pa), which is considerably high as compared to the other CMOS-compatible materials. Ultra-low-pressure detection (<0.4 Pa), flexibility over high pressure (>200 kPa), excellent air stability (> several months) with huge life cycles (>1000 cycles) are the key feathers of the device. The superior sensing performances of the nanostructured Si can be utilized in different areas of pressure sensor-based nanotechnology.

Keywords:

Si nanorod, piezoelectric, pressure sensor

B4.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Growth of Pure Wurtzite InGaAs Nanowires for Photovoltaic and Energy Harvesting Applications

강항규[1], 김준영[2], 노명섭[3], 강종윤[3], 김영동[4], 송진동*[2], 조만호*[1]
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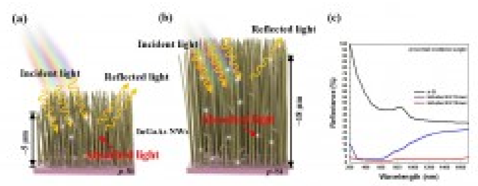
Abstract:

Vertically aligned and dense InGaAs nanowires were grown on Si (111) substrates by Au-assisted molecular beam epitaxy, and its antireflection characteristics were characterized. The bandgap of InGaAs NWs was tuned by varying the In to Ga ratio; the compositions of Ga and In were changed to obtain a bandgap of ~1.0 eV. The obtained nanowires were vertically aligned with a diameter of ~20 nm near the top and ~44 nm at the bottom, a slightly tapered morphology. This microstructure was formed because of the different surface diffusivities and affinities of In and Ga to the Au catalyst. By controlling the deposition conditions, InGaAs nanowires with no significant stacking defects, kinking, and bending were grown successfully on Si (111) substrates. High-resolution transmission electron microscopy studies showed that the InGaAs nanowires were grown with a pure wurtzite single crystalline structure with a maximum length of ~18 μm. Photo-reflectometry and spectroscopic ellipsometry measurements showed a significant reduction in the reflectance, less than ~5% for normal incidence in the wavelength range of 200-1700 nm and considerable reduction at incident angles of 30-70°, demonstrating the antireflection properties of the InGaAs nanowires. Furthermore, piezoelectric properties were observed in all the areas where InGaAs nanowires were grown for a contact area of 2 μm × 2 μm, as the growth direction was along the polar *c*-axis (〈111〉 direction) of the hexagonal structure is in the 〈111〉 direction in 2 μm × 2 μm contact area.



Keywords:
InGaAs nanowires, antireflection, wurtzite, polarization, piezoelectric response, polar c-axis

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B4.03*

Electrical properties of individual CaVO (CalciumVanadate) nanowire

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Abstract:
Low-dimensional nanostructures have gained wide attention recently. V_2O_5 (vanadium pentoxide) nanowire is one of such low-dimensional material. Its electrical properties are widely studied from various researches. Especially, it is well known that V_2O_5 shows outstanding conductivities ranging from 10^{-6} S/cm to almost 1 S/cm. V_2O_5 has metal-insulator phase transition at 68℃. We wonder what will happen if we add Calcium to V_2O_5. In this study, we measured the electrical properties of CaVO and investigated how its electric properties change by doping (adding) Ca. Our sample consists of three mixed materials: V_2O_5, $Ca_{0.17}V_2O_5$, CaV_2O_6. CaVO nanowires were synthesized by sol-gel method by adding acidic vanadium solution and calcium hydroxide solution. Electrical device of CaVO nanowire was fabricated by conventional nano-lithography processes. The basic current-voltage and transfer characteristics were measured and its semiconducting properties were studied. We found a peculiar temperature dependence transition of resistance measurement. Details of synthesis, fabrication, and electrical properties of our nanowire and devices will be presented at this presentation.

Keywords:
CaVO, 2D material, nanowire, electrical property, transition

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B4.04*

In-situ Coalesced Chalcogen Vacancy Formation of $MoSe_2$ Mimics the Noble Metals in Hydrogen Production through the Enhanced Volmer-Tafel Reaction

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Abstract:

The activation of the inert transition metal dichalcogenides (TMDs) basal plane plays a key role to achieve high-performance TMDs-based electrocatalysts for hydrogen production. Recently, the introduction of chalcogen vacancy in TMDs lattice through post-treatments could optimize reaction coordinate free energy difference in hydrogen production, leading to improving hydrogen evolution reaction (HER) activity. In this work, Se vacancy density was modulated through hydrogen reactivity control during the chemical vapor deposition process and vacancy $MoSe_2$ was synthesized by optimizing hydrogen concentration. The one-step synthesized vacancy-$MoSe_2$ exhibited coalesced vacancy in the lattice structure, which resulted in enhanced overall HER electrocatalytic performance (improved onset potential, exceptionally low Tafel slope (33 mV dec^{-1})), one of the lowest values reported for TMDs to date in our knowledge. Computational analysis revealed that the coalesced vacancy in the $MoSe_2$ lattice promoted Volmer-Tafel reaction by reducing the hydrogen adsorption free energy for Volmer reaction and hydrogen diffusion barrier to activate the Tafel reaction. Our results present a new perspective for developing high-performance TMDs-based electrocatalysts with simple processability, which can benefit the hydrogen production more viable.

Keywords:

chalcogen vacancy, density functional theory, hydrogen evolution reaction, molybdenum diselenides, Volmer-Tafel reaction

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B4.05*

Linearly polarized Raman spectroscopy of ReS_2

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Abstract:

In-plane anisotropy of rhenium disulfide (ReS_2), one of the group-VII transition metal dichalcogenides(TMDs), gives additional degrees of freedom in manipulating device properties using anisotropic electronic and optoelectronic properties. ReS_2 has a direct bandgap from 1-layer (1.58 eV) to bulk (1.5 eV) unlike group-VI TMDs such as MX_2 (M=Mo, W, X= S, Se) [1]. The covalent bonding of the transition metal atoms (Re-Re) causes the anisotropic 1T' (distorted trigonal) structure and all axes are not normal to other axes of the crystal. Therefore, up- and- down faces of monolayer ReS_2 are inequivalent, and the physical properties are related to the crystallographic orientation of ReS_2 [2][3].

In this study, we performed linearly polarized Raman measurements on 1- to 3-layer ReS_2 on both up- and down-sides. The thickness was determined by interlayer vibration modes in the low frequency region (< 30 cm^{-1}) [4]. We investigated the polarization dependence of the 18 Raman modes with the several excitation energies (514, 532, 633nm). For some Raman modes, the polarization dependences are similar for different excitation energies. Whereas, some modes show dramatic variation in the polarization behavior depending on the excitation energy. Furthermore, splitting of intralayer vibration modes was observed in the high frequency region (> 400 cm^{-1}) with varying thickness. From the relation of the polarization dependence of two Raman modes at 152 cm^{-1} and 212 cm^{-1}, we classified the sides of samples corresponding to two vertical orientations. We also identified the Re-chain direction using the polarization direction of the Raman modes at 212 cm^{-1}. We also measured transmission electron microscopy (TEM) to correlate the crystallographic orientation with the polarized Raman results.

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[4] E. Lorchat *et al*. ACS Nano, **10** 27525(2016)

Keywords:
TMDs, ReS2, polarized Raman spectroscopy

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B4.06*

Enhanced Contribution of Edge Tunneling Effect to Current-Voltage Characteristics of Al/Si and Al/Graphene/Si Junctions with Lateral Size Scaling

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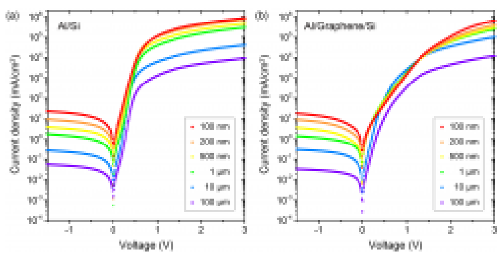
Abstract:



The origin of Fermi-level pinning in a Schottky junction is known to be the electric dipole layer associated with the localized surface states on the semiconductor substrate. The influence of this electric dipole layer affecting the electrostatic potential profile across the interface is notably reduced when the junction size becomes small [1,2]. In this study, it is demonstrated experimentally that the effective Schottky barriers of Al/Si and Al/Graphene/Si junctions decrease with the lateral width of junction decreasing. From the finite-element electrostatic modeling to obtain the energy band profile across the junction, the current-voltage (I-V) characteristics are found to be dominated more and more by the tunneling of charge carriers around the edges as the lateral size of junction becomes smaller. In case of the Al/Graphene/Si junction, the non-ideal I-V curve for forward bias was also observed, which is considered to be due to the recombination current in the graphene layer [3]. It is believed that our work can provide a physically-reasonable clue for understanding the drastic size-dependent variation of I-V characteristics in metal/Si junctions, the rectifying behavior of large-area junction [2] and the ohmic-like behavior of small-area one [4, 5]).

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Keywords:
Schottky Contact, Size Scaling, Fermi-Level Pinning, Edge Tunneling Effect, Graphene

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B4.07*

Deformation of monolayer graphene by using laser irradiation and the temporal evolution of Raman modes during the deformation process

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Abstract:
We have investigated the effect of laser irradiation on monolayer graphene and observed the swelling up of the monolayer from the SiO_2 substrate upon laser illumination. The mismatch in the thermal expansion between the SiO_2 substrate and the graphene can result in the structural deformation. By using atomic force microscope and Raman spectroscopy, we analyze effects of the laser irradiation. We report the temporal evolution of G and 2D Raman modes and their split during the deformation process.

Keywords:
graphene, deformation, laser irradiation, raman

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B4.08*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Large magnetoresistance of monolayer graphene in contact with $BIFeO_3$ nano-island array

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Abstract:

단일층 그래핀은 높은 이동도와 높은 영률(Young's modulus)를 포함하여 근본적으로 우수한 특성을 가지고 있기 때문에 nano-electronics, nano-mechanical 과 같은 분야에서의 응용 가능성이 지속적으로 증가하고 있다. 그러나 그래핀은 실온에서 작은 자기 저항, 반/강자성 특성의 부재, 제로 밴드갭과 같은 제한적인 특성을 가지고 있다. Defect engineering은 그래핀의 물리적 특성을 변화시켜 제한적인 특성을 극복할 수 있는 강력한 방법이다. 예를 들어, 스트레인을 받고 있는 그래핀은 변형 정도에 따라 밴드갭이 열린다. 구부러진 그래핀은 평평한 그래핀보다 spin-obit coupling이 강해질 수 있다. mosaic-like 그래핀은 고전적인 선형 자기저항(MR)을 보인다. 질소 도핑된 그래핀과 불균일한 다층 그래핀은 상온에서도 양자 선형 MR을 보인다.

그래핀은 넓은 온도 범위에서 포화되지 않는 큰 MR을 구현할 수 있는 최상의 후보이다. 그래핀에서 자기저항 특성을 유도하기 위해, 고전적인/양자 선형 MR 메커니즘이 주로 사용되어왔다. 그러나 순수한 그래핀은 실온에서 선형 MR을 나타내지 않습니다. 또한 선형 MR을 얻기 위해 그래핀에 결함을 만들면 그래핀의 우수한 특성이 저하되어 상온에서 큰 MR을 얻을 수 없다. 그래핀에서 큰 자기저항 특성을 유도하기 위해서 이용할 수 있는 또 다른 메커니즘이 있다. 서로 보상하는 두 종류의 전하 (전자와 정공)로 구성된 반 금속은 자기장이 가해질 때 전자-정공 공진에 의해서 큰 MR을 나타낸다. 이 경우, 전자와 정공 사이의 균형과 높은 전하 이동도를 가지고 있는 고순도의 샘플을 제작하는 것이 중요하다. 높은 이동성을 가진 물질인 단일층 그래핀은 한 종류의 전하를 가지고 있기 때문에 charge compensation system에 의한 MR 특성이 실현될 수 없다. 우리가 단일층 그래핀에서 *n*-type puddle과 *p*-type puddle을 분리하고 전자와 정공의 균형을 유도할 수 있다면, 그래핀은 큰 MR 특성을 보장할 것이다. Defect engineering을 이용하여 그래핀의 물리적 특성을 조정하는 것이 이러한 문제를 극복할 수 있는 유일한 방법이다.

본 연구에서는 단일층 그래핀과 $BiFeO_3$ nano-island array의 접합 소자를 제작하였고, 이를 통해 extrinsic/intrinsic defects을 그래핀에 생성하였다. AFM과 라만 측정을 이용해여 그래핀이 가지고 있는 defects을 확인하였고, 온도에 따라 Hall 측정을 수행하여 그래핀의 전자기적 특성을 분석하였다. 우리가 제작한 그래핀 / $BiFeO_3$ nano-island array의 접합 소자는 상온에서 250% 정도의 자기저항 특성을 보여주었다.

Keywords:

자기저항, 그래핀, BiFeO3, defects

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B4.09

Fabrication of vertical Si nanorod field effect transistor array by metal assisted chemical etching

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Abstract:

We present a position-and-dimension-controlled Si nanorods (Si NRs) based vertical field effect transistor (VFET). Position- and dimension-controlled Si NR arrays were fabricated using a typical metal assisted chemical etching (MACE) method. In order to control the position and dimension of Si nanorods, electron-beam lithography (EBL) were employed. The typical dimensions of the Si NRs used for VFET fabrics were a diameter of 500 nm and varIable lenght from 2 -7 μm. The VFET is fabricated by evaporating the electrodes in an axial direction separated by insulating polyimide layers. The first PI spacer layer was coated on Si NRs and cured at 300 °C under nitrogen atmosphere for 3 min and the gate electrode was fabricated by a thin Au layer with a thickness of 80 nm. The PMMA spin coated and only the upper part of the Au electrode was removed by O_2 plasma treatment, so that the NRs above are exposed. Then, a second layer of polyamide was coated and cured at 300 °C. The drain electrode patterns were made by EBL, followed by conformal deposition of a Ti / Au (20/60 nm) layer using an e-beam evaporator. Finally, the second PI layer was removed from the gate electrode by exposing the wafers to O_2 plasma. The VFET exhibits a high on / off ratio of 10^7 and high current of 200 μA. These results open up huge opportunity of utilizing Si nanorod based VFETs into various cutting-edge applications.

Keywords:

Si nanorod, VFET

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B5.01

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Ultrastable Ti:Sapphire optical frequency comb with 10^{-19} fractional instability

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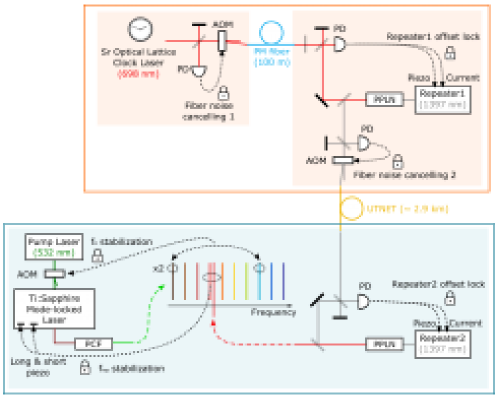
Abstract:



An optical frequency comb, a train of coherent pulses with regular time spacing, has been used as an absolute optical frequency measure with its broadband spectrum that consists of discrete, equally spaced sharp lines. When two degrees of freedom of the spectrum, a carrier-envelope offset frequency (f_{CEO}) and a repetition frequency (f_{rep}), are stabilized, all optical frequencies of the individual comb teeth are determined precisely. To achieve a better precision, one tooth of the comb can be stabilized to a stable, narrow-linewidth optical reference such as optical atomic clocks. By phase-locking optical frequency combs to the optical standard, the unprecedented accuracy and uncertainty of the optical atomic clocks would be transferred to the whole spectrum of the optical frequency comb. Here, we demonstrate stabilization of an optical frequency comb to Sr optical lattice clock laser that is sent through telecom-wavelength fiber networks. As the two degrees of freedom stabilized, the frequencies of the optical frequency comb spanning throughout visible and near infrared wavelengths are determined with the precision of the optical atomic clocks. The achieved total relative instability of the optical frequency comb with respect to the optical atomic clock laser is 6.7×10^{-18} at 1s and 1.0×10^{-19} in 1000 seconds, which are better than the current limit of optical atomic clocks. This work would be a cornerstone to fully utilize the next-generation time-frequency standard of optical atomic clocks by distributing the precision over the entire visible to near infrared frequencies, as well as controlling pulse lasers with ultra-low time jitters for attosecond science beyond the spatial constraint for precision time-resolved measurements and metrologies.

Keywords:
Optical frequency comb, precision measurements

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B5.02*

Temporal characterization of laser pulses for a broad wavelength range from UV to IR

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Abstract:

A laser pulse is an essential tool in many scientific applications. The temporal characterization of a laser pulse is required before the laser pulse is used for the study. A new pulse characterization technique called tunneling ionization with a perturbation for the time-domain observation of an electric field (TIPTOE) has recently been demonstrated [1,2]. This method uses the extreme nonlinearity of ionization in air. It is expected that the method will be applicable for a broad wavelength range. However, the validity of TIPTOE is demonstrated only for single-cycle and few-cycle laser pulses so far.

In this study, we show that the TIPTOE method can be applied to measure multi-cycle laser pulses from UV to IR wavelength ranges. In the TIPTOE method, ionization is used as a temporal gate. Since multiple ionizations occur in a multi-cycle pulse, the effect of the multiple sampling should be properly taken into account. We demonstrate reconstruction processes developed for the TIPTOE measurement. The reconstruction processes are tested using theoretical calculations and experimental measurements. The experiments were performed with laser pulses at the center wavelength of 266 nm, 1800 nm, 4000 nm and 8000 nm. To test if the measurement was successful, the laser pulses were measured by varying the dispersion. The dispersion measured by the TIPTOE measurement is compared with the dispersion calculated using the refractive index of the materials. The results obtained at 1800 nm and 4000 nm were compared with the results obtained other technique called the frequency-resolved optical gating. They show a good agreement, confirming the validity of the TIPTOE method for multi-cycle laser pulses from UV to IR wavelength ranges.

Keywords:
Optics

B5.03*

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2019-04-24 - 2019-04-26

파장 가변형 적외선 레이저 Optical Cavity 적용을 위한 GIG(Graphene-Insulator-Graphene) 이종 접합 구조 개발

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Abstract:

본 연구의 주요 목적은 optical cavity의 구조적인 변화 없이 파장 가변성을 함유하는 레이저 소자를 개발하는 것이다. 기존의 레이저의 경우 파장 가변성을 확보하기 위해서 optical cavity의 길이 조절 혹은 prism의 각도 변화 등의 복잡하고 추가적인 구조적인 변화들이 있었다. 이에 따라서 좀더 간소화 시킨 구조를 함유하는 기술 개발의 필요성이 대두되고 있다.

파장 가변성 적외선 레이저 optical cavity 기술에서 제시하고자하는 것은 GIG 이종 접합 구조를 이용한 레이저 매질이다. 기존의 레이저 매질의 경우 고정된 파장의 종모드(longitudinal mode)를 생성시키는 역할을 해왔고 파장 가변성에 대해서는 optical cavity의 구조적인 변화가 그 역할을 수행했다. 해당 GIG 이종 접합 구조의 경우, Graphene-Insulator-Graphene의 이종 접합으로 인해 전기적으로 가변적인 graphene의 fermi level을 이용해서 밀도 반전과 fermi level 차이를 조절하는 것이 매우 용이하다. 이를 이용해서 인가시켜주는 bias의 변화를 통해서 레이저 매질로부터 생성되는 파장의 대역대에 가변성을 부여할 수 있다.

해당 발표에서는 접합 구조에 용이한 Insulator를 선정하고, GIG 이종 접합 구조 제조 및 bias에 의한 gating 특성 조사에 대해서 발표할 예정이다.

Keywords:
Graphene, Heterojunction, Optical Cavity, GIG, laser, lasing medium, 파장 가변성

B5.04*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Comparative test between UV inspection and ESLI used in semiconductor processing

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Abstract:

반도체 생산의 모든 단계에서 게이트 키퍼 역할을하는 결함 검사는 전체 제조 공정에서 필수적인 역할을 수행한다. 계속되는 반도체 집적도 향상에 따라 wafer나 mask에 발생하는 작은 defect 또한 공정 과정에 영향을 주게 되고, 따라서 미세한 크기의 defect을 inspection 하기 위해 현재 EUV 검사 기술 및 장비들이 개발됨에 따라 이미 신뢰성이 검증된 광학적 방식의 UV를 이용한 검사 시스템을 구성하여 EUV 검사 기술 중의 하나인 Actinic 검사 기술과의 comparative test를 수행하여 feasibility를 보여주기 위한 연구를 진행한다.

UV inspection system은 조명광학계, 결상광학계, linear stage 그리고 TDI line camera로 구성된다. 광원으로는 파장이 365 nm인 UV LED를 사용하고, 조명영역에서의 beam uniformity를 고려하여 조명광학계를 설계 및 제작하여 구성한다. Line camera와 적합하게 사용하기 위해 object surface 상에 선형으로 형성되도록 anamorphic design으로 설계한다. 결상광학계는 objective lens와 image lens로 구성되며, inspection 하고자 하는 결함의 크기와 detector의 픽셀 크기, 배율 등을 고려하여 설계 및 제작하여 구성한다.

이와 같이 구성한 inspection system으로 이미지 획득 실험을 진행한다. 실험 샘플로는, 반도체 공정에서 주로 문제가 되는 defect의 성분과 동일한 nanopowder로 한다. 실험은 세가지 단계로 진행되며, 먼저 SEM을 통해 inspection 하고자 하는 샘플의 정확한 위치와 크기를 측정하여 reference data로 설정한다. 두번째로, optical microscope로 봤을 때 나타나는 이미지와, 마지막으로 uv inspection system와 Actinic 검사 기술을 통해 획득한 이미지를 비교함으로써 구성한 시스템의 성능을 확인한다.

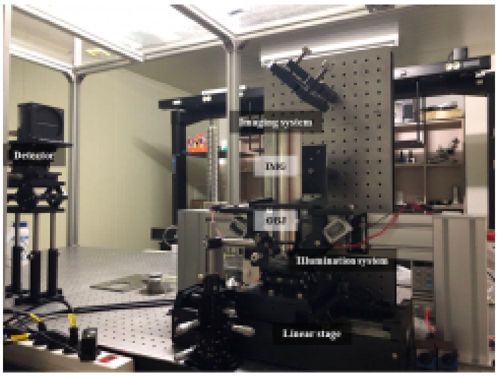

Figure 1. Total system layout of UV inspection system

Keywords:
defect, inspection, EUV, UV, comparative test, feasibility

B5.05

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

AWG 기반 광파장모니터링 구조를 활용한 다채널 FBG 반사파장 측정에 대한 연구

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Abstract:

50-GHz, 96-채널 AWG(Array Waveguide Grating)를 장착한 온도 계측을 위한 FBG(Fiber Bragg grating) 특성파장 측정시스템을 개발하였다. -25℃~85℃ 범위에서 한 개의 FBG 스펙트럼은 AWG 여러 채널에 걸쳐 이동하는데 스펙트럼 복원 알고리즘을 사용하면 FBG 중심파장의 변화를 계산할 수 있다. 0.38 nm 대역폭을 가진 12개의 직렬 연결된 FBG 센서열에서 반사된 빛의 스펙트럼을 측정했을 때 온도민감도는 FBG 제작 후 재코팅된 아크릴레이트 물질의 열팽창 특성과 관련하여 양의 온도구간에서 0.10 nm/℃, 음의 온도구간에서는 0.17 nm/℃ 를 갖는 것으로 분석되었다.

* 본 연구는 산업통상자원부의 우수기술연구센터사업(과제번호:10062998)의 지원으로 수행되었습니다.

Keywords:

DWDM, AWG(Array Waveguide Grating), FBG(Fiber Bragg grating) 온도 센서

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B5.06*

Selective nanolaser excitation at hierarchical photonic topological states

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Abstract:
위상부도체(Topological Insulator)의 발견으로부터 탄생한 위상광자학(Topological Photonics)의 주된 개념은, 위상 상수(Topological invariant)가 다른 두 광구조의 계면에 새로운 가장자리 상태의 존재가 가능하다는 것이다. 일반적으로 n 차원의 구조에서는 n-1 차원의 가장자리 상태가 존재하고 가장자리 상태의 개수는 bulk-edge correspondence에 의해 결정된다. 그러나 최근 higher-order topological insulator (HTI)라고 불리는 구조에서, n 차원의 bulk에 n-1 차원뿐만 아니라 n-1 보다 작은 차원의 다양한 가장자리 상태의 존재가 가능함이 예측 되었고 [1], 이후 몇몇 시스템에서 HTI가 실험적으로 입증된 바 있다 [2-4]. 그러나 아직 위상광자학 시스템, 특히 optical frequency 영역의 wavelength-scale에서는 HTI 관측은 물론 이러한 계층적 가장자리 상태에서의 레이저 발진이 가능한 지에 대해 연구된 바 없다. 본 연구에서는 multipole moment가 없는 간단한 2차원 SSH (Su-Schrieffer-Heeger) 모델에 기반한 위상광자학적 광자결정 구조를 설계하고, 이를 InGaAsP 양자우물 웨이퍼를 이용하여 구현하였다. 광펌핑을 통해 bulk, edge, corner 각각의 상태에 대한 레이저 발진에 성공하였고, 이를 스펙트럼 분석과 직접적인 이미지 관찰을 통해 확인하였다. 아울러 이러한 실험 결과를 시뮬레이션을 통해서도 재차 확인하였다.

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[2] Peterson, Christopher W., et al. "A quantized microwave quadrupole insulator with topologically protected corner states." *Nature* **555**, 7696 (2018).
[3] Serra-Garcia, Marc, et al. "Observation of a phononic quadrupole topological insulator." *Nature* **555**, 7696 (2018)
[4] Xue, Haoran, et al. "Acoustic higher-order topological insulator on a kagome lattice." *Nature materials* **18,** 2 (2019).

Keywords:
Topological Photonics, Photonic crystals, Nanolasers

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B5.07

Development of Micro Spot Spectroscopic Ellipsometer and Measure the Optical Properties of MoS_2 Monolayer using This

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Abstract:

In the semiconductor industry, the size of the region for thickness measurement using the Spectroscopic Ellipsometer(SE) is about a few tens μm. For measure the thickness of micro range, such as semiconductor industries, the micro spot SE system is absolutely needed. In this paper, we will talk about the development of the micro spot SE, And talk about measurement results of the optical properties of MoS_2 monolayer using this.

We developed a micro spot SE using a reflective optical system and a transmissive optical system. We will show the result of spot size determination of the transmission type optical micro spot SE using the pattern sample. And, we will also show the optical properties of the MoS_2 monolayer at a few um in size using the reflective optical system micro spot SE.

This study(10067487) was supported by Korea Evaluation Institute of Industrial Technology(KEIT).

Keywords:

Micro Spot, Spectroscopic Ellipsometer, MoS2

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B6.01

New understanding and engineering of defect qubits in diamond

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Abstract:

Defects in diamond and other wide bandgap semiconductors with electronic spins that may be optically initialised and readout are promising qubit systems for a great diversity of quantum technologies. The negatively-charged nitrogen-vacancy (NV) centre in diamond is the best understood of these defects. It has driven major advances across quantum technology, including quantum computing, nanosensing and microscopy, and communications. However, there still remain unanswered questions about how best to employ it to initialise and read out clusters of coupled nuclear spin qubits. Recently, the negatively-charged silicon-vacancy (SiV-) and germanium-vacancy (GeV-) centres in diamond have come to prominence as possible alternatives to the NV centre in quantum computing and communications due to their superior optical properties. However, they currently suffer from poorer spin properties. Although not prominent, the ST1 centre in diamond promises superior performance as a bus for quantum registers formed from clusters of nuclear spin impurities. Progression towards using the ST1 centre has been hampered because its structure remains a mystery as well as difficulties in its reproduction. In the meantime, the search for new defects for quantum technologies is increasing in breadth and speed.
In this presentation, I will report the discovery of a new defect with an optically-addressable electronic spin: the neutral silicon-vacancy (SiV^0) centre in diamond; as well as new knowledge of the ST1 centre's structure, methods to enhance the spin properties of SiV- centres, and new insight into the NV centre's mechanism of single-shot readout/ projective initialisation of nuclear spin qubits.

Keywords:
Diamond NV center, defect qubits

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B6.02

Discrete time-crystalline order in black diamond: realization and probe of quantum many-body dynamics

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Abstract:

Strongly interacting solid-state spin ensembles provide a promising platform to explore quantum many-body physics. In particular, Nitrogen-Vacancy (NV) centers in diamond are appealing as they exhibit excellent spin properties even at room temperature. In this talk, I will present how a high-density NV ensemble can be used to investigate out-of-equilibrium quantum many-body phenomena. In particular, I will discuss the recent experimental observation of discrete time-crystalline (DTC) order: a nonequilibrium order characterized by a spontaneous breaking of time-translational symmetry and manifested in robust, long-lived subharmonic responses of a periodically driven system [1]. By engineering different types of effective interactions, we find that the spin ensemble can exhibit a long-lived robust subharmonic response over a wide range of parameters. Additional systematic investigation of the lifetime of the DTC response reveals three different regimes of relaxation dynamics, that can be continuously varied from disorder-induced slow thermalization, to driving assisted relaxation, and ultimately to universal Markovian dynamics [2]. These results highlight the utility of high-density NV ensembles as a probe of many-body dynamics and thermalization, an important aspect in the quest for the understanding and control of quantum matter, and may enable novel applications in quantum simulation and metrology with strongly correlated quantum matter [3].

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[2] J. Choi *et al*, Phys. Rev. Lett. 122, 043603 (2019)
[3] S. Choi *et al*, arXiv:1801.00042 (2018)

Keywords:
Diamond NV center, time-cystalline order

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B6.03

Quantum Nanoscience: Atoms on Surfaces

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Abstract:

The scanning tunneling microscope is an amazing tool because of its atomic-scale spatial resolution. This can be combined with the use of low temperatures, culminating in precise atom manipulation and spectroscopy with microvolt energy resolution. In this talk we will apply these techniques to the investigation of the quantum spin properties of magnetic atoms sitting on thin insulating films.

We will start our exploration with the understanding of the quantum spin states (also called the magnetic states) of these adsorbates. To measure these states, we combined scanning tunneling with x-ray absorption spectroscopy and found amazing agreement of those vastly different techniques (*Science* 2014, *PRL* 2015).

Next, we will investigate the lifetimes of excited states. Surprisingly, we find lifetimes that vary from nanoseconds to hours, a truly amazing consequence of the quantum states of different adsorbates.

Finally, we will explore the superposition of quantum states which is inherent to spin resonance techniques. We recently demonstrated the use of electron spin resonance on single Fe atoms on MgO (Science 2015). This technique combines the power of STM of atomic-scale spectroscopy with the unprecedented energy resolution of spin resonance techniques, which is about 10,000 times better than normal spectroscopy.

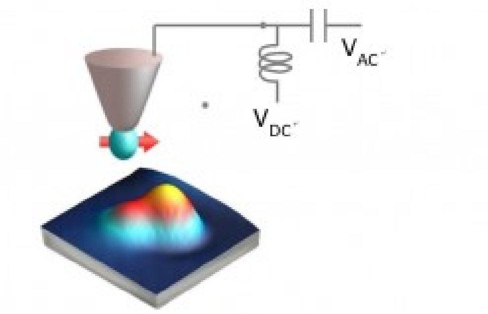

Fig 1. STM image of two Ti atoms on thin MgO film. Superimposed is a model of a spin-polarized STM tip

Keywords:
scanning tunneling microscopy, quantum nanoscience

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Random magnetism in the Kitaev candidate material Cu_2IrO_3

최광용*[1], 최영수[1], 이찬현[1], 이수헌[1], 윤성원[1], 이원준[1], 김가령[2], 이종수[2]
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Abstract:
We report on magnetization M(H), dc/ac magnetic susceptibility χ(T), specic heat C_m(T) and muon spin relaxation (┬μSR) measurements of the Kitaev honeycomb iridate Cu_2IrO_3 with quenched disorder. In spite of the chemical disorders, we nd no indication of spin glass down to 260 mK from the C_m(T) and ┬μSR data. Furthermore, a persistent spin dynamics observed by the zero-field muon spin relaxation evidences an absence of static magnetism. The remarkable observation is a scaling relation of χ[H,T] and M[H,T] in H/T with the scaling exponent ♂ α= 0.26-0.28, expected from bond randomness. However, C_m[H,T]/T disobeys the predicted universal scaling law, pointing towards the presence of additional low-lying excitations on the background of bond-disordered spin liquid. Our results signify a many-faceted impact of quenched disorder in a Kitaev spin system due to its peculiar bond character.

Keywords:
Kitaev honeycomb lattice, random magnetism, quantum scaling

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B7.02

Field-induced magnetic phase transition of the Kitaev model with third neighbor Heisenberg interactions

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Abstract:

The Kitaev model is a spin model of a honeycomb lattice whose ground state is a quantum spin liquid. The spin-spin interaction of directional Ising-type interactions can be interpreted with Majorana fermions and fermionic chracter gives rise to fractionalized spin excitation. Recent proposals that α-$RuCl_3$ is the best candidate to be proximate Kitaev model and the magnetic field can induce the quantum liquid state have triggered intensive studies.
In this study, we have investigated the magnetic and thermal properties of the Kitaev model with third neighbor Heisenberg interactions. Based on the numerical calculation with the exact diagonalization method of periodic 24-site cluster, we have found that third neighbor Heisenberg interaction gives rise to the transition from the Kitaev spin liquid to antiferromagnetism with zigzag order. We have also observed that clear intermediate phase is manifested during the phase transition from the zigzag ordered phase to fully polarized phase when applying the external field.

Keywords:

Kitaev model, Mangnetic phase transition, Exact diagonalization

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B7.03

High-velocity spin waves in the $Sr_2IrO_4/Sr_3Ir_2O_7$ heterostructure

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Abstract:

Oxide heterestructures offer a fertile ground for novel phenomena not found in the bulk constituents such as interface superconductivity, magneto-elastic coupling, and the quantum Hall effect, through the reconstruction of the charge, spin, and orbital states at the interface on the nanometer scale. However, how the spin dynamics changes under the constraints set by interfaces remains largely unexplored. In this talk, I will discuss the effect of magnon velocity renormalization in a magnetic heterostructure composed of Sr_2IrO_4 and $Sr_3Ir_2O_7$, which are magnetic insulators with predominantly Heisenberg and Ising interactions, respectively. Using resonant inelastic x-ray scattering, we observe that the magnon velocity in the Sr_2IrO_4 layer near the magnetic zone center is enhanced by almost a factor of two relative to its bulk counterpart. I will discuss possible origins of this phenomenon, in particular in connection with the suppression in the heterostructure of the magnetoelastic coupling which is manifest in the bulk Sr_2IrO_4.

Keywords:

magnon, spin-orbit coupling, iridate, hetetrostructure

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B7.04

The fate of J_{eff}=3/2 state under pressure

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Abstract:
Recently, a novel J_{eff}=3/2 state has been theoretically suggested in a series of 'lacunar spinel' compounds, GaT_4X_8 (T=Nb and Ta, X=S, Se, and Te) [1,2]. And later it has been experimentally confirmed for the case of $GaTa_4Se_8$ by using resonant inelastic x-ray scattering (RIXS) [3]. A key remaining question is about the fate of this magnetic state under pressure since this material exhibits the insulator-to-metal transition followed by superconducting transition as a function of pressure. Here we report and discuss our recent first-principles calculation result along with RIXS data. We found that the J_{eff}=3/2 moment is well maintained in the metallic region and presumably also in the superconducting phase. Our result suggests an interesting new playground to study the intriguing material phase in which J_{eff}=3/2 moment plays a significant role.

Reference

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[2] H. Lee et al., EPL (in press)
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Keywords:
Spin-orbit coupling, magnetism, transition-metal compounds

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Lifshitz transition driven metal-insulator transition in moderately spin-orbit coupled $Sr_{2-x}La_xRhO_4$

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Abstract:
Motivated by the novel insulating state of Sr_2IrO_4 from strong spin-orbit coupling (SOC), we investigate, by means of angle resolved photoemission (ARPES), the metal-insulator transition (MIT) mechanism in $Sr_{2-x}La_xRhO_4$ whose mother compound is isovalent and isostructural but has smaller SOC strength compared to Sr_2IrO_4. Transport and ARPES results from single crystalline $Sr_{2-x}La_xRhO_4$ revealed that the MIT occurs coincidentally with a multi- to single-band transition (Lifshitz transition) at $x = 0.4$. Starting from $x = 0.4$, there is a gradual but anomalous enhancement in the band gap size with additional electron doping, suggesting that the insulating phase in $Sr_{2-x}La_xRhO_4$ is a new type which has been rarely investigated. These results suggest that the insulating phase in $Sr_{2-x}La_xRhO_4$ is likely induced by the moderate SOC strength and electron doping effect from the La. Our ndings not only elucidate the MIT mechanism in $Sr_{2-x}La_xRhO_4$, but also open new avenues for novel MITs research in moderate SOC regimes.

Keywords:
ARPES, spin-orbit coupling, metal-insulator transition

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B8.01

Spin dynamics and field-induced magnetic phase transition in the honeycomb Kitaev magnet alpha-Li2IrO3

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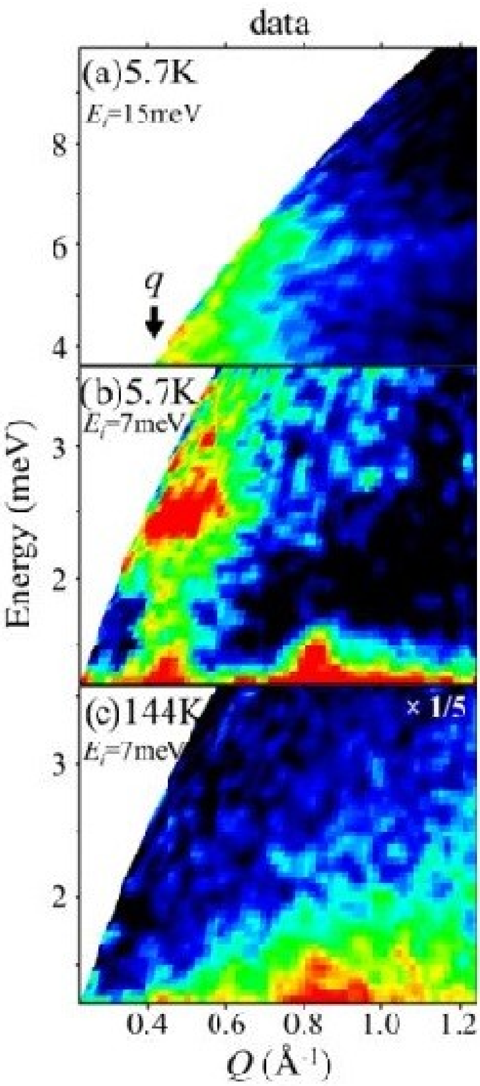
Abstract:

Quantum magnet is one of the most actively studying subjects in condensed matter physics as it shows exotic magnetic properties often related to novel applications such as energy-efficient devices. Kitaev quantum spin liquid is one of such phases that do not stabilize a long-range magnetic order even at 0 K. In this talk, we will present our recent experimental studies using various techniques to understand the two-dimensional honeycomb iridate magnet considered to be close to a quantum spin liquid phase.

The layered honeycomb iridate alpha-Li2IrO3 displays an incommensurate magnetic structure with counter-rotating moments on nearest-neighbor sites, proposed to be stabilized by strongly frustrated anisotropic Kitaev interactions between spin-orbit entangled Ir4+ magnetic moments. Powder inelastic neutron scattering measurements observe sharply dispersive low-energy magnetic excitations centered at the magnetic ordering wave vector, attributed to Goldstone excitations of the incommensurate order, as well as an additional intense mode above a gap ~2.3 meV. Zero-field muon-spin relaxation measurements show clear oscillations in the muon polarization below the Neel temperature TN~15 K with a time-dependent profile consistent with bulk incommensurate long-range magnetism. Pulsed-field magnetization measurements find that only about half the saturation magnetization value is reached at the maximum field of 64 T. A clear anomaly near 25 T indicates a transition to a phase with reduced susceptibility. The transition field has a Zeeman energy comparable to the zero-field gapped mode, suggesting gap suppression as a possible mechanism for the field-induced transition.

Reference: Sungkyun Choi, S. Manni, J. Singleton, C. V. Topping, T. Lancaster, S. J. Blundell, D. T. Adroja, V. Zapf, P. Gegenwart, and R. Coldea, Phys. Rev. B 99, 054426 (2019).



Keywords:
quantum magnet, Kitaev quantum spin liquid, iridate, susceptibility, neutron scattering, muon spin relaxation, Pulsed-field magnetization

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B8.02

Magnetic excitation in pyrochlore iridate $R_2Ir_2O_7$ (R = Sm, Eu) studied by Raman scattering

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Abstract:

We present results of temperature dependence of magnetic excitation Raman scattering on high quality polycrystallines $R_2Ir_2O_7$ (R = Eu, Sm). $Eu_2Ir_2O_7$ and $Sm_2Ir_2O_7$ have been belived to host the nontrivial topological state due to time reversal symmetry breaking by the all-in-all-out (AIAO) magnetic order. They are under the magnetic (and accompanied with metal to insulator) transition below the Neel temperature T_N ~120 K without showing any structural phase transition. Beside six phonons of cubic *Fd-3m* phase, Raman spectra of both compounds showed a set of multiple well-separated M peaks arising below the T_N. The energy of M peaks are ~ 23.7, 27.9, and 31.5 meV for $Sm_2Ir_2O_7$, and ~ 25.2, 27.3, and 30.1 meV for $Eu_2Ir_2O_7$. Moreover, the intensity of M peaks in $Eu_2Ir_2O_7$ are strongly depend on polarization configuration. These results indicate that the new features are magnetic driven excitations in iridate pyrochlores. Combine with linear spinwave calculation, we discuss serval possible origin of the magnetic excitation such as one-magnon, two-magnon excitation, on-site *f-f* transition. Our Raman study shed light on nature of magnetic excitation in 5*d* pyrochlore iridate, which becomes a challenge to investigate by other conventional techniques.

Keywords:

Sm2Ir2O2; Eu2Ir2O2 ; AIAO magnetic order; pyrochlore iridate.

B8.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Chiral anomaly magnetoresistance of antiferromagnetic TbPtBi single crystals

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Abstract:

Half-Heusler compounds, especially REPtBi (RE: rare-earth), is revealed as Weyl semimetal due to the formation of Weyl points with applying a magnetic field. The transformation of topological materials was verified by the phenomena such as the negative magnetoresistance, the anomalous Hall effect and the planar Hall effect. We report the magnetic and transport properties of TbPtBi single crystals where Tb^{3+} has the quantum numbers, S = 3, L =3 and J = 6. The experiments were conducted considering the facet plane of TbPtBi is (111) plane. The magnetic measurements show the antiferromagnetic order below T_N = 3.6 K, the magnetic anisotropy and the field-induced different magnetic phases. In transport properties, the behavior of the magnetoresistance (*H*//[111], *I*//[11-2]) is apparently changed around T_N. In the case of *H*//*I*//[11-2], the negative magnetoresistance is observed, which is attributed to the chiral anomaly. The physical properties will be discussed in terms of the formation of Weyl points and the chiral anomaly which are reflected in transport properties.

Keywords:

Half-Heusler compound, Weyl semimetal, Chiral anomaly

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2019-04-24 - 2019-04-26

B8.04

Degenerate *f* Orbitals in doped CeO_2 for Ferromagnetic Insulators

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Abstract:

In some rare cases, a puzzling coexistence of ferromagnetic and insulating properties have been reported, however, understanding localized electrons interactions is a long issue. Various attempts have been taken to explain them and in process Goodenough-Kanamori-Anderson (GKA) superexchange interactions (SEI) rules were built but mostly for *d*-orbital systems, where crystal filed splits the d orbital into t_{2g} and e_g orbitals, employing either ferromagnetic (FM) or antiferromagnetic (AFM) SEI. On the other hand, f orbitals stay deep in energy and degree of crystal field splitting is very small resulting in multiple degenerate orbitals those have both orthogonal and non-orthogonal symmetry with cation's sigma orbital. In order to determine the net SEI, we extend well known GKA rules to multiple SEI, which considers both FM and AFM SEI to determine net SEI. We studied all seven *f* orbitals interactions based on the orthogonality of cation's and anion's orbital wavefunction and predicted possible SEI. We showed that the proposed multiple SEI works well with three examples of doped CeO_2 and found that Pr doped CeO_2 exhibit ferromagnetic and insulating properties at specific doping concentration. This work shows a systematic way to design ferromagnetic insulators by adapting GKA rules in fluorite structure by means of density functional theory using GGA-PBE +*U* scheme.

Keywords:

Superexchange interactions, Ferromagnetic insulators

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2019-04-24 - 2019-04-26

B8.05*

Zeeman splitting and Berry phase determined from SdH oscillations in $NbSb_2$

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Abstract:

Shubnikov-de Haas (SdH) oscillations in topological materials have become a conventional experimental tool for determining the Berry phase, which is the main criterion to judge the topological state to be trivial or non-trivial [1]. It is well known that topologically non-trivial materials have p Berry phase of SdH oscillations [2]. In the SdH oscillation, however, the p phase can also be attributed to Zeeman splitting [3]. In the single crystal of $NbSb_2$, we observe clear SdH oscillations as varying the direction of applied magnetic field. From the analysis, we find abrupt p phase change at certain angles. This change is most likely to arise from the Zeeman splitting, not the Berry phase, because the intensity of oscillations abruptly goes to zero at those angles. Furthermore, the determination of Berry phase in three-dimensional materials is difficult due to the complex shape of Fermi surfaces giving rise to the curvature phase factor [3]. From the strong harmonics observed in SdH oscillations, we successfully determine the exact Berry phase ~ 0.8p, implying that $NbSb_2$ is a massive Dirac system with linear dispersion. This analytical technique is introduced in the presentation.

Reference

[1] G.P. Mikitik and Yu. V. Sharlai, *Phys. Rev. Lett.* **32**, 2147 (1999).
[2] A. A. Taskin and Yoichi Ando, *Phys. Rev. B.* **84**, 035301 (2011).
[3] D. Shoenberg, *Magnetic Oscillations in Metals* (Cambridge University Press, 1984).

Keywords:
Shubnikov-de Hass effect, Berry phase, Zeeman splitting

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2019-04-24 - 2019-04-26

B8.06*

Magnetism of lanthanide elements embedded into ultra -thin magnesium oxide layers on Ag(100)

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Abstract:

The purpose of this investigation is to advance the understanding of magnetism at the atomic level and reduce the size of data storage and quantum computing unit to the ultimate limit. Recent studies have shown that holmium atoms **adsorbed** on a magnesium oxide (MgO) film on Ag(100) can retain their magnetization up to 30K with a relaxation time of 1500s at 10K[1,2]. However, at higher temperatures their structural stability is lost owing to diffusion, nucleation and thus loss of the structural symmetry. In particular, the latter plays a very important role in generating the strong uniaxial anisotropy that stabilizes the magnetization of Ho adsorbed atoms. Hence, the necessary conditions to stabilize the magnetization of single atoms at ever higher temperature is to enhance their structural stability. This could be achieved by **embedding** the lanthanide atoms in the oxide layer.

In this experiment, we attained that aim by growing different films of MgO on Ag(100) co-depositing holmium, dysprosium, erbium, samarium, gadolinium and thulium. We prepared our samples in ultra-high vacuum (chamber pressure below 10^{-9}mbar) to minimize contamination. We have used synchrotron radiation and related measurement techniques such as x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD) to measure the spin and orbital moments, as well as the magnetic anisotropy of the embedded lanthanide. XAS and XMCD are sophisticated techniques which not only are element specific but also are able to assess the magnetic properties of samples with very low concentrations of magnetic elements (as low as 1% of an atomic layer). Our measurement reveals out-of-plane anisotropy for Tm and Sm, whereas in plane anisotropy for Ho and Dy. In addition, we find negligible anisotropy for Er and Gd. Combining our experiments with density functional theory and multiplet calculations we have a better understanding of the interaction of the embedded atom with its crystal environment and the consequence of those effects on its magnetic properties.

F. Donati, S. Rusponi, S. Stepanow et al., Science 315, 319 (2016).
F.D. Natterer, K.Yang, W. Paul et al., Nature 543, 226 (2017)

Keywords:
X-ray Magnetic Circular Dichroism, surface magnetism, quantum magnets, single atom magnets

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B8.07*

Room temperature ferromagnetism in a magnetic-metal-rich van der Waals metal

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Abstract:
In spintronics, two dimensional (2D) van der Waals (vdW) crystals constitute a most promising material class for long-distance spin transport or effective spin manipulation at room temperature. To realize all-vdW-material-based spintronic devices, however, new vdW materials with itinerant ferromagnetism at room temperature are needed for spin current generation and thereby serve as an effective spin-source. We report theoretical design and experimental realization of a new iron-based vdW ferromagnet Fe_4GeTe_2 showing the highest T_c
of 280 K among vdW ferromagnets, together with a large magnetization and a high conductivity. Our findings highlight Fe_4GeTe_2 as a promising candidate for spin source operation at room temperature and hold a promise to further increase T_c in vdW ferromagnets by theory-guided material discovery.

Keywords:
van der Waals ferromagnet

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B10.01

확률 동역학계에서 물체의 모양과 상호작용의 역할

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Abstract:
Shapes and interactions of objects play nontrivial roles in physics of the system they constitute, as evident from emergent phenomena such as the nematic phase of elongated molecules and like-charged attraction between polyelectrolytes mediated by dumbbell-like counterions. Nevertheless, the fundamental understanding of their effects on dynamical systems remains elusive. We study how shapes of objects and interactions between them interplay with stochastic dynamics in the context of chiral separation by flow, diffusion of anisotropic objects, and random target searching in a confined space. In the first part of the presentation, motivations, methodologies used, and key results of each research will be briefly reviewed. In the second part, recent results on optimal searcher distribution minimizing the random searching time and the effects of interactions between the searchers on the searching time will be discussed.

Keywords:
stochastic process, shape, interaction, hydrodynamics, first-passage dynamics

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B10.02*

Impact of Cooperation in Two-Species Interacting Particle System

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Abstract:

We study a two-species interacting particle system as a model for the emergence of multicellularity in microbial systems. In our model, each species behaves like the one in the contact process (CP) except for additional cooperative reactions between species which represent a division of labor. First, we present the mean-field approximation of the model as a tool for the study of the qualitative features. Next, we perform extensive stochastic simulations of the model in (1+1)-dimension. From the results of the mean-field theory and Monte Carlo simulations, we construct the phase diagram and find the conditions that co-existence of both species doing division of labor is predominant and maintained. Also, both methods show that there are two types of phase transitions. The first type is an absorbing phase transition which occurs from a fluctuating active phase into an absorbing state. Besides, the model displays another phase transition from a segregated domain phase into a mixed domain phase depending on the cooperation constant. When the cooperation effect is weak, the system is dominated by the segregated single-species domains. In this case, each species lives separated from the other by a well-defined boundary. On the other hand, when the cooperation effect is strong enough, the mixed-species domain emerges, within which both species live and mingle together. Within such domain, different species cells tend to locate adjacent to each other and effectively behave like bi-cellular organisms. We characterize these two types of phase transitions and critical phenomena from the perspective of non-equilibrium phase transition. We confirm that our model belongs to the universality class of directed percolation (DP) in most cases when we only consider the first type of transition. In the case of the second type of transition, we identify that the model shows DP critical behavior in some regions; however, in others, the critical behavior seems to be different from that of the DP.

Keywords:
Two-Species Interacting Particle System, Cooperation, Division of Labor, Phase Transitions, Critical Phenomena

B10.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Collective phenomena in corporate bankruptcy and information disparity

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Abstract:
This study aims to offer a different standpoint with respect to the origin of collective phenomena in firm size distribution by allowing corporate bankruptcy. Our model expects that (i) firms with high bankruptcy possibilities would exhibit stronger collective phenomena than that of all firms; and (ii) information disparity would positively affect the collective mechanism. We empirically verify the model by using the data of US corporate bankruptcy filings. Our findings imply that the outcomes of shocks originated from large firms could have stronger impact in a better information environment.

Keywords:
Collective system, Corporate bankruptcy, Information disparity

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B10.04*

Large-scale Information-theoretic analysis of composition in painting

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Abstract:
Artists, designers, and architects have attentively embedded various geometric proportions such a half, a third, or the golden ratio into their artworks reflecting the varying aesthetic elements in the art history. Here we propose a quantitative systematic framework for assessing the compositional proportion in landscape paintings using an image partitioning algorithm based on information theory. Analyzing a large-scale painting dataset from the Renaissance to the contemporary period, we identify the typical composition of landscape painting commonly preferred by painters over a variety of nations. However, the preferred proportions among painters gradually varied over time. Next, we construct and visualize the composition-similarity network among painters based on individual preference on compositional proportion. Painters of the same community in the network are found to have worked in temporally similar period compared to other communities. Finally, we explore color harmonization between partitioned sub-blocks in paintings and reveal that there is a continuously increasing trend in complementary color contrast and decreasing trend in analogous color usage.

Keywords:
information theory, painting analysis, art history

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B10.05*

디지털 통화: 평형에서 멀지 않은 곳에 (Digital Currency: Not Far From Equilibrium)

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Abstract:

본 연구는 디지털 통화 가운데 암호화폐의 일종인 비트코인의 자산으로서의 특성을 알아보고자 하였다. 이를 위해 비트코인을 포함한 주요 자산군의 시계열분석을 바탕으로 경제물리척도: Hurst 지수, Power-law 지수, 그리고 symbolic time-series analysis 를 적용한 Shannon 엔트로피를 측정하였다. 계량적 실증분석 결과, (i) 비트코인은 효율적 시장 가설 측면에서 기존 자산들에 비해 비효율적이지만, (ii) 엔트로피 측면에서서는 기존 자산들과 비교하여 큰 차이가 없었다. 이는 시장의 신규성이나 투자자의 경험 미숙 등으로 충분히 성숙하지 않은 비트코인 시장에서 단순히 실현된 결과값이 다를 뿐, 시장(시스템) 장기균형의 측면에서는 그 평형의 정도가 다른 자산군과 크게 다르지 않은 것으로 이해된다. 이러한 비트코인의 특성을 이해하기 위해, 우리는 Fokker-Planck 방정식 및 Schrödinger 방정식으로부터 평균회귀속도(speed of mean reversion)와 확산도(dispersion)가 반영된 확률밀도함수를 도출하여 이를 설명하였다.

Keywords:

Market equilibrium; Efficient market hypothesis; Entropy

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2019-04-24 - 2019-04-26

B10.06*

Diverse environmental conditions accelerate the searching speed of genetic algorithm

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Abstract:
In the development of the genetic algorithm (GA) to solve various optimization problems, genetic selection has always been a crucial component which significantly affects the performance of the used algorithm. Most existing GA's, inspired by the general concept of natural selection, implement ways, some basic and others sophisticated, to efficiently search decent solutions over broad area in a given fitness landscape. We in this work suggest that assigning different environmental conditions can also improve this procedure, and apply our method to the Ising spin-glass model in statistical mechanics. In our proposed extension of GA, we assign heterogeneous and time-varying external field to each genetic entity to mimic different environmental conditions. Our numerical results reveal that our method is able to speed up the search of the global minimum significantly. We also find that a proper amount of parental difference can benefit the acceptance probability of offspring entity.

Keywords:
genetic algorithm, spin glass, heterogeneity, search algorithm

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B10.07*

Foraging path formation with directional pheromones

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Abstract:
Many ant species form foraging paths between the nest and food by depositing pheromones. Even if each individual ant can only gather local pheromone information to be processed with its limited cognitive ability, the collective path is often observed to be stable and near-optimal. We propose an agent-based model for path formation of ants, in which each agent moves with sensing directional pheromones within a cutoff distance. The model shows that foraging paths are successfully formed over a wide range of modeling parameters, suggesting robustness of the proposed mechanism. In particular, the model exhibits phase transition between ordered and disordered foraging as the cutoff distance exceeds a threshold. We discuss biological and theoretical justifications for the idea of directional pheromones, the key ingredient of our model.

Keywords:
ant; path formation; pheromone; chemotaxis

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B10.08

Analytically solvable autocorrelation function for correlated interevent times

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Abstract:
Long-term temporal correlations observed in event sequences of natural and social phenomena have been characterized by algebraically decaying autocorrelation functions. Such temporal correlations can be understood not only by heterogeneous interevent times (IETs) but also by correlations between IETs. In contrast to the role of heterogeneous IETs on the autocorrelation function, yet little is known about the effects due to the correlations between IETs. In order to rigorously study these effects, we derive an analytic form of the autocorrelation function as a function of the memory coefficient between two consecutive IETs for an arbitrary form of the IET distribution, by adopting the Farlie-Gumbel-Morgenstern copula for the joint probability distribution of two consecutive IETs. Our analytic results are confirmed by numerical simulations for exponential and power-law IET distributions. For the power-law case, we find the tendency of the steeper decay of the autocorrelation function for the stronger correlation between IETs. Our analytic approach enables us to better understand long-term temporal correlations induced by the correlations between IETs.

Keywords:
time series analysis, autocorrelation function, bursts, correlated bursts

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B11.01

Algorithmic assembly demonstrated by DNA

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Abstract:

Although structural DNA nanotechnology is a well-established field, computations performed using DNA algorithmic self-assembly is still in the primitive stages in terms of its adaptability of rule implementation and experimental complexity. Here, we discuss the feasibility of constructing an M-input/N-output logic gate implemented into simple DNA building blocks. To date, no experimental demonstrations have been reported with M 〉 2 owing to the difficulty of tile design. To overcome this problem, we introduce a special tile referred to as an operator. We design appropriate binding domains in DNA tiles, and we demonstrate the growth of DNA algorithmic lattices generated by eight different rules from among 256 rules in a 3-input/1-output logic. The DNA lattices show simple, line-like, random and mixed patterns, which we analyse to obtain errors and sorting factors. The errors vary from 0.8% to 12.8% depending upon the pattern complexity, and sorting factors obtained from the experiment are in good agreement with simulation results within a range of 1 ~ 18%.

Keywords:
DNA, Self-assembly, Algorithm, Logic implementation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B11.02

Biophysics of Z-DNA

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Abstract:

DNA is the central molecule of life and heredity. Since the structure of DNA was first determined in 1953, the field of biology has been revolutionized and biology became a molecular science. The very structure discovered by Watson and Crick is not the only structure possible for nucleic acids. Many non-canonical structures are found to exist. One striking example is left-handed Z-DNA. Although its *in vivo* existence and role are not fully established yet, Z-DNA attracts much attention from structural biologists, chemists, and biophysicists for its exotic structure, unusual properties, and potential applications. Here, I would like to summarize our research on Z-DNA. We have not only revealed the critical role of torque in the B-Z transition, but also unveiled the reaction pathway in a protein-driven B-Z transition. Recently, we successfully demonstrated that the B-Z transition can be used to detect the degree of methylation of DNA, suggesting that Z-DNA like other non-B-DNAs can be used as a biosensor. Taken together, non-B structures are interesting subjects to study from a biophysical point of view and promise great potential as building blocks for nano devices and sensors.

Keywords:

Z-DNA, non-B, non-canonical DNA, single-molecule biophysics, methylation

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2019-04-24 - 2019-04-26

B11.03

Reprogramming Extreme Bendability of DNA Through Epigenetic Principles

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Abstract:

In biology, the main role of DNA is a carrier of the genetic information in the form of a long linear sequence of four nucleotides: A, T, G, and C. The goal of the modern biology is understanding how four nucleotides encode various genes and how those genes interact one another. From the physics or materials point of view, DNA is a remarkable smart polymer made by the mother nature. For DNA polymers longer than the persistence length (50 nm), DNA behaves like an ideal polymer that can be well described by a simple model such as the worm-like chain. Mysteriously, DNA shorter than the persistence length can be extremely flexible or rigid depending on the nucleotide sequence, significantly deviating from the ideal behavior. Here, we tackle the problem using fully atomistic molecular dynamics simulations of DNA minicircles, in which DNA is highly bent to form a closed circle. From the simulations of 150 microseconds in total, we determined the free energy landscapes of 35 different minicircles. By decomposing the free energy landscapes into the sum of dinucleotide step energy, we came up with the stiffness coefficients of all possible dinucleotide steps that vary dramatically depending on the sequence of dinucleotide. Using the sequence-dependent stiffness coefficients, we can explain the previously observed extreme bendability of short DNA polymers. Further, we demonstrate the DNA bendability can be rationally reprogrammed using the principle we discovered.

Keywords:
DNA, Biophysics, Persistence length, flexibility

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B11.04

Real-time Observation of the Conformational Dynamics of Highly Bent Short dsDNA

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Abstract:
Bending with high curvature is one of the major mechanical properties of double-stranded DNA (dsDNA) which is critical to its biological functions. The emergence of a kink due to local melting in the middle of dsDNA, has been suggested as a mechanism of releasing the energy cost of high bending, an alternative to simple bending of dsDNA. Here, we show that strong bending induces two types of short dsDNA (30 base pairs) deformations, induced by two types of local melting, i.e., a kink in the middle and forks at the ends, which we demonstrate by applying single-molecule fluorescence resonance energy transfer to D-shaped DNA nanostructures. We directly demonstrated that the two types of deformed dsDNA structures are not permanently stable but dynamically interconvert with each other on a millisecond scale. The transition from a fork state to a kink state is dominated by entropic contribution (anti-Arrhenius behavior), while the transition from a kink state to a fork state is dominated by enthalpy contribution with an free energy barrier of 8 - 12 kcal/mol. The presence of mismatches in dsDNA accelerates kink formation, and the transition from a kink state to a fork state is fully removed when the mismatch size is three base pairs.

Keywords:
DNA, bending, persistence length, single-molecule

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B11.05

DNA-based Brownian motor for directional nanoparticle delivery - computational design

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Abstract:
Brownian particles subject to a periodic, asymmetric potential can be transported in a specific direction along the potential by repetitively switching the potential on and off. In this work, we design a DNA-based Brownian motor for directional transport of positively charged nanoparticles along a single, long double-stranded DNA (dsDNA) with elaborately designed flexibility variation. We prove its realization by Brownian dynamics simulations of coarse-grained models. A periodic and asymmetry potential for nanoparticle binding is constructed along a single dsDNA by a novel strategy that utilizes variation in sequence-dependent DNA flexibility. Directional and processive motion of nanoparticles is achieved by changing salt concentration repetitively over several cycles to switch the asymmetric potential on and off. This work suggests that dsDNA molecules with elaborately designed flexibility variation can be used as a molecule-scale guide for spatial and dynamic control of nanoparticles for future applications.

Keywords:
DNA flexibility, Brownian motor, nanoparticle delivery

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B11.06

Utilizing the sequence-dependent mechanical properties of DNA nicks for twisted DNA origami design

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Abstract:
DNA nick is one of the important structural motifs abundant in DNA origami nanostructures which affects their three-dimensional shape and physical properties. However, its mechanical properties have not been systematically characterized at base level. In this presentation, the sequence-dependent mechanical properties (elastic stiffness) of nicked dinucleotide steps investigated using all-atom molecular dynamics simulation will be discussed. Results suggest that nicks can effectively soften the torsional rigidity up to 82% depending on the sequence presumably by relaxing the torsional constraint by backbones. Other rigidity values were not significantly affected by nicks. We will also present how we utilized the quantified nick properties to control the twist angle of DNA origami nanostructures. Both computational and experimental studies demonstrate the importance and opportunities of taking the sequence-dependent properties into consideration in DNA nanostructure design.

Keywords:
Nick, DNA Origami, Mechanical Properties, Design Principle, Computer Simulation

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B11.07

Protein-mediated DNA looping: effects of non-specific protein-DNA interactions

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Abstract:

The DNA and proteins are the two most important molecules for all living systems, and their specific protein-DNA complexes govern many biological processes. Protein-mediated DNA loop formation is an example of such complexes that play important roles, for instance, in transcriptional regulation. In this talk, I will present a new theoretical approach using a discrete-state stochastic model to analyze the DNA loop formation by non-specific protein-DNA interactions. We show that depending on the protein-DNA interactions, there are different loop formation dynamic regimes. Moreover, the loop formation time can be optimized by varying the protein sliding length, size of the DNA loop. Our results demonstrate the importance of non-specific protein-DNA interactions in the dynamics of DNA loop formations.

Keywords:
DNA looping, First passage process, protein-DNA interactions

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B12.01*

Argon clusters in supercritical fluid and their effect on the laser produced plasma

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Abstract:
It is found that the argon clusters produced by continual compression into a high-pressure chamber float in the argon supercritical fluid with an extremely long lifetime over an hour. The typical size of clusters is about a few hundreds of nanometers estimated from laser scattering image. An empirical model to explain the production and destruction of clusters is proposed based on the measurement of cluster number density during and after compression. The model incorporates the generation and destruction rates of clusters as the key parameters. The latter has a strong dependence on the temperature of the surrounding fluid, which significantly affects the cluster lifetime. In supercritical argon fluid with a dense population of clusters, jet-like plasmas are produced by ns pulse laser. The lifetime of the plasma jet is much longer than the laser pulse duration and becomes longer for higher number density of clusters.

Keywords:
argon clusters, supercritical argon plasma, high pressure plasma, long-lived plasma

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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B12.02

Gyrokinetic simulation study of parity dependence of tokamak magnetic heat transport

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Abstract:

In the past, a main focus of physics study of finite-β effect on plasma transport in magnetic fusion devices had been linear stabilization of modes in drift branch [1,2], and onset of kinetic ballooning mode (KBM) [3] above a certain critical β. The finite-β linear stabilization is well known to originate from magnetic field line bending. More recently, considerable attention has been paid to finite-β effect on transport in the presence of fully developed turbulence [4,5]. Nonlinear electromagnetic gyrokinetic simulations have showed that magnetic transport by ion temperature gradient (ITG) turbulence makes significant modification to net turbulent heat flux. Parity analyses of the electromagnetic ITG turbulence have showed that nonlinearly generated tearing parity modes play an important role in the magnetic heat transport [6] by making full stochasticity of fluctuating magnetic field [7]. In this work, we study further details of parity dependence of the magnetic heat transport of finite-β tokamak plasmas in ITG mode dominant regime using GKV code [8], with a special emphasis on transport efficiency. Results of nonlinear GKV simulations for cyclone base case parameters show clear disparity between electron and ion transport channels, low and high radial wavenumbers, and quasi-linear and nonlinear fluxes on the parity dependence of magnetic heat transport.

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Keywords:

Gyrokinetics, parity, turbulence, ITG mode, finite-β, magnetic transport

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B12.03

Discovery of the fundamental physical mechanism of the ohmic breakdown in tokamaks

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Abstract:

Although the ohmic breakdown is one of the major methods to initiate the plasma in the tokamak, its physical mechanism has been obscured for several decades due to the complex electromagnetic topology. To simplify the problem, the traditional Townsend theory has been widely adopted for the ohmic breakdown study. However, we found clear evidence from the KSTAR experiments that the Townsend theory is not valid for the ohmic breakdown. We developed a theoretical plasma response model and a multi-dimensional particle simulation code BREAK [1] to study the underlying mechanism of the ohmic breakdown in the complex electromagnetic topology. As a result, we established the first systematic ohmic breakdown model in the tokamak, a turbulent ExB mixing avalanche [2], which successfully explains the KSTAR experiments. This model describes the crucial roles of the space-charge and corresponding self-electric fields during the ohmic breakdown that drastically decrease the plasma growth rate and cause dominant ExB transports. Also, the model provides a comprehensive understanding of the complex electromagnetic topology including the role of X-point in the ohmic breakdown.

References:
[1] Min-Gu Yoo, *et al.*, Computer Physics Communications **221,** 143-159 (2017).
[2] Min-Gu Yoo, *et al.*, Nature Communications **9**, 3523 (2018)

Keywords:
tokamak, ohmic breakdown, particle simulation, plasma response

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B12.04*

Residual Zonal Flows in ITER like plasmas

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Abstract:

We investigate the residual zonal flow [M.N. Rosenbluth and F.L. Hinton, Phys. Rev. Lett. 80, 724 (1998)] in the presence of fuison product α-particles in tokamak plasmas using the modern gyrokinetic theory in the electrostatic limit. The residual zonal flow is predicted to be enhanced considerably for ITER plasmas in the radial wavelength regime of $k_r\rho_{i,eff}$~10^{-1}, where $\rho_{i,eff}$ is the Larmor radius of a thermal ion of background plasma consisting of Deuterium and Tritium. This is because of the Larger Lamor radius of a energetic α-particles which leads to an enhancement (a reduction) of the classical (neoclassical) polarizability at that wavelength regime compared to the case without α-particles. This enhancement is slightly more pronounced for the slowing down distribution compared to the Maxwellian if $T_e \gtrsim 20keV$ for $E_\alpha = 3.5MeV$. In addition, we find that the Rosenbluth-Hinton formula for the residual zonal flow level which has been derived for the Maxwellian equilibrium ion distribution remains valid in the long wavelength ($\mathrm{k}_r\rho_{i,b} \ll 1$, $\rho_{i,b}$ is the banana orbit width) and high aspect ratio limit, for any well-behaved ion distribution function which is isotropic in velocity space.

Keywords:

Residual Zonal Flow, Plasma turbulence, Gyrokinetics in Plasmas

KPS 한국물리학회 The Korean Physical Society

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B12.05

Non-axisymmetric field influences and its physics mechanism on L-H Transition in KSTAR*

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Abstract:
A significantly contrasting influence of resonant and non-resonant fields on L-H transition has been identified using high precision non-axisymmetric in-vessel control coils (IVCC) in KSTAR. Specifically, considering that KSTAR has an order of magnitude lower n=1 intrinsic non-axisymmetric field [1] and toroidal field ripple [2], such a sensitive variation of resonant magnetic field on P_{TH} had been thought to be associated with the ExB shearing rate change. Had such a premise been valid, we should have observed a similar dependence, even if the applied non-axisymmetric field would be replaced by non-resonant magnetic fields which would alter the plasma rotation exclusively without affecting the particle or heat transport. However, we have found no sensitivity of non-resonant field on L-H transition even at the maximum affordable level of non-axisymmetric field current. Thus, we speculate that the L-H power threshold might be determined by ExB shearing rate but also that a turbulent transport driven by resonant magnetic field would be much more stochastically involved than that of non-resonant magnetic field. At the same time, this strongly suggests that the ITER might not need any dedicated correction of non-resonant magnetic fields, while requiring a high-quality resonant magnetic field control to secure the access to H-mode, in particular, at the marginal level of auxiliary heating sources.

*This work was supported by the Korean Ministry of Science and ICT under NFRI R&D programs (NFRI-EN1901-10).

[1] Y. In et al, Nucl. Fusion (2015)
[2] H.H. Lee et al, Phys. Plasmas (2016)

Keywords:
KSTAR, Non-axisymmetric field, L-H Transition

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B12.06*

Semi-analytic Shape Function of High-harmonic Electron Cyclotron Emission in Magnetically Confined Plasma

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Abstract:
A semi-analytic expression of the normalized spectral electron cyclotron emissivity (ECE shape function) has been established for arbitrary high harmonics with the readily-integrable test function fitting the original integrand of the ECE shape function. The fitting parameters of the readily-integrable function are determined systematically by applying regression analysis. The discrepancies between the shape functions obtained from the semi-analytic expression and the numerically calculated ECE have been widely evaluated to estimate the applicable boundaries of this work, in particular, on fusion plasma regime. The expressions can be applicable for high-speed analysis of both high and low harmonic ECE diagnostics as well as their corresponding synthetic diagnostics. In addition to such obvious utilization, the expressions can provide means to utilize the high harmonic ECE for efficient measurements of turbulent fluctuations and indirect measurement of energetic electrons. This work was supported by the National Research Foundation of Korea under grant **No. NRF-2017M1A7A1A03064231** and **BK21+** program.

Keywords:
Plasma radiation(emission, absorption, transport), Fusion plasma diagnostics, Electron Cyclotron Emission (ECE)

Stability and global MHD mode stabilization research on KSTAR

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Abstract:
H-mode plasma operation during the 2018 KSTAR device campaign produced discharges having strong m/n = 2/1 tearing instabilities. At normalized beta, β_N, lower than the ideal MHD no-wall beta limit, the magnitude of the highly unstable mode exceeded 30 G which consequently reduced plasma confinement and toroidal plasma rotation significantly. Mode stability alteration was attempted by varying plasma heating, safety factor, collisionality, and rotation profile. The experiment confirmed that an extended duration of the electron cyclotron heating (ECH) at the initial phase of the discharge plays a critical role in mode destabilization. To study destabilizing mechanisms that affect the mode growth, the stability of the observed tearing modes is computed by using the resistive DCON code and the M3D-C^1 code. Equilibrium reconstructions that include constraints from Thomson scattering, charge exchange spectroscopy, motional Stark effect diagnostic data, and allowing fast particle pressure are used as input for reliable computation of stability. The classical tearing stability index, Δ', from resistive DCON is compared to modes from significantly higher β_N plasmas and the result indicates that their stability is governed by different physical mechanisms. In preparation for plasma operation at higher beta utilizing increased plasma heating power in 2019, a resistive wall mode (RWM) active feedback control algorithm has been completed and enabled on KSTAR. To accurately determine the dominant n-component produced by RWMs, an algorithm has been developed that includes magnetic sensor compensation of the prompt applied field and the field from the induced current on the passive conductors. Use of multiple toroidal sensor arrays is enabled by modifying the sensor toroidal angles assumed in mode decomposition to include the effect of varied mode helicities in the outboard region where the mode measurement is made. This analysis on stability, transport, and control provides the required foundation for disruption prediction and avoidance research on KSTAR. This work is supported by US DOE Grant DE-SC0016614.

Keywords:
MHD, magnetohydrodynamics, plasma instability, resistive wall mode, RWM, tearing mode, NTM, KSTAR, plasma control, disruption

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B12.08

Plasma instability study for the black aurora and fusion devices

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Abstract:

Underlying mechanism of the strong electric field formation across the black aurora is explained by the Gyro-Center Shift (GCS) current due to the charge exchange reactions between ions and neutrals[1]. The instability of Edge Localized Mode (ELM) at the boundary of nuclear fusion devices is one of the major obstacles must be overcome for the realization of commercial fusion energy production. Two common features of black aurora and ELMs are found; the first is strong electric field and the second is the instability with circular structure. The introduction of GCS analysis and observations of instabilities in the black aurora and ELMs will be presented as well as the synergetic opportunity of collaboration between the aurora research and the tokamak research.

[1] Kwan Chul Lee, "Electric field formation in three different plasmas: A fusion reactor, arc discharge, and the ionosphere", *physics of Plasmas,* Vol. 24, 112505, Nov. 2017

Keywords:

plasma, E-field, ELM, fusion

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B13.01*

Higgs inflation and the refined dS conjecture

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Abstract:

The refined de Sitter derivative conjecture provides constraints to potentials that are low energy effective theories of quantum gravity. It can give direct bounds on inflationary scenarios and determine whether the theory is in the Landscape or the Swampland. We consider the 'Higgs inflation' scenario taking the refined de Sitter derivative conjecture into account. Obtaining the critical lines for the potential, we find a conjecture parameter space in which the 'Higgs inflation' is to be in the Landscape. Comparing with the model independent observational bounds from recent data we find that the observational bounds represent the Higgs inflation can be in the Landscape.

Keywords:
Swampland conjecture, Higgs inflation

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B13.02

de Sitter Swampland, H_0 tension & holography

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Abstract:
We review tension in the Hubble constant in light of the de Sitter Swampland conjecture of Vafa et al. We introduce an alternative late-time cosmology to ΛCDM and comment on observational constraints.

Keywords:
String theory Swampland, cosmology

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Large AdS black holes from QFT

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Abstract:

We study the index of $\mathcal{N}=4$ Yang-Mills theory on $S^3\times\mathbb{R}$ at large angular momenta. A generalized Cardy limit exhibits macroscopic entropy at large N. Our result is derived using free QFT analysis, and also a background field method on S^3. The index sets a lower bound on the entropy. It saturates the Bekenstein-Hawking entropy of known supersymmetric AdS_5 black holes, thus accounting for their microstates. We further analyze the so-called Macdonald index, exploring small black holes and possibly new black holes reminiscent of hairy black holes. Finally, we study aspects of large supersymmetric AdS_7 black holes, using background field method on S^5 and 't Hooft anomalies.

Keywords:

N=4 Yang-Mills theory, large angular momenta, supersymmetric AdS5 black holes

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B13.04*

Constructing the S-matrix for black holes as point particles

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Abstract:

The recently developed spinor-helicity formalism for massive particles is applied to S-matrix elements involving black holes. How to construct the simplest S-matrix elements, coupling of a black hole to a graviton and the gravitational analogue of Compton scattering for black holes, will be presented. Some comments will be made on the structures of the resulting S-matirx elements and their relation to physical properties of black holes.

Keywords:

black holes, quantum gravity

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

B13.06*

Wrapped Branes in Romans *F(4)* Gauged Supergravity

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Abstract:
We explore the spectrum of lower-dimensional anti-de Sitter solutions in $F(4)$ gauged supergravity in six dimensions. The ansatz employed is reminiscent of branes partially wrapped on various supersymmetric cycles. In this article we consider the cases of 3-cycles and 4-cycles within Calabi-Yau threefold, and manifolds with G_2 and $Spin(7)$ holonomy manifolds. We also report on the study of non-supersymmetric vacua, and check their stability using Breitenlohner-Freedman bound.

Keywords:
Wrapped Branes, Supergravity, AdS/CFT, F(4) Supergravity, Supersymmetry, Holographic Renormalization Group Flow

B13.07

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Inhomogeneous mass deformation of ABJM theory

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Abstract:

We consider various mass deformations of ABJM theory where the mass term depends on spatial coordinates. N=1,2 and 3 supersymmetric inhomogeneous mass deformed ABJM theories are constructred. In addition we study the vacuum structure of N=3 case. We also discuss on the gravity duals of the theory.

Keywords:

ABJM theory, Mass deformation, Supersymmetric field theory, Gauge/gravity duality

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B13.08

Boomerang RG and Entanglement Entropy

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Abstract:
We consider 4D holographic models that translation invariance on the boudary is broken by relevant operators and have the same AdS4 vacuum at the UV and IR fixed point. These flows are called boomerang RG flow. We calculate holographic entanglement entropy for these models and show that entropic c-function is not monotonic.

Keywords:
Boomerang RG flow, Holographic entanglement entropy

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B14.01

Particle physics in the KISTI-5 supercomputing era

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Abstract:
Last November KISTI-5 supercomputing has launched. Let us discuss on the application and usages of KNL-based system of KISTI-5 supercomputer for particle physics. The goal of this talk is to have in-depth discussion about technical issues and solutions on high performance computing with Intel KNL(Knights Landing) clusters for particle physics. Let me show some of potential works which are evolution of universe, Geant4, deep learning and so on.

Keywords:
Particle physcis, supercomputer, compuational science, Geant4

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B14.02

Neural Networks for the Abstraction of Physical Symmetries in the Nature

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Abstract:
Neural networks are so powerful universal approximator of complicated patterns in large-scale data, and nowadays they are leading the explosive developments of AI in terms of deep learning in everywhere. However, in most cases, neural network models are trained to possess very poor level of abstraction, so that their predictability can be quite unstable and low, depending on the quality and amount of the data used for training. In this presentation, we introduce a new neural network architecture which can augment the missing and unstable predictability of current neural networks, with its improved capability on the key feature abstraction for natural science. We demonstrate its improved ability, with an application for high energy particle scattering processes at the LHC.

Keywords:
machine learninng, deep learning, collider physics, particle physics, natural science

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B14.03

A study of data-driven background generated with Wasserstein Generative Adversarial Network

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Abstract:
Generating Monte Carlo for rare processes at the LHC is time-consuming. Although generated Monte Carlo in some channel has large uncertainties even at NLO. Therefore, to producing background samples, we tried a data-driven method for reducing uncertainties with a deep learning technique called Wasserstein generative adversarial network (WGAN) for saving time.

Keywords:
Monte Carlo, Deep Learning, WGAN

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B14.04*

Applying Self-Attention to Particle Physics

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Abstract:

Recently, deep learning has been applied to various fields of high energy physics such as physics object discrimination, event topology classification and detector response simulation. We study the data representation and the deep learning architecture suitable for the collision experiment. In particular, we will discuss why the self-attention mechanism is suitable for our high energy physics data analysis.

Keywords:
deep learning, self-attention, attention mechanism, jet tagging, event topology classification,

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B14.05*

Quark Gluon Jet Discrimination with Weakly-Supervised Learning

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Abstract:

Higher collider energy makes more quarks and gluons. It is important to configure which jet is from quark or gluon. Weakly supervised learning work for categories having approximate probability. For jet discrimination, we select Z boson associated jet production and dijet production process having different proportion of quarks jets and gluon jets. We use Recurrent Neural Network(RNN) and Convolutional Neural Network(CNN) and compare results by different jet energy range.

Keywords:

jet discrimination, deep learning, weakly supervised learning, CNN, RNN

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B14.06*

Measurement of top quark polarization in single top t-channel process

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Abstract:
Top quark is one of the elementary particles in Standard Model(SM) which is heaviest and decays before hadronization. Nowadays the precision measurements of characteristics of top quark is important in the particle physics field since its deviations from SM predictions can be probes for the Beyond SM. Especially, the polarization of top quark is expected to be sensitive because of its relation to an interaction which is unknown. Here we present preliminary studies of measuring the polarization of top quark in the t-channel production of single top quarks, which can provide more clear and unambiguous results than top quark pair process. Especially we used an event selection by machine learning method with variables to discard more events from background.

Keywords:
standard model, top quark, single top quark, polarization

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B14.07*

Study for $|V_{ts}|$ measurement

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Abstract:

V_{ts} is element of CKM matrix which describes quark flavour change through the weak interaction and has unitarity in the standard model. Since the branching ratio of top-quark to b-quark is about three order larger than top-qaurk to s-quark, the previous studies of top-quark decays dosen't focus on the decay from top-quark to s-quark but from top-quark to b-quark and use unitarity of the matrix to get $|V_{ts}|^2$. However, in the beyoud standard model scenario, this unitarity may be broken and therefore we should directly measure $|V_{ts}|^2$ to confirm the scenario. In our study, we suggest to directly measure the matrix element $|V_{ts}|^2$ by using the decay from top-quark to s-quark and W-boson and hence, it is important to improve the performance to discriminate s-quark from all other quarks. We present results of testing machine learning algorithms, such as BDT, to improve the s-quark identification.

Keywords:

CKM matrix, Vts, top, s quark, LHC, CMS, particle physics

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B14.08

Search for new physics in final states with boosted W bosons or top quarks using the razor variables at 13 TeV

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Abstract:

A search for supersymmetry in hadronic final states with highly boosted top quarks or W bosons and b jets is presented. The search is performed using proton-proton collision data at a center-of-mass energy of 13 TeV, collected by the CMS experiment at the LHC, corresponding to an integrated luminosity of 35.9 fb^{-1}. Events are analyzed with the razor variables M_R and R^2, which characterize a possible signal as a peak on a smoothly falling background. The observed event yields in the signal regions are found to be consistent with the expected contributions from standard model processes, which are predicted using control samples in the data. The results are interpreted in terms of gluino and top squark pair production.

Keywords:

CMS, SUSY

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B14.09*

Search for Dark Matter using Monojet signature under dark Higgs model

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Abstract:
Searches for dark matter (DM) particles at the Large Hadron Collider (LHC) are a thriving research field after the discovery of the Higgs boson as there is not yet any evidence for non-gravitational interactions between the DM and Standard Model (SM) particles. If such interactions exist, particles of the DM could be produced at the LHC. Since the DM particles themselves do not produce any signal in the detector, one way to observe them is when they are produced in association with a visible SM particle X(=g, q, ɣ, Z, W, or h). Such reactions, which are observed at colliders as particles or jets recoiling against an invisible state, are called mono-X or MET+X, where MET is the missing transverse momentum observable in the detector. Especially, the most sensitive analysis channel to the DM production is the one where a gluon or a quark is emitted as initial state radiation (ISR), known as the mono-jet channel. In this talk, signal studies of the production of the DM at the LHC resulting from the emission of an additional Higgs boson which couples to the DM will be presented and compared to the simplified model. Besides the signal studies, the Compact Framework for Elaborate Algorithms (COFFEA) analysis tools development based on columnar big data techniques will be reported.

Keywords:
dark matter, dark higgs boson, monojet, BSM, CMS, LHC

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B15.01

Formulation of functional soft materials with microfluidics

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Abstract:

This talk will describe the use of microfluidic devices to make very uniform droplets with highly controlled structure, and to use these as templates to create new functional materials. These materials have broad uses in many different applications, ranging from skin care to drug delivery.

Keywords:
Microfluidic device, controlled structure, functional material, skin care, drug delivery

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B15.02

Evaporation and deposition of colloidal fluids

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Abstract:

Colloidal fluids are promising materials for modern printing and coating. Here we demonstrate a versatile method to control evaporation and deposition from colloidal fluids on membranes or micropattern arrays. We show a detailed process for how colloidal fluids turn into deposits through droplet evaporation with X-ray microscopy and tomography. We discuss what mechanisms should be controlled to achieve uniform crack-free deposition of colloidal fluids. Understanding evaporation and deposition will increase a feasibility for high-quality drying-mediated deposits of colloidal fluids.

Keywords:

Collods, Fluids, Micropattern Arrays, Evaporation, Deposition

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B15.03

A nanopipette enables manipulation of nano-matters in fluids

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Abstract:

The ability to print and manipulate nanoscale objects affects diverse fields as materials science, nanotechnology, and biomedicine. Although many scientists and engineers have continually developed clever and high-precision techniques, new methods are still in great demand for different materials and geometries. Here I will present nanopipette-assisted methods for single particle manipulation and 3D printing: 1) scanning-aperture electrostatic tweezers and 2) meniscus-guided 3D printing. First, I will discuss an interesting finding that surface charges of glass nanopipettes can be used to pick and place single charged nanoparticles at will in a fluid. This technique, scanning-aperture electrostatic trap, enables contact-free, size-independent trapping of very small single nanoparticles. The application to fundamental study on plasmonics will also be discussed. Second, I will discuss a meniscus-guided 3D printing method that exploits a mechanically flexible liquid meniscus formed at a pipette-substrate gap to 3D print functional materials at the micro/nanoscale. This technique can be successfully applied to various materials such as polymers, graphene, metals, CNTs, and soft microbubbles.

Keywords:

Nanopipette, single particle manipulation, 3D printing, plasmonics

B15.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Fluidic channel integrated resonators via traditional microfabrication and unconventional fabrication

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Abstract:

Suspended microchannel resonators [1] are one of the most promising microfluidic MEMS devices that measures mass, density, and volume of micro-/nanoparticles and single cells by monitoring change in the resonance frequency. While they offer outstanding performance metrics, fabrication is still extremely complicated thus only a few research groups can make them so far. An efficient and simple fabrication process can be realized by the silicon-on-nothing (SON) [2] process that has previously been used to improve the dielectric barrier strength of miniaturized semiconductor devices and fabricate MEMS devices such as pressure sensors and biological patch clamps. In the first part of talk, a simple and cost-effective fabrication approach that utilizes the SON process to make hollow microfluidic resonators will be presented. For further simplification and researchers who have no or limited access to standard microfabrication facilities housed in a cleanroom, a smart solution employing commercially available capillaries rather than flat wafers will be presented in the second part of talk.

References
[1] T. Burg *et al., Nature*, 446, 1066-1069 (2007).
[2] I. Mizushima, T. Sato, S. Taniguchi and Y. Thunashima, *Appl. Phys. Lett.*, 77(20) 3290-3292 (2000).

Keywords:

MEMS, Microfabrication, SON, hollow microfluidic resonantor

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C1.01

The production of Ξc0 in pp collisions at 13 TeV

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Abstract:

양자색역학(Quantum ChromoDynamics, QCD)는 표준 모형을 기술하는 이론 중 하나로 우주를 이루는 기본 입자를 이해하기 위해서는 QCD의 이해가 필요하다. 표준 모형을 이루는 기본 입자 중 하나인 Charm quark(c)는 약 1.3GeV/c^2의 질량을 가지고 있다. 이 쿼크는 현재까지 발견된 쿼크 중 비교적 큰 질량을 가지고 있다. 기본 입자 충돌에서 c를 포함한 중입자의 생성은 잘 알려져 있지 않다. c는 QCD 척도 변수(~200MeV)보다 큰 값의 질량을 가지고 있어 c로 이루어진 강입자는 횡단 운동량(transverse momentum)이 낮은 영역에서도 섭동 이론으로 계산 가능하다. 따라서 c를 포함한 중입자는 중이온 충돌(heavy ion collision)에서 입자 생성 메커니즘을 이해하는데 아주 중요한 역할을 한다. 또한, c를 포함한 중입자는 쿼크-글루온-플라즈마(quark-gluon plasma, QGP) 내에서 자유도에 대한 이해를 제공한다. 그러므로 중이온 충돌에서 c를 포함한 중입자의 측정은 QGP의 특성을 이해하는데 아주 중요한 역할을 한다.

본 연구에서는 Ξ_c^0가 전자를 포함해 붕괴하는 채널을 이용해 Ξ_c^0의 생성량을 측정하고자 한다. 전자를 포함하는 붕괴 채널을 이용한 분석은 붕괴 확률(branching ratio)가 크고, background가 적다는 장점이 있지만 중성미자를 포함하여 Ξ^-의 질량분포의 꼭지점이 나타나지 않고, 불확정성이 크다는 단점이 있다. 연구 방법은 다음과 같다.

Cut을 가해 전자와 Ξ^-를 구별해 낸 뒤, 전자와 Ξ^-을 결합하여 Right Sign pair과 Wrong Sign pair을 만든다. Right Sign은 Ξ_c^0 붕괴에서 생성되는 입자들의 쌍($e^+\Xi^-$, $e^-\Xi^+$)을 말하고 Wrong Sign은 다른 쌍($e^+\Xi^-$, $e^-\Xi^+$)을 말한다. 이후 Right Sign 에서 Wrong Sign을 빼고 효율을 보정한다. 이를 통하여 실제 Ξ_c^0의 붕괴에서 생성된 실제 쌍의 개수를 알 수 있다. 중성미자는 검출기에 검출되지 않으므로 pair subtraction 분포에서 Ξ_c^0질량의 피크가 발견되지 않는다. 따라서 Unfolding을 통해 Ξ_c^0의 횡단 운동량과 충돌 단면적을 구한다. 마지막으로systematic error를 계산한다. 본 발표에서는 현재까지의 연구 진행 상황을 설명하고자 한다.

Keywords:

QCD, cascade, heavt ion collision

C1.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Status of the measurement of electrons from beauty-hadron decays in pp collisions at $\sqrt{s}$ = 13 TeV in ALICE

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Abstract:

Heavy quarks (charm and beauty), due to their large masses exceeding the QCD parameter, are produced via hard scattering in early stage of heavy-ion collisions, compared to the formation time of the Quark-Gluon Plasma (QGP). Due to their long lifetime, heavy quarks can experience the full evolution of the system created by such collisions. Therefore, heavy quarks are natural probe of the QGP. By separating beauty quarks from charm quarks, the mass dependence of the parton energy loss in the QGP can be studied. Long lifetime of beauty hadrons leads large impact parameter of decay products. Therefore the electrons from beauty-hadron decays are separated from background electrons based on wider impact parameter distribution than the others. In the ALICE experiment the excellent vertex and impact parameter resolution are provided by ITS, and electron identification capability is provided by TPC and TOF. Measurements in pp collisions are essential as a reference to quantify medium effects in heavy ion collisions. In addition, it can be tests for perturbative QCD calculations. We present the current status of the measurement of beauty-decay electrons in pp collisions at $\sqrt{s}$ = 13 TeV in ALICE.

Keywords:

beauty quark, electron, heavy flavour, ALICE, LHC

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C1.03*

Study of the bottomonium production in pp, pPb and PbPb collisions at 5.02 TeV with CMS

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Abstract:

The cross sections and nuclear modification factors for Y(1S), Y(2S) and Y(3S) production have been measured as functions of rapidity (y) and transverse momentum (p$_{T}$) in pp, pPb, and PbPb collisions at 5.02 TeV using the CMS detector. New results on the production of the three upsilon states in pPb are reported and the data show a stronger suppression of the excited states (2S and 3S) as compared to the ground state (1S). The event activity dependence of the forward-backward ratio of all three upsilon states is also reported. The results in PbPb, as a function of centrality, p$_T$ and y, show similar pattern, while the yields of all three states are found to be more significantly suppressed compared to pPb, and also compatible with a sequential ordering of the suppression.

Keywords:

CMS, Heavy Ion, Bottomonium, Quarkonia, Nuclear modification factor, QGP

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C1.04

Measurements of secondary neutrons from the collision of 800 MeV/u Si on C

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Abstract:

Nuclear data for heavy ion reactions are required for many purposes including studies of nuclear structures and reactions and the production of medical isotopes, etc. There is no evaluated nuclear data for heavy-ion reactions while the demand for the heavy ion reaction data is increasing. A heavy-ion facility RAON is under construction in Korea to provide radioactive ion beams. For the development of shielding design for safety, it is important to measure secondary neutrons from heavy-ion reactions and compare the data with the results from Monte Carlo simulations. In the Monte Carlo simulations related to heavy ions, one of the physics models most often used is the quantum molecular dynamics (QMD). For the verification of various physics models, such as QMD, experimental data of heavy-ion reactions are needed. Heavy Ion Medical Accelerator in Chiba (HIMAC), which can deliver heavy ion beams with energies of around a few hundred MeV/u, is used to measure the double differential cross sections and the thick target yield of secondary neutrons from a carbon target bombarded by 800 MeV/u silicon beams. Neutron spectra were measured at 8 different angles (5°, 10°, 15°, 30°, 45°, 60°, 75°, and 90°) by the time-of-flight technique with use of NE-213 liquid organic scintillators. To eliminate the background signals scattered by surrounding structures, iron bars were arranged between the carbon target and each NE-213 neutron detector. The experimental results are compared with Monte Carlo simulation results obtained by the Particle and Heavy Ion Transport code (PHITS).

Keywords:
Time of flight, Nuclear data, Heavy ion reaction, Monte Carlo simulation

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C1.05*

First measurement of transverse single spin asymmetry for very forward π^0 production in polarized p + p collisions at sqrt(s) = 510 GeV

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Abstract:
In polarized p + p collisions, production mechanism of a particle can be deeply studied by transvere single spin asymmetry, TSSA, which is defined as a left-right cross section asymmetry to the beam polarization. With first observation of a large TSSA of π^0 in 1980s, the origin of its finite magnitude has been usually interpreted based on partonic interactions between two nucleons because many experiments have concentrated trying to measure the π^0 in the pseudorapidity (η) range of $3 < \eta < 4$. However, recently more detailed analysis for the event condition in inclusive π^0 has started showing a possible contribution from the diffractive dissociation. RHICf experiment firstly measured the TSSA in very forward ($6 < \eta$) production at STAR experiment in June, 2017. TSSA of very forward π^0 and its correlation with other STAR detectors for the event type dependence study will provide a new input to understand its production mechanism from the view points of diffractive and non-diffractive interactions. We introduce the RHICf experiment and our preliminary result for the inclusive π^0 measurement. Status of the RHICf-STAR combined analysis will also be presented.

Keywords:
RHIC, RHICf, single spin asymmetry, spin, diffractive, very forward

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C1.06

Flow of heavy quarks in Pb+Pb and p+Pb collisions in the CMS experiment

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Abstract:
The asymmetry of the azimuthal angular distribution of particles (flow) in heavy ion collision is known as the decisive evidence of the production of QCD medium. As the integrated luminosity in LHC experiments has dramatically increased, the precision measurement of flow also provided crucial keys to access to the geometry of the initial state of collision in both heavy ion and proton collisions. The discovery of flow in heavy-flavored mesons, such as J/psi and D, was a big surprise because it implies the possibility of unknown physics processes in QCD medium. In this presentation, we will review the flow results of heavy quarks in PbPb collisions at 5 TeV and pPb collisions at 8.16 TeV. Also, novel techniques for flow measurement in the CMS experiment are introduced.

Keywords:
heavy quark, CMS, flow, heavy ion, QGP, PbPb, pPb

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C1.07*

Multiplicity dependence of f0(980) resonance production in pp collisions at 13 TeV with ALICE at the LHC

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Abstract:
Light flavor resonances with short lifetimes are one of main probes to investigate the hadronic phase in the ultra-relativistic heavy-ion collisions, due to their lifetimes comparable to the time span between chemical and kinetic freeze-out. To properly understand the late hadronic phase in heavy-ion collisions, same measurements in pp collisions are essential. In this respect, we present the multiplicity dependence of the production of f0(980) at mid-rapidity in pp collisions at 13 TeV.

Keywords:
ALICE, f0(980), light flavor, resonance, scalar meson

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C1.08

Resonances in hadronic medium in heavy ion collisions

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Abstract:
By investigating the self-energy of resonances we study the modification of the resonance properties in hadronic matter in heavy ion collisions. We first consider the effects on resonances from the hadronic medium made up of pions and nucleons, and then take into account the contribution from nucleon excitations in the hadronic matter. We mostly focus on the dependence of the resonance spectral function on the resonance finite three-momentum, and discuss our results in comparison with previous studies in other approaches.

Keywords:
resonance, hadronic medium, heavy ion collisions

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C1.09

Quarkonium dissociation in perturbative QCD

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Abstract:

For weakly bound quarkonia, we rederive the next-to-leading order cross sections of quarkonium dissociation by partons that include the hard thermal loop (HTL) resummation. Our results calculated with an effective vertex from the Bethe-Salpeter amplitude reduce to those obtained by potential nonrelativistic QCD (pNRQCD) in the relevant kinematical limit, and they can be used in a wide temperature range applicable to heavy quark systems in heavy ion collisions. Based on the lattice computation of the temperature-dependent binding energy, our numerical analysis on Υ(1S) indicates that at high temperature the dominant mechanism for quarkonium dissociation is inelastic parton scattering as expected in the quasifree approximation, while it is the gluo-dissociation at low temperature. By comparing with the momentum diffusion coefficient of a heavy quark, we discuss possible O(g) corrections to the next-to-leading order thermal width.

Keywords:

quarkonium

C2.01

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Metamaterials as next generation materials for applications in electromagnetic-wave absorber and bio-sensor

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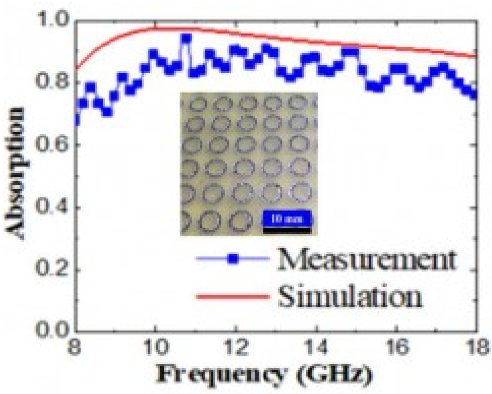
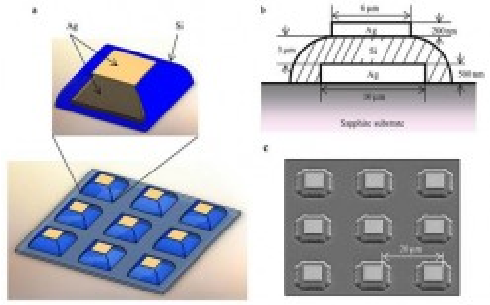
Abstract:

In recent years, perfect absorption phenomenon of electromagnetic (EM) wave using metamaterials (MMs) has been explored vigorously to the realization of future purposes, such as bolometers, thermal images, solar cells, sensors, photodetectors, etc. By the association of perfectly-matched impedance and strong resonance phenomenon the incoming EM wave is completely consumed inside a size far smaller than that of the traditional absorbers. For the rapid growth of telecommunication devices, in particular, we are investigating the ultrathin metamaterial perfect absorber (MPA) models in the VHF and UHF bands (0.1 - 3.0 GHz) [1,2]. By integrating parasitic capacitors and through interconnects in the common model, the next generation of ultrathin and angularly-stable MPAs, which have an extremely-thin thickness (816 times smaller than the operating wavelength, for example), are realized in calculation, simulation and experiment. In addition to the miniaturization of MPA, the extension of absorption bandwidth is being studied by using different approaches. The first one is based on the near-field coupling of resonators and the second one is obtained by doping low-conductivity materials to MPA structure [3,4]. These results are promising for potential actualizations in the radio band, such as radio-frequency shielding devices, single/dual-frequency filters, and single/multi-mode switching devices.





Recently, molecular sensing using MMs is a flourishing research field in expecting the real application. However, in the THz region, sensing by detecting molecular vibrations is still challenging because of low sensitivity, complicated spectral features, and relatively little accumulated knowledge of molecules. Therefore, we investigated advanced meta-structures, which functions as an amplifier for enhancing the vibrational signal of an ultrathin adsorbed layer of large organic molecules at the THz region [5]. We examined bovine serum albumin (BSA) as a prototype large protein molecule and Rhodamine 6G (Rh6G) and 3,3 ′-diethylthiatricarbocyanine iodide (DTTCI) as examples of small molecules. These results were confirmed by both simulation and experiment. This work demonstrated that a THz MM with an appropriate design exhibits a molecular sensing ability similar to that of surface-enhanced spectroscopies at optical frequencies (SERS and SEIRA).

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Keywords:
metamaterials, electromagnetic wave absorption, molecular sensing

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C2.02

Stable and enhanced performance of flexible piezoelectric nanogenerators made of GaN based core-shell nanowires

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Abstract:

The piezoelectric nanogenerator (PNG) is a self powered nanodevice which is sensitive to tiny mechanical energy and converts it to electrical energy. There are numerous other energy harvesters which could be one of the ideal power supply choices. Amongst them, PNGs provide inexhaustible and clean energy that can be used to power up health monitoring devices and various other wearable/portable electronics. Our group is focusing on gallium nitride (GaN) which is one of the prominent piezoelectric semiconducting materials. We extensively studied the application of GaN in piezoelectricity because its wurtzite crystal structure exhibits a larger stain-induced piezoelectric field along polar direction. We have grown c-plane GaN thin films (TFs), polar and non-polar GaN nanowires (NWs), and nanobridges using MOCVD. However, the existence of free carriers even in un-doped GaN degrades the piezoelectric performance by screening the piezoelectric polarization. Initially, GaN TF based flexible PNGs were investigated by studying pn-homojunction and heterojunction to reduced the junction current screening effect due to controlled p-type conductivity. The fabricated PNGs exhibited substantial piezoelectric output but lacked with the high flexibility and sensitivity. These factors limit the application of TF based PGNs in many self-powered electronics where stable output and higher flexibility is needed. In order to fabricate the highly flexible, biocompatible, and sensitive PNG, the MOCVD grown GaN NWs with controlled crystallographic orientations are utilized in PNG fabrication. In principle, single crystal GaN NWs can be grown defect free with controlled density of surface states because of reduced lattice mismatch strain owing to elastic relaxation near the NW surface. The single crystallinity and flexibility of GaN NWs enhance their applicability in self-powered electronics and the confinement of lateral movement of electrons reduces the free carriers screening effect. Based on these advantages, GaN NW based flexible PNGs were fabricated by transferring PDMS embedded GaN NWs from c-plane GaN TF to flexible PET substrates using doctor blading technique. Initially, three PNGs were fabricated by utilizing the pristine c-axis GaN NWs with variable length of 4.5 μm, 9.4 μm, and 14.5 μm. The PNG with longer NWs exhibited maximum piezoelectric output voltage and current of 20.8 V and 253 nA, respectively, and was found stable after testing for more than 20,000 cycles. In order to further enhance the piezoelectric performance, GaN/V_2O_5 core-shell NWs of controlled crystallographic orientations were utilized in PNG fabrication. Catalyst-assisted c- and m-axis GaN NWs were grown on c-plane GaN thin film using MOCVD regardless of the catalyst size and choice of substrate. The V_2O_5 with controlled resistivity was conformally deposited on the reported NWs using RF magnetron sputter to suppress the internal screening effect. The flexible PNGs were then fabricated by sequentially transferring the NWs to flexible PET substrates. All the PNGs were found stable after 36,000 cycles at 10 Hz, however the maximum output voltage (27 V) and current (850 nA) were exhibited by the PNG based on c-axis GaN/V_2O_5 core-shell NWs. The V_2O_5 shell with controlled resistivity overall enhanced the piezoelectric performance but still the suppression of junction current screening effect and reduction in leakage current were not up to the level to measure static signal. We further investigated the GaN/Al_2O_3 core-shell NW structure by sequentially depositing Al_2O_3 with variable shell thickness of 4 nm, 6 nm, and 8 nm on GaN NWs. The GaN/Al_2O_3 core-shell NWs were then utilized to fabricate flexible PNGs. The conformally deposited Al_2O_3 with variable thickens on GaN NWs acts as carrier blocking layer and suppresses the junction current screening effect. The maximum piezoelectric performance (30 V) is exhibited by the PNG based on Al_2O_3 shell with thickness of 6 nm under compressive stress normal to the top surface of PNG. The increase in thickness of insulator reduces the piezoelectric performance due to reduce capacitance of the PNG which is inversely proportional to the insulator thickness. The insulator having thickness of 4 nm further reduces the piezoelectric performance due to direct tunneling current of metal-insulator-semiconductor (MIS) structure. The capacitive behavior of MIS interface owing to the remnant piezopotential enables PNGs to measure static signal under compressive strain.

Acknowledgement
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Keywords: GaN, nanowire, piezoelectric, generator

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C2.03

Synthesis of graphene nanocomposites by plasma-enhanced electrochemical exfoliation method for energy storage application

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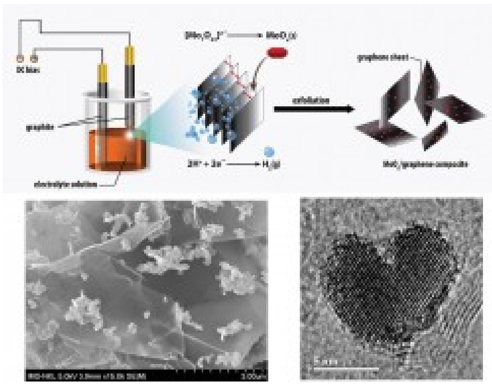
Abstract:

The preperation of graphene nanocomposites generally conducted by using oxidative percursor and graphite oxide solution via reduction-oxidation process at high temperature, high pressure, vacuum condition and requiring harmful chemicals. In this study, we report a simple, scalable, low-cost and eco-friendly methodology to produce graphene hybridized with transition metal dichalcogenides (TMDC) such as MoS_2, MoO_2 and MnO_2 by plasma-enhanced electrochemical exfoliation process (PE^3P) from high purity graphite rod in various electrolyte solutions. The obtained composites was characterized with scanning electron microscopy, X-ray diffraction, Raman spectroscopy and was tested electrochemically with cyclic voltammetry, galvanostatic charge-discharge, electrochemical impedance spectroscopy. The results revealed the layer-by-layer structure of graphene with TMDC nanoparticles decorated on the sheet surface. Thanks to synergy effect, the specific capacitance of MnO_2/graphene composite was calculated to be 706.91 F/g (at scan rate of 5 mV/s). We believe that our composite could be a promising candidate for supercapacitor application.



Keywords:
energy storage, graphene nanocomposite, plasma-enhanced electrochemical efoliation

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C2.04

Nonlinear Optical Properties of Two Dimensional Transition Metal Dichacolgenides

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Abstract:

Over the last few decades, the silicon-based technology has dominated in the industrial electronics market. However, in the recent decades ago, the advent of graphene, the first true two dimensional (2D) materials, marked a historic point for potentially new-generation of electronics. Not long after that, the successive discoveries of different 2D materials including an insulator (hexagonal Boron Nitride), semiconductors (transition metal dichalcogenides, TMDCs), and metallic (graphene) provide a great chance to achieve extremely thin and light optoelectronic devices. In order to achieve the high performance optoelectronic, yielding 2D materials with remarkable quality is highly desirable. The essence of this work lies in growth technique that produces high quality 2D materials applicable to new-generation of 2D optoelectronic devices.

In this presentation, I will briefly introduce layer-dependent physical and structural properties monolayer TMDCs as well as the current synthesis approaches for growing large-scale, highly optical quality monolayer TMDCs. An additional part of this presentation will discuss the nonlinear optical characteristic of monolayer TMDCs towards design a broad and strong second harmonic susceptibility $\chi^{(2)}$ materials. Nonlinear properties theory will be mainly discussed in term of second harmonic generation. In particular, nonlinear characteristics of typical members of monolayer TMDCs, MoS_2 and MoSe2 onto SiO2/Si substrate, was investigated using both intensity dependent SHG and wavelength dependent SHG techniques. The results suggested its potential use of high-powered second-order NLO devices. As a necessary step to the quest of high NLO material, the resonant second harmonic generation characteristics were analyzed in ternary monolayer alloy $MoS2_{(1-x)}Se_{2x}$, showing a feasibility to apply them into tunable second-order NLO devices. Finally, our preliminary but interesting results on artificially stacked monolayers TMDCs for next-generation of 2D optoelectronic devices will be presented.

Keywords:

transition metal dichalcogenides; monolayer, nonlinear optical properities

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Diffusion of metal atoms in perovskite materials

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Abstract:

Perovskite complex metal oxides have been extensively studied and used in many applications due to their stability as well as their peculiar properties such as electric and magnetic susceptibility, ferroelectric or ferromagnetic order, super-conductivity. $BaTiO_3$ and $PbTiO_3$ are typical ferroelectric perovskite oxides with a large polarization of around 1 C/m2 at room temperature. It is known that the vacancy of oxygen atoms is more common than that of metal atoms due to the high vacancy energy and diffusion barrier of metal atoms compared to oxygen atoms. The diffusion barrier through the formation of vacancy is an important physical property for some applications such as solid-state electrolyte for Li ion battery. Perovskite metal oxides are not good candidates for Li ion battery since oxygen atoms diffuse easily not metal atoms. Recently it was noticed that the antiperovskite structure could be stabilized in some combinations of atoms. One good example is Li_3OCl and Na_3OCl. Even though these materials are not stable in contact with water, it is stable under phonon vibration. Since these materi- als have Li and Na, they can be good candidates for Li or Na ion batteries. In this presentation, I am going to show our theoretical study on the anti-perovskite materials focusing on the stability of Na_3OCl under the tilting of Na_6O octahedra.

Keywords:

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C3.01*

Bioinspired Diffractive Optics: Fabrications and Applications

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Abstract:
자연은 빛을 사용하기 위하여 독특한 광학적 구조를 사용한다. 대체로 다중 계층 구조로 이루어져 있는데, 다중 계층 구조의 단위 격자에서 일어나는 회절현상에 의해서 들어오는 특정 파장의 빛을 특정각도에서 보강간섭을 일으켜서 특정 각도에서 특정한 색을 나타낸다. 이러한 구조를 통하여 나오는 색을 우리는 구조색 이라고 한다. 자연은 이러한 구조색을 가지고 꽃가루 매개자에게 신호를 보내기도 하고, 푸른고리문어 처럼 구조색을 통하여 적에게 경고를 보내기도한다. 자연은 다중 계층 구조의 요철 구조의 주기 혹은 결정구조 등을 복잡하게 다양화하여 이러한 구조색을 다양화 시킨다. 그래서, 이러한 구조색을 인위적으로 만들고, 조절 하기 위한 인간들의 노력은 자연의 구조색을 이해하고 응용하는데 있어서 중요하다.
이 발표에서는 아조고분자 (Azo-polymer)의 편광 의존성에 의한 요철 구조 형성을 통하여 구조색을 다양화 하는 방법을 소개 하고자 한다. 다중 계층 구조 제어의 결과 (곡면체에 기록된 1차원 격자, 2차원격자, 준결정 격자 구조)로 나오는 구조색 제어 및 회절 무늬 패턴의 다양화 전략에 대하여 논의하며, 이 방법이 다른 구조색 제어 방식에 비하여 좋은 점에 대하여 논의할 것이다.

Keywords:
Bio-inspired, Hierarchical structure, Structural colorization, Surface Relief Gratings

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C3.02*

Surface treatment에 따른 ultra-thin Si 이용 GIS (Graphene-Insulator-Semiconductor) 구조의 고성능 광 검출 소자 디자인

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Abstract:

그래핀과 실리콘의 이종 접합을 이용한 Schottky 광 다이오드는 누설 전류가 적어 on/off ratio가 크다는 장점을 가지고 있다. 이러한 이종 접합 구조 내에서 누설 전류를 줄여 on/off ratio를 향상시키는 역할을 하는 것이 실리콘 상의 계면에 존재하는 절연 층이다. 이 절연층은 추가적으로 실리콘 내에 depletion 영역을 형성하는 역할도 수행한다.
앞서 시행된 연구들에서는 실리콘 상의 native oxide를 그대로 이용하는 방법을 채택했다. 그러나 이는, Fermi level이 가변적인 그래핀을 통해 Schottky barrier height를 조절할 수 있다는 GIS 구조의 장점을 충분히 활용하지 못하게 한다. 이러한 한계를 극복하기 위해 본 연구에서는, 실리콘의 surface treatment를 통해 insulator 층을 최적화하고자 했다. 실리콘 표면에 passivation 처리를 다양한 온도 조건에서 수행하며 향상되는 성능을 확인하고 소자 특성에 미치는 영향을 탐구했다. 결과적으로 GIS 구조의 광 검출 소자를 majority carrier 동작 소자로서 활용할 수 있도록 디자인했다. 이를 통해 신호 증폭 효과에 획기적인 변화를 꾀하고 양자 효율을 향상시킬 수 있다. 실리콘 층의 경우 SOI wafer를 이용해 depletion width 미만의 ultra-thin Si를 적용했다. 이 결과 높은 광 반응성과 함께 빠른 응답 속도를 겸비한 소자 디자인을 소개할 것이다.

Keywords:

GIS, graphene, silicon, heterojunction, Schottky barrier, interface, majority carrier

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C3.04*

White Phosphor UV-LEDs using ZnO and ZnO-Graphene Oxide Quantum dots

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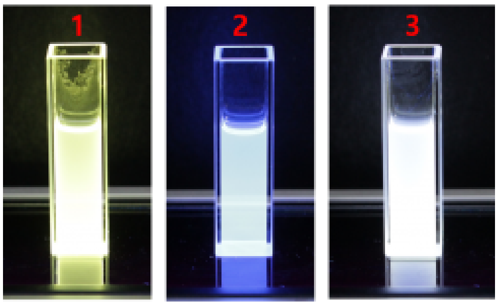
Abstract:

As a broad-bandgap semiconductor, Zinc oxide (ZnO) has a large bandgap (~ 3.44 eV) and an exciton binding energy of 60 meV at room temperature (RT), which is larger than GaN (26 meV) or ZnSe (25 meV). Also, ZnO has several favorable properties, such as high electron mobility, good transparency, and strong room-temperature (RT) luminescence. Optcal emissions related to intrinsic defects in ZnO have been long controvertial in the research society. In the photoluminescence (PL) spectra, ZnO has emission bandgaps in the ultraviolet (UV) and visible (red, yellow, green, blue and violet) regions. The UV emission regions usually have relevance to direct bandgap of ZnO. But, the visible emission regions are usually linked closely to defects located within bandgap of ZnO ; Zn_i, V_O, V_{Zn} and so on.[1]



It has been revealed that ZnO-nanocarbon hybrid nanoparticles could effectively vary band-to-band transition into blue emission by charge transfer from conduction band of ZnO to the attached graphene[2] . Herein, we report on the synthesis of ultra-small size quasi consolidated ZnO-graphene nanoparticles. This nanoparticle has dominantly defect states at 3.02, 2.58, 2.67 and 2.51 eV. By conjugating the graphene, we could perfectly convert the green (2.2 eV) and red emission (1.83 eV) path related to the defects of oxygen vacancy (V_O) of ZnO into violet-purple-blue emission. Also, we perfectrly explain the mechanism about the electronic transition in both ZnO and ZnO-graphene nanoparticles by measuring the time-resolved photoluminescence (TR-PL). Based on this ZnO-graphene QDs, we successfully fabricate the white phosphor UV-LED.

[1] B. H. Zeng et al., Blue Luminescence of ZnO Nanoparticles Based on Non-Equilibrium Processes: Defect Origins and Emission Controls, *Adv. Funct. Mater.*, 20 (2010) 561-572.
[2] D.I. Son et al, Emissive ZnO-graphene quantum dots for white-light-emitting diodes, Nat. nanotechnol. 7 (2012) 465-472.

Keywords:
ZnO, defects state, Zinc vacancy, Oxygen vacancy, ZnO-graphene, white phosphor UV-LED

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C3.05*

Plasmonic Nanoparticle-on-Mirror Cavity Mode Control by Using Roundest Au Colloids

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Abstract:
최근 플라즈모닉 캐비티 분야에서는 금속나노입자를 금박막 위에 올려 비교적 간단한 방법으로 고성능의 캐비티를 구현해 낼 수 있는 Nanoparticle-on-Mirror (이하 NPoM) 캐비티 구조에 대한 연구가 활발하게 진행되고 있다. 최근 수년간 나노입자 합성법의 비약적인 발전으로 인하여 매우 균일하고 둥근 형태의 금나노입자를 얻을 수 있게 되었음에도 불구하고 최근 개발된 매우 둥근 입자를 가지고 NPoM 캐비티 시스템에 대해서는 연구된 바가 없다. 이에 따라 본 연구진은 최신 합성법으로 합성된 매우 둥글고 균일한 입자를 이용하여 NPoM 캐비티 구조를 제작하였고 이를 통해 극한으로 작은 크기(수~수십 nm^3)의 나노 캐비티를 구현하고자 하였다. 뿐만 아니라, 기존의 합성법으로 합성된 울퉁불퉁한 면을 지닌 금나노 입자를 이용하여 둥근 입자와 동일하게 NPoM 캐비티 시스템을 구현하였고 각각의 나노 캐비티에서 발생하는 플라즈모닉 모드의 차이를 정량적으로 비교 분석하여 나노입자와 금박막사이의 모폴로지의 결정적 차이점을 밝혀내었다.

Keywords:
플라즈모닉스, nanoparticle-on-mirror cavity, antenna mode

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C4.01

Self-selective van der Waals heterostructure for terabit-scale memory integration and neuromorphic applications

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Abstract:

The large-scale crossbar array is a promising architecture for hardware-amenable energy efficient three-dimensional (3D) memory and neuromorphic computing systems. While accessing a memory cell with negligible sneak currents remains a fundamental issue in the crossbar array architecture, up-to-date memory cells for large-scale integration suffer from process and device integration (one selector one resistor, 1S1R) or destructive read operation (complementary resistive switching). To overcome such issues, we introduce a self-selective memory cell (without any need for additional devices like transistors or selectors) based on two-dimensional (2D) hexagonal boron nitride (h-BN) and graphene in a vertical heterostructure of h-BN/graphene/h-BN. Combining volatile silver (Ag) filaments and non-volatile boron vacancies in the two h-BN layers, we demonstrate a self-selectivity of 10^10 with an on/off resistance ratio larger than 10^3 and an operation time constant of tens of nanoseconds in the heterostructure. The graphene layer efficiently blocks the diffusion of volatile Ag filaments to integrate the volatile and non-volatile memories in a novel way, which makes our self-selective cell distinguished from former memory devices, shedding light on the role of stable 2D materials for highly selective memory in crossbar array. Our self-selective memory minimizes sneak currents on large-scale memory operation, thereby achieving a practical readout margin for terabit-scale and energy-efficient memory integration.
Moreover, I will introduce 2D MoS2-based devices for short-term plasticity and neuromorphic applications.

Keywords:

2D heterostructure, sneak current, neuromorphic applications, MoS2, short-term plasticity

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C4.02

Shedding Light on Atomically Thin Materials

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Abstract:

Atomically thin crystals have been studied because of their unique physical properties and possible applications in electronic and optical devices. Light scattering techniques, such as Raman and photoluminescence spectroscopy, have become essential tools to characterize atomically thin crystals. By careful investigation of such spectra, we can further elucidate the intrinsic physical properties of crystals. In this presentation, I will discuss the development of optical methods to extract physical properties of few-atom-thick materials, which are difficult to measure via other techniques. First, low-frequency polarized Raman spectroscopy can be used to determine almost all the mechanical constants of layered materials. The coupling between in-plane uniaxial strain and interlayer sliding is observed, and the unexplored off-diagonal components of the elasticity tensor for MoS_2 can be obtained. Secondly, the magnetic ordering in atomically thin crystals is studied by temperature dependent Raman spectroscopy. Antiferromagnetic ordering in the atomically thin limit is challenging to measure because of the inherently small net magnetic moment. Due to the change of some Raman modes resulting from the antiferromagnetic ordering, magnetic phase transition in metal phosphorus trisulfide is studied down to the monolayer limit. Finally, a tunable photoluminescence imaging system has been developed and applied to investigate large-area, atomically thin materials synthesized via metal-organic chemical vapor deposition. Photoluminescence and absorption images of samples can be obtained from the micron- to wafer-scale with short acquisition times under wide-field illumination.

Keywords:

Atomically thin materials, Raman spectroscopy, Photoluminescence

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C4.03

Soft Graphene Meta-Devices

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Abstract:

본 강연에서는 그래핀을 이용한 메타광학 소자의 원리 및 구현에 대해서 소개하고자 한다. 메타광학을 통해 빛과 물질 사이의 상호작용을 비자연적으로 극대화할 수 있다. 특히 비자연적 고굴절 메타물질의 경우, 메타원자내 유도된 강한 전기적 쌍극자들끼리의 커플링을 통해 유전율을 극대화하여 빛과 물질 사이의 상호작용을 극대화할 수 있다. 이러한 메타물질에 그래핀을 집적하게 될 경우, 전기적 신호를 통해 그래핀의 전도도를 조절할 수 있고 이에 따라 메타원자내 유도된 전기적 쌍극자의 커플링을 조절하여 메타광학 특성을 변조할 수 있는 소자가 된다. 이를 메타소자라 한다. 더불어 원자층의 얇은 두께 때문에 상대적으로 약할 수 밖에 없는 그래핀-물질간 상호작용 정도도 비자연적으로 증강될 수 있다.

이러한 그래핀 메타광학 소자의 물리적 원리, 소자의 응용 가능성을 소개하고, 테라헤르츠 대역 부터 광대역에서 작동할 수 있는 그래핀 메타광학 소자 제작을 위한 소프트 공정에 대해서 토론하고자 한다. 특히 콜로이드/DNA/고무와 같은 소프트 물질을 이용한 그래핀 메타광학 소자 구현 및 그 가능성에 대해 소개될 예정이다.

Keywords:
그래핀, 메타물질, 소프트 물질, 광 변조기

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C5.01

Ultra-high-Q resonators and low loss waveguides on a chip: from the near-IR to the mid-IR

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Abstract:

Ultra-high-Q optical resonators have played an important role over a wide range of research fields including nonlinear optics, cavity optomechanics, quantum information, and optical telecommunications. Recently, it has been demonstrated that these essential components can be implemented on a chip in different forms based on semiconductor fabrication technology. We also demonstrated wedge disk resonators of around 900 million Q on a silicon chip and successfully performed initial works with the resonators to develop narrow linewidth lasers, reference cavities for frequency stabilization, micro-comb, and stable microwave synthesis. In this talk, these previous works and future research directions on ultra-high-Q resonators and their application will be presented and discussed including works on low-loss waveguides on a silicon chip. In addition, the current efforts will be introduced, to extend the operation wavelength of the on-chip ultra-high-Q resonators and low loss waveguides from the near-IR to the mid-IR based on the hybrid material system to apply the well-matured micro-fabrication technique to untamed materials of good optical properties in the mid-IR.

Keywords:

Ultra-high-Q resonators, on-chip, the mid-IR, nonlinear optics

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Cooling Semiconductors via Radiative Heat Transfer

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Abstract:
We design and fabricate ultrathin (a thickness < 500 nm), visibly transparent (transmittance of > 0.9) radiative coolers in which a high emissivity is achieved over an entire range of mid-infrared wavelengths (8 - 25 μm). With the incorporation of fabricated radiative coolers into Si substrates, we observe a temperature drop of approximately under daytime light.

Keywords:
radiative heat transfer, passive cooling, thermal infrared radiation

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포토닉구조 기반 발색형 플렉서블 수동 복사 냉각

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Abstract:

에너지 절감에 대한 수요가 급증하면서, 차세대 고효율 냉각기관에 대한 연구가 활발히 이루어지는 가운데 최근에는 열복사(heat radiation)를 제어하여 냉각 특성을 보이는 연구가 보고되고 있다. 수동 복사 냉각 (passive radiative cooling)이라 불리는 열복사 제어 기술은 광대역 태양광 반사 및 선택적 적외선 방사를 통해 시료의 온도를 주변보다 낮출 수 있는 기술이며, 외부 전력의 공급이 필요 없기 때문에 대류를 기반으로 하는 냉각기술보다 친환경적이다. 본 보고에서는 태양광 전대역 및 장적외선 대역을 동시에 고려한 광구조를 고안하여 수동 복사 냉각을 시연하였으며, 색상구현이 가능함과 동시에 냉각이 이루어지도록 하는 에스테틱형(aesthetic) 복사 냉각 기술을 보인다. 또한 플렉서블 동작이 가능하도록 하는 공정방법 및 측정결과에 대해서도 소개한다.

그림 1. 발색형 플렉서블 수동 복사 냉각 구조에 대한 도식화 그림

Keywords:
복사 냉각(radiative cooling), 포토닉구조(photonic structure)

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C5.04

Recent Advances in Mid-Infrared Graphene Plasmonics: Metasurface for Complex Amplitude Modulation and Compact Waveguide Switch

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Abstract:
Tunable plasmonic modes offered by graphene provide new opportunities to create electo-optically active devices with novel characteristics that have thus far been impossible to be realized by using conventional media. Here we introduce two recent theoretical research results in mid-IR graphene plasmonics: (1) Dynamic complex amplitude modulation in graphene-based metasurfaces and (2) modulated resonant transmission of graphene plasmons across a deep-subwavelength plasmonic waveguide gap.

Keywords:
Plasmonics, Graphene, Metasurface, Active Photonics

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C5.05

Mid-infrared plasmon resonance in periodic modulations

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Abstract:

The demand for compact, cost-effective, integrated mid-infrared optical devices is increasing for the development of high-performance portable optical devices including sensor platforms in health and environmental monitoring, high-speed free-space optical communications, and remote detection in earth and space technologies. The localized surface plasmon resonance in artificial nanomaterials using the periodic modulations in the geometry or the dielectric constants allow us to develop new optical devices in the mid-infrared wavelength regime with extremely small size compared to the wavelength. In this talk, I will discuss the localized surface plasmon resonance in the low-dimensional materials with periodic modulations and the rational design of the deep subwavelength nanophotonic systems operating in the mid-infrared wavelength regime.

Keywords:

mid-infrared, localized surface plasmon resonance

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C6.01

Using Optical Pulses for Quantum Control and Sensing

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Abstract:

Nitrogen-vacancy (NV) centers in diamond represent a forefront platform for secure quantum networks and high-precision sensing. In this talk, I will discuss novel techniques using controlled optical excitation to implement high-speed quantum control and high resolution quantum sensing. Going beyond conventional microwave control of NV center spins, we utilize resonant and near-resonant optical transitions to achieve robust single-qubit operations. We leverage three-level energy structures in the NV spin-orbit optical manifold for holonomic quantum gates and 'superadiabatic' state transfer. Finally, I will introduce a new synchronized optical pulse sequence for using the NV center to probe the transport properties of low-dimensional materials. Optical control improves sensitivity and provides high spatiotemporal resolution. These methods are broadly generalizable to other quantum and material systems and highlight the potential of spin-light interactions for emerging applications.

Keywords:

Diamond NV center, spin-light interaction

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C6.02

Nanoscale magnetic resonance detection towards nano MRI

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Abstract:

Magnetic resonance imaging (MRI) with its ability to provide three dimensional, elementally selective imaging has had a revolutionary impact in research fields including medicine and the neurosciences. In the sense that its extension to the nanometer scale could provide a powerful tool for non-destructively visualizing the three dimensional morphology of nanoscale structures, another impact is naturally expected with the development of nano MRI. Recently, negatively charged nitrogen-vacancy (NV) color centers in diamond have been proposed as a promising system for nanoscale magnetic field sensing. NV centers are atomic-sized point defects and can be brought to within a few nanometers of magnetic samples, allowing for nanometric spatial resolution. Over the past few years, these properties have led to rapid progress in developing NV-based magnetometers and magnetic resonance spectroscopy. Here, we introduce some of recent demonstrations of proton magnetic resonance imaging using a NV spin sensor and discuss its limitations and research directions to overcome them.

Keywords:

Diamond NV center, nano MRI

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C6.03

Towards measurement induced quantum state engineering

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Abstract:
Quantum theory predicts that a quantum system will collapse from superposition of several possible states, to just one, in the moment it is measured. As quantum systems are never isolated from their surrounding environment (quantum bath), its measurement and the associated collapse should also affect the environment coupled to it. The affected spin bath will then effect the trajectory of the quantum system. We demonstrate the role of measurement back-action of a coherent spin environment on the dynamics of a spin (qubit) coupled to it, by inducing non-classical (Quantum Random Walk like) statistics on its measurement trajectory. We show how the long-life time of the spin-bath allows it to correlate measurements of the qubit over many repetitions. We have used Nitrogen Vacancy centers in diamond as a model system, and the projective single-shot readout of the electron spin at low temperatures to simulate these effects. We show that the proposed theoretical model, explains the experimentally observed statistics and their application for quantum state engineering of spin ensembles towards desired states.

Keywords:
Diamond NV center, quantum state engineering

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C6.04

Quantum control of a single-spin quantum emitter in diamond via coupling with a mechanical oscillator

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Abstract:

There has been rapidly growing interest in hybrid quantum devices involving a solid-state spin and a macroscopic mechanical oscillator. Such hybrid devices create exciting opportunities to mediate interactions between disparate qubits and to explore the quantum regime of macroscopic mechanical objects. In particular, a system consisting of the nitrogen-vacancy defect center in diamond embedded inside a high quality factor diamond mechanical oscillator is an appealing candidate for such a hybrid quantum device, as it combines the highly coherent and versatile spin properties of the defect center with the excellent mechanical properties of diamond resonators.

In this talk, we will present recent experimental progress on diamond-based hybrid quantum devices in which the defect's spin and orbital dynamics are mechanically driven by the motion of a mechanical oscillator. We will discuss the potential usage of multiple mechanical modes to fully engineer the strain environment of the defect center. For instance, simultaneous motion of flexural and torsional modes in T-shaped diamond cantilever can provide selective controls of linear and shear strain terms. We will also discuss future prospective applications, including strain-assisted indistinguishable photon generation, long range, phonon-mediated spin-spin interactions and phonon cooling and lasing in the quantum regime.

Keywords:

Diamond NV center, strain control, mechanical oscillator

C7.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Non-symmorphic Dirac semimetallic state in layered iridates

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Abstract:

Whereas Dirac carrier responses have been extensively investigated in weakly-correlated-systems, it is rare to observe the Dirac physics in strongly-correlated-materials. Here, we provide experimental and theoretical evidences of an emergence of a Dirac dispersion in doped spin-orbit-coupled Mott insulator Sr_2IrO_4 which exhibits a semi-metallic and paramagnetic ground state. From the symmetry analyses, we find that the multiple crystal symmetries including nonsymmorphic symmetry play a pivotal role in the development of the Dirac dispersion, and furthermore, an intrinsic d-wave gap order collapses the line-nodal Dirac dispersion into the point-nodal dispersion. Linear dispersion of the energy band near the Fermi level is confirmed by angle-resolved photoemission spectroscopy, and the Dirac carrier responses are further manifested by an extremely low-scattering rate (~6 cm^{-1}) of free carriers.

Keywords:

Sr2IrO4, Dirac semimetal, correlation effect

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C7.02

Magnetic field induced topological phases in pyrochlore iridates near a quantum critical point

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Abstract:

I am going to talk about unusual magneto-transport properties of pyrochlore iridate bulk systems near the magnetic quantum critical point (QCP). Considering the generic topological band structure near QCP in the presence of magnetic field, we will show that the competition between different energy scales can generate various topological semimetal phases near the QCP. Here the central role is played by the presence of a quadratic band crossing (QBC) with fourfold degeneracy in the paramagnetic band structure. Due to the large band degeneracy and strong spin-orbit coupling, the degenerate states at QBC can show an anisotropic Zeeman effect as well as the conventional isotropic Zeeman effect. Through the competition between three different magnetic energy scales including the exchange energy between Ir electrons and two Zeeman energies, various topological semimetals can be generated near QCP. Moreover, we have shown that these three magnetic energy scales can be controlled by modulating the magnetic multipole moment (MMM) of the cluster of spins in a unit cell, which can couple to the intrinsic MMM of the degenerate states at QBC. We propose the general topological band structure under magnetic field achievable near QCP, which would facilitate the experimental discovery of novel topological semimetal states in pyrochlore iridates

Keywords:

Pyrochlore iridates, Magnetic quantum critical point, Weyl semimetal, Quadratic band crossing

C7.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Strain-induced cubic symmetry breaking and large anomalous Hall effect in $Nd_2Ir_2O_7$ thin film

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Abstract:

Pyrochlore iridates $R_2Ir_2O_7$ (with R=rare earth element) have been predicted to exhibit many fascinating topologically non-trivial states [1]. Due to the large spin orbit coupling and comparably large electron-correlations, it will be the fertile playground for correlated topological phase. The bulk pyrochlore iridates are predicted to have Weyl semimetal state which possesses topologically protected bulk and surface state at the Fermi surface [2]. In addition, theoretical studies revealed the emergence of a new topological phase of which are hidden in the bulk and manifest only in thin films [3-5]. In spite of these exotic phenomena, not many experimental studies are done on these compounds due to extreme difficulty of synthesis. The multi-phase boundary of iridium presents a key difficulty in the growth of such thin film samples.

Here, we report a high quality $Nd_2Ir_2O_7$ thin film grown on Yttrium stabilized ZrO_2 (YSZ) substrates by pulsed laser deposition, using a special *in-situ* growth technique called repeated rapid pulse annealing epitaxy. Our epitaxial $Nd_2Ir_2O_7$ thin film is fully strained by YSZ substrate, which applies ~1% compressive strain. A large anomalous Hall effect signal was observed in $Nd_2Ir_2O_7$ thin film. We speculate the cubic symmetry-broken lattice of $Nd_2Ir_2O_7$ is the origin of anomalous Hall effect which would not be seen in its cubic bulk phase. Our finding highlights the symmetry-broken lattice of pyrochlore iridate as a means of exploring topological phase such as Weyl semimetal.

Reference

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[3] B.-J. Yang *et al., Phys. Rev. Lett.* (2014).
[4] K. Hwang and Y. B. Kim, *Scientific Reports* (2016)
[5] P. Laurell and G. A. Fiete, *Phys. Rev. Lett.* (2018).

Keywords:
correlated topological phases, anomalous Hall effect, pyrochlore iridate thin film, magneto-transport

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C7.04*

Symmetry Protected Magnetic Weyl Nodal Loop in Cubic Double Perovskite Osmates

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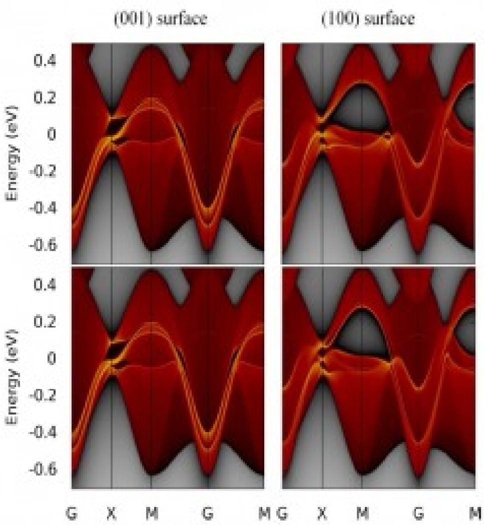
Abstract:

In condensed matter physics, effects of spin-orbit coupling (SOC) are one of the vital ingredients to understand the electronic and magnetic properties. In particular, SOC as well as symmetries play an important role in topological physics. For example, in the systems with both inversion (IS) and time-reversal symmetries (TRS), four-fold linear crossing bands are gapped and inverted by SOC, leading to topological insulators. Furthermore, additional crystalline symmetries, such as rotation, mirror and non-symmorphic symmetries, can yield four-fold Dirac points (DPs) or two-fold Weyl points (WPs) even for inclusion of SOC. Systems having these DPs or WPs show various abnormal transport properties like ultra-high mobility, extreme large magnetoresistance, and chiral anomaly.

Using first principles approach, we have investigated topological properties in the cubic double perovskite osmates. Interplays among various symmetries, a strong SOC, and a moderate correlation strength in the 5d systems lead to topologically nontrivial phases. In the absence of SOC, the nonmagnetic phase shows four-fold degenerate points at W and around K points, resulting in Dirac nodal lines (DNLs) on the mirror planes. When breaking TRS, DNLs convert into two Weyl nodal lines (WNLs). Considering SOC along the [001] direction, the magnetic WNLs are survived only on the $k_z = 0$ and π planes. These are robust even for inclusion of correlation effects, since the WNLs are protected by the mirror symmetry(M_z) with mirror eigenvalues of $\pm i$. In this presentation, we will address the mechanisms of these topological characters in these osmates in detail.



Acknowledgements: This research was supported by NRF-2016R1A2B4009579.

Keywords:

Topological phase, osmates, spin-orbit coupling, first principles

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C7.05

Systematic electronic structural studies on $Ca_{2-x}Sr_xRuO_4$

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Abstract:

$Ca_{2-x}Sr_xRuO_4$ displays not only one of the most drastic metal-insulator transitions but also many novel electronic and magnetic phases, ranging from p-wave superconductivity (x=2.0) to Mott insulating state (x=0). Especially, various studies have shown that there are plenty of exotic phases near the Mott transition (0<x<0.5). In spite of the importance of the system, there is severe lack of the electronic structure information to address the important physics issues. Here, we present our systematic electronic structure studies on $Ca_{2-x}Sr_xRuO_4$ to reveal how their electronic structures evolve as a function of Sr doping rate. We believe that our results will provide valuable information to understand complex issues in $Ca_{2-x}Sr_xRuO_4$.

Keywords:

ARPES, metal-insulator transition, CSRO

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C7.06*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

RIXS study of *dd*-excitations in Ca_2RuO_4

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Abstract:

Many aspects of magnetism can be approximated by a conventional description at the macroscopic level, despite of their origins rooted in quantum mechanics. However, in recent years there has been growing interest in material systems whose magnetic phenomenon doesn’t have any classical analogue, directly manifesting its quantum mechanical origin. For example, the *excitonic magnetism*[1] of Ca_2RuO_4 turns out to carry an amplitude fluctuation (*i.e.*Higgs mode) of soft moments [2]. This soft moment is based on the details of Ru-ion’s multiplet structure which involves a variety of quantum mechanical interactions. For the better understanding of its exotic magnetism, it is highly demanded to investigate different coupling parameters consistently.

This problem can be nicely accessed by the resonant inelastic X-ray scattering (RIXS) which settles down as one of the most powerful experimental tools nowadays, because its spectra involve optically forbidden *dd*-excitations necessary at unveiling local multiplet structure of a system.

This talk mainly provides an introduction to RIXS and intriguing magnetism of Ca2RuO4. We will also briefly discuss recent experimental data and how we extracted out the coupling parameters governing the magnetism. Similar interpretations can be applied to different systems which ion has four *d*-electrons in its valence shell.

[1] Giniyat Khaliullin, Phys. Rev. Lett. **111**,197201 (2013).
[2] A. Jain, et. al., Nature Physics **13**, 633-637 (2017).

Keywords:

Magnetism, Resonant Inelastic X-ray Scattering, dd-exciations

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C8.01*

Giant ferroelectric polarization in $(Pb_2O_3)_{0.5}(PbTiO_3)_{0.5}$ alloy

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Abstract:
Using first-principles density functional theory calculations, we designed a highly stable and novel checkerboard-type $(Pb_2O_3)_{0.5}(PbTiO_3)_{0.5}$ alloy with an alternating ordering of Pb_2O_3 and $PbTiO_3$ materials. Even though the tetragonal phase of Pb_2O_3 is known to be unstable, we found that the checkerboard-type $(Pb_2O_3)_{0.5}(PbTiO_3)_{0.5}$ alloy shows a tetragonal $PbTiO_3$-type structure with high c/a ratio (1.26), and exhibits a giant ferroelectric polarization as large as 120μC/cm^2. The underlying mechanism for a giant polarization and the phase stability of $(Pb_2O_3)_{0.5}(PbTiO_3)_{0.5}$ alloy will be discussed in detail.

Keywords:
Density functional theory, Ferroelectricity, Spontaneous polarization

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C8.02*

First-principle study of cobalt spinel Co_3S_4 and Co_3O_4

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Abstract:

Through first-principle calculations using the Hubbard-*U* method and the screened hybrid functional, the fundamental physics of cobalt spinel Co_3S_4 and Co_3O_4 are examined. These materials are very challenging to describe their properties in the framework with density functional theory-based approaches. In this work, we explore the electronic properties and the magnetic stability of them by varying the values of effective *U* in the Hubbard-U method and the Fock exchange in the hybrid functional. In addition, we attempt to figure out what make the difference in the electronic features of two materials although the materials have the same crystal symmetry and magnetic ground state.

Keywords:

first-principles calculations, Co3S4, Co3O4

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C8.03

First-principles study on the intrinsic origin of the large anomalous Hall effect in perovskite La_{1-x}Sr_{x}CoO_{3}

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Abstract:
We investigate the electronic and transport properties of perovskite $La_{1-x}Sr_xCoO_3$, in which the large anomalous Hall effect (AHE) is reported with strong doping dependences. Using first-principles density functional plus *U* (DFT+*U*) method, we find the significant change in the orbital character of Co-d derived bands with respect to the Fermi level shift. Without spin-orbit coupling, we identify the doubly degenerate nodal lines near the Fermi energy, protected by space group symmetry. We find that the inclusion of the spin-orbit coupling lifts the degeneracy from the three-fold rotation symmetry. We calculate the Berry curvature associated with the band splitting to investigate the variation of the anomalous Hall effect depending on the position of Fermi energy. Our finding may provide the mechanism of doping dependent anomalous Hall effects in $La_{1-x}Sr_xCoO_3$.

Keywords:
Condensed Matter Physics, First principles

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C8.04*

Prediction of shift current generation in room temperature organic molecular solids

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Abstract:

The bulk photovoltaic effect (BPVE) characterized by the generation of a steady photocurrent without the aid of external p-n junction has attracted a lot of attention due to its novel physics and high-performance possibility as a solar cell device. This quantum effect is coming from the wavefunction of valence and conduction states which have different charge center in non-centrosymmetric materials, called shift current. We report photovoltaic properties of tetrathiafulvalene-p-chloranil (TTF-CA), non-centrosymmetric organic material only below 81K, using first principle calculation. We observe large shift current spectra at infra-red frequency unexplored previous study. Moreover, our calculations indicate that shift current mechanism depending on temperature and non-zero shift current can be obtained in room temperature phase of TTF-CA using ferroelectric underlayer.

Keywords:

condensed matter physics, density functional theory, shift current, ferroelectrics, bulk photovoltaic effect

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C8.05

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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First-principles study of magnetic structures of ultrathin fcc Fe layers on a Cu(001) substrate

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Abstract:

Magnetic structures of fcc Fe/Cu(001) have remained a subject of great interest for several decades. Here, we revisit the problem of the structural and magnetic properties of fcc-Fe. we carry out non-collinear-spin density-fucntional-theory calculations for free-standing fcc Fe films and epitaxial Fe films on Cu(001) substrat using the OpenMX code. Various magnetic configurations are taken into account, including FM, stripe AFM (AFM-A), single-layer AFM (AFM-G), double-layer AFM (AFM-2G), and non-collinear spin spiral (SS) states. The topmost two surface layers of Fe are always found to be ferromagnetically coupled regardless of the film thickness, while the magnetic coupling among other Fe layers varies depending on the layer thickness n. The magnetic ordering of Fe shows five diverse regions: For $n \leq 3$ ML, FM state is most stable, while the ground mangetic structure shifts to AFM-2G state for 4 ML $\leq n \leq$ 8 ML. Moving further, 9 and 10 ML shows a mixed state of AFM-A and AFM-2G, which evolves to AFM-A state for 11 and 12ML. For $n \geq$ 13 ML, the fcc Fe turns into a bcc lattice. Contrary to the recent claim of the SS ordering originating from the out-of-plane Fermi surface (FS) nesting [1], no such nesting is found in our calculation. Also our total energy results exclude a non-collinear ordering in the ultrathin fcc Fe film on Cu (001).

[1] J. Miyawaki, A. Chainani, Y. Takata, M. Mulazzi, M. Oura, Y. Senba, H. Ohashi, and S. Shin, Phys. Rev. Lett. **104**, 066407 (2010).

Keywords:

fcc Iron, magnetic structure, non-collinear calculation

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C8.06*

Atomistic origins of low-resistance indium metal contacts to MoS_2: Beyond the energy band calculations

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Abstract:
In realizing high-performance electronic devices based on transition metal dichalcogenides (TMDCs), the high contact resistance at the metal-TMDC interface remains a major obstacle to overcome. Recently, van der Waals (vdW) contact through transferring metal films with MoS_2 has been demonstrated as a promising scheme to increase carrier mobility for ultrathin TMDC transistors [1], but its atomistic mechanism remains unclear. Here, carrying out density functional theory (DFT) and DFT-based matrix Green's function (MGF) method, we systematically explore the contact properties of metal|2H MoS_2 and metal-influenced 2H MoS_2/channel 2H MoS_2 interface in lowering contact resistance by considering different electrode metal species (In, Au). Firstly, we separate the Schottky barrier region *via* MGF calculations, and demonstrate that the main Schottky barrier region is not in the metal|2H MoS_2, but in the metal-influenced 2H MoS_2/channel 2H MoS_2 interface. Next, we confirm the indium metal contact to MoS_2 shows low contact resistance rather than gold metal due to Ohmic contact at the In|2H MoS_2 interface.

[1] Y. Liu, J. Guo, E. Zhu, L. Liao, S. J. Lee, M. Ding, I. Shakir, V. Gambin, Y. Huang, and X. Duan, Nature, **557**, 7707, 696-700 (2018).

Keywords:
Density functional theory, Contact resistance, Metal-MoS2 interface, Top contact

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C8.07*

Role of Indium in phase change mechanism of $AgInSbs_{18}Te_4$: First Principle Study

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Abstract:

Among phase change materials for next generation memory device elements, GeTe-Sb_2Te_3 pseudo-binary alloys and Sb-rich alloys have been widely investigated for real applications. Especially, $Ge_2Sb_2Te_5$ has attracted a lot of attentions and been studied intensively on various phase change properties such as recrystalization mechanism. On the other hand, even though they exhibit enhanced performances in phase change behaviors, Ag-In-Sb-Te alloys have been much less studied and their phase change mechanism has not yet been clearly known, such as the roles of Ag and In atoms. Performing intensive molecular dynamics simulations based on *ab initio* density functional theory, we investigate the local structures and phase transition properties of $AgInSb_{18}Te_4$ as an exemplary model configuration. We identify its crystalline structure by considering a number of atomic configurations and its amorphous phase through melt-quenching MD simulation. Evaluating and analyzing its radial distribution function, angle distribution function, and solid angle distribution and their analysis, we find that the In atom plays an important role not only in phase transition process, but also in retaining amorphous phase.

Keywords:

DFT, PCRAM, PCM, Phase Transition

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C8.08*

Study of intrinsic anomalous Hall conductivity using DFT+U method

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Abstract:

We study intrinsic anomalous Hall conductivity (AHC) of 3d ferromagnetic materials such as Co and Ni, based on the noncollinear-spin density function theory (DFT) calculation including spin-orbit coupling. We implement the AHC calculation to the SIESTA code which uses localized pseudoatomic orbitals to expand electronic wavefunctions, and test the convergence of AHC with respect to various parameters of the DFT calculation including real-space grids and k-point grids. We also test the dependence of AHC on different types of pseudopotentials, exchange-correlation functionals, and pseudoatomic orbital basis sets. Since the electrostatic repulsion among 3d electrons is underestimated in the local density approximation or the generalized gradient approximation, we also consider the Coulomb interaction parameters, U and J, for 3d electrons and examine their influence on AHC values. We analyze the energy and momentum dependences of the Berry curvature, and compare our AHC values and their temperature dependence with previous theoretical results as well as experimentally measured results. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2018-CRE-0097).

Keywords:

Intrinsic anomalous Hall conductivity

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C8.09*

Nontrivial Berry phase in square-net material due to electron-hole asymmetry

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Abstract:

In recent years, the topological semimetal phase was observed in tetragonal P4/nmm space group materials with square-net substructure, such as AMnBi2 (A=alkali earth/rare earth metals) and ZrSiS-type materials [1,2,3,4]. However, the origin of the non-trivial topology was not understood in previous studies [5]. In this work, we performed a first-principles electronic structure calculation and constructed effective tight-binding Hamiltonian including the 3rd nearest neighbor hopping between p-orbitals. We showed that the nontrivial topology comes from the electron-hole asymmetry induced by the 3rd nearest neighbor hopping term. We show phase diagram as a function of electron/hole doping level and electron-hole asymmetry.

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[4] G. Lee, et. al., Phys. Rev. B 87, 245104 (2013)
[5] S. Hyun, et. al., Phys. Rev. B 98, 165108 (2018)

Keywords:

Nodal line semimetal, DFT

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C10.01

4차 산업혁명과 지식재산권

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Abstract:

한국 내 4차 산업혁명 관련 특허출원건수는 이미 1만 5000건 이상인 것으로 집계되었으며, 한국 정부도 4차 산업혁명 기술투자와 특허지원에 보다 적극적으로 임하므로 미래 산업의 주도권을 잡아야 함을 강조하고 있습니다. 이에 대하여 특허청에서는 4차 산업혁명에 관련한 새로운 특허분류 체계를 준비하고 있으며, 7대 기술분야(인공지능, 3D 프린팅, 사물인터넷, 자율주행차, 빅데이터, 지능형 로봇, 클라우드)를 기존의 특허분류 체계에 부가하여 수립하였습니다. 이러한 4차 산업혁명의 실현을 위해서는 무엇보다도 4차 산업혁명을 구동하게 하는 출발점이 될 수 있는 미래 소재의 선점이 필수적이며 이렇듯 인공지능, 빅데이터 및 최첨단 기술과의 융·복합화가 가능한 소재가 결국 미래사회를 구성하는 혁신 시스템의 중심이 될 수 밖에 없습니다. 본 특별 세션에서는 미래소재의 첫걸음으로서 현재 국내에서 연구중인 경량-철강소재 및 경량-탄소섬유 복합소재뿐만 아니라 이들의 제조기술에 대한 최근 특허동향을 살펴보고자 합니다. 더불어 4차 산업혁명 관점에서 산업재산권과 저작권으로 분류되는 지식재산권에 대한 개념 및 지식재산권 침해 예방과 대처에 대해서도 함께 고찰해 보고자 합니다.

Keywords:

4차산업혁명, 지식재산권

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

C10.02

세상을 바꾸는 힘 (Strong Force)

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Abstract:

물리학을 전공하고 있는 여학생과 여성전문가들의 롤모델로 MIT에 입학한 최초의 흑인 여학생이며 고에너지물리학 박사인 셜리 앤 잭슨을 소개하고자 합니다. 셜리 앤 잭슨은 “세상을 바꾸는 힘 (Strong Force)”을 가슴에 품고 물리학자의 논리적 사고방식과 여성 특유의 공동체 의식을 바탕으로 미국 사회에 크게 기여해 왔으며, 현재 만 73세의 나이지만 여전히 열정적으로 미국 RPI대학교 총장직을 훌륭하게 수행하고 계십니다. 이 분이 걸어온 발자취와 제가 살아온 길을 되짚어 보면서 우리 물리학을 전공한 여성들이 앞으로 나아갈 길을 함께 생각해 보는 시간이 되길 바랍니다.

Keywords:

Strong Force

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2019-04-24 - 2019-04-26

C10.03

산업체에서 여성전문인력에게 필요한 역량이란?

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Abstract:

산업체에 근무하는 물리학을 전공한 여성 인력은 많지 않습니다. 특히 제가 근무하는 회사와 같은 제조업을 하는 회사는 더 그렇습니다. 또 석/박사 여성 전문인력들이 최근에 많이 채용이 되고 있으나 대부분은 공학을 전공한 분들이며, 그 중 물리를 전공한 분은 찾기가 힘듭니다. 산업체 보다는 연구소나 학교 등에 관심이 더 있어서 일 수도 있을 것 같습니다. 물리학을 전공하고 회사에 관심 있으신 분들에게 조금이나마 도움이 되었으면 하여 경험 및 회사 내 자료 등을 바탕으로 회사 입사 및 입사 후 전문 여성으로 positioning을 하고 능력을 발휘하기 위해 전문성뿐 아니라 그 외에 중요한 것들이 무엇이 있는지에 대해 잠깐 이야기 하고자 합니다.

Keywords:

산업체, 여성전문인력

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C11.01

Label-free and high-resolution optical imaging deep within scattering media

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Abstract:

Optical microscopy suffers from a loss of resolving power when target objects are embedded deep within scattering media such as biological tissues. The scattering medium attenuates signal waves and generates speckle noise by means of multiple light scattering. Furthermore, it gives rise to angle-dependent phase retardation of the unscattered signal waves, thereby distorting the point-spread-function. In this talk, I will present a label-free and high-resolution imaging method that can identify sample-induced aberrations in illumination and imaging paths separately without the need for guide stars and even in the presence of multiple light scattering. We use a time-gated optical coherence imaging to record the amplitude and phase maps of backscattered waves from the specimens for various illumination angles. In the image reconstruction process, we introduce separate angle-dependent phase factors for the incident and reflected waves, and identify phase corrections that preferentially accumulate signal waves over multiple- scattered ones for the forward and phase-conjugation processes. By applying these angle-dependent phase corrections to the initial data, we could not only optimize the accumulation of signal waves but also significantly reduce the effect of image distortion. Using this method, which we term 'closed-loop accumulation of single scattering' (CLASS) microscopy, we achieved a spatial resolution of 600 nm up to the imaging depth of seven scattering mean free paths. To demonstrate the applicability of CLASS microscopy to biological tissues, we performed *in vivo*and label-free volumetric imaging of a living zebrafish as old as 21 dpf and visualized myelinated axons in the entire neural network by the ideal diffraction-limit spatial resolution.

Keywords:

Deep-tissue imaging, label-free imaging, optical coherence imaging, adaptive optics

KPS 한국물리학회 The Korean Physical Society

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C11.02

Shaping light for imaging through turbid media

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Abstract:

Aberrations and multiple scattering of light remains as the ultimate barrier that we must overcome to enable high resolution imaging as well as precise control of light inside deep tissue. Here, we will discuss our recent efforts to either utilize multiple scattered light, or to differentiate only the ballistic components of light to enable high resolution imaging through turbid media.

Keywords:
aberrations, multiple scattering

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

C11.03

Interferometric scattering microscopy: new label-free imaging technique for investigating the dynamics of cytoplasmic material in living cells

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Abstract:

초고해상도 형광 현미경으로 대표되는 최신 형광 이미징 기법은 현재까지 세포의 특정 미세 구조를 가장 세밀하고 명확히 규명할 수 있는 방법으로 널리 사용되고 있으나, 형광 표지자의 세포 내 주입 또는 발현 과정에서 유발될 수 있는 세포 구조 및 기능 변화와 형광 분자의 산화에 따른 관찰 가능 시간의 제한이라는 기술적 문제점 또한 갖고 있다. 본 발표에서는, 형광 이미징의 기술적 한계점을 보완하기 위해 최근에 개발된 비표지 이미징 기법 중 하나인 간섭 산란 현미경(interferometric scattering microscopy)을 이용한 세포 이미징 연구를 소개하고자 한다. 본 이미징 기법은, 세포 지질막 또는 다양한 세포 내 소기관들로부터 산란/반사되어 나오는 매우 약한 신호의 빛을 세포가 성장하고 있는 유리 표면으로부터 일정하게 반사되어 나오는 강한 빛과 간섭시킴으로써, 세포 내부의 미세 구조를 고감도로 관찰할 수 있을 뿐 아니라 동적 변화 양상에 대한 초고속 영상 취득을 가능하게 한다. 실제로 세포 내 소기관들의 다층 지질막 구조를 반영하는 것으로 추정되는 다양한 간섭 파형들이 확인되었을 뿐 아니라, 긴 시간에 걸쳐 진행되는 세포 접착 단백질(focal adhesions)의 동적 변화 과정 및 세포 내 골격 섬유(actin filament)를 따라 이동하는 지질 소포(lipid vesicle)들의 수송 과정 등에 대한label-free 이미징이 가능함을 확인하였다. 이러한 연구 결과는, 향후 형광 이미징 기법과 결합되어 세포 내 미토콘드리아 또는 리보솜 등의 소기관 확산 현상이나 바이러스의 세포막 침투 과정의 이해와 같은 중요한 생물학적 연구에 대한 광범위한 응용 가능성을 제시한다.

Keywords:
간섭 산란 현미경, 비표지 이미징 기법

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C11.04

20-nm resolution molecular imaging of organs via iterative expansion microscopy

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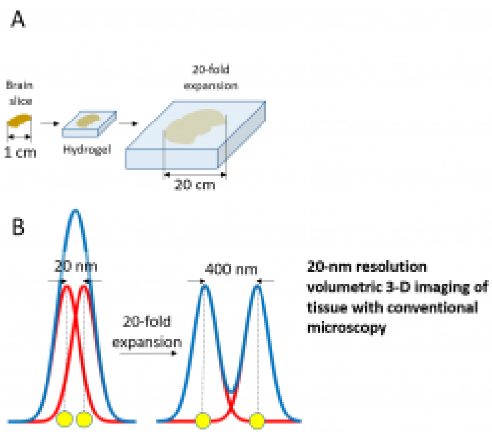
Abstract:

Understanding the organ-wide molecular architectures of biomolecules is essential to dissecting the mechanisms of diseases, such as brain disorders and cancers. Recently, various optical microscopy techniques have been implemented to visualize such molecular profiles, but their resolution has been insufficient to precisely measure nanoscale changes in the distribution and expression levels of biomolecules. In 2015, a new super-resolution imaging technique, called expansion microscopy (ExM) was developed. This technique improves the resolution of conventional diffraction limited microscopy 3- to 4-fold, by physically expanding biological specimens via a swellable hydrogel. Here, we demonstrate the application of ExM to various systems and also demonstrate even better resolution by expanding biological specimens more than 4.5-fold, a process we call 'iterative expansion microscopy(iExM)'. In iExM, biological specimens are expanded more than 20-fold and 20-nm spatial resolution is achieved with confocal microscopy. By scanning such expanded specimens with a high-throughput microscopy system, large-volume super-resolution imaging can be easily achieved. We demonstrate the super-resolution imaging of various cellular structures, including cytoskeletons, nuclei, and mitochondria of cultured cells. We also demonstrate the super-resolution large-volume imaging of various cell types in a brain, as well as the single-molecule resolution imaging of mRNA molecules in a brain via ExM. ExM and iExM would revolutionize how we see and understand biological systems and how we develop new therapeutics and medical devices.



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Keywords:

Super-resolution imaging, brain imaging, expansion microscopy

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C11.05

Cellular softness of cancer cells depends on tissue type

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Abstract:

Cancer cells show unique characteristics including undifferentiated states, abnormal nuclei, lack of normal signaling pathways, abnormal energy metabolism, and vascularization. Compared to healthy normal cells, cancer cells also exhibit the unique physical property of elasticity. Cell elasticity indicates the ability of the cell to deform in response to external stress. Recent research demonstrated that cancer cells are softer than normal cells. Metastatic cancer cells taken from the body fluids of patients with suspected lung, breast, and pancreas cancer were over 70% softer than benign cells. In this study, we measured cancer cell softness by using atomic force microscopy (AFM). We selected cells from breast, cervix, and lung tissues. One counterpart normal cell and three cancer cells were obtained from each tissue. Among the cancer cells, two were non-metastatic cells and one was a metastatic cell. Cellular softness measurements were carried out using an AFM in liquid conditions. Changes in the content and structure of the F-actin cytoskeleton were observed, and the results were compared with cellular softness. All cancer cells were softer than their counterpart normal cells; however, the softening was dependent on the tissues. Softening was the largest in cancer cells from the cervix, followed by cells from the lung and breasts. The F-actin cytoskeleton was diminished and showed structural changes in all cancer cells. However, changes in the contents and distribution of F-actin were dependent on tissue type. We demonstrated that the softening of cancer cells depends on tissue type, and changes in F-actin also differed by tissue type.

Keywords:
Cancer cell, cellular softness, AFM

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C11.06*

Imaging the dynamics of engram in CA1

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Abstract:
During learning and memory formation, the immediate-early genes (IEGs) such as Arc, c-fos, and egr-1 are rapidly induced in the subset of neurons. Recent findings revealed that these IEG expressing neurons store the information that are needed for the memory recall. Since memories are theoretically thought to be distributed in specific neurons or ‘engrams’, IEG expression has been used as a marker for engram cells. However, little is known how the engram representing a specific memory changes over time. To investigate the dynamics of engrams in a live animal, we used a transgenic mouse in which endogenous Arc mRNAs are fluorescently labeled by the PP7-GFP system. By using *in vivo* two-photon imaging through hippocampal windows, we were able to find neurons transcribing Arc mRNA in a few minutes after behavioral experiments. We compared the engram patterns in the CA1 region of the hippocampus after contextual fear conditioning and fear memory recall. This longitudinal imaging of engrams will shed a light on the dynamic processes of encoding, consolidation, and retrieval of memory *in vivo*.

Keywords:
*Memory *Engram *Immediate-early genes *Arc

C11.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Cell alignment mediated by actomyosin contraction and microtubule-based transport on micro-scale topographic surface

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Abstract:

Micron-scale topographic surface was fabricated to be used as a cell culturing substrate to guide cell alignment and migration. Topographic substrate with various groove and ridge patterns was fabricated by UV curable polymer resin on a glass coverslip coated with 1 μm parylene-C. It was confirmed that cells have tendency to be aligned along the edges of grooves and ridges. Alignment and migration of cells were analyzed by parameters such as cell's aspect ratio, aligned cell's angle with groove pattern and cell's circularity. We also confirmed that groove depth and alignment ratio were in linear relationship which can be explained by balance of cell contractility. Myosin and microtubule-related proteins inhibition caused less alignment than normal cell in a same groove depth. These results suggest that actomyosin contraction and microtubule-based transport play important roles in cell alignment and migration. We expect this work will help understanding mechanism of cell alignment and migration on micron scale topographic surface which is important for advanced tissue engineering.

Keywords:

Cell alignment, surface topology, actomyosin, microtubule

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C11.08*

Vertical aptasensors for real-time monitoring of bacterial growth and antibiotics susceptibility test in blood

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Abstract:
The aptamer-functionalized horizontal capacitance biosensor was reported to detect bacteria growth and antibiotic susceptibility in culture media in real-time. However, this sensor is not proper to detect bacterial growth and antibiotic susceptibility in whole blood because various proteins and biomolecules in the whole blood sink down by gravity during measurements, and they interfere with the detection of bacterial growth. To solve this problem, we have developed an aptamer-functionalized vertical capacitance biosensor. Indeed, bacteria at a concentration of 10 CFU/ml in whole blood can be detected less than 24 h using the vertical biosensor. However, unlike in culture media, during bacterial growth in blood, the capacitance decreases, which is attributed to biofilm formation.

Keywords:
Aptasensor, Antibiotic susceptibility, Real-time monitoring, Sepsis, Biofilm, Vertical sensor

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C12.01

빔 구동 웨이크필드 전자 가속의 연구 동향

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Abstract:

CERN의 거대강입자가속기(LHC)를 통해 힉스입자를 발견한 고에너지 입자 물리학계에서는 힉스입자의 엄밀한 성질 규명 및 새로운 고에너지 물리현상 발견을 위해 고에너지 경입자(Lepton) 충돌형 가속기의 건설을 간절히 고대하고 있다. 금속 가속관이 가지는 기술적인 한계로 인하여, 현재 건설 논의 중인 경입자 충돌형 가속기는 그 크기가 수십 km에 이르고, 건설 비용도 수 조원이 넘을 것으로 예상된다. 이를 극복하기 위한 대안으로 플라즈마를 이용한 가속기의 개발이 그동안 활발히 연구되어 왔는데, 플라즈마 내에 웨이크필드를 발생시키고, 이때 만들어 지는 강력한 전기장을 이용하여 전자를 가속하는 개념이다. 해외의 경우, 향후 20년간의 로드맵이 제시되어 레이저에 기반한 웨이크필드 가속 연구와 입자빔에 기반을 둔 웨이크필드 가속 연구가 서로 경쟁을 하면서 균형적으로 상호 발전해 가고 있는 반면, 국내에서는 레이저에 기반한 연구가 주를 이루어 왔다. 이 발표에서는 입자빔에 기반을 둔 웨이크필드 전자 가속의 최근 연구 동향을 UNIST 연구진이 참여중인 해외의 실험(CERN의 AWAKE, ANL의 AWA, DESY의 PITZ 등)과 PIC 시뮬레이션 연구를 중심으로 소개하고자 한다.

Keywords:

빔구동 웨이크필드, 전자가속, CERN, 고에너지물리

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C12.02

Rapid and uniform heating of materials using laser-accelerated ions

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Abstract:

We have used a beam of laser-accelerated aluminum ions to heat solid density gold and diamond foils uniformly and rapidly above 10,000 K. Although matter at such an extreme state, known as warm dense matter, is commonly found in astrophysics (e.g., in planetary cores) as well as in high energy density physics experiments, its properties are difficult to predict theoretically and are not well understood. A sufficiently large warm dense matter sample that is uniformly heated would be ideal for these studies, but has been unavailable to date. For the first time, we visualized directly the expanding warm dense gold and diamond with an optical streak camera. We developed a new technique to determine the initial temperature of these heated samples from the measured expansion speeds of gold and diamond into vacuum. We anticipate the uniformly heated solid density target will allow for direct quantitative measurements of equation-of-state, conductivity, opacity, and stopping power of warm dense matter, benefiting plasma physics, astrophysics, and nuclear physics.

Keywords:

Warm dense matter, high energy density physics, high power laser

C12.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Energy modulated proton beam from a structured target irradiated by an ultraintense laser pulse

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Abstract:
2000년대 초반에 강한레이저와 고체 타겟의 상호작용으로 고에너지 양성자빔의 발생을 관측한 이 후, 가속원리에 대한 관심과 함께 기존의 양성자 가속기를 대체할 수 있는 기대감에 많은 연구들이 진행되어 왔다. 이러한 노력으로 기본적인 가속원리에 대해 밝혀졌으며, 더 좋은 성능의 이온빔을 얻기 위한 여러 방안들이 제안되고 실증되어 왔다. 하지만, 여전히 실제 응용에서 필요한 정도의 이온빔을 얻는데 어려움을 겪고 있으며 특히 기존의 암치료장치를 대체하기 위한 고에너지의 이온빔을 얻지 못하고 있다. 이러한 상황에서 본 연구팀은, 현재 세계적으로 주목받는 Radiation Pressure Acceleration 가속 원리를 활용하는 수십 나노미터 두께의 매우 얇은 타겟을 시도하는 대신, 수 마이크로미터 두께의 금속과 폴리머 층으로 결합된 다층구조의 타겟을 이용한 연구를 진행하고 있다. 이와 같은 다층구조의 타겟에서는 기존의 두꺼운 타겟에서 발생하는 열적인 분포의 이온빔과 달리 강한 에너지 변조를 보여주는 이온빔을 관측하였다. 본 발표에서는 이러한 결과와 함께 다층 구조를 사용하여 레이저 유도 플라즈마 가속을 이용한 이온빔 발생의 한계를 극복하기 위한 방안에 대해 논의하고자 한다.

Keywords:
이온 가속, Radiation Pressure, Structured Target, 고출력 레이저

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C12.04

플라즈마 라디에이션 및 레이저-플라즈마 최신 이슈 소개

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Abstract:
일반적으로 초고강도 레이저와 플라즈마의 상호작용을 다루는 레이저-플라즈마 시스템은 컴팩트 입자 가속, 의료용 가속, 테라헤르츠 및 X-ray 또는 gamma-ray 파장의 고출력 광원, 관성 핵융합 등 다양한 연구 분야와 관련되어 있다. 본 발표에서는 이러한 다양한 분야의 핵심 이슈들을 간단히 언급하면서 그 중에서도 특히 레이저-플라즈마 상호작용을 이용한 테라헤르츠 대역 광원, 라만 산란을 이용한 레이저 증폭 시스템에 대해 중점적으로 다룬다. 또한 ELI 개발에 따라 차세대 첨단 이슈로 부상하고 있는 여러 가지 이슈에 대해 간단히 언급할 것이다.

Keywords:
Plasma Emission, Coherent Light Source, ELI

C13.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Complexity of Holographic Superconductors

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Abstract:

We study the complexity of holographic superconductors (Einstein-Maxwell-complex scalar actions in d+1 dimension) by the "complexity = volume" (CV) conjecture.
First, it seems that a universal property: the superconducting phase always has the smaller complexity than the unstable normal phase below the critical temperature, which is similar to a free energy. We investigate the temperature dependence of the complexity. In the low temperature limit, the complexity (of formation) scales as T^{α}. where α is a function of the complex scalar mass m^2, the U(1) charge q, and dimension d. In particular, for $m^2 = 0$, we find α = d-1, independent of q, which can be explained by the near horizon geometry of the low temperature holographic superconductor. Next, we develop a general numerical method to compute time-dependent complexity by the CV conjecture. By this method, we compute the time-dependent complexity of holographic superconductors. In both normal and superconducting phase, the complexity increases as time goes on and the growth rate saturates to a temperature dependent constant. The higher the temperature is, the bigger the growth rate is. However, the growth rates do not violate the Lloyd's bound in all cases and saturates the Lloyd's bound in the high temperature limit at late time.

Keywords:

AdS/QI, AdS/CMT

C13.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A Resistivity of an Einstein-Maxwell-Scalar(s) model at finite temperature

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Abstract:

Various strange metals including cuprates, pnictides and heavy fermions shows linear-in-T resistivity phenomenon. The Einstein-Maxwell-Dilaton-Axion model is one of the holographic models invented to study strongly correlated system. At the small temperature limit, the EMD-Axion model seems to allow the linear-in-T resistivity. Some specific model, for example the Gubser-Rocha model, shows linear-in-T resistivity up to finite temperature. However, there are still lack of knowledge in the finite temperature physics of other EMD-Axion model. We numerically study the relation between temperature and resistivity of one of such EMD-Axion model.

Keywords:

Linear-T-resistivity, EMD-Axion theory, UV completion

C13.03*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Chiral symmetry breaking in holography and Mandelstam-'t Hooft duality

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Abstract:

We consider the axial sector of Quantum Choromodynamics (QCD) using holographic principle, and show that chiral symmetry breaking is enough to establish the confinement with linear Regge trajectory whose slope is given by the value of the chiral condensation. We first map the axial sector of one flavor QCD to holographic abelian Higgs models, which has been known as a theory of superconductor, and then show that the model has stringy spectrum. Here, two completely different phenomena are described by exactly the same model according to the interpretation of the charge. This is a formulation of Mandelstam- 't Hooft duality : QCD vacuum is an electromagnetic dual to the superconductivity. We also provide a simple phenomenological model of QCD for all sectors with linear Regge trajectory

Keywords:

QCD, Regge Trajectory, AdS/CFT, AdS/QCD, Chiral condensation, holography

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C13.04

Stability of Topological number and topological dipoles in holography

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Abstract:
We study the holographic Weyl semimetal model which introduce fermion doubling and the topological structure for this model. Near the Weyl-points, we can define topological numbers such as Berry phase, and it is found that such topological numbers are stable under the variation of temperature and the change of interaction strength.
We also construct another holographic model with axial vector interaction without fermion doubling and found that we have non-trivial topological number and topological dipole structure.

Keywords:
Holography, Berry phase, Weyl semi-metal, Topological dipole

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C13.05

Holography of Massive M2-brane Theory with discrete torsion

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Abstract:

In the context of the gauge/gravity duality between N=6 mass-deformed ABJM theory with U(N)XU(N) gauge symmetry and 11-dimensional supergravity on LLM geometries, we investigate the role of the discrete torsion l when the gauge symmetry is generalized as U($N+l$)XU(N). Using the droplet representation in dual gravity, we extend invariant quantities to include l. In the 1/N expansion of the invariant quantities, the l contribution appears in the subleading terms.

Keywords:

mass-deformed ABJM theory, LLM geometries, discrete torsion, droplet representation

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C13.06

Saving Tachyons in Open String Theory

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Abstract:

Tachyons are present inherently in open bosonic string thery. They indicate unstability of the system of open bosonic strings on D-branes. By carefully examining their field theoretical actions which may be obtained by evaluatiing multi-particle scattering amplitudes, we will discuss a possibility of spontaneous breaking of local gauge symmetry and stabilization of the system thanks to condensation of tachyons.

Keywords:

open bosonic string, tachyon, spontaneous symmetry breaking.

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C13.07

Consistency of partially massless graviton

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Abstract:
We perform a systematic analysis on the gauge consistency of theories involving a partially massless graviton.

Keywords:
partially massless graviton

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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C13.08

Classification of non-Riemannian string backgrounds in Double Field Theory

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Abstract:
Recent years have seen a surge of interest regarding non-Riemannian gravitation theories, the most prominent examples thereof being Newton-Cartan and Carroll gravities. We first review the kinematical content of these theories and then show how the associated geometries naturally appear within the context of Double Field Theory as part of a classification result of possible generalized metrics.

Keywords:
Double Field Theory, Non-Riemannian geometry, Newton-Cartan gravity

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C14.01

Long Baseline Neutrino Experiments, Past, Present and Future

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Abstract:

The discovery of neutrino oscillations has established the massive neutrino and the presence of physics beyond the Standard Model. With the measurement of a non-zero value for the third mixing angle, $₩theta_{13}$, by reactor experiments and T2K, the potential for an new source of CP violation in the mixing of neutrinos has been realized. The current generation of accelerator based long-baseline experiments, T2K and NOvA, along with atmospheric neutrino experiments, Super-K and IceCube, and reactor neutrino experiments, Daya Bay, RENO and Double Chooz, are making ever more precise measurements of neutrino oscillation parameters, searching for CP violation in neutrino oscillations and probing the hierarchy of neutrino mass states. The next generation of long baseline neutrino experiments, Hyper-K and DUNE, will make even more precise measurements of neutrino oscillation parameters that probe the origin of flavor, aim for unprecedented sensitivity to CP violation, and search for new physics beyond the 3-neutrino mixing paradigm. In this talk, I will review the past and current accomplishments of long baseline neutrino experiments and discuss the prospects of future experiments and their status. I will also discuss the challenges to realize the neutrino oscillation precision measurement program in the next generation experiments, including the critical sources of systematic uncertainty that must be controlled.

Keywords:

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C14.02

Outlook on Particle Physics with Future Colliders

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Abstract:
What do we expect to do in particle physics with future colliders? We will first overview the status of proposed future colliders: upgraded LHC, ILC, FCC, CEPC, and CLIC. Then we will summarize inputs suggested to the European (Particle Physics) Strategy. We can gauge where we are heading to as well as what we need in order to complement the future-collider programs.

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C15.01

Hydrodynamic effects on self-organization of soft matter

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Abstract:

The hydrodynamic degrees of freedom have a strong impact on self-organization of soft matter [1]. They can produce the dynamical coupling to other degrees of freedom in a system such as the composition field in a binary mixture and colloidal particles in a colloidal suspension.

Here we show a few examples of interesting couplings. The first example is the coupling between the velocity and composition field in a critical binary mixture [2]. We find that the so-called Brownian coagulation mechanism for droplet phase separation is not correct in an exact sense, and a non-trivial coupling between diffusion and flow leads to a novel mechanism: Droplets move directionally under thermal fluctuations, following the chemical potential gradient produced by composition diffusion.

The second example is the impact of many-body hydrodynamic interactions on colloid phase separation [3-6]: cluster and gel formation. We numerically solve the Navier-Stokes equation by approximating solid colloids as undeformable fluid particles [3] while incorporating full hydrodynamic interactions between colloids under thermal noise [4,5]. Thanks to the scale invariant nature of the phenomena, we succeed in reproducing the processes of colloid aggregation and gelation experimentally observed by 3D confocal microscopy almost perfectly without any adjustable parameters [6]. This predictive power of our simulation method may significantly contribute not only to the basic understanding of the kinetics of colloidal suspensions but also to computer-aided material design.

This work was partially supported by Grants-in-Aid for Specially Promoted Research from the Japan Society for the Promotion of Science (JSPS).

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Keywords:

Hydrodynamic effect, self-organization, soft matter, colloid

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C15.02

Computational study of equilibrium structures of water molecules confined within a multiply connected carbon nanotube

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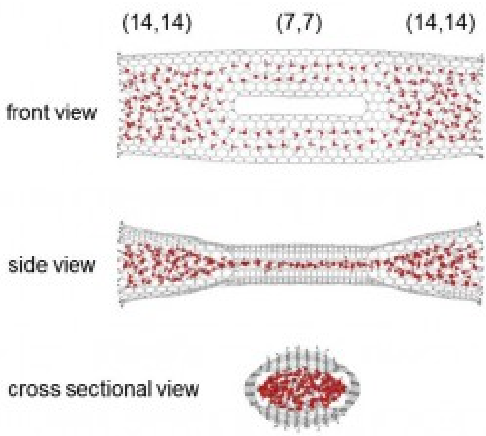
Abstract:

We have studied a water nanostructure formed inside a topologically complicated carbon nanotube in dynamic equilibrium in an external water bath, using molecular dynamics simulations that took into consideration the density of water molecules and the formation of hydrogen bonds. We introduce a multiply connected carbon nanotube (MCCNT) of which the (14, 14) CNT branches into two (7, 7) CNTs, which are then fused into the (14, 14) CNT. Remarkable changes occur in the (14, 14) CNT section approximately 6 - 7 Å before the junction in terms of the density and at approximately 4 - 10 Å in terms of the ordering of the water molecules. The increased hydrogen bonding in the (7, 7) CNT arm of the MCCNT would be expected to eventually correspond to that of pure (7, 7) CNT as the distance is increased. Both the dynamic and static behavior of water molecules inside a topologically complicated nanostructure is of fundamental importance because of their numerous possible applications.



Keywords:
multiply connected carbon nanotube, water transport, molecular dynamics

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C15.03

Phase Change of Water on Slippery Asymmetric Bumps

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Abstract:

Designing surfaces that enable droplets to grow rapidly and be shed as quickly as possible by capturing vapor is fundamental to dew harvesting systems, thermal power generation, etc. However, cutting-edge approaches suffer from intrinsic trade-offs that make it difficult to optimize both growth and transport at once. Inspired by an unconventional interpretation of the role of the beetle's bump geometry in promoting condensation, we show how to maximize vapor diffusion flux at the apex of convex millimetric bumps by optimizing curvature and shape. Integrating this apex geometry with a widening slope analogous to cactus spines couples rapid drop growth with fast directional transport. This coupling is further enhanced by a slippery, pitcher plant-inspired coating that facilitates feedback between coalescence-driven growth and capillary-driven motion. We envision that our fundamental understanding and rational design strategy can be applied to a wide range of liquid collection applications and can further be used for ice or frost formation control.

Keywords:
Phase change, Water, Slippery asymmetric bump, Curvature

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C15.04

Ice-VII-like Molecular Structure of Ambient Water Nanomeniscus

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Abstract:

Structural transformations originating from diverse rearrangements of the hydrogen bonding network in water create various phases of liquid and ice. Although most water phases have been well investigated down to the molecular level, the molecular structure of the nanomeniscus, a ubiquitous form of nanoscale water produced between hydrophilic surfaces in nature, still remains unexplored. Identification of molecular structure of water, especially in nanoconfinement, has been challenging and even incorrect despite its increasing interest as well as extensive works done to date. We use surface-enhanced Raman spectroscopy to trace the molecular fingerprints of the hydrogen-bonding configuration of water nanomeniscus that is formed in dried manoparticulate of silver, and show that such ubiquitous water exists surprisingly as ice-VII in normal ambient conditions, beyond general expectation of its existence only in extreme conditions such as in Earth's deep mantle. In particular, the ice-VII structure for such nanoconfined water is evidenced by the spectral independence with respect to the temperature variation as well as the surface types including the material, size and shape of nanoparticles. Our results may be useful for a better understanding of molecular aspects of water at nanoscale such as biological water.

Keywords:

ice-VII, nanomeniscus, molecular structure, surface enhanced Raman spectroscopy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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D1.01

Controlling the motions of two kinds of fermions in a nucleus, a new energy degraded RI beam line OEDO

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Abstract:

The nuclear physics aims to understand how the nucleus is built up with building bilks, two fermions protons and neutrons. The nuclear force as a glue of nucleons has been studied in the past by the nucleon scattering and recently even QCD calculation can tell us the property. The structure of more than two nucleons, however, shows us rich phenomena originated from the quantum many body effect like collective motion by bozonization of two same fermions. In the case of the exotic nuclei, where the number of neutrons and protons are unbalanced, it is observed that the nuclear property changes from that of the stable nuclei like shell evolution [1] and halo structure [2]. The quantum many body effect in such nuclei attracts much attentions these days.

To study the nuclear structure microscopically, the wave function of the nucleons in a nucleus is demanded to be determined. In a simple statistical manner, the nucleon at the Fermi surface has an energy around 20 MeV. Namely low-energy beams around 20 MeV/nucleon is required to transfer a nucleon onto a nucleus beam. We constructed a new beam line which can energy- degrade the radioactive isotope beams of around 200 MeV/nucleon from RIBF down to a few 10 MeV/nucleon. More importantly, OEDO can squeeze a beam size which is always problematic for the energy degrade. Two physics experiments, (d,p) reaction and fusion- evaporation reaction with proton in inverse kinematics, have been conducted for studies of the nuclear transmutation of the nuclear wastes after the commissioning experiment [3,4]. In this talk, we will discuss the OEDO beam line with the two experiments. In addition, we also discuss about the future experiments at OEDO like nuclear structure and the nuclear astrophysics.

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Keywords:

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D1.02

Studying Astrophysical reactions and Nuclear Clusters with low-energy RI beams

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Abstract:

Studies on nuclear astrophysics, nuclear structure, and other interests have been performed with the radioactive-isotope (RI) beams at the low-energy RI beam separator CRIB, operated by Center for Nuclear Study (CNS), the University of Tokyo. Recent technical improvements at CRIB and a series of studies on nuclear astrophysics are discussed.
The elastic resonant scattering is a striking tool to study astrophysical reactions and nuclear clusters. In particular, when it is coupled with thick target and inverse kinematics, the measurement can be very efficient and even feasible with low-intensity RI beams. Recent successful applications of the resonant elastic scattering with the thick-target method at CRIB are for the ^{7}Be+a [1], ^{10}Be+a [2], ^{30}S+a [3], and ^{15}O+a systems. By measuring the resonance parameters, we can evaluate the resonant reaction rates of astrophysically relevant reactions. With our ^{7}Be+a and ^{30}S+a measurements, ^{7}Be(a, g) and ^{30}S(a, p) reactions in explosive stellar environments were studied. The a-particle clustering in the compound nuclei is another interesting topic which can be studied with the resonant elastic scattering.
In 2017, an ^{26}Al beam as a mixture of the ground (5^{+}) and isomeric (0^{+}) states was produced at CRIB, and applied for a proton resonant scattering measurement. The measurement is relevant for the identification of the astrophysical sites of the galactic g-ray.
There have also been experiments based on the indirect technique of the reaction measurement. The first Trojan horse method (THM) measurement using an RI beam was performed at CRIB, to study the ^{18}F(p, a)^{15}O reaction at astrophysical energies via the three body reaction ^{2}H(^{18}F, ^{15}O)n. The ^{18}F(p, a)^{15}O reaction rate is crucial to understand the 511-keV gamma-ray production in nova explosion phenomena, and we successfully evaluated the reaction cross section at novae temperature and below experimentally for the first time [4]. The second THM experiment at CRIB was performed for the cosmological ^{7}Li abundance problem. The ^{7}Be(n, p) and ^{7}Be(n, a) are possible destruction reactions to explain the discrepancy in the ^{7}Li abundance between the Big-bang nucleosynthesis model and the observation. We performed a THM measurement with ^{7}Be beam at CRIB as one of the first applications of THM for neutron induced reactions [5].

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Keywords:

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D1.03

Study of the ^{19}Ne structure from the ^{15}O+alpha experiment

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Abstract:

In classical novae, the intense ɣ-rays due to the beta decay of ^{18}F are emitted by the HCNO cycle. The ^{18}F(p,α)^{15}O reaction, as one of the two main destructive channels, is important to determine the amount of ^{18}F. We performed an alpha elastic scattering experiment with a radioactive ^{15}O beam for investigating the structure of ^{19}Ne near the proton threshold. Several experiments and theoretical works have been reported on the resonances of ^{19}Ne near and above the proton threshold. However, many relevant parameters are still unknown. The experiment was performed using the CRIB facility at the Center for Nuclear Study using the thick target method. The excitation function of ^{19}Ne was obtained between Ex=3.53 MeV and Ex=11.13 MeV. We also investigated the alpha cluster structure of ^{19}Ne and compared with theoretical study. The experimental details and results of our study will be discussed.

Keywords:

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D2.01

Characterization of Energy Storage Materials Using Surface Analysis Techniques

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Abstract:

The high performance of lithium-ion batteries (LIBs) is in increasing demand for a variety of applications in rapidly growing energy-related fields, including electric vehicles. For this purpose, it is crucial to characterize various properties of LIB materials unambiguously, as well as the to develop new materials for LIB. In this talk, three topics will be presented in terms of the characterization of LIB materials mainly using surface analysis techniques.

Firstly, I will present the nanoscale probing technique of electrical degradation of LIB electrodes, $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ (NCA) cathode and Si-C composite anode, materials, using scanning spreading resistance microscopy (SSRM) [1-3].

Secondly, the analytical approach to characterize the electronic structure of garnet-structured oxide electrolyte ($Li_7La_3Zr_2O_{12}$, LLZO) will be presented, based on surface analysis techniques such as reflection electron energy loss spectroscopy (REELS), scanning photoelectron microscopy (SPEM), and nanoscale charge-based deep level transient spectroscopy (Nano Q-DLTS) [4].

Lastly, the *in-situ* Auger electron spectroscopy/microscopy (AES/AEM) technique, which was utilized for the real time observation of lithium metal plating into sulphur-based solid-state electrolyte (Li_6PS_5Cl, LiPS) for all-solid-state batteries, will be introduced [5].

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Keywords:
Lithium ion battery, all-solid-state battery, scanning spreading resistance microscopy (SSRM), in-situ Auger electron spectroscopy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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D2.02

Advanced electrode for battery electric vehicle (BEV) with long range

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Abstract:

The high energy density of Li-ion batteries (LIB) make them attractive for energy storage in applications ranging from mobile products to electric vehicles (EV) and dedicated energy storage systems (ESS). However, slow progress in improvement limits the feasibly of widespread LIB. Among the various cell components, the capacity and activity of cathode materials, such as $LiCoO_2$ and $LiMnO_2$, are limiting factors to increase energy density. For satisfying the high energy density requirements for high-power LIBs used in EV and hybrid electric vehicles (HEV), the high capacity cathode materials with more than 200 mAh/g are required. There are two candidate material for achieving this capacity. One is Li-rich layered-oxide cathode materials, referred to as over-lithiated layered oxides (OLO), in the solid solution system Li_2MnO_3-Li**M**O_2 (where ***M*** is Co, Ni, or Mn). OLO have been produced with capacities exceeding 250 mAh/g at high operating voltages (>3.5 V vs. Li/Li+). The other is Ni-rich layered oxide cathode materials (Ni-rich NCM or NCA), such as $LiNi_xCo_yMn$ (or Al)$_{1-x-y}O_2$ ($x > 0.6$) with high specific capacity and low manufacturing cost. However, the major drawbacks of OLO and Ni-rich layered oxide must be overcome for successful commercialization. To ameliorate these shortcomings and overcome the limited energy density due to inhibited active cathode materials, the surface modification of cathode materials, for example by applying surface coatings or doping with other foreign elements, is broadly considered to be a viable remedy to alleviate problems associated with poor discharge capacity and cyclability fading. We introduce various coating material and coating method for overcoming the drawbacks.

Keywords:

Li ion battery, Cathode, over-lithiated layered oxides (OLO), High Ni NCM

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전고체 이차전지용 복합전극의 계면안정성(Interfacial stability of composite cathodes for all-solid-state batteries)

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Abstract:

현재 리튬이온전지(LIB)는 소형 전지기기와 전기 자동차, 에너지 저장 시스템과 같은 다양한 응용 분야의 전원으로 널리 사용되고 있다. 그러나 응용분야가 넓어짐에 따라 새롭게 부각되는 문제점이 있는데 유기계 액체전해질로 인한 안전 문제가 그 중 하나라고 할 수 있다. 특히 전지의 크기가 대형화가 될수록 안전문제는 매우 심각한 결과를 초래할 수 있기 때문에 이 문제를 해결하기 위한 많은 노력이 이루어지고 있는 상황이다. 근본적으로 이와 같은 문제는 유기계 액체전해질의 높은 가연성에 있다. 따라서 연소가 어려운 무기계 고체전해질을 사용하는 것은 가장 궁극적인 해결방법이 될 수 있다. 이를 위해 다양한 고체상태의 무기계 물질들이 리튬 이온의 전도체로 연구되어 왔으며 최근에는 황화물계를 중심으로 액체전해질 못지 않은 높은 이온전도성을 보이는 고체전해질 물질들을 많이 개발하였다. 또한 황화물계 고체전해질의 경우 기계적인 가공을 통해 전극물질과의 접합이 가능하기 때문에 상용성이 매우 높은 것으로 평가받고 있다. 그러나 황화물계 고체전해질은 높은 반응성을 가지고 있어 전극 물질과 접촉 시 불안정한 계면을 형성한다는 문제점이 있다. 이 문제를 극복하기 위한 방법으로 제시된 것이 양극 분말의 표면에 안정한 물질을 코팅하여 계면을 안정화 하는 것이다. 이와 같은 표면 코팅법은 이미 리튬이온전지용 양극물질에 상용화 되어 사용되고 있지만 황화물계 고체전해질을 사용하는 전고체 이차전지의 경우 액체전해질과는 근본적으로 다른 원인에 의해 계면 불안정성이 발생하므로 기존에 연구된 표면 코팅 기술과는 다른, 새로운 표면 코팅 기술이 제시되어야 한다. 본 발표에서는 황화물계 고체전해질과 양극물질간의 계면 문제를 살펴 보고 이를 극복할 수 있는 표면 코팅 방법에 대해 설명하고자 한다.

Keywords:

이차전지, 전고체, 복합전극, 표면코팅

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D2.04

리튬 이차전지용 음극활물질

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Abstract:
최근 리튬 이차전지는 휴대용 전자기기 같은 소형기기 뿐 아니라 전기 자동차(xEV) 및 에너지저장 장치 (Energy Storage System)의 중대형 기기로의 응용범위가 크게 확대되고 있다. 이에 따라 리튬 이차전지의 성능도 기존의 휴대용 전자기기용 리튬 이차전지에 비해 보다 향상된 고출력 및 장수명의 특성이 요구되고 있다.

리튬 이차전지가 상용화된 이래 지금까지 음극 활물질로서는 탄소재가 사용되어 왔으며 최근에는 가격이 상대적으로 저렴한 구형화 천연흑연이 주로 사용되어 왔으나 출력 및 수명 특성의 한계로 인조 흑연 및 신규 음극소재의 개발이 요구되고 있다.

따라서, 본 연구에서는 기존의 구형화 천연흑연의 문제점을 살펴보고 이의 개선을 위한 방안에 대해서 알아보고자 한다.

Keywords:
리튬 이차전지, 음극 활물질, 구형화 천연 흑연

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D2.05

Electrolytes for High-Performance Lithium-Ion Batteries

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Abstract:

Lithium-ion batteries (LIBs) are one of the most promising energy storage devices because of their high power and energy densities, current technical maturity, and economic considerations. Although LIBs have been successfully commercialized, a noticeable improvement in the energy densities of Li-ion cells will be necessary to satisfy society's needs for high power and/or capacity, for applications such as power tools and electric vehicles, or the efficient use of renewable energies. High energy density in a battery can be attained by increasing the reversible capacity of the electrodes, by decreasing the working potential of the anode, or by increasing the working potential of the cathode. Conventional carbonate solvents such as ethylene carbonate (EC) have been widely used as solvents because of their high dissociation ability, reasonably high ionic conductivity, and ability to form a proper SEI layer on the carbonaceous anode. However, conventional carbonate-solvent-based electrolytes exhibit inferior anodic stability of lower than 4.3 V vs. Li/Li^+, which makes them highly unstable against high-voltage cathodes and undergo the electrochemical reduction at the anodes, thereby resulting in the formation of a resistive surface film. The formation of surface films through the use of reducible and oxidizable additives in the electrolytes is considered to be one of the most effective strategies to protect the electrode surface.

In this presentation, an alluring way to stabilize the electrode-electrolyte interface will be introduced. Functional additives are useful in making a robust interlayer that serves as a barrier to electrolyte decomposition. It is obvious that building innovative electrolyte additives is an immediate technological solution for high performance LIBs.

Keywords:
Li-ion battery, Electrolyte, Interface, Additives

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D3.01

Quantum optics in silicon nanophotonics

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Abstract:
Silicon-on-insulator (SOI) wafers have been developed for electronic integrated circuits, but are also one of the most promising platforms in photonic integrated circuits due to its low loss, high refractive index, ability to fast phase modulation, and well-developed fabrication technologies. With advantages to handling light with a small volume and high modulation speed, silicon photonics has been intensively investigated as the next generation platform of signal processing, interconnection, and communication devices. Recently, silicon photonics has been attracted great interests in quantum optics communities as optical quantum systems for linear optical quantum computing are achievable using silicon photonic components including beam splitters, phase modulators, and filters and the small footprint of a silicon photonic quantum system has unprecedented performances of high stability and scalability. Here we show our recent results on the fabrication of silicon photonic elements for quantum applications. We fabricated low-loss optical waveguides, efficient fiber-to-waveguide grating couplers, resonator-based optical filters, and tunable beam splitters and tested their performances. A micro-sized heater is attached on a Mach-Zehnder interferometer, showing stable operation as a slow phase modulator. In addition, phase modulators using plasma dispersion effects are under investigation. Finally, the quantum characteristics of photon pairs generated by spontaneous four-wave mixing in silicon waveguides are investigated. These results will be an essential cornerstone for the realization of quantum optical computing and quantum communication devices.

Keywords:
Quantum photonic integrated circuits, photon pairs, silicon photonics

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D3.02

Near-field levitated optomechanics with a photonic crystal cavity

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Abstract:

Optically levitated dielectric particles have emerged as a new exciting system for quantum optomechanics. It allows for excellent mechanical coherence under high vacuum and provides a possibility to optically configure potential landscapes. An outstanding problem is to realize control of the particle at the quantum level. Here we introduce a nanophotonic cavity to address this challenge. By optically trapping a 150 nm silica particle and placing it in the near field of a nanofabricated photonic crystal cavity, we achieve a single-photon optomechanical coupling between the particle's motion and the cavity, $g_0/2\pi$ = 9 kHz. By efficiently guiding the light through the fiber-cavity assembly, we demonstrate a significantly enhanced 'per-photon' displacement sensitivity, which are two orders of magnitude larger than previously reported in levitated optomechanics. I will discuss future outlook of the work towards realizing quantum experiments on the motion of a sub-micron sized particle.

Keywords:

Optomechanics, Quantum Optomechanics, Optical Levitation, Photonic Crystal Cavity

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D3.03*

Photon-Triggered Current Generation in Chemically-Synthesized Silicon Nanowires

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Abstract:

Exposing a porous Si segment to light can trigger a current in a Si nanowire (NW) with a high on/off ratio. Using this unique property, photon-triggered NW transistors, photon-triggered NW logic gates, and a single NW photodetection system have been recently demonstrated[1]. Here, we develop a reliable and simple procedure to fabricate porous Si segments in chemically-synthesized Si NWs for photon-triggered current generation. To achieve this, we employ 100-nm-diameter chemical-vapor-deposition grown Si NWs that possess an n-type high doping level and extremely smooth surface. The NW regions uncovered by electron-beam resist become selectively porous through metal-assisted chemical etching, using Ag nanoparticles as a catalyst. The contact electrodes are then fabricated on both ends of such NWs, and the generated current is measured when the laser is focused on the porous Si segment. The current level is changed by controlling the power of the incident laser and bias voltage. The on/off ratio is measured up to 1.5×10^4 at a forward bias of 5 V. In addition, we investigate the porous-length-dependent responsivity of the NW device with the porous Si segment. The responsivity is observed to decrease for porous segment lengths beyond 360 nm. Furthermore, we fabricate nine porous Si segments in a single Si NW and measure the identical photon-triggered current from each porous segment; this single NW device can function as a high-resolution photodetection system. Therefore, our fabrication method to precisely control the position and length of the porous Si segments opens up new possibilities for the practical implementation of programmable logic gates and ultrasensitive photodetectors.

1. Jungkil Kim et al. Photon-triggered nanowire transistors. *Nat. Nanotech.* **12**, 963-968 (2017).

Keywords:
photon-triggered current, silicon nanowire, porous silicon, chemical synthesis, photodetector

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D3.04

Study of metal nanostructure array for near-IR hyperbolic metasurface

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Abstract:
We present hyperbolic metasurface operating in broad wavelength from visible to the near-infrared range using gold nanowire array. The transverse electric mode, the electric field of which is highly confined in the gap, exhibits a hyperbolic dispersion, because of the strong near-field coupling between individual gold nanowire modes. The modal properties and dispersion relations of the metasurface-supporting modes are calculated by the finite-element method (FEM). Using the finite-difference time-domain (FDTD) method, we theoretically demonstrated that the hyperbolic metasurface on a silicon nitride slab waveguide supports the negative refraction for the transverse electric incidence. The correlation between the hyperbolic dispersion and negative refraction is successfully identified. The loss compensation of the hyperbolic dispersion mode by employing a gain medium is also examined.

Keywords:
Plasmonics, gold, structural color, hyperbolic metamaterial

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D3.05

Unique Scattering Properties of Silicon Nanowires Embedded with Porous Segments

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Abstract:

The advanced imaging tools are important for investigating the several properties of nanostructures of nanomaterials. In this work, we developed a simple and without damaging the samples method based on polarization-resolved light scattering measurements to characterized the structural and optical properties of complex nanomaterials. In particular, we examined a single Si nanowire embedded with porous Si segments, in which the porous Si could not be easily distinguished from solid Si by scanning electron microscopy. The polarization-resolved scattering analysis shows unique optical features of porous and solid Si. In particular, the porosity, diameter, and number of porous Si segments in a single Si nanowire are identified from the dark-field scattering measurements. Furthermore, we performed the optical simulations based on Bruggeman's model of effective medium approximation in individual porous and solid Si nanowires. A good agreement between the simulation and measurement results enabled the estimation of the structural parameters of the nanowires, such as diameter and porosity. We believe that our method can be further extended to various nanomaterials to characterize their structural and optical properties without the use of complicated and uneconomical imaging tools.

Keywords:

Si nanowire, porous structure, light scattering, dark-field image, finite-element method

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D4.01

일반 물리학 교육 개선을 위한 단기/장기 계획 및 교육 위원회 사업 소개

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Abstract:
본 강연에서는 물리학회 교육위원회의 다양한 활동 (정책, 사업, 대중화)과, 일반 물리학 교육 개선을 위한 단기/장기 계획에 대해 간략히 발표하고자 한다.

Keywords:
교육위원회, 일반 물리학 교육 개선

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D4.02

어떻게 가르칠까에서 어떻게 배우게 할까로... (From how to teach to how to learn)

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Abstract:
동료교수법을 기반으로 한 거꾸로 수업을 통하여 학생들의 능동적 수업 참여 방법을 소개하고자 한다. 이는 가르치는 행위가 가장 실제적이며 효과적으로 배우는 것이라는 것에 근거하고 있다. 동료교수가 이루어지기 위해, 수업에 들어오기 전에 Perusall을 통하여 충분한 읽기와 토론을 할 수 있도록 하고 수업시간에는 적절한 개념 검사지 문항들을 통하여 서로 다른 의견을 가진 학생들을 찾아 일대일로 상대방에게 본인의 생각을 설명하는 과정을 밟도록 한다. 학생들로 하여금 수업에 능동적으로 참여하게 하기 위해서 물리튜토리얼 방식의 접근이 필요한데 이를 통하여 질문을 어떻게 단계적으로 만들고 매우 세밀하게 만들어야 하는지를 소개하고자 한다.

Keywords:
동료교수법, 물리튜토리얼, 거꾸로 수업

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D4.03

교양물리학 교육의 오래된 미래 (Old Future of Liberal Physics Education)

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Abstract:

고등학교를 졸업하는 학생들에게 물리학은 어려운 과목일뿐더러 가장 싫어하는 과목이다. 고등학교까지의 경험에 비추어 보면 거의 모든 과목의 내용을 외워서 해결해 왔다. 그런데 물리학은 가장 외워야할 것이 많고 외우기 힘든 과목이었기 때문이다. 교양물리학을 가르치는 대부분 교수들의 경험은 이와 정 반대다. 고등학교 때 다른 과목에 비해 외워야할 것이 적었고, 최소한의 원리만 알고 몇 가지 단계만 거치면 모든 시험 문제를 해결할 수 있었다. 물리학을 전공하고 나니, 물리학은 세상의 모든 문제를 해결해 줄 수 있고, 심지어 아름답기까지 하다.
이런 상황은 전 세계 선진국의 대학에서 공통으로 겪는 문제다. 공통의 과제는 이공계를 전공하기에 필요한 기초 지식을 교양물리학에서 가르쳐야 한다는 것이다. 4차 산업혁명이 이끄는 변화에 학생들을 적응시키기 위해서는 새로운 교육 패러다임을 도입해야 한다.
이미 물리학을 새로운 방식으로 가르쳐야 한다는 운동은 1990년도에 미국에서 시작되었다. Active Learning이다. 2000년대에 스마트기기가 보급되면서 이 방식은 Flipped Learning이라는 이름으로 인기를 끌었다. 이 방식은 확실한 교육효과가 있음에도, 교수자가 이 방식의 교육을 위해 시간을 많이 투자해야 한다는 부담 때문에 많이 채용되지 않고 있다. 그러나 학생의 미래를 위해서는 꼭 필요한 교육 방식이고, 이를 소개하고자 한다.

Keywords:
교양물리학

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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D4.04

일반물리학에서 피지컬 컴퓨팅의 적용

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Abstract:

21세기의 일반 물리학 교육은 물리학의 기초 이론이 다양한 전공 분야에서 활용될 수 있음을 학생들이 알게 하는 것이 필요하다. 특히 4차산업 혁명이 강조되고 있는 시대에서 다양한 소프트웨어 능력 및 피지컬 컴퓨팅 능력은 물리학 이론과 괴리되거나 무관한 것이 아니라, 오히려 강력하게 결합되어 있으며 물리학 이론이 더 강하게 뒷받침할 수 있음을 보여주는 것이 필요하다. 본 발표에서는 물리학의 주요한 기초 개념들이 소프트웨어 능력 및 피지컬 컴퓨팅과 결합될 수 있는 예시들을 통하여 향후 우리나라 일반물리학 교육의 개선 방향을 제시하고자 한다.

Keywords:

4차 산업, 소프트웨어, 피지컬 컴퓨팅, 일반물리학

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D5.01

Applications of field-based microscopy

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Abstract:

The deterministic description for light propagation through complex media requires field-based representation using both the amplitude and phase information. This is essential for including the wave nature of light into the picture. In order to measure both the information simultaneously, the quantitative phase imaging method has been used in wide raging applications. Here in this presentation, we will introduce how the field-based microscopy has been utilized with the framework of the transmission matrix (TM) in our early development of deep-tissue imaging methods. In addition, several microscopic techniques based on the complex field measurements will also be introduced.

Keywords:

light propgation, complex media, quantitative phase imaging

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D5.02

Super-depth light energy delivery exploiting eigenchannels

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Abstract:

For non-invasive optical imaging, sensing, and stimulation of target objects embedded deep within a scattering medium, efficiently delivering light energy to target objects is crucial. However, multiple light scattering induced random wave diffusion drastically limits the light waves reaching the target object. Here, we present a method to focus multiple-scattered waves at the deeply embedded target. We experimentally identified and coupled light to the time-gated reflection eigenchannel which preferably enhances the reflection of multiple-scattered waves that have interacted with the target object. For targets not resolved by optical imaging, we achieved a more than tenfold enhancement in light energy delivery compared to uncontrolled inputs. This work provides a foundation for enhancing the working depth of optical methodologies.

Keywords:

super-depth, light energy delivery, eigenchannel, time-gating

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D5.03

Acousto-optic approaches to solve optical complexity in biological tissues

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Abstract:
This talk will explore two acousto-optic approaches to solve the optical complexity in biological tissues and present the proof-of-concept of seeing through biological tissues. One approach is to retrace multiple light scattering in a 'time-reversed' fashion using optical phase conjugation and the other is to reject the multiply scattered light for a better visibility of ballistic light. I will also discuss our recent efforts towards integrating the acousto-optic approaches with the time-resolved approaches to further improve the optical imaging depth inside a biological tissue.

Keywords:
complex optical system, imaging, wavefront shaping, acousto-optics, ultrafast optics

D5.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Deep imaging based on matrix approach

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Abstract:

Light waves propagating in biological tissues undergo wavefront distortion because of spatial heterogeneity of anatomical structure and cellular distribution, etc. This results in blurring of the optical focus and the reduction of the resolving power. Numerous efforts have been made to compensate the sample-induced aberration by adaptive optics and to recover the diffraction-limited spatial resolution for deep-tissue imaging. Typically, previous AO microscopes have been developed for fluorescence imaging by using focused guide star. However, it generally requires to measure wavefront deformation or to iteratively feedback control of wavefront shaping prior to image acquisition. On the contrary, we have investigated novel methods for deep imaging using time-gated reflection matrix. Experimental setup is based on full-field and time-gated interferometric microscopy. Adaptive optical correction is computationally processed by analyzing time-gated complex-fields of backscattered waves for various incident angles, thereby the single-scattered waves are distinctly enhanced by collective accumulation. Our method of distinguishing single- from multiple-scattered waves will open new ways to deep imaging and studying the physics of the interaction of light with complex media

Keywords:

multiple scattering, adaptive optics, interferometric microscopy

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D6.01

Exotic thermal phase transitions in topological phases

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Abstract:
Fathoming deconfined phases is one of the key issues in modern condensed matter since striking many-body effects including massive quantum entanglement and coherence may be realized, as manifested in quantum spin liquids and topological orders. Here, we show that deconfined phases even host exotic thermal phase transitions. Constructing Z2 lattice gauge models with interactions between Z2 gauge fluxes, we prove the existence of a deconfined-confined thermal phase transition in two spatial dimensions in sharp contrast to its absence in the Wegner model. We also show that symmetry breaking transitions in deconfined phases may be unconventional. Z2 and U(1) symmetry breaking transitions in three spatial dimensions may be in the same universality class, which is impossible under the conventional Landau-Ginzburg-Wilson paradigm. Characteristic signatures of the transitions in experiments and candidate strongly correlated systems such as Kitaev materials are also discussed.

Keywords:
Deconfined phase, topological order, thermal transition

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D6.02

Shining light on van der Waals materials: symmetry and topology

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Abstract:

Searching for “universality” is equivalent to the finding of “types of order” in solid-state physics. A long-standing belief was the Landau symmetry breaking; yet modern quantum theory invoked topology to comprehend the solid-state version of “universality”.

This talk is all about the “symmetry” and “topology”. A key connector is Berry phase, which is easily parameterized as the quantum degrees of freedom (DoF) in van der Waals (vdW) materials. Followed by a brief introduction, focus will be made on the following exceptional observations when the vdW systems are taken out of equilibrium by optical excitation. (i) The spin-valley locking in vdW can be unlocked by circularly polarized optical excitation in the heterostructures of transition metal dichalcogenides (TMD) and topological insulators (TI) [1]. (ii) Broken in-plane symmetry in TMD enables to observe the excitonic quantum coherence, manifested by the quantum beats and optical Stark effect [2,3]. (iii) Symmetry protected Dirac surface in 3D TI provides extrinsic means for observing and exploiting the quansiparticle Fano inteterference [4,5].

References

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Short bio of Hyunyong Choi

Professor Hyunyong Choi received his B.S. degree in Department of Electrical and Electronic Engineering at Yonsei University in 2002. He did his M.S. and Ph.D. in Department of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor in 2004 and 2007, respectively. After the postdoctoral work at Lawrence Berkeley National Laboratory from 2008 to 2010, he has been working at Yonsei University as an Assistant Professor (2011.3-2015.8) and as an Associate Professor (2015.9-present).

Keywords:
symmetry, topology, topological insulators, graphene, van der Waals materials

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D6.03

Enhanced Superconductivity in “Magic” Conducting Networks in Charge-Density Waves

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Abstract:

We present a novel theory of a conducting honeycomb network as a low-energy description of electronic states in some nearly commensurate charge-density wave systems. In this model, we theoretically uncover the emergence of a large number of flat bands and symmetry-protected quadratic/Dirac band crossings. Due to these features, the system generically has strong instabilities toward exotic superconducting states and topological band insulators. We extensively explore the unusual symmetry representations, topology, and emerging superconductivity of this new model. We compare our model with that of the twisted bilayer graphene and discuss its relevance to the experimentally available materials, e.g., TaS_2. As a byproduct of this theoretical investivation, we also provide a general recipe for realizing "flatter" bands and thus “higher”-Tc superconductors.

Keywords:

Unconventional Superconductor, Charge Density Wave, Topological States, Twisted Bilayer Graphene,

D7.01

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Graphene Transistor Based on Tunable Dirac-Fermion-Optics

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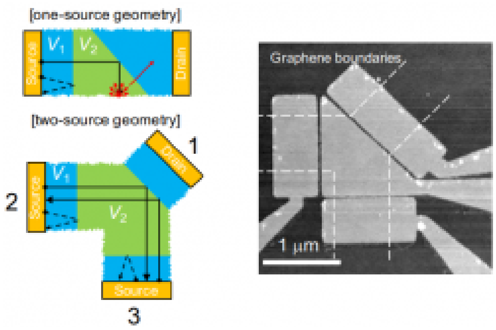
Abstract:

The linear energy-momentum dispersion, coupled with pseudo-spinors, makes graphene an ideal solid-state material platform to realize an electronic device based on Dirac-Fermionic relativistic quantum mechanics. Employing local gate control, several examples of electronic devices based on Dirac fermion dynamics have been demonstrated, including Klein tunneling, negative refraction and specular Andreev reflection. In this work, we present a quantum switch based on analogous Dirac-fermion-optics (DFO), in which the angle dependence of Klein tunneling is explicitly utilized to build tunable collimators and reflectors for the quantum wave function of Dirac fermions. We employ a novel dual-source design with a single flat reflector, which minimizes diffusive edge scattering and suppresses the background incoherent transmission. Our gate-tunable collimator-reflector device design enables measurement of the net DFO contribution in the switching device operation. We measure a full set of transmission coefficients of DFO wavefunction between multiple leads of the device, separating the classical contribution from that of any disorder in the channel. Since the DFO quantum switch demonstrated in this work requires no explicit energy gap, the switching operation is expected to be robust against thermal fluctuations and inhomogeneity length scales comparable to the Fermi wavelength. We find our quantum switch works at an elevated temperature up to 230 K and large bias current density up to 102 A/m, over a wide range of carrier densities. The tunable collimator-reflector coupled with the conjugated source electrodes developed in this work provides an additional component to build more efficient DFO electronic devices.



Keywords:
Graphene, Dirac Fermionic Optics, Ballistic transport

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D7.02

Valley dependent directional emission of transision metal dichalcogenides layers

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Abstract:

We demonstrate the valley(spin)-dependent directional emission of transition metal dichalcogenides (TMD) into plasmonic eigenstates of a silver nanowire. A monolayer of TMD materials has direct bandgaps consisting of two (energy-degenerate) valleys at the corners of the Brillouin zone (K, K'), which provide an opportunity to manipulate the additional degree of freedom, i.e., the valley degree of freedom. And valley information can be optically addressed and detected using the spin angular momentum of light, due to their valley-dependent optical selection rule. The highly confined mode of a plasmonic nanowire provides a high degree of local transverse optical spin, and its handedness is locked to the propagation direction of the mode. As a result, the emission from the two different valleys of TMD material will couple to the plasmonic modes propagating in opposite directions. The high valley polarization of TMD and high density of the transverse optical spin of the plasmonic wire together offer a novel platform for a chiral network even at room temperature without any magnetic fields. This result paves the way towards a new platform for exploiting a valley pseudospin in integrated valleytronics devices using nanophotonics structures.

Keywords:
2D semiconductor, valley psedospin, chiral interaction

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D7.03*

Coexistence of surface and bulk Dirac fermions in a correlated kagome metal FeSn

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Abstract:
Kagome lattice is a two-dimensional network of corner-sharing triangles, originally spotlighted for their frustration-driven exotic spin orders. Recent theoretical investigations have extended the interest to electronic excitations in kagome lattice, where the combination of lattice symmetry, spin-orbit coupling, and unusual magnetism sets an ideal stage for novel topological phases. Very recently, the proposed topological phases including magnetic Weyl semimetals and Chern insulators have been successfully realized in binary kagome compounds TM_mX_n (TM = Mn, Fe, Co, X = Sn, Ge, m:n=3:1, 3:2, 1:1), in which concomitant large intrinsic anomalous Hall conductivities have been universally detected. Interestingly, despite the common kagome building blocks, the topological electronic structures in TM_mX_n series seem to vary widely from 2D massive Dirac fermions (Fe_3Sn_2) to 3D magnetic Weyl fermions (Mn_3Sn) depending on the stacking of kagome planes. This demonstrates the wide variety of topological physics hosted by kagome compounds with different interlayer interactions. Here, we investigated a single-layer kagome metal FeSn with simplest yet unstudied stacking structure. Our thorough electronic structure study combining surface-sensitive angle-resolved photoemission spectroscopy (ARPES) and bulk-sensitive de Hass van Alphen experiment (dHvA) proposes FeSn as the first material simultaneously hosting the surface and bulk Dirac fermions.

Keywords:
kagome lattice, topological materials, Dirac fermions, angle-resolved photoemission spectroscopy

D7.04*

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Temperature-driven Lifshitz transition triggering non-Fermi liquid behavior in monoclinic Nb_2Se_3

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Abstract:

Quadratic temperature dependence of resistivity at low temperature observed in many transition metals is understood by Fermi liquid model. However, some systems show non-Fermi liquid behaviors, where resistivity-temperature exponent is less than two. While quantum fluctuations or external parameter-induced Lifshitz transitions have been investigated as the origin of the non-Fermi liquid behaviors, the understanding is not clear and suitable materials are needed for the rigorous studies. Here, we report on temperature-driven Lifshitz transition and non-Fermi liquid behavior in layered monoclinic Nb_2Se_3 single crystals. Since the Nb_2Se_3 has enough carrier density (~10^{15} cm^{-2}) and the Lifshitz transition is solely induced by temperature, we could simplify the scattering mechanism in the electrical transport, and the non-Fermi liquid behavior is quantitatively explained by a developed semiclassical scattering model.

Keywords:

Layered semimetal, temperature-driven Lifshitz transition, non-Fermi liquid

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D8.01

Reformulation of the U(1) gauge symmetry free of redundancy and a generalized Byers-Yang theorem

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Abstract:
We present a reconstruction of the U(1) gauge theory by eliminating the redundancy inherent in the conventional approach. The gauge symmetry in our framework is associated with a physical transformation, that is, invariance of the equation of motion under change in the distribution of the external electromagnetic field at a distance. Observational consequences will be discussed in terms of the generalized Byers-Yang theorem applied to a superconducting weak link.

Keywords:
U(1) gauge symmetry wiithout redundancy, Byers-Yang theorem, superconducting weak link

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D8.02

Coulomb Enhanced Superconducting Pair Correlations in the Frustrated Quarter-Filled Band

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Abstract:

The competition between broken symmetry phases and magnetism in the cuprate high temperature superconductors has been extensively studied in recent years. Similar phases exist also in many other correlated-electron superconductors, including quasi-two-dimensional superconducting organic charge-transfer solids. Strong electron-electron interaction is believed to play the key role in these superconductors. We propose that the attractive interaction between the charge careers is the tendency to form nearest neighbor spin-singlet bonds, which is strongly enhanced at the carrier density of 0.5 a charge carrier per site. We have performed state of the art numerical calculations on different finite size triangular lattices. We have shown that the pairing tendency for each cluster is enhanced by electron-electron interaction only for density ~ 0.5, far away from the density range thought to be important for superconductivity. Although initial focus is on charge-transfer solids, the results of the research will impact the field of correlated electron superconductivity as a whole. The calculations will provide fundamental and fresh insight to the theory of superconductivity in strongly correlated systems.

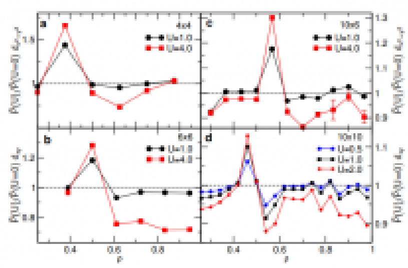

FIG. 2: Density dependence of dominant ground state pair-pair correlations. [illegible]

Keywords:

superconductivity, quarter-filling, organic superconductors, magnetism, broken symmetry, strongly correlated system

D8.03

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Projected BCS theory for strongly-correlated high-temperature superconductivity

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Abstract:

In order to investigate whether strong correlation is a source of high-temperature superconductivity or not, we perform a variational analysis of the *d*-wave BCS Hamiltonian projected onto the constrained Hilbert space with no double occupancy induced by the infinitely strong on-site correlation. For convenience, let us call such an analysis the projected BCS theory. In this work, we compute the overlap between the ground states of the projected BCS theory and of the *t-J* model which are obtained via the exact diagonalization method. It lets us conclude the projected BCS theory provides excellent variational states for the ground states of the *t-J* model in the entire range of hole concentration including both half filling and finite doping. By computing the overlap between the resonating valence bond (RVB) state and the ground states of the *t-J* model, we show the RVB state is closely related to the ground state of the projected BCS theory, while quite different at low doping.

Keywords:

projected BCS theory, t-j model, RVB state, exact diagonalization

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D8.04

The maximum superconducting T_C on the metal-insulator phase boundary of the normal state

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Abstract:
We show that the maximum superconducting Tc is on the phase boundary between metallic and insulating states of the normal state based on the half-filled Hubbard-Holstein model. The prototype model for understanding the interplay between an instantaneous local Coulomb interaction U and the electron-phonon coupling g is the Hubbard-Holstein model. The ground state is metallic when both |U| and g are small, but is insulating when |U| or g is large and they are distinguished to Mott-Hubbard insulator (MHI) and bipolaron insulator (BPI) respectively. In particular, we discuss the variation of superconductivity by changing both the Coulomb interaction and the electron-phonon coupling and we identify the superconducting properties in the BCS and BEC regimes. In addition, the effect of phonon softening on superconductivity is investigated in the strong correlation regime.

Keywords:
superconductivity, Hubbard-Holstein model, electron-phonon coupling

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D8.05

Quasi-one dimensional nanoscale electronic modulation in iron pnictides and chalcogenides

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Abstract:

Impurity scattering is found to lead to quasi-one dimensional nanoscale modulation of the local density of states in the iron pnictides and chalcogenides. This 'quasiparticle interference' feature is remarkably similar across a wide variety of pnictide and chalcogenide phases, suggesting a common origin. We show that a unified understanding of the experiments can be obtained by invoking a four-fold symmetry breaking dxz −dyz orbital splitting, of a magnitude already suggested by the experiments.

Keywords:
QPI, pnictides, chalcogenides, nematic, superconductivity, spin-density wave state

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D8.06*

Strain-Induced Rotation of Nematic Ordering in Fe-based Superconductor $Ba(Fe_{1-x}Co_x)_2As_2$: Instability of Nematic State

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Abstract:

We performed strain- and polarization-dependent near-infrared pump-probe measurements on $Ba(Fe_{0.955}Co_{0.045})_2As_2$. Polarization-dependent evolution of transient reflectivity change reveals broken C_4 symmetry in nematic state. Without strain, the breaking of C_4 symmetry occurs along crystallographic Fe-Fe bonding directions. Under uniaxial-strain, however, the breaking direction is rotated by 45 degrees so that it becomes diagonal to Fe-Fe bonding direction. Furthermore, broken C_4 symmetry is observed homogeneously in a wide spatial region but its intensity exhibits density-wave like stripe-pattern along a direction diagonal to the original twin-domain direction under no-strain. Our observations on strain-induced rotation of C_4 symmetry-breaking direction suggest the instability of nematic state in Co-doped Ba122 system.

Keywords:

Fe-based superconductor, nematicity, strain-induced effect, ultrafast phenomena

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Effect of low-energy carbon-ion irradiation in MgB_2 thin films

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Abstract:

We investigate the influence of low-energy carbon-ion irradiation on MgB_2 thin films with thicknesses of 400 (MB400nm) and 800 nm (MB800nm). The films were irradiated with 350 keV carbon (C) ions with a wide range of dose level, 1×10^{13} - 1×10^{15} C atoms/cm^2, and the mean projected range of irradiated C ions is around 560 nm, estimated from a SRIM (The Stopping and Range of Ions in Matter) Monte Carlo simulation program. The superconducting transition temperature (T_c) of both films gradually decreased with increasing dose levels, accompanied with an expansion of *c*-axis lattice constant, while the upper critical field (H_{c2}) of 6.16 and 5.85 T for pristine MB400nm and MB800nm increased to 11.09 T and 9.78 T, respectively, at the dose level of 2×10^{14} C atoms/cm^2. In addition, the field performance of critical current density (J_c) is largely improved after C-ion irradiations caused by the additional flux-pinning sites of normal point defects, such as vacancies and interstitials. Interestingly, the modified superconducting critical properties, such as T_c, H_{c2}, and J_c, of the C-ion irradiated MgB_2 films, as well as the expanded *c*-axis lattice parameter, were almost recovered to those in the pristine state after a thermal annealing procedure. These results indicate that the change of superconducting critical property of MgB_2 films by low-energy ion irradiation is induced by atomic lattice displacement, which is reversible by thermal annealing.

Keywords:

carbon-ion irradiation, MgB2 thin film, lattice displacement

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D8.08*

The vortex configuration of mesoscopic unconventional superconductors

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Abstract:
We investigate the vortex configuration in unconventional superconductors of mesoscopic size. It is well-known that, in such small systems, the size and its shape have a profound influence on the formation of the vortex structure, leading to interesting phenomena such as a giant vortex and an anti-vortex. We present unusual vortex structures when the order parameters are unconventional and multi-dimensional. Especially, we focus on the vortex configurations in mesoscopic unconventional superconductors. The results are compared with those in conventional ones. The vortex structures are obtained by minimizing the Ginzburg-Landau free energy, using the simulated annealing method.

Keywords:
unconventional superconductivity, vortex structure, mesoscopic system

D8.09

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Analysis of local magnetic properties of striated high-temperature superconducting tapes by using scanning Hall probe microscopy

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Abstract:
As the technology of the second-generation high-temperature superconducting coated conductor is skilled in recent years, various studies are required for applications. In particular, reducing AC losses is one of the main issues. It has been widely known that reducing the width of the superconducting layer according to the critical state model reduces the magnetization loss. Therefore, a method of effectively reducing the width of the superconducting layer using striated tapes has been proposed. In this study, we investigated the local magnetic fields of various geometrical types of GdBCO coated conductors by using scanning Hall probe microscopy. The magnetization loss of each sample was compared by the analysis of the local magnetic fields.

Keywords:
HTS tape, SHPM, GdBCO, hysteresis loss

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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D9.01

Towards High-Performance Solution-Processed Organo-Metal Halide Perovskite Cross-Point Array Resistive Memory Devices

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Abstract:
Resistive random-access memory (RRAM) has emerged as a future candidate for next-generation memory technology because of their merits such as non-volatility, low-operational energy, and simple operation principles based on resistive switching effect. Recently, RRAM devices based on solution-processed materials have been extensively explored owing to their easy and low-cost fabrication processes. Recently, resistive memory devices based on organo-metal halide perovskite materials have shown outstanding performances; a low-voltage operation and a high ON/OFF ratio which are essential for realizing low-power consumption memory. In this presentation, we report the results on unipolar resistive memory devices in a crossbar-array architecture made by using a non-halide lead source to deposit perovskite films via a simple single-step spin-coating method. Our perovskite memory devices achieved a high ON/OFF ratio up to 10^8 with a relatively low operation, a large endurance, and long retention times. In addition, we discuss a potential resistive switching mechanism for our perovskite memory devices which exhibit a unique unipolar (non-polar) resistive switching, unlike the previously reported perovskite memory devices. Furthermore, we directly demonstrate one-diode-one-resistor scheme with our perovskite memory devices to enhance the selectivity of memory operation. These results, combined with a high-yield device fabrication based on solution-process demonstrated here, will contribute towards developing low-cost and high-density practical perovskite memory devices.

Reference
1. K. Kang *et al.* manuscript under revision.

Keywords:
organo-metal halide perovskite, perovskite memory devices, nonvolatile memory, resistive switching, cross-bar array architecture

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D9.02*

Optoelectronic Properties with Excitonic Behaviors in Hybrid Perovskite Crystal

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Abstract:
Hybrid perovskites have gained tremendous attention for its attractive optical and electronical properties. Understanding and controlling the intrinsic properties of this material is important for solving the unsettled questions and advancing the performance of the diverse optoelectronic applications. At this point, we focused on the investigation of $CH_3NH_3PbCl_3$ perovskite single crystals which are considered an ideal form without having interfacial effects. We verified the structural properties by using the temperature dependence photoluminescence and transmission spectra. We observed the unusual excitonic behaviors near band edge region through the comparing both. In addition, we determined the surface potential distribution with/without the external light source via Kelvin probe force microscopy. Depending on the various light source, we presented the electronic band structures of perovskite crystal which reveal the semiconducting nature of the materials by consolidating the result values of the band gap energy, the work function, and surface photovoltage. We could suggest the structural properties of perovskite structure and possibility to apply to many optoelectronic devices.

Keywords:
Perovskite, Single crystal

D9.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Enhancing Vertical Charge Transport of a Conjugated Polymer Thin Film via Molecular orientation transformation by an ultrafast Laser process

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Abstract:

Modification of the molecular orientations and structures of organic compounds in organic thin films is in an urgent demand to achieve high-efficiency organic opto-electronics by overcoming the low levels of charge transport. We will present structural transformation and electrical characterization of a poly(3-hexylthiophene) (P3HT) organic semiconductor thin film under femtosecond laser irradiation at a level below the ablation threshold. A series of laser fluence levels ranging up to the ablation threshold was tested, and the P3HT film with a transformed face-on orientation resulting from the optimized fluence level showed a charge current in the vertical direction three times greater than did the pristine film. This enhancement in the charge current was attributed to the vertical π-π stacking of the face-on orientation.

A combination of GIWAXS(grazing incidence wide angle X-ray scattering) and NEXAFS(near edge X-ray absorption fine structure) analyses reveal that the laser procedure effectively switches the P3HT molecular orientation from edge-on to face-on, and the stability of this face-on orientation was also confirmed.

These results showed the effectiveness of our novel method for modifying organic thin films, and this method could be attractive for the applications of organic electronics and hybrid devices.

Keywords:

fs Laser, conjugated polymer, organic semiconductor, molecular orientation, carrier transport, c-AFM

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D9.04*

Effective fixed quantity drug delivery using by hyaluronic acid microneedle under ultrasonication and iontophoresis

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Abstract:

To realize effective transdermal drug delivery, multifunctional systems of Hyaluronic acid (HA) microneedles have been developed for the use in combination with ultrasonification and iontophoresis. A lot of HA microneedles were fabricated with different needle densities. By adjusting the concentration of the needles, we controlled the amount of drug that is delivered to the destination. Ultrasonication and AC electric field application were employed to promote the drug absorption, where ultrasonication induces vibration and cavitation effects on HA microneedles, and AC iontophoresis generates the electrical repulsion between HA ions and rhodamine b. In vitro gelatin hydrogel, we analyzed the release difference of rhodamine with/without ultrasound. We calculated the intensity and evaluated the AC frequency and voltage dependence on ion induction transfer. Results showed the material property of permeability is dominant as the frequency increases. Thus, we improved the melting of HA microneedles from about 30% to about 80% under initial minutes in gelatin by combining ultrasound and iontophoresis. By combining these multiple functions, drug delivery efficiency was evaluated from transport phenomenon perspective. This study provides a platform for synergy, and will find a useful application in the field of drug delivery.

Keywords:
Dissolving microneedle, Dissolution rate, Ultrasound, Iontophoresis, Gelatin hydrogel

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D9.05*

Effect of Ag Nanoparticles on the Performance of Inverted Perovskite Solar Cells

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Abstract:

Recently, perovskite solar cells (PSCs) have attracted a phenomenal research interest in their potential as the next-generation photovoltaic. However, increasing their power conversion efficiency (PCE) remains a critical issue for PSCs. In this work, we have investigated the application of Ag nanoparticles (NPs) via via-phase deposition onto perovskite active layers. The macaronic shape of Ag NPs that is confirmed by investigating the SEM, in addition, XPS spectra which show the formation of silver-iodide (Ag-I) accounted for the peculiar shape of Ag NPs. The PCE for devices incorporating an optimized size of Ag NPs of 90 nm increased from 11.63% to 13.46% with the improvement factor of 15.74%. The increase in PCE is attributed to the increase in J_{sc} that is assigned to increase absorption. As NPs can increase the optical path lengths of photons in the near field enhancement and scattering of light and consequently they can improve the photon to electron conversion efficiency (ΔIPCE) and PCE of PSCs. Also, the study of UPS revealed the decrease in hole injection barrier (ϕ_h) also contributed to enhanced performance.

Keywords:

Perovskite, Ag NPs, Macaroni shape,

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D10.01

Fluctuation: Fingerprint of Universal Principle

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Abstract:

As physicists, we are always striving to find a universal principle underlying a given physical phenomenon. However, it is not an easy task because clear picture of the principle is sometimes veiled by large fluctuation observed in experiments or numerical simulations. In this sense, fluctuation is usually regarded as a 'teasing' factor which keeps us from understanding or elucidating the universal principle. In this presentation, however, I will talk about a completely different aspect of fluctuation. With the information of fingerprint we can find its owner. Likewise, if we carefully look into the fluctuation, it sometimes acts as a fingerprint, so it helps us identify the underlying principle. As a concrete example, I will talk about universal features of fluctuation observed in resistance switching (RS) phenomena. Large fluctuation is commonly observed in RS phenomena. At first glance, the fluctuation looks random and predictable. However, we can find the universal principle from the material-independent scaling behavior of the fluctuation.

Keywords:

resistive switching, random circuit breaker network model, percolation

D10.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Non-Gibbs states on a Bose-Hubbard Lattice

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Abstract:

We study the equilibrium properties of the repulsive quantum Bose-Hubbard model at high temperatures in arbitrary dimensions, with and without disorder. In its microcanonical setting the model conserves energy and particle number. The microcanonical dynamics is characterized by a pair of two densities: energy density ε and particle number density n. The macrocanonical Gibbs distribution also depends on two parameters: the inverse nonnegative temperature β and the chemical potential μ. We prove the existence of non-Gibbs states, that is, pairs (ε,n) which can not be mapped onto (β,μ). The separation line in the density control parameter space between Gibbs and non-Gibbs states $\varepsilon\sim n^2$ corresponds to infinite temperature β=0. The non-Gibbs phase can not be cured into a Gibbs one within the standard Gibbs formalism using negative temperatures.
*This work was supported by the Institute for Basic Science, Project Code IBS-R024-D1. TE acknowledges financial support by the Alexander-von-Humboldt foundation through the Feodor-Lynen Research Fellowship program Nr. NZL-1007394-FLF-P.

Keywords:

Non-Gibbs states, Bose-Hubbard Lattice

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D10.03

Critical hysteresis on dilute triangular lattice

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Abstract:

We revisited the problem of critical hysteresis in the framework of random-field Ising model on a triangular lattice, by diluting the occupation probability c of one of its sublattices. Varying c translates the triangular lattice (c=1) which shows critical behavior to a honeycomb lattice (c=0) with no critical hysteresis. Our new result suggests the absence of criticality for \$c<0.6(approx)\$ which is a larger range compared to earlier result where critical hysteresis vanishes for \$c₩le1/3\$.

Keywords:

Phase transition, critical phenomena

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D10.04

First-passage statistics under stochastic resetting in bounded domains

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Abstract:

In this work, we investigate the first-passage problem where a random walker stochastically resets to a fixed position at a constant rate in a bounded domain. We put forward a novel analytical framework for this problem where the resetting rate r, the reset position xr, the initial position x0, the domain size L, and the particle's diffusion constant D are independent variables. From this we obtain analytical expressions for the mean-first passage time, survival probability and the corresponding first-passage time density in Laplace space in terms of the above independent variables, and closed forms in time-domain expression in some cases. For the first-passage time distributions their full-time profiles in time-domain are numerically obtained and validated by Monte Carlo simulations. We show that for the general resetting condition xr 6= x0 the first-passage process has rich nontrivial features as it combines effects from resetting and the finiteness of the domain. A phase diagram showing the regions for resetting-enhanced and -suppressed first-passages is obtained analytically. Counterintuitively, resetting facilitates the first-passage event even if the particle resets to a position that is further away from the target than where it started. Finally, we show that averaging over resetting positions, resetting never helps the search compared to a random search, unless the resetting position is displaced from the initial position.

Keywords:
First-passage time, Stochastic resetting, bounded domain, optimal search

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D10.05

Shortcuts-to-isothermal transport of a Brownian particle

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Abstract:

An isothermal process is a quasistatic process at a constant temperature which requires a long transition time. Recently, there have been many challenges to accelerate the isothermal process at the finite time, called shortcuts-to-isothermality. Here, we experimentally study the realization of shortcuts-to-isothermal transport of a Brownian particle dragged by the harmonic potential at the finite transition time. We achieve the faster particle relaxation from one equilibrium state to another than the intrinsic relaxation time of the harmonic potential. We also find that the probability distribution function of the particle position is invariant during the transport. Our result confirms that the particle stays in the instantaneous equilibrium although the total system is in highly nonequilibrium.

Keywords:
Nonequilibrium thermodynamics, Optical tweerzers

D10.06

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무작위 매질 속의 브라운 입자계에 대한 집합적 양을 이용한 장론적 접근방법 연구

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Abstract:
무작위 포텐셜의 영향 하에 상호작용하지 않는 브라운 입자에 관한 기존 연구들은 대개 개별 입자의 이동 성질을 다루었다. 그러나 무작위 환경 속의 입자들은 직접적인 상호작용이 없다해도 주어진 무작위 환경에 놓여 있다는 사실에 의해 서로 얽히며, 이로 인해 여러 집합적인 행동이 발생할 수 있다. 이와 같은 행동들을 다루기 위해, 본 연구에서 우리는 집합적인 물리량인 밀도를 이용하는 Martin-Siggia_Rose (MSR)형식의 동역학적 장론을 설계하였고 이를 통해 이 물리계의 intermediate scattering function을 주는 밀도-밀도 상관 함수와 같은 집합적인 물리량을 장론적 방법으로 계산하였다. 먼저 무작위 포텐셜의 크기가 작을 경우에 대해 섭동적 방법으로 반응 함수와 밀도-밀도 상관 함수의 무작위 포텐셜의 상관 함수에 대한 1차 보정항을 계산하였다. 그 결과 충분히 시간이 클 경우 두 보정항이 시간의 함수로 멱 법칙을 따른다는 것을 확인하였다. 이어서 Feynman diagram의 부분 합 방법을 이용하여 self-consistent 방정식을 유도하고 이를 통해 무작위 포텐셜의 크기가 클 경우의 밀도-밀도 상관 함수를 연구하였다. 우리는 이 연구가 다루는 MSR 액션에 존재하는 요동-분산 관계를 확인하였고 여러가지 부분 합 방법들이 그것을 만족시키지 않는다는 것을 확인하였다. 그 결과가 여러 부분합 방법에서 어떠한 문제를 일으키는지에 대해 연구하였다. 또한 이 문제를 해결하기 위하여 추가적인 장을 도입하여 부분 합 계산이 가능하도록 개선된 장론을 만들 수 있는 방법을 소개하였다.

Keywords:
Brownian motion, Random media, Martin-Siggia-Rose field theory, Intermediate scattering function

D10.07

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Oscillating bubbles in anisotropic viscoelastic fluids are microswimmers

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Abstract:
Propulsion at low Reynolds number (Re) has been of great interest because of its close relation to the design of artificial microswimmers as well as the study of microorganisms. It depends on various properties such as the shape and motion of swimmers and viscoelasticity of surrounding fluids, but physics tells us that the essence of the propulsion at low Re is how the swimmer breaks spatial and time-reversal symmetries. Namely, it should choose one direction to swim toward, and non-reciprocal motion is required for the swimmer to have a net displacement after a set of movement. Many theoretical models with only a few experimental model systems have been suggested to achieve this symmetry breaking. Here we propose a simple experimental model system based on an oscillating bubble utilizing the anisotropy and viscoelasticity of nematic liquid crystals (LC). First, a bubble dispersed in a homogeneously aligned nematic LC accompanies a topological defect because of a perpendicular boundary condition. Two different types of defects, i.e., a hyperbolic hedgehog point defect or a Saturn-ring defect, with the same topological charge have been observed, and only the bubble dressed with the point defect exhibits the broken spatial symmetry. Controlling the pressure, we modulate the size of the bubble in LC, then the flow generated by the size modulation of the bubble breaks the time-reversal symmetry because of the viscoelastic response of the nematic LC. We have investigated systematically how the propulsion speed depends on bubbles' average size, the amplitude/frequency of size modulation, and the confinement size. Finally, to explain the propulsion mechanism, we suggest a simple theoretical model based on the multipole expansion of the radial potential flow and the viscoelastic response of anisotropic fluids. We acknowledge the financial support of the Korean government via IBSR020-D1, NRF-2018R1C1B6002811, and NRF-2018R1A6A3A01010921.

Keywords:
Microswimmer, Liquid crystal, Reynolds number, viscoelastic response, viscosity, elasticity, symmetry breaking

D11.01

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2019-04-24 - 2019-04-26

Single-molecule observation of the folding pathways of β-adrenergic receptors

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Abstract:

Membrane proteins are designed to fold and function in a lipid membrane, yet folding experiments within a native membrane environment are challenging to design. Here we show that single-molecule forced unfolding experiments can be adapted to study helical membrane protein folding under native-like bicelle conditions [1]. After inducing mechanical unraveling of target membrane protein with high mechanical tension, we relaxed the membrane protein to restore its secondary structures as well as to ensure its membrane insertion. Under a low level of mechanical tension, we observed the single membrane protein completed its folding process while exhibiting defined intermediate states. Application of this experimental method revealed the folding pathways in unprecedented details for diverse membrane proteins that ranged from GlpG, an *e. Coli* membrane protease, to human b-adrenergic receptor, indicating general applicability of the developed method. The identified folding pathways share two important features: (1) N-to-C unidirectional folding and (2) high one dimensionality in the folding energy landscape. These features suggest that the folding pathways of integral membrane proteins are evolutionarily tailored to increase the fitness with co-translational folding.

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Keywords:

Membrane proteins, Magnetic tweezers

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

D11.02

Allosteric coupling mediated by intrinsically disordered regions in macromolecular assemblies

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Abstract:
Diverse cellular activities are regulated by multi-component macromolecular assemblies. A remarkable feature of many such assemblies is that their protein subunits contain long intrinsically disordered regions (IDRs) dynamically interconverting among multiple conformational states. Despite the abundance of IDRs in the eukaryotic proteome and their strong association with many pathological conditions, it remains elusive how they contribute to the functions of the macromolecular complexes at the molecular level. A representative system for such a problem is the Nuclear Pore Complex (NPC) that mediates molecular transport between the nucleus and the cytoplasm in eukaryotic cells. We characterized biophysical and structural features of the two main sub-complexes of the NPC and the interaction of each sub-complex with transport factors (cargo carriers). Our quantitative characterization demonstrates that these sub-complexes are assembled from weak and dynamic interactions among their building blocks (collectively termed nucleoporins or Nups). Remarkably, binding of a transport factor to an IDR present in each sub-complex allosterically modulates the Nup interaction network and the conformational state of the sub-complex. We propose that allosteric modulation of Nup assemblies by transport factors is critical for the NPC to regulate its conformation in response to various transport demands as well as for NPC biogenesis. The concept of IDR-mediated allostery and the quantitative methods developed in this study should be broadly applicable to other biological systems such as the eukaryotic transcriptional machinery.

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D11.03

Integrative Structure and Functional Anatomy of a Nuclear Pore Complex (NPC)

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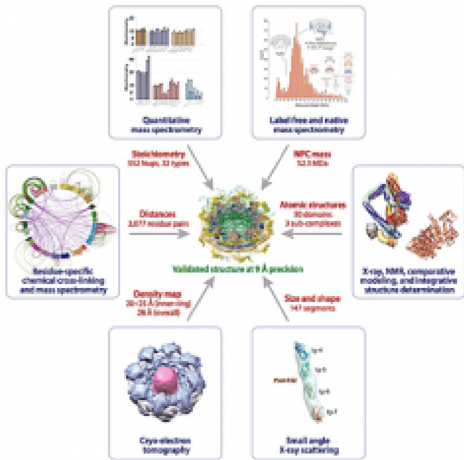
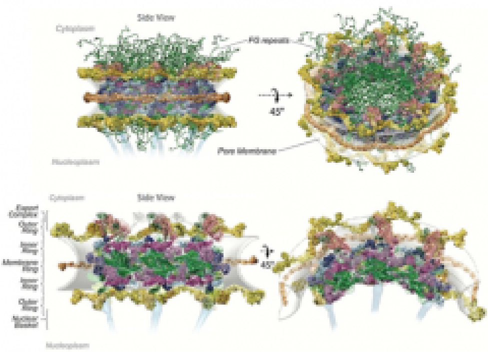
Abstract:

Nuclear pore complexes (NPCs, composed of 552 protein components, M.W. of ~50 MDa) are large proteinaceous assemblies studded through the nuclear envelope, the double-membraned barrier that surrounds the nucleus in a cell; NPCs are the sole mediators of macromolecular transport between the nucleus and the cytoplasm, and carry key regulatory platforms for numerous nuclear processes.

Despite the central role of Nuclear Pore Complexes (NPCs) as gatekeepers of RNA and protein transport between the cytoplasm and nucleoplasm, their large size and dynamic nature have impeded a full structural and functional elucidation. Here, we have determined a subnanometer precision structure for the entire 552-protein yeast NPC by satisfying diverse data including stoichiometry, a cryo-electron tomography map, chemical cross-links, and small angle X-ray scattering (**Fig. 1**). The structure reveals the NPC's functional elements in unprecedented detail (**Fig. 2**). The NPC is built of sturdy diagonal columns to which are attached connector cables, imbuing both strength and flexibility, while tying together all other elements of the NPC, including membrane-interacting regions and RNA processing platforms. Inwardly-directed anchors create a high density of transport factor-docking Phe-Gly repeats in the central channel, organized in distinct functional units. Taken together, this integrative structure allows us to rationalize the architecture, transport mechanism, and evolutionary origins of the NPC.





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Keywords:

Computational techniques Mass spectrometry Electron microscopy Integrative structure determination approach Biophysics Structural biology Computationl biology Biomolecular nuclear magnetic resonance X-ray crystallography Small Angle X-ray Scattering Bioph

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2019-04-24 - 2019-04-26

D11.04

Plasmonic Nanoprobe-Modified Lipid Bilayer Platforms for Biosensing and Molecular Computing Applications

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Abstract:

Plasmonically designed nanoprobes were modifed to fluidic 2D supported lipid bilayers (SLBs) to form functional nanoparticle-modified lipid bilayer (NLB) platforms. Dynamically tethered plasmonic nanoparticles (metal nanoparticles in many cases) can be monitored and analyzed in real time at single-particle level, and their interactions can be reliably quantified on SLB. The NLB concept and platform can applied in developing highly sensitive, quantitative, selective bioassays with high multiplexing potential, and offers various opportunities in biodiagnostics, bioimaging, biointerfacing (particularly with live cells) and molecular computing applications.

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2019-04-24 - 2019-04-26

D11.05

molecular details of NSF mediated SNARE disassembly

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Abstract:
NSF 단백질은 membrane fusion에서 가장 중요한 역할을 수행하는 SNARE 단백질의 recyling 과정에 기여하는 key protein입니다. NSF는 AAA+(ATPases Associated with diverse cellular Activities)라 불리는 family에 속하는 단백질로 ATP를 매게로 homo-hexamer를 형성하고 이 ATP를 사용하여 그 기능을 수행하게 됩니다. 지금까지 생화학적, 생물리학적 실험들을 통해 이 과정이 최대 6개 ATP의 one round turnover만으로 SNARE를 풀 수 있다는 사실을 밝혀내었습니다. 하지만, 어떻게 이과정이 효율적으로 일어날 수 있는지에 대한 molecular detail에 대해서는 밝혀지지 않았습니다. 이를 밝혀내기 위하여 Mutant가 포함되어있는 NSF hetero-hexamer를 정제하여 다양한 단분자 실험들을 통해 NSF가 ATP를 이용하는 방식에 대해 소개하고자 합니다.

Keywords:
NSF, SNARE, AAA+(ATPases Associated with diverse cellular Activities), ATP hydrolysis coordination

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D11.06*

Watching single membrane proteins fold

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Abstract:
Understanding membrane protein folding is a key part in biogenesis. Although It has been known that lots of mutations have been thought to affect membrane protein folidng and trafficking rather than function, comprehending membrane protein folding have been still progressed at a slower pace due to difficulty of experimental accessibility. Here we demostrate a newly optimized experimental method for observing in situ folding of integral membrane proteins in native-like bicelle condition. We firstly unfold the protein at high force (for the protein being a primary random coil state) and instantly lower the force to induce a loosely stretched state of secondary strutures. This new method with optimized physicochemical condition enabled us to characterize the complete folding pathway of two integral membrane proteins: the Escherichia coli rhomboid protease GlpG and the human beta2-adrenergic receptor. Albeit their long evolutionary distance, the identified folding pathways shared striking similarities, suggesting that the folding pathway of integral membrane proteins has evolved to maximize its fitness with co-translational folding.

Keywords:
Membrane protein, Protein folding, Single-Molecule Magnetic Tweezers

D11.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Observation of the immuno-oncology protein PD-1 and PD-L1 interaction at the single-molecule scale

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Abstract:

Single-molecule co-immunoprecipitation technology in TIRFM (Total internal reflection fluorescent microscope) empowers to detect various fluorescent signals of proteins. Our team has focused on measuring protein-protein interaction of cancer cells in vitro, not only for the cytosolic proteins but also for the membrane proteins. Here, in particular, we successfully observed PD-1 (Programmed cell death protein 1), to PD-L1 interaction from the cell lysate including the entire form of the target protein (either PD-1 or PD-L1). As a target of immune-cancer therapy, each PD-1 and PD-L1 stands in the membrane of the immune cell and the antigen-presenting cell, respectively. However, due to the physicochemical property of membrane protein itself, studying the interaction between the full-length form of those proteins are hardly succeeded. Using eGFP (enhanced green fluorescent protein) labeled PD-1, we discovered the very small portion of PD-1 nanoclusters, which were detergent resistant (Triton X-100, 1%). Even though the microscale clusters of PD-1 have been reported in the immunological context, it is the first time to report the nano-scale PD-1 clusters by themselves. This observation suggests the interesting physicochemical property of PD-1 by nature, especially in the in vitro protein-protein interaction context with its ligand, PD-L1. By virtue of the single-molecule imaging technique, we are working on to reveal stoichiometry and kinetic rates of PD-1:PD-L1 protein-protein interactions.

Keywords:

single-molecule, immuno-oncology, PD-1, protein-protein interaction

D11.08*

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Focused clamping of a single neuronal SNARE complex by complexin under high mechanical tension

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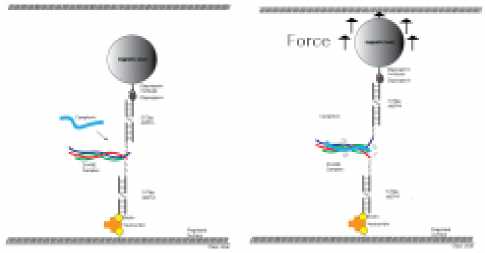
Abstract:



Neuronal SNAREs (soluble N-ethylmaleimide-sensitive factor attachment protein receptors) catalyze the fusion of synaptic vesicles with presynaptic membranes through the formation of SNARE complexes[1]. Complexin (Cpx) is the only presynaptic protein that tightly binds to the neuronal SNARE complex and therefore regulates synaptic vesicle fusion[2]. However, it remains unclear how Cpx modulates the energy landscape involved in the SNARE complex assembly, especially when mechanical tension is loaded on the SNARE complex. Using magnetic tweezers, we studied how Cpx interacts with a single neuronal SNARE complex and found that the molecular effects of Cpx manifested only under high mechanical tensions above 13 pN. We found that Cpx mechanically stabilized the central four-helix bundle composed of the SNARE motifs. At the same time, Cpx prevented the zippering of SNARE complexes from reaching completion by inhibiting assembly of the linker domains. These results suggest that Cpx generates a focused clamp for the neuronal SNARE complex in a linker-open conformation.

The last step of neurotransmitter release is joining of Ca^{2+} sensor Synaptotagmin-1(Syt1). Syt1 is expected to cue Ca^{2+} triggering the release of neurotransmitters by interacting with intact lipid membranes[3) 4)]. To reconstitute the synaptic terminal environment on magnetic tweezers, we cast synaptotagmin and artificial lipid membranes with SNARE complex.

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Keywords:

SNARE complex, Magnetic tweezers, Complexin, Synaptotagmin, Neurotransmission

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D12.01

Overview of KSTAR Project

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Abstract:

KSTAR 장치는 정상상태 고성능 토카막 운전 (Steady stated advanced tokamak operation)을 위해 초전도 자석을 이용해 만들어진 장치이며 2008년 이후 현재까지 계속 가동 중이다. 중성입자빔 가열장치, 전자공명 가열장치 및 이온공명 가열장치등 주요 가열 장치들을 보유하고 있고 플라즈마 변수의 분포 및 이미지를 측정할 수 있는 첨단 진단장치들을 함께 운영 중이다.

가열장치 및 진단장치들이 순차적으로 증설 및 도입되고 플라즈마 제어기술이 축적되면서 고성능 플라즈마의 성능이 점차 향상되고 있다. 향상된 성능의 대표적 예로서는 플라즈마 전류 1MA 달성, H-mode 90초 운전, 이중 수송 장벽 형성 20초 운전, 이온 온도 9keV 달성, 경계면 불안정성(ELM) 억제 운전 30초 달성 등을 들 수 있으며 이 외에 첨단 진단 장비를 이용한 기본 수송 현상에 대한 연구 등도 활발히 진행 되고 있다.

향후 운전 전류 및 온도, 밀도 등을 향상 시키고 정상상태 운전시간을 300초까지 증가 시키기 위해 가열 및 전류 구동 장치의 대폭적 증설이 예정되어 있고, 핵융합로 관련 환경 모사를 위하여 기존 그래파이트 플라즈마 대면재료를 텅스텐으로 교체할 예정이다.

KSTAR 장치 및 운전 현황 대해 전반적으로 소개하고 지난 10년동안 얻어진 성과 및 향후 계획에 대해 보고 하고자 한다.

Keywords:
KSTAR, 초전도 토카막, 정상상태, 고성능운전

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D12.02

Increased Electron Turbulence and Perpendicular Flow Bifurcation at the Edge of the RMP-driven ELM-crash Suppressed Plasmas

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Abstract:
The increase of turbulent fluctuations and the perpendicular flow ($v_\perp$) bifurcation at the transition of ELM-crash suppression have been investigated using electron cyclotron emission imaging (ECEI) system in KSTAR. The ECEI has revealed that resonant magnetic perturbation (RMP) enhances small-scale turbulent fluctuations in the edge, and thereby the large-scale pedestal collapse is prevented by nonlinear interaction with the ELM filaments. The $v_\perp$ estimation based on the correlation analysis showed that the

ELM crashes are suppressed with a rapid decrease of $v_\perp$ close to zero (small but finite) with its shear

reduction. The $v_\perp$ bifurcation is mainly attributed to the rapid change of E×B velocity and the $v_\perp$

magnitude is maintained the smallest near the normalized flux surface Ψ_N~0.95 during the ELM-crash

suppression. The plasma response to the RMP, normalized by $v_\perp$ changes, is strongest on the Ψ_N~0.95 just before the ELM-crash suppression. The hysteresis in the RMP strength was observed at the transition into and out of ELM-crash suppression, which is another observation that supports the plasma bifurcation.

Keywords:
Plasma, Plasma turbulence, Resonant Magnetic Perturbation, Edge Localized Modes (ELMs), Plasma rotation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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D12.03

Electron thermal transport with a magnetic island

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Abstract:

Tokamaks are a device to confine a hot and dense plasma within a magnetic field structure of nested tori. A magnetic island, formed by the reconnection of the distant field lines, is known to enhance the radial transport along the reconnected field line. Recent studies found that electron thermal transport with a magnetic island can be more complicated due to various dynamical interactions between the island and ambient turbulence. The magnetic island can modify the equilibrium flow profile significantly to regulate the turbulence transport [1, 2]. On the other hand, the turbulence around the island can affect the stability of the magnetic island, controlling the island transport [3]. It can either stabilize the island (minimize the island transport) or destabilize the island (maximize the island transport, or cause the minor disruption).

[1] M.J. Choi, et al., Nuclear Fusion 57 126058, 2017
[2] J.-M. Kwon, et al., Physics of Plasmas 25 052506, 2018
[3] M.J. Choi, et al., The 27th IAEA Fusion Energy Conference, India, 2018

Keywords:

Fusion plasma, magnetic island, turbulence

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D12.04

Development of advanced operation scenarios for KSTAR

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Abstract:

The KSTAR (Korea Superconducting Tokamak Advanced Research) tokamak aims at successful production of steady-state high-beta tokamak plasmas by utilizing fully superconducting magnets and a state-of-the-art plasma control system. To do this, we are developing advanced operation scenarios for KSTAR that can contribute to ITER and K-DEMO. Steady-state operation, high performance of the plasma and finding alternative solutions are the main interest in the research area. Modifications to the relaxed Ohmic current profile have been found to result in significant improvements in energy confinement. The initial current profile of the tokamak plasma is formed during the current increase at the start of the discharge, and current diffusion to the center of the plasma is slowed by the external Heating and Current Drive (H&CD) systems. The KSTAR uses the neutral beam injection (NBI) as a majority of H&CD, and effective use of the H&CD with instrumented plasma control and shaping parameters became a key to access to the advanced operation scenarios such as high βp, high li, high qmin, hybrid, ITB and low q. In this work, we present the recent progress of experimental studies on advanced operation scenarios in KSTAR.

Keywords:

Tokamak, KSTAR, advanced scenario

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D12.05

Analysis of Alfven eigenmodes in KSTAR high performance discharge

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Abstract:

In KSTAR high performance discharges such as high performance scenario, MHD modes in the Alfven eigenmode frequency range are observed and accompanied by confinement degradation. Alfvenic mode is one of strong candidates causing anomalous fast ion transport, and the critical role of fast ion confinement on the high performance discharge is identified by transport calculations. Ad hoc anomalous diffusion coefficient of fast ion in the transport calculation explains well the global confinement degradation. This presentation reports experimental observations focused on the Alfven eigenmode excitation and the confinement of global and fast ions. Numerical analysis for mode identification and its impact on fast ion transport will be followed. Especially, the result of NOVA/NOVA-K code analysis is presented for explaining the experimental result of Alfven eigenmode control using the electron cyclotron current drive. Preliminary investigation result of impact on the fast ion transport is also presented.

Keywords:

Nuclear Fusion

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D13.01

Structure formation in a dissipative dark sector

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Abstract:

We present the history of structure formation in a simple dissipative dark-sector model. The model has only two particles: a dark electron and a dark photon. Dark-electron perturbations grow from primordial overdensities, become non-linear, and form dense, dark galaxies. We show that asymmetric dark stars and black holes form within the Milky Way from the collapse of dark electrons. These exotic compact objects may be detected and their properties measured at new high-precision astronomical observatories, giving insight into the particle nature of the dark sector without the requirement of non-gravitational interactions with the visible sector.

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D13.02

Constraining Dissipative Dark Matter Self-Interactions

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Abstract:

Dark sector models with light or massless mediators naturally introduce elastic and dissipative self-interactions of dark matter. The heat exchange induced by the elastic scattering permits the gravothermal evolution of the halo. Through the evolution, a halo with a cuspy inner density profile develops a core first but become cuspy again at late time. We find that a mild dissipative scattering can significantly accelerate this evolution process. Constraints on the dissipative scattering cross section and the dissipated energy per collision can be inferred from the density cores of dwarf galaxies with low baryonic contents.

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D13.03

Primordial Black Hole Dark Matter and Gravitational Waves from Binary Mergers and from Curvature Perturbations

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Abstract:

Primordial Black Holes (PBHs) are a candidate of dark matter and may also be responsible for the LIGO/Virgo detections of gravitational waves from binary black hole mergers. From the particle physics point of view, they require a particularly flat part of the inflationary potential or the presence of an early matter dominated era instead of new dark matter particles. We demonstrate that a simple parametrization of the power spectrum with running parameters can explain either the dark matter abundance or the merger rate. The enhanced curvature perturbations from which PBHs are formed also induce stochastic gravitational waves. We complete the analytic calculation of the integration kernel of the induced gravitational waves, and discuss a potentially huge enhancement effect which may allow us to measure the reheating temperature.

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D13.04

Smallest Halos in Thermal Wino Dark Matter

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Abstract:

(Mini) split supersymmetry explains the observed Higgs mass and evades stringent constraints, while keeps good features of TeV-scale supersymmetry other than the little hierarchy problem. Such scenarios naturally predict thermal wino dark matter whose mass is around 3 TeV. Its non-perturbatively enhanced annihilation is a promising target of indirect detection experiments. It is known that identifying the smallest halos is essential for reducing an uncertainty in interpreting indirect detection experiments. Despite its importance, the smallest halos of thermal wino dark matter have not been well understood.

In this talk, we remark two aspects:

1) neutral wino is in kinetic equilibrium with primordial plasma predominantly through inelastic processes involving slightly heavier charged wino;

and 2) the resultant density contrast shows larger powers at dark acoustic oscillation peaks than in cold dark matter, which is known as an overshooting phenomenon.

The latter can enhance a total luminosity of dark matter annihilation in a halo significantly.

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D13.05

(Inelastic) Boosted Dark Matter and Novel Strategies of Dark Matter Search

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Abstract:

I will introduce the concept of boosted dark matter, focussed on inelastic boosted dark matter (iBDM) model, as a promising alternative of the conventional WIMP models. In such a class of model, a light DM which is boosted enough to pass the energy threshold can come from dense dark matter region in the universe, such as the galactic center, the sun, dwarf spheroidal galaxies, showing unique signal features easily separable from potential backgrounds. This motivates totally new strategies in dark matter searches in large volume neutrino experiments and dark matter direct detection experiments.

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D13.06

Searching for Light Dark Matter with Fixed Target Neutrino Experiments

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Abstract:

We consider a model of light (sub-GeV) dark matter that escapes many of the bounds placed by current dark matter searches. Such low mass dark matter candidates, if produced as a thermal relic in the early universe, must be accompanied by light mediators in order to reproduce the dark matter abundance observed in the present day universe. These light mediators provide new channels for the production and detection of dark matter at fixed-target neutrino experiments and proton beam dumps. The resulting relativistic dark matter beam could be detected through neutral-current-like interactions in detectors sensitive to relativistic neutrinos. We present the results of a dark matter search using the dedicated beam dump run by MiniBooNE, the untapped potential of recent fixed-target neutrino experiments, as well as the projected sensitivity of future experiments such as COHERENT and SHiP.

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D14.01

Progress Report of the SHiP Experiment

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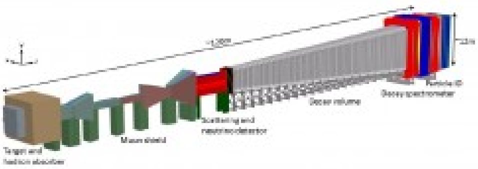
Abstract:

The SHiP (Search for Hidden Particles) Collaboration has proposed a general purpose experimental facility at the CERN SPS accelerator to search for feebly interacting GeV-scale particles. SHiP complements the world-wide program of New Physics searches by covering a large region of parameter space which cannot be addressed by other experiments. The SHiP detector is sensitive both to decay and scattering signatures of models with heavy neutral leptons (HNLs), dark photons, dark scalars, light dark matter and other super-weakly interacting particles. In addition, SHiP can perform unprecedented measurements with tau neutrinos and neutrino-induced charm production. Following the continued development since the Technical Proposal submitted in 2015, we submitted a paper, which is a comprehensive overview of the re-optimized SHiP spectrometers and the improved physics performance, to the update of the European Strategy for Particle Physics (ESPP). The current status of the experiment will be presented.



Keywords:
SHiP, Hidden Particles, Tau Neutrino, CERN SPS

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D14.02

Sensitivity of the SHiP experiment to Heavy Neutral Leptons and other physics issues

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Abstract:
Heavy Neutral Leptons (HNLs) are hypothetical particles predicted by many extensions of the Standard Model. These particles can explain the origin of neutrino masses, generate the observed matter-antimatter asymmetry in the Universe and provide a dark matter candidate. The SHiP experiment will be able to search for HNLs produced in decays of heavy mesons and travelling distances ranging between O(50 m) and tens of kilometers before decaying.
We present the sensitivity of the SHiP experiment to a number of HNL's benchmark models and provide a way to calculate the SHiP's sensitivity to HNLs for arbitrary patterns of flavour mixings.
We also present other physics issues discussed at the collaboration meeting.

Keywords:
SHiP experiment, Heavy Neutral Lepton, dark matter

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D14.03

Measurement of Time-dependent Charge Parity Violation in $B^0 \rightarrow K_SK_SK_S$ at the Belle experiment

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Abstract:

We want to measure the $\sin 2\phi_1$ parameter of time-dependent charge parity violation (TCPV) in $B^0 \to K_S^0 K_S^0 K_S^0$ decays using 711 fb^{-1} data collected at Upsilon(4S) resonance from the Belle experiment at KEKB asymmetric-energy e+e- collider. This decay mode occurs via b → s quark transition highly suppressed in Standard Model (SM) so that it decays by loop diagram which has sensitivity for new physics. The previous $\sin 2\phi_1$ measurements of the Belle and BaBar experiments using $B^0 \to K_S^0 K_S^0 K_S^0$ decays show about 2 sigma difference. This is the main reason that we would like to make precise measurement on the $\sin 2\phi_1$ with a full data sample of B-mesons. We present the measurement of TCPV in $B^0 \to K_S^0 K_S^0 K_S^0$ decays.

Keywords:

Belle experiment, TCPV, Rare B decay, CKM angle

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D14.04*

Study of Slow Control System Performance for the Belle II Trigger System

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Abstract:

Belle II experiment using the SuperKEKB collider at KEK in Japan starts data-taking in Phase III operation in March 2019 with full detectors to probe New Physics phenomena in heavy quark and lepton weak decays. We have prepared the Belle II trigger system that are crucial to stable DAQ operation for control and monitor. For the trigger monitoring and control, a trigger slow control system has been being built. The system consists of two main parts, one is the trigger run control which deals with the data-taking, and the other is trigger control which is related to control each sub-trigger itself such as experimental parameters reset or initialization. Through the first one, experimental parameters of sub-trigger systems are stored on Belle II main configuration database server run by run. Some of the significant outputs of sub-trigger systems are automatically archived on Belle II main archiver server by the second system. We report the performance of the trigger slow control system in Phase III.

Keywords:

Belle II, Trigger, DAQ, Slow Control, Database, Archiver, GUI

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D14.05

Korean group's production of 36 ton liquid scintillator for JSNS^2

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Abstract:

The JSNS^2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source) experiment is to search for sterile neutrino oscillation at 24m baseline with delta Δm^2 near 1 eV^2. JSNS^2 uses an intense neutrino beam from muon decay-at-rest from the collision of 3 GeV proton to a mercury target at J-PARC. The JSNS2 detector consists 17 tons of gadolinium loaded liquid scintillator as a neutrino target and 32 tons of unloaded liquid scintillator surrounding the target.

In this talk, we present production of 35 ton unloaded liquid scintillator at the RENO site.

Keywords:
JSNS2 neutrino JPARC

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D14.06*

Beam commissioning of the downstream charged veto detector for the KOTO experiment at J-PARC.

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Abstract:

We are performing a search for the rare decay $K_L \rightarrow \pi^0 \nu \bar{\nu}$ at the J-PARC KOTO experiment. The $K_L \rightarrow \pi^0 \nu \bar{\nu}$ decay is known as one of the most sensitive probes to new physics beyond the Standard Model (SM). Its branching ratio is estimated as 3.0×10^{-11} according to the SM calculation, thus major concern of the experiment is how to highly suppress background to the signal box. The single event sensitivity reached 1.3×10^{-9} and no candidate event was observed. The current sensitivity is limited by background sources such as the $K_L \rightarrow \pi^+ \pi^- \pi^0$ decay. For better sensitivity, we developed some new detector components which include the Downstream Charged Veto (DCV) detector for rejecting $K_L \rightarrow \pi^+ \pi^- \pi^0$ decays. The DCV is composed of two plastic scintillator pipes read out by MPPCs through wavelength shifting fibers. The DCV is placed inside the beam pipe to reject the $K_L \rightarrow \pi^+ \pi^- \pi^0$ decays downstream from the CsI detector. First beam commissioning results will be reported as well as test bench performance and fabrication process in this talk.

Keywords:

J-PARC, KOTO, Scintillator, Detector, KLtopi0nunubar

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D14.07

Search for Sterile Neutrino at the J-PARC

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Abstract:

The JSNS^2 experiment aims to search a concrete evidence of the sterile neutrinos using pulsed neutron beam suppressing background of effectiveness. We explain the current status of the experiment staring data acquisition at the end of autumn 2019, its prospects for potential physics and efforts of Korean group for the experiment.

Keywords:
JSNS2, Sterile Neutrinos

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D14.08

Current Status of DUNE

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Abstract:
DUNE, the next-generation intensity frontier, has reached the following stages in construction: The collaboration has begun collecting data from ProtoDUNE and is preparing a technical design report of the far detector. At the same time the design of near detector will be shown with its physical potential. This talk reviews the current status of each component of the DUNE facility.

Keywords:
DUNE, ProtoDUNE, long-baseline neutrino oscillation

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D14.09

Maintenance of Korean light scattering measurement system at Super-Kamiokande

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Abstract:
During the Super-Kamiokande upgrade in the period of June 2018 to January 2019, a Korean light scattering measurement system went through reinforcement that is necessary for adding gadolinium into the detector water. The light injecting part in the water needs to be replaced by material chemically resistive to gadolinium. In this presentation we report the maintenance work done by the Korean group at Super-Kamiokande.

Keywords:
superkamiokande, superk korean group, superkamiokande calibration for water transparency

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D14.10*

Measurement of cosmogenic background rate at RENO

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Abstract:

A high-energy cosmic muon produces various spallation isotopes in the RENO detector. Among them, cosmogenic isotopes of 9Li and 8He can mimic reactor neutrino candidate events and become one of the most serious background in precise determination of the neutrino mixing angle theta13. The spectral shape of the 9Li/8He background is measured using a control sample that is obtained by time correlation between a background candidate and its preceding muon. The 9Li/8He production rate is estimated by extrapolating from the background dominant region(8 ~ 12 MeV) by a fit to an observed reactor candidate spectrum using the measured 9Li/8He background spectral shape. In this talk, we present the measured production rate of cosmogenic 9Li/8He background in the RENO detector

Keywords:

cosmogenic backgroud RENO muon 9Li 8He

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D15.01*

Observation of Toroidal pseudo-spin texture in a Nodal line semimetal $SrAs_3$

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Abstract:
Dirac electronic state have gathered interests by their unconventional electronic states characterized by intrinsic chirality of (pseudo) spins. Recently, we found that $SrAs_3$ is a strong candidate of nodal-line semimetal confirmed by band structure calculations. We observed angular-dependent Shubnikov-de Haas (SdH) oscillations of a high-quality $SrAs_3$ single crystal. The berry phase factor extract from landau fan diagram shows strong angle dependence. We discuss how these observations related to unique toroidal pseudo-spin texture in a nodal-line semimetal $SrAs_3$.

Keywords:
Nodal line semimetal, Topological Semimetal, Berry phase crossover, Toroidal pseudo-spin texture

D15.02*

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Emergence of Metal-Insulator Transition and High Temperature Charge Density Waves in MBE-grown VSe_2 at the monolayer limit

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Abstract:

Electronic reconstruction, caused by the surface and interface modification of correlated-electron behavior, is a fundamental scientific issue and has been extensively applied to oxide heterostructures. However, the role of these phenomena in shaping the electronic properties in van der Waals heterointerfaces has hitherto not been established. Gaining an understanding of electronic reconstruction due to dimensionality and heterointerface coupling in layered van der Waals systems remains an open issue. By diminishing the material thickness and forming a heterointerface, we observed two types of charge-ordering transitions in monolayer VSe_2 on graphene substrates. Comprehensive combination of ARPES, STM, and renormalization group analysis enable us to reveal the low-dimensionality with perfect Fermi surface nesting and the heterointerface play important roles in enhancing charge density wave temperature to 350 K contrasted to the 105 K in bulk VSe_2 and in driving the unexpected metal-insulator transition at 135 K in the family of monolayered transition metal dichalcogenides.

Keywords:

Vanadium diselenide, Metal-insulator transition, Charge-density wave, Molecular beam epitaxy

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D15.03

Character of exciton condensation in a transition metal dichalcogenide 1T-$TiSe_2$

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Abstract:

We revisit the question of the transition metal dichalcogenide 1*T*-$TiSe_2$ charge density wave (CDW) state being an excitonic insulator. The BCS-like CDW gap equation with statically screened Coulomb interaction,V(q), was employed to calculate the transition temperature (T_c) as a function of the energy gap. Realistic dispersions for one hole band centered at Γ and three electron bands at M points in two-dimensional periodic hexagonal lattice were considered to model the $TiSe_2$. Measured effective mass for both hole and electron bands are also adapted. The obtained T_c (~240K) is comparable to measured one for monolayer (~232K), and T_c suppression as a function of doping concentration and pressure are reproduced well. We also found momentum dependency of CDW gap, weak coherence peak and asymmetric gap can be appeared in ARPES intensity and density of states through the Eliashberg-type self-consistent calculation. We discuss possibility of the 1*T*-$TiSe_2$ CDW state originating from exciton condensation via the comparison with experimental results.

Keywords:
TMDC, Excitonic insulator, CDW

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D15.04*

Temperature and magnetic field induced spin-flop transition in van der Waals (vdW) $MnPS_3$

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Abstract:
Dipolar anisotropy along the out-of-plane and single ion anisotropy along the in-plane define the easy magnetization axis of antiferromagnetic ordering in $MnPS_3$. We study the anisotropic magnetic properties of magnetic van der Waals $MnPS_3$ using torque magnetometry. A spin-flop transition of spin orientation from the out-of-plane to the in-plane direction takes place at 4T by applying external magnetic field along the trigonal *c*-axis. Angle dependent torque $\tau(\theta)$ of $MnPS_3$ under a fixed magnetic field reveals the effect of temperature on magnetization and spin orientation. The magnetic field has a significant effect on the spin orientation well below T_N. Our results suggest that the magnetization changes from an easy axis down to an easy plane below T_N where the moment along the in-plane is more towards the *b*-axis.

Keywords:
MnPS 3 , Torque measurements, Temperature effect, Magnetic field effect, Magnetic anisotropy

D15.05

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Nexus Fermion and Weyl Nodes in non-centrosymmetric compensated half-metals

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Abstract:

Over the past decade various topological phases have been proposed and intensively investigated due to the variety of exotic properties that emerge. Recently, three dimensional (3D) topological features mixing with zero dimensional (0D) (Dirac, Weyl, multi-Weyl, and triple-nodal points [TNPs]) or one dimensional (1D) (nodal loops) band-crossings have stimulated further interest. In particular, nexus fermions, which is formed by a connection of TNPs and nodal loops, in crystalline matter have been discussed occasionally, but never proposed for an existing material. Materials containing multiple topological characteristics become more exotic when combined with noncentrosymmetric crystal structures and unusual magnetic phases such as the compensated half-metal state, which is gapped on one spin direction and conducting in the other.

In this presentation, we will address a real intermetallic compound Cr_2CoAl with a unique collection of special properties. Our first principles calculations reveal these multiple topological features in the compensated half-metal Cr_2CoAl having numerous unusual characteristics:

neither time-reversal nor inversion symmetry in its cubic crystal structure
half-metallic (hence half-insulating) magnetic alignment
compensating up and down moments: no macroscopic magnetic field
a total of twelve pairs of magnetic Weyl points on mirror planes,
three distinct sets of triple nodal points near the Fermi level
the TNPs are interconnected with six symmetry related nodal lines
this combination gives rise to *"fully spin polarized nexus fermions"*

The observed high Curie temperature of 750 K and calculated tiny SOC hybridization mixing of several meV should make these topological features readily measurable. Unlike topological features discussed for other Heuslers which emphasize their strong ferromagnetism, this compensated half-metal is impervious to typical magnetic fields, thus providing a complementary set of experimental phenomena. Making use of the soft calculated magnetic state, large magnetic fields can be used to rotate the direction of magnetism, during which certain topological features will evolve. Our results suggest that these features may be generic in inverse-Heusler systems, particularly the isostructural and isovalent Ga and In analogs.

Acknowledgements:

We acknowledge W. E. Pickett for useful discussions and collaboration. We also thank to M. Richter, K. Koepernik, U. Rößler, R. Ray, J. Facio, and Y. Kim for fruitful discussions.
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Keywords:

Nexus Fermion, Magnetic Weyl points, inverse-Heusler, compensated half-metal, first principles calculations

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D15.06*

Multiple topological phases in compensated half-metallic Cr_2CoAl

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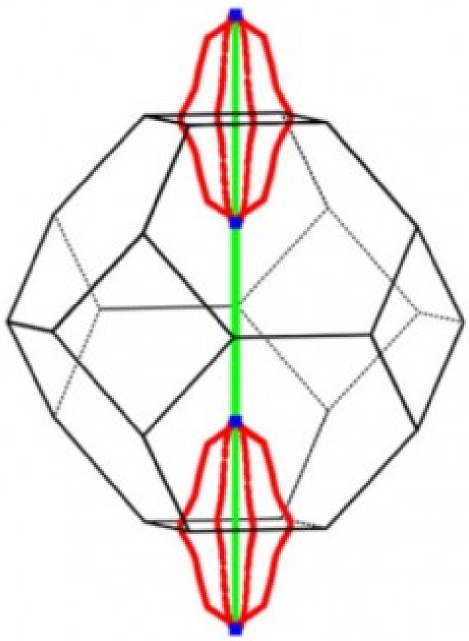
Abstract:

Recently, 3-dimensional topological materials have been one of hot issues in condensed matter physics due to their various exotic behaviors. They can be classified by dimension of band crossing points. Band crossings of the Dirac, Weyl, and triple nodal points (TNPs) are zero-dimensional (0D), whereas that of nodal lines is one-dimensional (1D). The connection of TNPs with the 1D crossings can lead to a nexus fermion.

In this presentation, we will address the exotic topological properties in the compensated half-metallic inverse-Heusler Cr_2CoAl that has neither time-reversal nor inversion symmetries. Using first principles calculations, we discover multiple topological characters protected by the six mirror and three C_2 rotational symmetries: 12 pairs of magnetic Weyl points and three sets of TNPs near the Fermi level. In the absence of spin-orbit coupling (SOC), TNPs are interconnected with nodal lines, leading to the nexus fermionic state which has not been reported in any realistic system. Considering the observed high Curie temperature of T_c ~750 K and negligible SOC strength of at most 10 meV, our results suggest that these nexus fermions right above the Fermi energy can be measurable experimentally. Therefore, our results are expected to provide a novel topological phase which can be suitable for various applications including spintronics.



[Figure] Plot the nexus fermions. The blue points denote TNPs, red lines are nodal loops on the mirror planes and green line is nodal line along the C_2 rotational axis.

Acknowledgements: This research was supported by NRF Grants No. NRF-2016R1A2B4009579.

[Reference]
H.-S. Jin, Y.-J. Song, W. E. Pickett, and K.-W. Lee, Phys. Rev. Materials 3, 021201(R) (2019).

Keywords:
topological semimetal, nexus fermion, magnetic Weyl points, inverse-Heusler, first principles

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E1.01

단일형 활성 픽셀 센서 기술을 이용한 실리콘 픽셀 센서의 디자인에 따른 전하 수집 시간 연구

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Abstract:

단일형 활성 픽셀 센서 (Monolithic Active Pixel Sensor, MAPS) 기술은, 센서와 신호 처리 회로를 결합시킨 기술로써, 이 기술을 접목시킨 실리콘 픽셀 센서는 뛰어난 공간 분해능과 효율을 가져 차세대 입자 검출기로서 각광받고 있다. 인베스티게이터 (Investigator)는 MAPS 기술이 접목된 실리콘 픽셀 센서로, 공핍층의 크기에 따른 검출시간과 위치의 측정효율을 연구, 개발하기 위해 고안되었다. 인베스티게이터는 서로 다른 픽셀 디자인을 가진 134개의 미니 매트릭스 (Mini-matrix)로 구성돼 있으며, 각각의 미니 매트릭스는 64개의 활성 픽셀들로 이루어져 있다. 64개의 픽셀들은 65 MHz의 진동수로 채집 (sampling)된 아날로그 신호를 동시에 출력할 수 있어, 다른 실리콘 픽셀 센서와는 다르게 전하 수집 시간 (Charge Collection Time)의 측정이 가능하다. 본 발표에서는 다양한 크기의 픽셀, 수집 N-well 크기 (Collection N-well size), 간격 (Spacing), 그리고 역전압에 따른 전하 수집 시간의 측정결과가 다루어질 예정이다.

Keywords:

단일형 활성 픽셀 센서, 실리콘 픽셀 센서, 인베스티게이터, 전하 수집 시간

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E1.02

Effect of growth ambient and co-doping on the scintillation properties of Ce doped $Gd_3Ga_3Al_2O_{12}$ single crystals

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Abstract:

Single crystals of $Gd_3Ga_3Al_2O_{12}$ doped with Ce have recently shown very promising scintillation properties having high light yield of about 57000 ph/MeV and fast decay time having major component of about 55 ns. These crystals have also shown an ability to discriminate alpha and gamma radiations based on the pulse shape discrimination method. The suitable co-doping has shown to improve the scintillation properties of these crystals significantly. However, due to their defect structure related to oxygen sub-lattice and oxidation of Ce valence state from 3+ to 4+ makes these crystals very sensitive to the growth ambient and after growth annealing treatment. To investigate these effects in details, two single crystals, having better scintillation properties have been grown in different conditions. One crystal has been grown in Argon ambient with B co-doping, while second has been grown in partial CO_2 ambient without use of any co-dopants. Their photo-luminescence, radio-luminescence, scintillation pulse height and pulse shape discrimination have been measured and compared. These results would be presented in addition with the low temperature thermo-luminescence measurements to compare the role of defect centers.

Keywords:

Single crystals, Scintillators, Radiation detectors

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LAMPS 중성자검출기의 우주선을 이용한 성능테스트 결과

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Abstract:

LAMPS 실험그룹에서는 2018년 주 검출기중의 하나인 중성자 검출기를 제작하였다. 중성자검출기는 핵반응에서 발생한 중성자의 비행시간을 측정하여 그 에너지와 운동량을 도출하는 검출기이다. 이 정보들은 또 다른 주 검출기인 TPC에서 얻어지는 하전입자의 에너지와 운동량 분포와 통합하여 핵물질의 대칭에너지 규명에 쓰일 것이다.
LAMPS 중성자 검출기는 4개의 레이어로 구성되어 있으며, 하나의 레이어에는 검출영역 10 cm x 10 cm x 200 cm의 섬광검출기가 x와 y방향으로 20개씩 나열되어있으며, 총 2 m x 2 m의 측정면적을 가진다. 하나의 섬광검출기는 섬광 플라스틱의 양단에 각각 PMT가 붙어 있는 형태로 두 PMT의 신호의 시간차로 입자의 입사위치를, 시간의 평균으로 입자의 입사시간을 측정하는 검출기이다. 5개의 모듈을 이용한 측정결과에 따르면 23 mm 의 위치분해능과 ┼┼┼┼┼┼┼┼┼┼140 ps 의 시간분해능을 가지고 있는 것을 확인 하였으며 이는 중성자 검출기에 요구되는 에너지/시간 분해능에 대한 조건을 만족한다. 중성자 검출기의 신호의 Digitization은 Notice사 에서 제작한 500 MHz FADC를 사용하는데, 이는 복수개의 중성자가 하나의 모듈에 들어왔을 때 그 신호를 분리해내는 것을 목표로 하고 있다.
현재 모든 중성자검출기 모듈이 구조체에 설치되어있으며, 4개의 레이어를 눕혀서 4개층으로 겹쳐서 우주선을 측정하였다. 우주선 데이터를 이용하여 모든 중성자 검출기들의 성능을 도출하였다. 본 강연에서는 이 결과들과 예상되는 중성자검출기의 중성자 검출성능에 대하여 발표할 것이다.

Keywords:

RAON, LAMPS, 중성자검출기, 신틸레이터,

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E1.04

알파 및 베타선 표면방출율 측정 일차표준기 개발

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Abstract:

표면오염감시기의 교정에는 알파 혹은 베타선을 방출하는 면적선원을 이용한다. 이 면적선원의 표면방출율은 국가표준기관에서 절대측정하거나 기준기급 대면적 다중선 비례계수기를 이용하여 측정해야한다. 한국표준과학연구원은 35년 전 다중선비례계수기를 자체 개발하였으며 이를 이용하여 면적선원의 표면방출율을 측정 및 보급하고 있다. 교정된 면적선원은 인증주기 2년마다 제 교정하여 선원의 소급성을 유지하고 있다. 노후화된 다중선비례계수기는 관리가 어렵고 안정성이 떨어져 새로운 다중선비례계수기의 개발을 수행하였다. 다중선 비례계수기는 21개의 50 um 두께의 스테인레스스틸 와이어로 구성된 어노드와이어면으로 101개의 20 um 두께의 스테인레스스틸 와이어로 구성된 가드와이어면으로 구성되어 있다. 측정 효율을 높이기 위해 면적선원을 다중선비례계수기 내부에 위치시키게 되는데, 이 선원의 구조때문에 다중선비례계수기 내부 전기장이 왜곡되는것을 방지하기위해 가드와이어면을 두게 된다. 알파입자의 경우 가드와이어와 충돌하여 효율이 떨어져 가드와이어가 있는 것과 없는 것을 각각 제작하였다.

본 발표에서는 새롭게 제작한 다중선비례계수기의 소개와 Cl-36, Am-241 면적선원을 이용한 예비결과를 보고할 예정이다.

Keywords:

다중선비례계수기, 면적선원, 일차표준기, 소급성

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E3.01*

Light momentum & air pressure assisted nano-droplets generator.

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Abstract:
Recently, there have been great advances in nanofluidics and the fine-volume liquid control system. For instance, nano fluidic channel, flow focusing method, and electro-hydrodynamics are widely utilized on intedisciplinary research such as drug delivery system, patterning, optics, and bio-medical applications. In response to this demand, our group had reported completely new laser driven nano-droplets generator which adopts light momentum as the source of the pressure for liquid jetting. In this paper, we have studied the role of the air pressure acting on the liquid inside this nano-droplets generator. This report is expected to pave the way for understanding the light momentum and application of the various liquid jet system.

Keywords:
Momentum of light, air pressure, nano droplets

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E3.02*

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Anomalous Dispersion in ZnO Nanoneedle Arrays

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Abstract:

광대역 전방향성 anti-reflection 특성은 다양한 광학 소자의 기능을 극대화할 수 있다는 점에서 중요성을 갖는다. 최근 anomalous 분산 관계를 갖는 메타물질에서 임피던스 정합을 통해 완전한 광대역 전방향성 anti-reflection 특성을 구현할 수 있다는 이론이 제안되었고, 마이크로 파장 대역에서 실험적으로도 증명되었다 [1]. 본 연구에서는 가시광 영역에서 anomalous 분산 관계를 갖는 ZnO nanoneedle array 구조의 물질을 시뮬레이션을 통해 설계하였고, 광대역 전방향성 anti-reflection 특성을 확인할 수 있었다. 시뮬레이션 연구 결과에 기반하여 anomalous 분산 관계를 갖는 ZnO nanoneedle array 물질 층을 적용한 실리콘 태양전지를 제작하였다. 입사각 및 편광 분해 태양전지 특성 분석을 통해 ZnO nanoneedle array가 적용된 소자의 경우 편광 및 각도에 대해 의존성이 거의 없으며, 향상된 광전변환 효율 특성을 보임을 확인할 수 있었다.

[1] Nature Photonics 12, 143-149 (2018).

Keywords:

Broadband anti-reflection, Omni-directionality, ZnO nanoneedle array, Solar cells

E3.03*

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여기 광에 대한 편광 의존성이 없는 2차원 광자결정 형광체

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Abstract:
형광체의 색변환 효율을 높이기 위한 방법으로 구조적 측면에서 설계된 광자결정 형광체를 제안하고 이를 실증한 바 있다 [1,2]. 하지만 지금까지 시연된 광자결정 형광체는 1차원 광자결정 구조를 이용했기 때문에 형광체의 색변환 효율은 획기적으로 높아졌으나 여기 광의 편광에 형광 효율이 크게 변하는 단점이 있었다. 본 연구에서는 이러한 편광 의존성이라는 단점을 해결하고 보다 높은 변환 효율을 얻기 위해 2 가지 측면의 구조적 개선을 시도하였다. 첫째, 2차원 광자결정 형광체는 4중 회전 대칭성(4-fold rotational symmetry)을 갖기에 편광 의존성을 효율적으로 상쇄할 수 있을 것으로 기대된다. 이를 통해 비편광성의 여기 광원을 사용하는 경우, 기존 1차원 광자결정 형광체 대비 2 배의 효율을 얻을 수 있다. 둘째, 의도적으로 광자결정 구조의 뼈대층 두께를 증가시킴으로써 TM 및 TE 공진 모드를 동시에 발현시킬 수 있고, 이 두 공진 모드를 동시에 활용함으로써 TE 공진 모드만 사용하는 경우보다 변환 효율을 배로 늘릴 수 있다. 이 연구에서는 두 개선 방안의 효과를 입증하기 위해 레이저간섭석판술(laser interference lithography)로 2차원 정사각 격자 패턴의 뼈대층을 만들고 그 위에 콜로이드 양자점 (colloidal quantum dot)을 스핀코팅 방법으로 도포함으로써 저비용으로 높은 색변환 효율을 갖는 광자결정 형광체를 제작하였다. 제작된 2차원 광자결정 형광체에 대한 실험적 측정 결과는 이론적 시뮬레이션 결과와도 잘 일치하였다.

참고문헌
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2. J. Lee, K. Min, Y. Park, K.-S. Cho, H. Jeon, *Adv. Mater.* **2018**, *30*, 1703506.

Keywords:
Phosphor, Photonic crystal, Photonic band-edge, Colloidal quantum dot, Laser interference lithography

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E3.04*

Plasmonic Metamolecule Programmed by 3D DNA origami

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Abstract:
Over the last decades, the self-assembled plasmonic metamolecule, a properly tailored metallic nanocluster which provides easy and robust modulation of meta-optics, have undergone considerable progress in the field of optical metamaterials. However, the reliable assembly of the 3D cluster with high structural integrity and programmability is still being compromised, owing to a limited ability of controlling the 3D cluster geometries. To address this challenge, we demonstrate deterministic strategy for assembling gold (Au) nanoparticles into plasmonic metamolecules using DNA origami as a pegboard. Guided by the programmability of DNA, metamolecular assemblies including asymmetric 3D clusters which have been challenging for other self-assembly methods were achieved with unmatched structural versatility. As expected, strong electric and magnetic dipole resonance, the hallmark of the unnatural plasmonic metamolecule, were successfully obtained from the assemblies and show great deal of agreement with theoretical calculations. Taken together, our work convincingly demonstrates a versatile strategy for deterministic engineering of self-assembled plasmonic metamolecules.

Keywords:
3D DNA origami, Round gold nanospheres, Metamolecules, Programmed self-assembly, Unnatural magnetism

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E4.01

물리 영재의 정의와 교육 방향에 대한 물리학 및 물리영재교육전문가 의견 탐색

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Abstract:
현재까지의 물리영재들에 대한 선발은 인지능력, 창의성, 과제집착력 등 일반 영재 이론에 따른 특성의 정의에 따라 진행되었다. 대부분 물리학 내용이 포함된 창의성검사에 준하는 문제해결 능력 위주로 물리 영재를 선발해 온 실정이다. 과연 이러한 물리 영재 정의나 선발이 옳은지에 대한 의문에 답하기 위해 물리학이라는 학문의 본성에 따라 물리영재를 다시 한번 정의해 볼 필요가 있다고 생각한다. 본 연구에서는 물리학자와 과학 영재 교육에 참여한 물리교육자들을 대상으로 심층 인터뷰를 진행하여 그 내용을 분석하였다. 질문 내용은 물리학의 정의, 물리 영재의 정의, 물리영재 교수-학습 내용 등이다. 분석 결과, 물리학이 가지는 특성을 기반으로 하는 물리영재에 대한 정의를 탐색하고 이를 통해 물리영재가 미래사회의 과학기술 분야의 우수한 인재로 성장하기 위한 선발 제도 및 교육 프로그램의 운영, 평가 등에 대한 방향을 새롭게 제안한다.

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Keywords:
물리학의 본성, 물리영재, 물리교육, 영재교육

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과학 영재 학생들이 생각하는 아름다운 물리 실험

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Abstract:
과학은 사람들이 세상을 이해하는 중요한 방식의 하나로 많은 사람들이 과학의 객관성, 논리성 등의 특성에 관심을 가져 왔다. 특히, 실험은 과학적 지식을 검증하는 도구로 이해되어 왔으며, 이를 위해 많은 사람들이 실험의 정확성, 엄밀성 등에 주목하고 있다. 반면 일련의 연구자들은 과학의 특성 중 주관성, 심미성 등에 주목하여 왔으며, 오히려 이러한 특성이야말로 과학을 더욱 과학답게 만드는 것이라 주장하고 있다. 최근 과학과 예술의 관계, 과학 및 실험의 아름다움, 과학 교육에서 미적 체험의 역할 등 심미적 관점에서 과학 및 과학교육을 고찰해 보기 위한 여러 시도가 있었으며, 이러한 관점은 기존의 관점에서는 파악하지 못했던 과학의 새로운 모습을 볼 수 있는 것으로 밝혀졌다. 본 연구에서는 과학 실험의 아름다움의 관점에서 학생들의 실험 교육이 가능할까라는 의문을 바탕으로 학생들이 1년간 실시한 일반물리학 실험 내용 중 본인이 생각하는 아름다운 실험은 무엇인지, 아름다운 실험의 기준은 무엇인지 알아보았다. 동시에 학생들이 생각하는 가장 인상적인 실험은 무엇인지도 함께 조사하였다. 연구 결과 학생들이 생각하는 가장 아름다운 실험으로 영의 이중슬릿 실험과 밀리컨의 기름방울 실험이, 가장 인상적인 실험으로 밀리컨의 기름방울 실험이 선정되었다. 영재학생들은 이론과 실험이 정확히 들어맞거나, 실험을 통해 생각지도 못했던 자연의 신비가 드러날 때 실험이 아름답다고 생각했다. 또한 실험이 그 자체로도 아름다울 수 있다고 생각했다. 연구자는 학생들이 실험을, 혹은 자연을 아름답다고 느낄 수 있도록 실험 수업의 목표를 정하는 것이 실험 수업을 개선할 수 있는 하나의 방안이 될 수 있다고 생각한다.

Keywords:
과학영재학생, 물리실험, 아름다움

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E4.03

과학영재아들이 제작한 과학 탐구 포스터의 형식과 내용 분석

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Abstract:
본 연구에서는 초등 과학 영재학생들이 자유탐구를 수행한 후 제작한 포스터를 형식적인 주요 구성 항목별로 특징을 분석하였다. 이를 위해 문헌조사에 의한 연역적 방법과 학생의 포스터에서 나타나는 특징에 의한 귀납적 방법을 함께 활용하였다. 그 결과, 포스터의 제목, 서론, 연구방법, 연구결과, 결론 영역별로 포스터 내용의 특징들이 범주화되었고, 각 영역에서 학생들이 어떤 측면에서 부족한지를 알 수 있었다. 특히 범주별로 제시한 실제 사례들은 학생의 포스터 제작에서 나타나는 특징들을 구체적으로 이해하는데 도움을 줄 수 있었다. 본 연구에서 발견된 내용들은 앞으로 학생들이 자유탐구를 수행한 후에 포스터로 제작하는 과정을 돕는데 실질적인 안내 역할을 할 수 있을 것으로 기대한다.

Keywords:
과학영재, 과학 열린탐구, 포스터, 과학 글쓰기

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E4.04

과학영재들의 역학과 전자기학 기초개념 이해도 비교

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Abstract:
본 연구에서는 국제적으로 널리 쓰이는 역학 기초개념 검사도구인 MBT(Mechanics Baseline Test)와 전자기학 기초개념 검사도구인 CSEM(Conceptual Survey of Electricity and Magnetism) 영문 원본을 활용하여, 본교 과학영재 고등학생들의 역학과 전자기학 기초개념 이해도를 각각 조사하여 그 결과를 비교하였다(2014년 2학기에서 2018년 2학기까지 총 144명 대상). 각 검사는 역학과 전자기학 해당 수업의 학기 첫 주(사전검사)와 마지막 주(사후검사)에 한 번씩 두 차례 실시되었다. 두 검사결과 모두에서 과학영재 고등학생들의 기초개념 이해도는 매우 높은 수준이었는데, 전자기학보다 역학 기초개념 검사에서 더 높은 정답률을 보였다. 사전 및 사후검사 비교에서는 사전점수가 MBT보다 낮은 CSEM에서 더 높은 개념변화획득지수를 나타내었다. 몇몇 문항에서 상대적으로 다소 취약한 면도 드러났지만 전형적인 오개념의 특성을 나타내는 문항은 거의 없었다. 그러나 CSEM 문항 중 전자기 유도 관련 영역에서 상대적으로 어려움을 겪고 있는 것으로 드러났는데(사전검사와 사후검사 정답률 각각 48%, 60%), 사후검사 정답률도 낮은 편이어서 수업 후에도 그 어려움은 여전한 것으로 보여 이 부분의 지도에 특별한 관심이 요구된다. 또한 기초개념 검사결과와 학기 성적과의 상관관계도 상당히 높아 기초개념 이해가 물리학 수업에서 매우 중요한 요소임을 확인하였다. 이렇게 학기 초 사전검사를 실시하여 오개념이나 취약한 부분 등 학생들의 학습 출발점을 미리 파악하고, 학기 말 사후검사를 통하여 수업 후 학습자 개개인의 물리개념 이해도를 평가하고 수업 전후 학습자의 개념변화를 정량화하는 것은 수업의 효용성이나 교수법의 효과를 확인하는 유용한 도구가 될 것으로 기대된다.

Keywords:
물리 오개념, MBT, CSEM, 과학영재

E5.01

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Terahertz nanophotonics with high-temperature superconducting thin films

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Abstract:

We experimentally demonstrate terahertz (THz) transmission properties of the two $GdBa_2Cu_3O_{7-x}$ (GdBCO) films with the thicknesses of 105 and 58 nm grown on a $LaAlO_3$ (LAO) single crystal substrate using a conventional pulsed laser deposition (PLD) technique. Ar-ion milling works well in thinning down to obtain 50 nm-thick films, still maintaining their superconducting property at below its critical temperature. Those thinner superconducting films are suitable to develop various optical applications combined with plasmonic nanostructures to enhance light-matter interactions in the THz and mid-infrared regions. Furthermore, this combined system would create opportunities in studying electrodynamics of Cooper pairs inside the limited volume underneath the plasmonic structures.

Keywords:

Terahertz time-domain spectroscopy, plasmonic nanostructure, high-temperature superconductor, atomic layer lithography

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E5.02*

THz electromagnetic wave generation via diffusive coupling between electron and acoustic phonon

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Abstract:

We observed terahertz (THz) generation induced by coupling between acoustic (AC) phonons and electrons in GaP/Si heterostructures, having GaP films with different thicknesses *d* of 16, 35, 45, and 56 nm on *n*-type Si (001) substrates. The coherent AC phonon wavepackets are initiated via deformation potential coupling with accumulated photo-carriers at the surface and interface of GaP/Si heterostructures by femtosecond laser excitation at 3.1 eV which is above bandgap energy of both materials[1]. The THz electromagnetic wave was generated via acoustic phonon-electron coupling when the AC wavepackets encounter with diffusively transporting electrons in Si layer during propagation in conventional THz time-domain spectroscopy. The waveform of THz is interrelated with the temporal periods of coupling of acoustic phonon-electron depending on GaP thickness *d*. The experimentally measured temporal periods is deviated from the propagation dynamics of AC wave with *d*=45 and 56 nm. This temporal deviation is currently under investigation by analyzing the THz spectra with *d* and electron transport dynamics.

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Acknowledgment

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Keywords:

THz radiation, Electron-phonon coupling, Coherent acoustic phonons

E5.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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All-Dielectric Soft Meta-Optics using Colloids

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Abstract:

소프트 나노광학 연구에 있어 빛과 물질과의 상호작용을 조절하기 위해 다양한 플라즈몬은 연구들이 선행되어 왔다. 하지만 가시광선 영역에서 열 손실로 인한 효율 감소와 발열로 인하여 실질적 응용에 있어 한계점들이 보고되었다. 이에 상대적으로 열 손실이 적고 굴절률이 높은 유전체 물질들이 최근 각광을 받게 되었다. 특히, 높은 굴절률을 갖는 실리콘(Si), 게르마늄(Ge), 그리고 갈륨비소(GaAs))들은 다양한 소프트 나노광학 연구에 초석이 되는 물질로써 여러 광학 현상을 규명하고 분석하는데 플라즈몬과 함께 연구되어 왔다. 하지만 이러한 물질들을 최근까지 보고된 합성법을 기반으로 살펴보면 합성 조건에 많은 제약이 존재한다. 특히, 균일한 크기의 실리콘 콜로이드 합성에는 고온, 고압의 조건(공융점)이 필요하다고 보고되었기 때문에 대학 연구 시설 측면에 있어 접근성이 좋지 않다. 이러한 한계로 인하여 굴절률이 높고 합성법이 용이한 새로운 유전체 물질 개발이 요구되어 왔다. 이에 본 연구에서는 굴절률이 약 2.8~3.1을 가지는 셀레늄 콜로이드를 대량으로 합성하고, 이를 통해 소프트 나노광학 연구에 접목시키고자 한다. 특히, 세가지 연구(Metafluid, Metamolecule, Meta-Crystal)의 틀로 나눠 다양한 관점에서 셀레늄 콜로이드를 분석하였고 이를 통해 소프트 메타 옵틱 연구에 널리 사용될 수 있게 이바지 하고자 한다.

Keywords:

Meta-Optics, high refractive index, Selenium colloids

E5.04*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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나노 입자 자기조립을 통한 비자연적 고굴절률 구현

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Abstract:

물질의 굴절률은 빛을 제어할 때 필수적인 요소이다. 하지만 물질이 일정한 간격으로 구조 또는 패턴을 가지고 있다면 이 물질은 구성 성분의 굴절률과는 다른 굴절률을 가질 수 있으며, 이 물질이 비자연적 굴절률을 가질 때 광학적 메타 물질이라 명한다. 메타물질이 작동하기 위해서는 빛의 파장에 비해 매우 작은 구조체를 가져야 하기 때문에 가시광선의 영역에서 작동하는 메타물질은 구조가 수 십 나노미터의 크기여야 하며 이런 구조 사이의 간격이 수 나노미터 이하의 크기를 이루어야 한다. 따라서 아직 리소그래피 공정과 같은 top down 방식으로는 이러한 수 나노미터 간격의 구조를 구현하기 어려운 상태이다. 최근 콜로이드 자기조립 연구는 top down 공정으로 만들어내기 어려운 3차원 구조나 수 나노미터 단위의 간격 등을 구현하였다.

이 발표에서는 금 은 등의 나노 입자의 콜로이드 자기조립으로 고굴절률을 얻어내는 방법을 소개하며, 특히 나노 입자 사이 간격의 변화 또는 입자 형태의 변화에 따른 굴절률 값의 변화를 보고하고자 한다. 최종적으로 가시광선 영역에서 작동할 수 있는 효과적인 고굴절률 메타 물질 디자인을 제안한다

Keywords:

자기조립, 고굴절률 , 메타물질

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2019-04-24 - 2019-04-26

Anderson localization of massless pseudospin-1 Dirac particles in a one-dimensional correlated random potential

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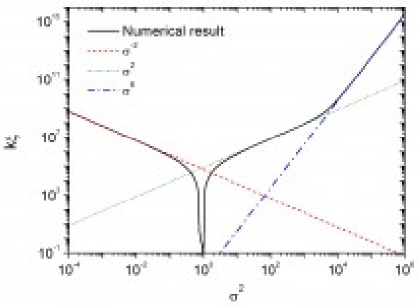
Abstract:

We theoretically study the Anderson localization of massless two-dimensional pseudospin-1 Dirac particles in a one-dimensional short-range-correlated dichotomous random scalar potential. We investigate the dependencies of the localization length ξ on the incident angle θ and the disorder strength 6. By the invariant imbedding method, we obtain precise numerical solutions of the localization length and its analytical expressions in weak and strong disorder limits. When the particle is incident normally on the potential, Anderson localization is absent due to the Klein tunneling effect. When the incident angle is sufficiently small, the localization length is found to be proportional to θ^{-4} for all strengths of disorder, in a sharp contrast to the previous result in [1]. As the strength of disorder increases from zero, the normalized localization length kξ initially decreases as 6^{-2} and then drops to zero abruptly near 6~1 as shown in the figure. Above 6=1, ξ increases as 6^{2} as the disorder strength increases until 6~100. Finally, it crosses over to the 6^{6} dependence in the strong disorder limit and the Anderson localization is destroyed. We explain these behaviors physically based on the concept of the effective wave impedance and the mode conversion arising from the presence of the flat band. Possible experiments are proposed.



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Keywords:
pseudospin 1 Dirac particle, Anderson localization

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E6.02*

A Revisit to Electron Magnetic Focusing

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Abstract:

Magnetic focusing is a crucial tool in ballistic electrons research. The technique is highly versatile, capable of investigating energy-momentum relations, 1D and 2D channel properties, and even hot electron relaxation processes. Recent magnetic focusing studies have expanded to wavefunction imaging, Dirac electrons optics, and exotic 1D channels. Here, we revisit the method to understand magnet-induced and nonequilibrium properties of conventional AlGaAs/GaAs-based high mobility 2D electron gas. The formation of Quantum Hall edge states was studied using two quantum point contacts (QPCs) of varying channel numbers from low to high magnetic fields. An anomalous oscillation was observed at the onset of edge state formation. Subsequently, hot electron focusing was studied by replacing a QPC with a quantum dot (QD) to inject monoenergetic electrons. The focusing spectrum showed an unexpected saturation of cyclotron radius above a certain energy.

Keywords:

magnetic focusing, 2D electron gas, quantum point contact, quantum dot

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Emergent Anisotropic Non-Fermi Liquid at a Topological Phase Transition in Three Dimensions

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Abstract:

Understanding correlation effects in topological phases and their transitions is a cutting-edge area of research in recent condensed matter physics. We study topological quantum phase transitions (TQPTs) between double-Weyl semimetals (DWSMs) and insulators, and argue that a novel class of quantum criticality appears at the TQPT characterized by emergent *anisotropic* non-Fermi liquid behaviors, in which the interplay between the Coulomb interaction and electronic critical modes induces not only anisotropic renormalization of the Coulomb interaction but also strongly correlated electronic excitation in three spatial dimensions. Using the standard renormalization group methods, large N_f theory and the $\epsilon = 4 - d$ method with fermion flavor number N_f and spatial dimension d, we obtain the anomalous dimensions of electrons ($\eta_f = 0.366/N_f$) in large N_f theory and the associated anisotropic scaling relations of various physical observables. Our results may be observed in candidate materials for DWSMs such as $HgCr_2Se_4$ or $SrSi_2$ when the system undergoes a TQPT.

Keywords:

Double-Weyl Semimetals, Topological phase transition, Non-Fermi liquid, Renormalization group

E6.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Topological phase control of Bi_2Se_3 via spin-orbit coupling modulation through hybridization with Hf in close proximity

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Abstract:

Conventional attempts to utilize magnetic doping, mechanical tuning, structural engineering, external bias, and external magnetic fields suffer from a lack of reversible switching and have limited tunability. We demonstrate the direct control of topological surface states in a bismuth selenide (Bi_2Se_3) topological insulator with 3-nm thickness by molecular beam epitaxy-grown films through the hybridization of the topological surface states with the hafnium (Hf) *d* orbitals in the topmost layer of an underlying oxygen-deficient hafnium oxide (HfO_2) substrate. The higher angular momentum of the d orbitals of Hf are hybridized strongly by topological insulators, thereby enhancing the spin-orbit coupling and perturbating the topological surface states asymmetry in Bi_2Se_3. As a result, resistance of 3nm Bi_2Se_3 can be modulated as 20 times (at room temperature) to >1000 times (at 2K) in same thickness. As the oxygen defect is cured or generated reversibly by external electric fields, our research facilitates the complete electrical control of the topological phases of topological insulators by controlling the defect density in the adjacent transition metal oxide. In addition, this mechanism can possibly be applied in other related topological materials such as Weyl and Dirac semimetals in future endeavors to facilitate practical applications in unit-element devices for quantum computing and quantum communication.

Keywords:

Topological insulator, Bi2Se3, Topological surface states, proximity effect

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E7.01

Control of elemental defects on physical properties in Ruthenates epitaxial thin films

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Abstract:
Elemental defects in transition metal oxides (TMOs) play a central role in determining the electronic structures which lead to a variety of materials properties including superconductivity, magnetoelectric coupling, low dimensional effect, and electrochemical activity. In ABO_3 perovskite, the elemental defects can be categorized into anion (oxygen) and cation defects, and nature of the materials changes depending on the type and concentration of the defects. Thus, to accurately design and take advantage of the desirable materials characteristics of TMO thin films, it is essential to comprehend the formation and role of various elemental defects.
Ruthenates ($ARuO_3$, A = Sr, Ca, and Ba) are an interesting material system with the possibility of tuning the physical properties by changing the both A-site cation and oxygen vacancy concentration. In this study, we investigated the correlation among chemical stoichiometry (both cation and oxygen), crystal lattice, and electronic/magnetic properties of Ruthenates epitaxial thin films using the pulsed laser epitaxy (PLE). In $SrRuO_3$ thin films, the elemental vacancies introduced by a low oxygen partial pressure growth induces a phase transition in the crystalline lattice from orthorhombic to tetragonal symmetry. This is accompanied by a transition in the electronic structure, i.e., a substantial decrease of Ru-O hybridization. When the growth pressure decreases further, the perovskite $SrRuO_3$ eventually becomes a layered perovskite of Sr_2RuO_4, the first Ruddlesden-Popper phase of $Sr_{n+1}Ru_nO_{3n+1}$ with n = 1. The mechanism of the structural phase transition depending on the chemical potential and resultant suppression of ferromagnetism will be discussed. In $CrRuO_3$ thin films, the crystal lattice structure does not change as much, even though with a large variation in the elemental defect concentrations. However, the electronic structure of the CRO thin films shows systematic changes, following the change in the cation ratio (Ca/Ru). With increasing off-stoichiometry of the cation, charge transfer transition indicating the hybridization strength between the Ru 4d and O 2p orbitals are increased. We suggest that inter-atomic modifications for ions surrounding the vacancy, i.e., modification of bonding length or bonding perturbation, can lead to the hybridization engineering.

Keywords:
defects, Ruthenates, epitaxial thin film, phase transition, electronic structure, hybridization

E7.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Enhanced phase separation in freestanding $La_{0.7}Ca_{0.3}MnO_3$ membranes

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Abstract:

We present a significantly different transport characteristic of the exfoliated $La_{0.7}Ca_{0.3}MnO_3$ electrical dead layer from its strained counterpart. One can exfoliate the $La_{0.7}Ca_{0.3}MnO_3$ film by growing a water-soluble sacrificial layer of $Sr_3Al_2O_6$ between $SrTiO_3$ substrate and $La_{0.7}Ca_{0.3}MnO_3$ film. We discover that the exfoliated film displays a large electroresistance over a wide range of temperatures. The drastic change in resistance appears to come from direct tunneling through antiphase boundaries, the effect of which is magnified due to revived phase separation in the exfoliated film. Our results suggest a possible reduction of the electrical dead layer in the exfoliated membrane, which indicates a hitherto unexplored avenue to overcome the serious hurdle of the dead layer in making ultrathin nano device.

Keywords:

phase separation, epitaxial strain, transport

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E7.03

Enhanced uniformity in resistive switching by confining vertical conducting filament using a Au-probe tip as the top electrode for epitaxial brownmillerite oxide thin films with a relatively rough surface

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Abstract:

Resistive random access memory (ReRAM) devices with the metal-insulator-metal (MIM) structures have great potentials in nonvolatile memory applications. Previously, we discovered the resistance switching phenomena in $SrCoO_x$ epitaxial thin films, and we interpreted the results in terms of the topotactic phase transformation between their insulating brownmillerite phase to the conducting perovskite phase and the existence of a rather vertical conducting filament. However, the $SrCoO_x$ thin-film-based device suffered from poor endurance and non-uniform distribution in key switching parameters. The rough interface observed between the $SrCoO_x$ and the Au top electrode might lead to fluctuation in the switching induced by the non-reproducible generation/rupture of the conducting filament because of the many possible local minimum paths for the filament near the top electrode. To minimize the surface roughness effect on the device switching, in this work, we studied the resistive switching properties of a $SrCoO_x$ device by placing a Au-coated tip (conventional probe tip in the probe station, tip end area ~0.5 μm^2) directly on the film surface as the top electrode. Confining the oxygen ion distribution should therefore reduce the randomness of the conducting filament. The resulting device displayed improved endurance and showed high uniformity in key switching parameters as compared to the device having a large top electrode area. A simulation result confirmed that the Au-coated tip provides a local confinement of the electrical field, resulting in confinement of oxygen ion distribution and therefore localization of the conducting filament. This work shows a strong indication of achieving uniform and high endurance switching in ReRAM devices that have a rough surface.

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V. R. Nallagatla, J.Jo, S. K. Acharya, M. Y. Kim, and C. U. Jung, *Scientific reports* **2019** (9), 1188.

Keywords:

Resistive switching memory; brownmillerite thin film; Vertical conducting filament; surface roughness; high endurance; uniform switching parameters

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Manipulation of charge density waves in Niobium dislenide: a hierarchy change

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Abstract:

We report on a hierarchy change of charge density waves in Niobium diselenide in the presence of atomic adsorbates, by means of ab-initio calculations. Starting from the most favoured, the triangular hollow-centred, the triangular chalcogen-centred and the hexagonal structures are found in the clean limit, in agreement with the literature, whereas with adsorption of Co and Mn, we find that two solutions related to the hexagonal structure are favoured, a symmetric one and an asymmetric one. In the asymmetric solution, we analyse how the charge distribution changes in direct and reciprocal space, proposing a connection to a recently observed stripe phase in NbSe2 [1].

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Keywords:

"charge density wave", single-layer, "transition metal dichalcogenides", "magnetic adsorbates"

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E8.02*

Calculations of Spin Hall Conductivity of Heavy Metals

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Abstract:

Spin Hall effect has been extensively studied recently in the field of spintronics. In this study, the intrinsic spin Hall conductivity (SHC) is studied using first-principles calculations. SHC of heavy metals, Ta, W, Pd, Pt, Au and Bi, are calculated, whose values range from -142, -783, 1380, 2422,380 and 340(WŸcm)$^{-1}$, respectively, in good agreement with previous studies [1-3].The origin of SHC is discussed more using the band-resolved Berry-curvature, where lifted degeneracies play an important role. Furthermore, different contribution associated with structure, face-centered-cub, body-centered-cubic, monoclinic ones, are compared.

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Keywords:
Spin Hall , first principles, heavy metals

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2019-04-24 - 2019-04-26

E8.03*

Novel 2D RuO_2 oxide design

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Abstract:
Recently, low dimensional materials such as graphene, hexagonal boron-nitride, and transition metal dichalcogenides have emerged among the hottest classes of materials owing to their unique and promising properties for future applications. However, two dimensional (2D) complex oxides materials exhibiting highly strong interactions between spin, charge, lattice and orbital have not been actively investigated yet. Here, by combining genetic algorithm and density functional theory calculations, we designed novel 2D RuO_2 oxide, and its electronic structure and new physical properties will be presented and discussed along with experimental results.

Keywords:
Two dimensional material, Oxide material, Density functional theory, Material design, Ruthenium oxide

E8.04*

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Stabilization of Atomically Precise Non-precious Metal Cluster on Bilayer C_2N for Enhanced Catalytic Activity: A First-principles Study

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Abstract:

While it will have significant implications for the sustainable energy devices, many challenges still remain in the development of active and durable electrocatalysts for hydrogen evolution reaction (HER) and oxygen reduction reaction (ORR) which play crucial roles in water splitting and operation of fuel cell, respectively. Two-dimensional (2D) carbon-based materials, such as graphene and its derivatives, are promising candidates because of their unique structures and electronic properties. Recently, nitrogen-carbon 2D structures (C_2N) have been successfully synthesized through experiments, showing a great potential for high active catalyst. Carrying out extensive first-principles calculations in systematic approaches, for the first time, we demonstrate that the periodic holey structure in stacked C_2N can leads to provide enough space for possessing atomically precise metal cluster. The spatially constrained C_2N holes change relaxed metal cluster geometries comparing their shape in vacuum and the cluster can act as one active site. This specially designed catalyst exhibits enhanced structural stability than single atom catalyst (SAC) approach and excellent catalytic ability in both HER and ORR. This study establishes the few-atom clusters embedded in 2D host materials as a promising scheme toward the achievement of high catalytic activity and stability that surpass those of single-atom counterparts.

Keywords:

hydrogen evolution reaction, oxygen reduction reaction, atomically precise cluster catalyst, density functional theory

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E9.01

Unraveling the competing effect of electron transfer and agglomeration in Li-TFSI doping

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Abstract:

Molecular doping has emerged as an effective strategy to overcome the low conductivity problem of organic semiconductors. To enhance the conductivity of a hole transport layer (HTL) in perovskite solar cells and dye-sensitized solar cells, particularly, bis(trifluoromethane)sulfonimide lithium salt (Li-TFSI) has been widely employed as an efficient p-dopant. Despite the frequent use for improving electrical properties of HTLs, however, the exact working mechanism has not been revealed due to the hygroscopicity of Li-TFSI in ambient air.

Herein, we investigated the electronic structure of Li-TFSI and *N,N′*-Di(1-naphthyl)-*N,N′*-diphenyl-(1,1′-biphenyl)-4,4′-diamine (NPB) HTL with in situ measurements. The results showed that the relative polaronic levels of the host and dopant are more important than the relative ionization energy and electron affinity values of those. The direct electron transfer through polaronic states enabled the reduction of a hole injection barrier between Li-TFSI-doped NPB and indium tin oxide, enhancing the device performance of hole-only devices and organic light-emitting diodes significantly. In addition, the competing effect of the electron transfer and agglomerative properties of Li-TFSI will be discussed.

Keywords:

molecular doping, Li-TFSI, electronic structure, hole injection barrier, aggregation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E9.02*

Raman study of metal nanoparticle attached Polypyrrole nanowire with density functional theory calculation.

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Abstract:

In this study, we investigate Raman shift of polypyrrole nanowire with Au and Ag nanoparticle attachment (PPy-Au/Ag) by density functional theory (DFT) calculation. Phonon, crystal-orbital overlap population (COOP), and partial density of state (PDOS) calculations are performed to characterize the Raman scattering frequency and charge transfer of PPy-Au/Ag nanoparticles. In our DFT calculation, Raman spectra of the PPy are detected near 1300 (ring stretching) and 1600 cm^{-1} (C=C stretching). Also, depending on the attached nanoparticle, the ring stretching Raman shift decreases while the C=C stretching Raman shift increases.

Keywords:

polypyrrole nanowire, density functional theory, Raman

E9.03*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Organo-compatible superhydrophobic protecting layer for organic field effect transistors

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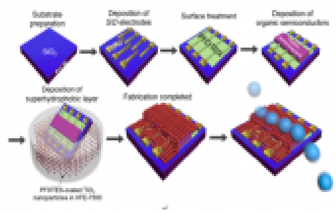
Abstract:



Organic semiconductors have attracted significant interest for realizing next-generation electronics due to their fast, low-cost, and low-temperature processabilities [1]. Nevertheless, it is widely reported that they could be easily degraded by water-based hindrances. Although some efforts to address this issue by encapsulating with various materials have been reported, novel approaches to introduce an effective protection layer directly on organic components are highly desirable. In this regard, the introduction of a superhydrophobic protection layer onto the organic semiconducting layers can be a promising approach to realize reliable and practical organic semiconductor applications. The materials and processes for the superhydrophobic protection layer formation need to be organo-compatible, so that they do not damage physically or chemically when placed on the organic layers, and thus their electrical characteristics would not be degraded.
In this presentation, we report a facile method to directly fabricate an organo-compatible superhydrophobic protection layer on organic devices under ambient conditions. The superhydrophobicity was achieved by simply dipping organic devices in a highly fluorinated solution dispersed with fluoroalkylsilane-coated titanium-dioxide nanoparticles [2]. Furthermore, the uniform protection layer could be deposited using a simple dipping process without any physical damages by optimizing the solvent system to match surface energy with underlying organic semiconductors. The proposed superhydrophobic protection layer had good resistance against mechanical-stress, light-stress and water-based threats. Moreover, protected organic devices exhibited reliable electrical properties even exposed to strong solvents while maintaining self-cleaning properties from extreme water. This approach could be a good alternative solution to protect low-cost and flexible organic electronics working in the opened air.
H. Sirringhaus, Adv. Mater. 26, 1319 (2014).
D. Yoo, Y. Kim, M. Min, G. H. Ahn, D. H. Lien, J. Jang, H. Jeong, Y. Song, S. Chung, A. Javey, T. Lee, ACS Nano, 12, 11062 (2018).

Keywords:
Superhydrophobic, Organic field effect transistor, Protection layer, Nanoparticle

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E10.01

Physics is in Everything

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Abstract:
This presentation composes of two parts.
In the first part, I briefly talk about the moments of my challenges to become a physicist.
In the second part, I present how fast digital change happens and
how to challenge this exponential change, on the light of my life.

Keywords:
Physics is in everything

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

E10.02

Physics, Woman, Politics and Me

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Abstract:
Starting my career as a physicist interested in liquid crystals, neural networks, and biological physics, I became active in the issue of promoting women in science. As I wondered about how public policy could advance science and improve society, I was drawn into politics. Right now, I am mainly concerned about how to foster a free democratic society and the liberation of North Korea.

Keywords:
Physics, Woman, Politics, Statistical Physics

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E11.01

In situ whole cell capacitance measurement of controlled cell number and alignments via optical tweezing

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Abstract:

A capacitance biosensor allows real-time and label-free sensing to measure various cell activities and interactions. Generally, cells are cultured between the sensing electrodes and average analysis method is used to represent measured values from a group of cells. However, it has been proven that collecting capacitance values of individual cell is very important in applications such as cell phenotyping or cell sorting. As a matter of fact, several methods have been developed which include patch clamping, alternating current electrokinetics and microfluidics. Yet, they are either labor-intensive, slow or inaccurate due to cellular membrane deformation. Furthermore, abovementioned techniques are generally opportunistic i. e., they do not allow precise control, selectivity nor directed mobility of individual cell.

In this talk, a method to measure whole cell capacitance with controlled cell number and cell alignments is discussed. An optical tweezing technique is utilized to place controlled number of cells between the sensing electrodes with controlled spacing and alignments. First, fabrication methods of standard linear electrodes that enable effective capacitance measurement of optically trapped single or several cells are discussed. Next, optical tweezing conditions and single cell capacitance calculation method from measured values are presented. Comparison of single, double, triple and multiple cells, along with different alignments such as adjacent or spaced, and perpendicular or parallel proved the presence of electrostatic interaction between the cells.

Keywords:

Cell capacitance, optical tweezing, single cell, cell alignment, electrostatic interaction.

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E11.02

Single-molecule functional anatomy of endogenous dimers of human receptor tyrosine kinases

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Abstract:

Many type of human cancer proliferate via HER family RTK. Therefore, targeting HER famiy with kinase inhibitor can selectively kills the cancer cell. But, cancer cell can also evade from the kinases inhibitor by making HER2, HER3 heterodimer. The reason, why this specific combination of HER2, HER3 heterodimer can generate the such a strong proliferative signal was elusive due to the difficulty of purifying the funtional membrane proteins. Here we introduced the way of immunoprecipitating functional HER2 dimer on an imaging surface of singe molecule fluorescence microscopy. Then, we observed and quantitatively analyzed kinase acitivity of each type of HER2 dimer, explaining the mechanism of resistance via HER2,HER3 heterodimer is due to its overwhelming phosphorylation rate even under activity of kinase inhibitor and phosphatase. We further applied the developed single co-IP methods as high-throughput screening assay which is followed by finding small molecule that can effectively inhibits HER2, HER3 heterodimer. Drug we found was able to potently inhibit the HER2, HER3 pathway in breast cancer cells and tumor xenograft models.

Keywords:

RTK, HER2, HER3, kinase inhibitor, singe molecule fluorescence microscopy , phosphorylation , high-throughput screening assay , tumor xenograft models

E11.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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나노피펫 탐침을 이용한 쥐의 해마 신경세포에서의 선택적 이온 농도 측정법

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Abstract:

본 연구에서는 나노피펫 탐침을 사용하여 쥐의 해마 신경세포의 안과 밖에서 특정 이온의 농도 변화량를 측정하였다. 나트륨, 칼륨 또는 칼슘 등의 특정 이온을 각각 선택적으로 분리 검출할 수 있는 PVC막을, 나노피펫의 내부에 잘 형성시키고 이를 탐침으로 적용하였다. 분리 검출된 이온들로부터 생성된 미세한 이온전류는, 나노피펫 내부 상단에 위치한 silver wire 전극을 거쳐 주사터널링현미경 측정법에서 사용되는 sub-pico 암페어 전류 측정시스템을 통해 계측되었다. 나노피펫 탐침의 위치를 변화시킴에 따라, 쥐의 해마 신경세포 내의 국소적 위치의 특정 이온의 농도 변화량을 실시간으로 관찰할 수 있었다.

Keywords:

나노피펫, 나트륨, 칼륨, 칼슘, 신경세포

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E11.04

Simulation Method for the calculation of Biological Effectiveness of Neutron capture therapy

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Abstract:
Relative Biological Effectiveness (RBE) of neutron beam plays an important role in neutron capture therapy (NCT). In this study, simulation method is investigated to estimate RBE of NCT in terms of born dose, nitrogen dose, hydrogen dose and gamma dose. Each dose component is simulated by using Geant4 Monte Carlo toolkit in a given simple geometry. The lineal energy of each beam component is calculated and connected to the biological effectiveness of each dose component. Finally, the photon effective weighting factor, RBE is estimated for each beam component.

Keywords:
Biolocial model, Neutron capture therapy, RBE, Simulation, Geant4

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E12.01

Turbulence Spreading and Mesoscopic Transport Events in Magnetized Plasmas

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Abstract:

This presentation covers a pedagogical review of turbulence spreading and mesoscopic transport events in magnetized plasmas. It is based on a recent comprehensive review [1]. It is now clear that the conventional picture of localized turbulence and quasi-linear calculation of fluxes fails to address and account for the phenomenology of tokamak transport. One key issue is the observed departure from the expected gyro-Bohm transport scaling. The causes of this breakdown of Fick's law include turbulent avalanching and pulse propagation (turbulence spreading). Both are mesoscopic transport events, and both tend to de-localize the flux-gradient relation. Turbulence spreading is described by theoretically-motivated, phenomenological reaction-diffusion models for the turbulence intensity field. Such models imply that spreading will occur by propagation of intensity fronts. After discussing the basic theory, this presentation will cover several critical tests of turbulence spreading models using gyrokinetic simulation. Avalanching refers to a process whereby correlated topplings of nearby localized cells overturn sequentially and drive a burst of transport. Avalanching is a process intrinsic to systems that support a broad range of scales l between a cell size Δ and system size L, i.e., $\Delta < l < L$. Therefore, the PDF (probability distribution function) of avalanches as a function of l is a crucial quantity, necessary for predicting confinement in a system like ITER, with a very large-scale separation between L and Δ. The presentation traces the intellectual prehistory of avalanching through the advent of self-organized criticality. Evidence for avalanching in basic and confinement experiments is summarized. Throughout the presentation, an effort is made to set fusion theory and phenomenology in the context of ideas discussed in the broader scientific community.

References:

[1] T.S. Hahm and P.H. Diamond, J. Korean Phys. Soc. **73**, 747 (2018).

Keywords:
Self-organization, Turbulence spreading, Avalanches, Entrainment, Mesoscopic transport, Intermittency, Non-local transport, Self-organized criticality, Magnetically confined plasma, Transport events, Fluctuation front propagation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E12.02

Halo mechanisms of high intensity beams in linear accelerators

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Abstract:
As the beam intensity increases in modern high-power accelerators, self-field effects of the beam become significant and it is the utmost goal to minimize the beam loss of halo particles by avoiding or minimizing contributions of various halo mechanisms. There are two distinct families of space-charge halo mechanisms in high-intensity linear accelerators, and yet they need to be differentiated: resonances (single particle resonances or incoherent resonances) and instabilities (parametric resonances or coherent resonances). What we call resonances are resonances of the beam particle excited through the space-charge nonlinear multipoles. What we call instabilities (or envelope instabilities) are instabilities of the beam envelope. Instabilities are also called parametric resonances because they are parametric resonances of the envelope equation. They would better be called *envelope parametric resonances* to distinguish them from particle parametric resonances. Resonances and instabilities may look alike in the phase space, and yet they have distinct differences. Instabilities (or envelope parametric resonances) do not have the resonant frequency component. Various orders of resonances and instabilities are presented along with the beam distributions with which the particular mechanism is observed.

Keywords:
halo, space charge, resonance, instability

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E13.01

Status of NEOS Phase-II

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Abstract:
The NEOS phase-II experiment (NEOS-II) is being carried out in the tendon gallery of Hanbit-5 reactor, measuring the electron anti-neutrinos from the reactor core at 24 m distance. From the first phase of the measurement in 2015-2016, no strong evidence for active-to-sterile neutrino oscillation was found, and the 5 MeV bump was observed. The phase-II measurement has started from September 2018 and will continue for a full fuel cycle (~ 500 days) of the reactor. We present the current status of the NEOS-II with its 200 days of data set.

Keywords:
Neutrino Experiment, Reactor Experiment, Reactor Anomaly

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E13.02

Search for Sterile Neutrinos at RENO

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Abstract:

The RENO experiment has successfully measured θ_{13} using the disappearance of electron anti-neutrinos in three-flavor neutrino oscillations. We search for sterile neutrinos in four-flavor oscillation model using 2200 days of data collected by the RENO experiment. We have not seen any positive signal and obtain an excluded region of the oscillation parameters. We present an excluded contour plot in $\sin^2(2\theta_{14})$ - Δm_{41}^2 space without any constraint on the other oscillation parameters.

Keywords:

neutrino, sterile neutrino, neutrino oscillation, RENO

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Observation of fuel-composition dependent variation of reactor antineutrino yield and spectrum

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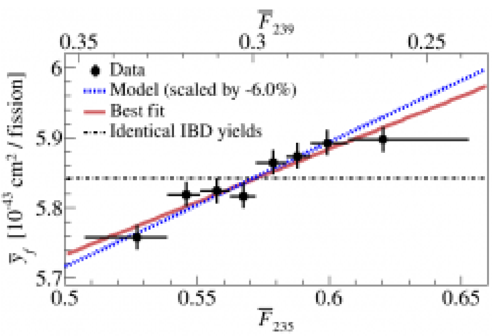
Abstract:

The RENO experiment has observed changes in the reactor antineutrino flux and spectrum with respect to the reactor fuel evolution. This study utilizes reactor antineutrinos detected through inverse beta deacy (IBD) in the near detector for 1807.9 live days. The antineutrinos are produced for multiple fuel cycles by the six reactors at Hanbit Nuclear Power Plant in Korea. A fuel-composition dependent variation of reactor antineutrino flux is observed and compared to the reactor model prediction. The deficit of observed reactor IBD events relative to a prediction, so-called reactor antineutrino anomaly, can be mostly explained by reevaluation of the 235U isotope yield. We also report an interesting hint on correlation between the 5 MeV excess in the IBD prompt spectrum and the 235U fission isotope fraction.



Keywords:
Reactor, RENO, neutrino, oscillation, antineutrino

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E13.04

Theta13 measurement using 1500 days of neutron captures on hydrogen at RENO

주경광*[1], 신창동[1], 곽필준[1], 김재률[1], 문동호[1], 박영서[1], 서준후[1], 임인택[1], ATIF Zohaib[1], 김우영[2], VLADIMIR Kavtanyuk[2], 박명렬[3], 최준호[3], 장한일[4], 권은향[5], 김상용[5], 김수봉[5], 서현관[5], 이동하[5], 이현기[5], 김종건[6], 서지웅[6], 유인태[6], 전상훈[6], 정다은[6], CARSTEN Rott[6], 장지승[7], 양병수[8], 유종희[8], 주기원[8]
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Abstract:

RENO has been taking data since August, 2011 and successfully measured the smallest neutrino mixing angle, theta13. The measurement values are obtained from the observed reactor anti-neutrino events with neutron captures on gadolinium (n-Gd) in the target detector region. The experiment has also measured the mixing angle using an independent sample of neutron captures on hydrogen (n-H). Because of a large accidental background in the n-H sample, an improved technique has been developed to make an effective removal of the background. In particular, the (n-H) analysis utilizes events in both target and gamma-catcher and thus obtains a more than twice larger sample than that of (n-Gd). This independent measurement provides a valuable systematic cross-check of the theta13 measurement. In this talk, we will present the results from the 1500 days of n-H data sample.

Keywords:
RENO, neutrino

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E13.05

Results from 2500 days of RENO data

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Abstract:

The RENO experiment has measured precise values of neutrino mixing angle θ_13 and mass squared difference ddm^2_ee, using reactor antineutrinos from the reactors at Hanbit Nuclear Power Plant since Aug. 2011. In 2018, RENO published the results using 2200days of data. We have added roughly 300 more day data and obtained an updated result from 2500 day data. In the period of latest 100 days of the data, only one or two reactors out of total six were operated and produced relatively low flux of antineutrinos. In this talk, we present the updated result from the 2500 day data.

Keywords:
RENO, 2500, low flux of antineutrinos

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E14.01

Thermodynamics of the rotating black hole with an anisotropic matter field

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Abstract:

We present a family of the rotating black hole solutions of Einstein's equations with an anisotropic matter field, generalizing the Kerr (Kerr-Newman) spacetime. We obtain the geometry representing the rotating black hole by employing the Newman-Janis algorithm. For the energy-momentum tensor, we fix the basis vectors of the orthonormal frame to measure physical quantities, energy density and pressure, where the energy-momentum tensor is diagonal. We investigate the thermodynamic properties associated with the event horizon for black hole solutions, which means that the contributions from the matter fields are added to the physical quantities associated with the event horizon. The mass formula is presented with nontrivial contributions and the first law of thermodynamics is also presented.

Keywords:

rotating black hole, thermodynamics, mass formula

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E14.02

Gravitational Faraday Rotation

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Abstract:

The Faraday rotation is an interaction between light and a magnetic field in a medium, causing a rotation of the polarization plane of light. We have considered the interaction between light and a plane gravitational wave. The polarization plane of light also tilts due to gravitational waves passing - the so-called gravitational Faraday rotation. Several main features of such effect and a possible application to detecting gravitational waves are briefly discussed.

Keywords:

Faraday rotation, Gravitational waves

E14.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Singular solutions in string theory

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Abstract:
We discuss on singular black-hole-like solutions in string theory which is motivated by double field theory. Although this shows a singular null hypersurface, this can be a natural realization of the firewall. We first illustrate the causal structures and second discuss possible scenarios of black hole evaporation.

Keywords:
black holes, string theory, firewall

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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E14.04

중력상호작용하는 비등방 물질의 엔트로피

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Abstract:
유한한 영역안에서 자체 중력상호작용을 하는 비등방물질의 엔트로피를 일반상대론적으로 구하였다. 구체적으로는, 구대칭 에너지 분포의 지름 방향과 고체각 방향의 압력이 다른 비등방물질로 구성된 계에 해당하는 값을 열역학과 연속방정식 으로부터 도출하였다. 이 엔트로피의 극값의 변분방정식이 비등방 물질의 중력장 방정식을 재현함을 보였다. 이로써, 중력과 열역학의 상관 관계를 다시 한 번 확인하였다. 블랙홀이나 웜홀 등 몇가지 시스템들에 이 엔트로피를 적용시켜 보았다.

Keywords:
비등방물질, 엔트로피

E15.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Chiral symmetry breaking in holographic abelian Higgs model and stripes in bipartite system

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Abstract:
We show that the holographic abelian Higgs model have the stringy spectrum by showing two point functions of fields with any spin have linear Regge trajectory. We also point out that the superconductivity, charge density wave and QCD axial sector can be described by the same model with different charge identifications, which realizes the t' Hooft-Mandelstam conjecture, QCD as the dual superconductivity, as a consequence. We suggest that it can be the reason for the the stripes in the unconventional superconductors, and it provide a mechanism for CDW or stripes which does not request Fermi surface and its nesting.

Keywords:
Holography, chiral symmetry breaking, stripe patter

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E15.02*

Possible quantum spin liquid phases on the kagome lattice

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Abstract:

We study possible phases of pyrochlore spin ice subject to external magnetic field along [111] direction. Within moderate strength of the field, the system can be decomposed of kagome layers and the spinon excitation is enfoced to migrate on the honeycomb lattice. While Ising interaction defines the ground-state manifold and background electric field, the exchange interaction is mapped to hopping of spinon excitations. Particularly, for frustrated exchange, the spinon experiences pi-flux around the honeycomb plaquette. Applying the U(1) compact gauge theory, the effective action is developed to analyze the phase transition out of spin liquid through spinon condensation. We also compare our results with relevant experiments and quantum monte carlo simulations.

Keywords:
Pyrochlore lattice, Quantum spin liquid, U(1) gauge theory, spinon.

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E15.03*

Topological phases with emergent chiral spin states on the kagome lattice at 1/3 filling

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Abstract:
The study of kagome lattice and materials with kagome lattice structure like herbertsmithites and jarosites have been an active area of research. The credit of the discovery of some exotic phases of matter like quantum spin liquid goes to the materials with kagome lattice structure. Recently, kagome lattice has also gained attention in the study of system with non-trivial topology. Motivated by the richness of the model and the possible realization in real materials, we study the interacting kagome lattice at 1/3 filling in the presence of the spin-orbit coupling. Using mean-field approximation, we present the phase diagram and report new types of topologically trivial and non-trivial phases accompanied with unique charge and spin orderings on the kagome lattice: spin-charge density wave, Chern ferromagnet insulator, time reversal broken quantum spin Hall insulator, Chern umberlla insulator, etc. In particular, the presence of spin-orbit coupling and electron interaction generically open a new type of Chern insulating phase stabilized by umbrella like spin ordering with finite spin chirality. We discuss these new phases on symmetry grounds and Hartree-Fock mean-field perspective.

Keywords:
kagome lattice, spin-orbit coupling, Hubbard interaction, mean-field theory, spin chirality

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E15.04

Stacking sensitive topological phases in a bilayer Kane-Mele-Hubbard model at quarter filling

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Abstract:

Layered quasi two dimensional systems have garnered huge interest in both understanding emergent physics such as unconventional superconductivity, topological phases and in the advancement of technology. In particular, the study of topological properties of some bilayer systems such as transition metal chalcogenides and iridates has been pointed to by comparatively strong spin orbit coupling of transition metal ions. In this paper, we analyze the topological phases induced by the interplay of electron correlation and spin orbit coupling in different stacking orders of bilayer hoenycomb lattice at quarter fi lling. Considering the two most common stacking orders, AA and (AB) stacking, we show that the stacking order plays a crucial role in the topological phase transitions of the bilayer interacting system. For AA stacking case, the system realizes quantum spin Hall insulator or magnetically ordered insulator breaking time reversal symmetry of the system. For bernel stacking case, however, additional phases such as charge ordered insulator or Chern insulator with charge order and magnetic order can be stabilized. Based on our analysis, we discuss the scope of experimental realization in real materials like bilayer transition metal chalcogenides.

Keywords:

Bilayer honeycomb lattice, Kane Mele Hubbard model, topological transitions

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F1.01

Low energy nuclear physics experiments at RAON

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Abstract:

The low energy nuclear physics plays a key role to understand the origin and properties of atomic nuclei. Since the advent of RIBs (Rare Isotope Beams) in mid of 1990's, researchers have made remarkable progress in fields of nuclear structure and nuclear astrophysics. However, due to the limitation of RIBs' specifications such as intensities and species, there are much remains to be solved.

The RAON (Rare isotope Accelerator complex for ON-line experiments), which is under active construction at Daejeon, Republic of Korea, will push the frontiers of nuclear science by reaching more than 80% of the unexplored region in the chart of nuclide with wide range of RIBs' energy (a few keV/nucleon to a few hundreds MeV/nucleon). In this talk, experimental systems and scientific program for researches on low energy nuclear physics will be discussed

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F1.02

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Towards comprehensive mass measurements with MRTOF mass spectrographs at RIKEN RIBF

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Abstract:

The exotic isotopes 249-253Md [1] as well as many other rare isotopes of heavy- [2,3] and intermediate-mass nuclei [4] - 80 isotopes in total - have successfully been measured with a multi-reflection time-of-flight mass spectrograph (MRTOF-MS) at RIKEN's gas filled recoil ion separator GARIS-II in 2016-2017. In the series of experiments, we showed that the mass spectrograph can precisely and accurately measure atomic masses with high efficiency even for very short-lived isotopes having a half-life of 10 ms. After successful completion of the first campaign, we are expanding to have mass spectrographs at multiple facilities of RIKEN RIBF such as the new GARIS-II, GARIS-III, KISS, and BigRIPS + SLOWRI, to perform comprehensive mass measurements of all available nuclides at RIBF. The flagship experiment will be for hot-fusion super heavy nuclides, in particular 288Mc and 284Nh to make an anchor for the new element Z=119.

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[4] S. Kimura et al., Int. J. Mass Spectom. 430, 134-142 (2018)

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F1.03

High precision mass measurement in RAON

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Abstract:

The multi-reflection time-of-flight mass spectrograph (MRTOF-MS) has been recently gathering attentions from various scientific fields, i.e., Mass measurement and Beam purification.
Nuclear mass, one of most important physical parameters for nuclear astrophysics, should be measured with high precision, e.g. less than 100 keV for the r-process study. The MRTOF-MS can provide sufficiently high mass resolving power of m/dm ~ 100,000 within a few tens ms, which is very suitable for mass measurement of r-process nuclei usually having short lifetimes. The MRTOF-MS system consists of a gas catcher, a trap system and a MRTOF analyzer. In this presentation, current status of the R&D work of MRTOF-MS system at RAON, which is committed under the collaboration with KEK/WNSC (KEK, Wako Nuclear Study Center) including scientific programs.

Keywords:

Nuclear Mass, MRTOF, Nucldear physics

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F2.01

GaN nano device technologies

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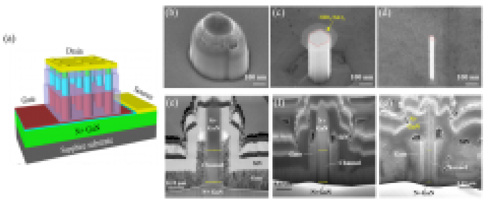
Abstract:

Gallium nitride (GaN) and GaN based heterostructure have been promising candidate for high-voltage, high frequency and high-temperature operation because of its superior material properties such as wide band-gap energy, high breakdown field, and high electron saturation velocity. Compared with conventional GaN transistors, GaN based 3-dimensional FinFETs or nano-channel transistors have been shown improved device performances such as suppressed trapping effect, extremely small off-state leakage current, significantly improved linearity, simple realization of normally-off operation, possibility of subthreshold swing below 60 mV/dec and enhancement of heat dissipation. Moreover, GaN based transistors using nanowires provide the chance for the application as a logic devices. The scaling issues (such as short channel effect and off-state leakage current) can be effectively suppressed by not only large effective mas and low permittivity of GaN but also nanowire structure. In addition, nanowire structure increase the gate controllability of transistors which result in low saturation voltage below 0.5 V, low threshold voltage of 0.5 V and negative transconductance. Those characteristics of GaN based nanowire transistors will be advantageous for the logic applications.



(Fig. 1 (a) The epitaxial structure used in GaN VNWMOSFET. (b) SEM image after dry etching of VNW. (c) SEM image of VNW with the diameter of 120 nm after TMAH etching. (d) SEM image of VNW with the diameter of 56 nm after TMAH etching. (e) Schematic of GaN VNWMOSFET. (f) Microscope image of GaN VNWMOSFET.)

Keywords:
GaN, FinFETs, nanowire FETs

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F2.02

국내외 SiC 단결정 wafer 기술개발 동향

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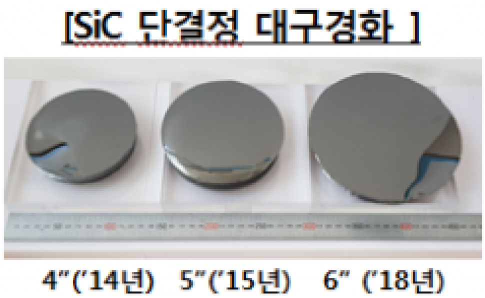
Abstract:

기존 Si-계 전력반도체 대비 고효율을 나타내는 SiC 전력반도체에 대한 관심 및 개발/신업화가 가속화되고 있으며, 2007년 4“ 기판에 이어 2014년 6”기판의 상업적 이용이 가능해짐에 따라 SiC계 전력반도체 상용화가 본격적으로 진행되고 있다.

SiC 단결정 wafer 소재는 p형과 n형의 양쪽이 모두 가능한 화합물반도체로서 Si보다 절연파괴강도가 10배, 열전도도가 3배 크고 열과 화학적 특성이 안정하므로. 기존 Si wafer의 한계를 넘는 high power, 고온동작 내환경 디바이스로의 응용이 기대되어 폭발적인 시장 잠재성을 보여주고 있다.

특히, 최근 10년간 전세계적으로 태양광 및 전기차등의 신성장 산업군에서 친환경 고효율 전력반도체에 대한 산업적 필요성 확대 및 이를 위한 고효율 SiC 전력반도체 채용확대가 본격 진행되고 있다.



본 발표에서는, 고효율 SiC 전력반도체의 핵심소재인 SiC 단결정 wafer 제조기술과 관련된 국내외 개발현황을 보고하고자 한다.

Keywords:
SiC Single Crystal Wafer, powersemiconductor, PVT, wafering, SiC Epitaxy

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F2.03

Device Technologies in SiC

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Abstract:

It has been known that silicon carbide (SiC) show superior material properties enabling operation at higher temperatures and voltages, as well as improved switching speeds of power devices, such as diodes and MOSFETs, thanSi technology.
Whereas a new generation of SiC power devices is being developed for future power applications in which traditional Si power devices show limited operation, still the principles of design parameters of conventional structure remain important.
This talk will cover a review of the historic innovations that have led to the evolution of aconventional power MOSFET technology and also reviews most recent trends in SiC power semiconductor device technology.
The power transistor has been displaced by silicon power MOSFETs in low voltage systems and by the silicon IGBTs in high voltage systems. The process technology for MOS-gated devices has shifted from V-MOS in the early 1970s to DMOS in the 1980s, with more recent introduction of the UMOS technology in the 1990s for Si.
For the very high power systems, the thyristor and GTO continue to dominate, but significant effort is underway to develop MOS-gated thyristors (MCTs, ESTs, DG-BRTs) to replace them before the turn of the century. Beyond that time frame, it is projected that silicon carbide-based switches will begin to displace these silicon devices. A brief introduction to the recent SiC device technology will also be given.

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F2.04

Recent progress in Diamond-based semiconductor device technologies

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Abstract:
Wide bandgap semiconductors have received considerable attention during the last decade due to their outstanding properties for many applications [1]. The better power and frequency handling capabilities, and higher thermal conductivity of wide bandgap semiconductors will give them significant advantage over classic semiconductors. Diamond is an excellent semiconductor material with an ultra-wide band gap and possesses such as high carrier mobility, high saturation velocity, high chemical and radical inertness, and the highest electrical breakdown field strength among semiconductor materials [2]. In this presentation, we will review recent diamond device technology for power and RF applications.
In addition, diamond with the highest thermal conductivity among broadband semiconductors is the most promising material as a thermal diffusion substrate for RF / power devices. For example, despite the maturity of GaN device technology, the heat generated during device operation is a limiting factor that maximizes the performance of GaN devices [3,4], but it can be overcome with high thermal conductivity diamond [3]. This presentation will also present recent research and development trends of GaN-on-Diamond semiconductor electronic devices.

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[2] A. Q. Huang: IEEE Electron Dev. Lett. Vol. 25,p.298,2004
[3] H.S. Lee et al, : IEEE Electron Dev. Lett. Vol. 33,p.982, 2012
[4] H.S. Lee et al, : 24th Korean Conference on Semiconductor,2017

Keywords:
Ultra-wide bandgap semiconductor, Diamond Device, Thermal conductivity, GaN, GaN-on-Diamond semiconductor

F2.05

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Ga_2O_3 semiconductor device technologies

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Abstract:

산화갈륨(Ga_2O_3) 반도체는 그림 1과 같이 GaN, SiC등과 같은 WBG 보다 밴드갭이 더 넓고 전계강도등 물성이 우수하여 내환경 센서, 단파장 광소자, 고성능 전력반도체등 다양한 응용을 위한 차세대 Ultra-wide bandgap (UWBG) 반도체 플랫폼으로 최근 들어 국제적으로 연구개발 주제로 각광을 받고 있다.
본 발표에서는 아직 연구개발 초기단계 수준에 있지만 소재강국 일본을 선두로 미국과 유럽 등에서 활발하게 진행되고 있는 Ga_2O_3 반도체 소자기술의 글로벌 연구개발 동향에 관하여 말씀드리고자 한다.[1-3] 아울러 국책과제를 계기로 최근 설립된 "한국산화갈륨연구회"의 향후 나아갈 방향에 관하여 함께 고민해 보고자 한다.

	Si	4H-SiC	GaN	β-Ga_2O_3
Bandgap E_g (eV)	1.1	3.3	3.4	4.5–4.9
Electron mobility μ ($cm^2 V^{-1} s^{-1}$)	1,400	1,000	1,200	200–300
Breakdown field E_{br} ($MV cm^{-1}$)	0.3	2.5	3.3	7–8
Relative dielectric constant ε	11.8	9.7	9.0	10
BFOM $\varepsilon\mu E_{br}^3$	1	340	870	2,000–3,400
Thermal conductivity ($W cm^{-1} K^{-1}$)	1.5	2.7	2.1	0.27 [010] 0.11 [100]

그림 1. Ga_2O_3 반도체의 물성비교 및 다양한 응용분야 (출처: NICT(일), 자체번역2016)

* 본 연구는 산업통상자원부 소재부품개발사업 (전략적핵심소재기술개발사업, 과제번호: 10080736) 지원에 의하여 수행되었음.

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Keywords:
Ga2O3, 산화갈륨, 울트라와이드밴드갭, power device, 전력소자, FET, SBD

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F3.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Multibit Optical memory properties realized by 2D top floating gate flash memory

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Abstract:

Recently, optical memory properties were reported in $CuIn_7Se_{11}$, MoS_2/functionalized SiO_2, and MoS_2/graphene, in which the optical memory effects originate from photo-induced charge trapping and detrapping in defects and disorders. However, these devices exhibit too low on/off ratio and short retention time to be used for practical applications. Here, we report MoS_2-based devices with a top floating gate of Au, graphene, or MoS_2. Unlike the reported hybrids and conventional floating gate memory devices, the floating gate is at the top and the MoS_2 channel layer is below it. The photoresponsive floating gate, such as graphene and MoS_2, is at the top, so the devices can be controlled by light pulses as well as gate voltage pulses. In particular, upon illumination of 532 or 635 nm light, multilevel optical memory properties are observed, whose photon energy is lower than the tunneling barrier height from the top floating gate to the MoS_2 channel. Compared with the conventional floating gate memory devices, our devices have the advantage that it is easy to access the light source because of the top floating gate and it is possible to modulate the multilevel optical memory states by adjusting top floating gate materials.

Keywords:

Multilevel optical memory, top floating gate, 2D flash memory, Nanodevice application, MoS2

F3.02*

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Effects of Surface Oxidation on Electronic Structures of Transition Metal Dichalcogenides

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Abstract:

Surface oxidation is a popular method to engineer electrical properties of transition metal dichalcogenides (TMDCs), such as p-doping and the reduction of contact resistance with metal. The origin of the electrical property change is the Fermi level difference between TMDCs and transition metal oxides (TMO). For example, TMO induces p-doping in TMDC because it has a higher work function (> 5 eV, which depends on the oxidation state of the transition metal) than TMDC. While such effects of surface oxidation have been understood to some extent, it has not known how much charges transfer to meet the Fermi level equilibrium and how TMO energy levels are aligned with TMDC. To figure out the effects of surface oxidation completely, the direct observation on the charge transfer and energy level alignment is necessary. In this regard, we traced the electronic structure at the interface between TMDCs (MoS_2, $MoSe_2$, $MoTe_2$, WS_2, WSe_2) and their counterpart TMO. The interfacial electronic structure was analyzed with direct/inverse photoelectron spectroscopy, which can measure the Fermi level and density of states of both valence and conduction band. Our results show that the charge transfer and semiconductor type can be controlled by the oxidation state of TMO.

Keywords:

Transition metal dichalcogenides, photoelectron spectroscopy, energy level, oxidation

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F3.03*

AuCN Nanowire Epitaxy on Graphene for Hybrid Phototransistor

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Abstract:

The van der Waals epitaxy of functional materials provides an interesting and efficient way to manipulate the electrical properties of various hybrid two dimensional (2D) systems. We study the controlled epitaxial assembly of semiconducting one-dimensional (1D) atomic chains, AuCN, on graphene and investigate the electrical properties of 1D/2D van der Waals heterostructures. AuCN nanowire assembly is tuned by different growth conditions, although the epitaxial alignment between AuCN chains and graphene remains unchanged. Semiconducting AuCN chains endow the 1D/2D hybrid system with a strong responsivity to photons with an energy above 2.7 eV, which is consistent with the bandgap of AuCN. A large UV response (responsivity ~10^4 A/W) was observed under illumination using 3.1 eV (400 nm) photons. Such optical and electrical responses are changed by tuning the morphology of AuCN nanowires. Our study clearly demonstrates that 1D chain-structured semiconductors can play a crucial role as a component in multifunctional van der Waals heterostructures.

Keywords:
Nanowire, AuCN, Graphene heterostructure, Epitaxy, Phototransistor

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F3.04*

Intracellular GaN microrod laser

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Abstract:

Cell labeling techniques play an essential role in cell imaging and individual cell tracking. In medical and biological science, the cell labeling is used for studying cell migration, differentiation, dynamic behavior of cells, progression of many diseases including cancer cell metastasis. For cell labeling, fluorescent dyes or quantum dots have widely been used, but their relatively broad emission spectrum makes it difficult to distinguish each cell. To address this issue, small lasers exhibiting sharp spectral lines have been employed]. For the cell labeling applications, the lasers must be small enough to be internalize into the cells, have high efficiency and compatibility. Among numerous nanomaterials, inorganic materials including CdS nanowires and AlGaInP multi quantum well nanodisks have been used for inorganic intracellular lasers due to their excellent lasing characteristics and stability. Here we propose that GaN microrods can also be a good candidate for intracellular laser because of their excellent lasing characteristics and biocompatibility.

The GaN microrods were grown on graphene films using metal-organic vapor phase epitaxy without employing any metal catalysts. GaN microrods with a diameter of 1.5±1 μm and a length of 10±3 μm were employed for intracellular lasing experiments. To internalize into cells, the microrods were detached from the substrate by sonication and dispersed into a petri dish where HeLa cells were cultured. The GaN microrods were internalized into cells via endocytosis process in few hours. For the intracellular lasing experiments, micro-photoluminescence spectroscopy was used using a Nd:YAG pulse laser (355 nm, 10 Hz, 6 ns pulse width). The laser beam was focused on each cell using a 39X UV objective lens (NA=0.50). We investigated lasing characteristics in a single intracellular GaN microrod. Below lasing threshold, a broad emission centered at 370 nm was observed. With increasing excitation power density, sharp and complex peaks appeared. Because of the existence of multiple waveguide modes, these lasing spectra have quite complex lasing peaks with irregular mode spacing and intensity ratios. Since such a complex lasing spectrum highly depend on the diameter and length of GaN microrods, we believe that this would be used for individual cell tracking method.

Keywords:

Microlaser, intra-cellular laser, GaN, cell labeling

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F3.05

부분 팁 게이팅에 의한 그래핀 리본의 전기 전도성 변화 모델링

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Abstract:
그래핀은 탄소원자들이 2차원 평면형태로 구조를 이루고 있는 물질로 전기전도도, 열전도도 등이 뛰어난 신소재로 각광받고 있다. 특히 2000년대 초·중반에 기초 연구를 포함한 많은 연구들이 진행되어 왔고, 특히 뛰어난 전기전도도를 활용하기 위하여 그래핀을 전자기기에 활용하고자 하는 노력들이 많았다.
그래핀은 주변 환경에 민감하게 반응하기 때문에 이를 활용한 응용 연구들이 활발하게 이루어지고 있지만, 한편 이러한 특성 때문에 소형화된 기능성 기기에 활용하기 위해서는 다양한 환경 요인을 고려한 세심한 설계가 필요하다. 특히 소자의 도선 및 트랜지스터 등으로 활용 가능한 그래핀 리본은, 그 폭의 변화에 따라 전기 전도도가 달라진다는 것이 잘 알려져 있다.
본 발표에서는 그래핀 리본의 폭이 달라질 때 팁 게이팅 및 백 게이팅에 의해 변화되는 전기전도도를 모델링 및 시뮬레이션을 통하여 계산한 결과를 발표한다. 그래핀 리본의 폭은 실제 응용 개발에 활용 가능한 수준인 서브 마이크로미터급 폭 (100 ~ 500 nm)을 적용하였다. 팁 / 백 게이팅시, 그래핀 리본의 폭이 좁을수록 그래핀의 전기전도도 변화는 컸다. 특히 팁 게이팅시, 백 게이팅을 적용했을 때 보다 그래핀의 물성변화는 작았지만, 분명한 변화가 있음을 확인할 수 있었다.

Keywords:
그래핀 리본, 팁 게이팅, 전도도 변화, 시뮬레이션

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F3.06*

대면적 MoS_2 기반 전계 효과 트랜지스터을 활용한 AMOLED Pixel 회로 구현

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Abstract:
그래핀은 21세기 초반에 매우 주목을 받던 물질이었지만, 밴드갭이 존재하지 않아 트랜지스터로 제작하기에는 한계가 있었다. 이를 대체할수 있는 물질로 2차원 물질이 등장 하였는데, 밴드갭이 존재하고 각 층이 반데르발스 힘으로 붙어 있어 박리가 용이하다는 이유에서 많은 관심을 끌었다. 특히, 여러 2차원 물질중 이황화 몰리브덴(MoS_2)는 높은 캐리어 이동도와 전류점멸비(on/off ratio)을 보여주어 n-type특성을 가지는 물질로서 각광받고 있다. 때문에, 이황화 몰리브덴(MoS_2)은 소자를 위한 반도체 물질로서 실질적인 잠재력을 지닌다. 하지만, 기존의 공정 방법인 화학적, 기계적 박리법은 크기와 두께를 조절할수 없는 한계가 있다. 그러므로 상업화가 되기에는 큰 문제점이 되는데, 이를 해결할 수 있는 방법으로 대면적 화학기상증착법(CVD)이 주목받고 있다. 본 연구에서 화학기상증착법으로 성장된 대면적 이황화몰리브덴을 사용하여 노광공정을 통해 전계효과 트랜지스터(FETs)를 제작한다. 이를 이용하여 초록색, 파란색 유기발광 다이오드(OLED) 픽셀을 디지털, 아날로그 스위칭 및 구동시킬수 있는 전계효과 트랜지스터로서의 가능성을 보여준다. 더 나아가, 전계효과 트랜지스터의 문턱전압(Vth)와 히스테리시스 균일성이 개선되게 하기 위해서 산화알루미늄(Al_2O_3)유전체 위에 매우 얇은 소수성 폴리스티렌(polystyrene) 스핀코팅을 했다.

Keywords:
이차원물질, 이황화몰리브덴, 전계효과트랜지스터, 유기발광다이오드

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F3.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Remote homoepitaxy of ZnO microwire arrays across graphene interlayers

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Abstract:
We report on remote homoepitaxy of ZnO microwire arrays on ZnO substrates across graphene layer using hydrothermal growth method. Despite of the presence of poly-domain graphene interlayer, the ZnO microwires were epitaxially grown on *a*-plane and *c*-ZnO substrates, which were found to have homogeneous in-plane orientation over the entire surface of graphene-coated ZnO substrates. Such homoepitaxial relationship across graphene between ZnO microwire and substrate was revealed through cross-sectional transmission electron microscopic and selected area electron diffraction analyses. The density-functional theory calculations suggested that the charge redistribution occurring near graphene induces the electric dipole formation, so the attracted adatoms lead to formation of the remote-epitaxial overlayer. Because of a strong potential field caused by long-range charge transfer given from the substrate, even the use of bi-layer and tri-layer graphene resulted in the remote-epitaxial ZnO microwires. The effect of substrate crystal planes is also theoretically and empirically demonstrated. The ability of the graphene, which can be released from the mother substrate without covalent bonds, was applied to delaminate the microwire arrays overlayer. This unconventional epitaxy technique offers an opportunity of producing well aligned, transferrable and flexible epitaxial nano/microstructure arrays templates for epitaxial electronics and optoelectronics applications while regenerating the substrate for cost-saving device manufacturing.

Keywords:
Remote homoepitaxy, ZnO, graphene, hydrothermal growth

F3.08*

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Site-Specific Growth of Anisotropic 2D Materials on Atomically Flat Graphene Surface without Dangling Bonds

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Abstract:

Rhenium disulfide, a new family of two-dimensional transition metal dichalcogenides, has received growing interests in polarization-sensitive optoelectronic devices owing to its unique anisotropic atomic structure. Synthesis of high-quality rhenium disulfide along the in-plane direction is one of the most important issues for its widespread application into functional devices. However, in-plane growth of rhenium disulfide is still challenging due to its weak interlayer coupling effect, leading to preferred growth in the out-of-plane direction. Here, the rhenium disulfide is successfully grown along the in-plane direction on atomically smooth and chemically inert graphene surface without developing any structural defects by chemical vapor deposition process, resulting in high-quality graphene/rhenium disulfide heterostructure. Furthermore, the patterning of vertical heterostructure was achived using the site-specific growth of rhenium disulfide. These results will provide valuable information for better understanding the growth behavior of van der Waals heterostructure based on two-dimensional materials.

Keywords:

chemical vapor deposition, graphene, heterostructure, rhenium disulfide, site-specific growth

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F3.09

Artificial ultrasensitive synapses based on 2D material $CrPS_4$

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Abstract:

To emulate the learning of biological synapses and overcome the energy and throughput limitations of neuromorphic computing systems, we need to high sensitivity and reproducibility are crucial for transmitting information quickly and accurately. But, they usually present limited high power consumption. Therefore, electronic devices that can have want characteristics with minimal performance variations remain limited.

Here, we demonstrate that two-dimensional layered single-crystal chromium thiophosphate ($CrPS_4$) can be used as a non-volatile binary resistive switching memory, which shows good switching uniformity, retention and endurance as well as ultralow operation voltages and high on/off ratio. The memory device can be also used for artificial ultrasensitive synapses with analog resistive switching and good reproducibility. In addition, with the help of ex-situ transmission electron microscopy and density functional theory (DFT) calculations, we observed that the behavior resulted from a resistive switching mechanism based on the migration of Ag ions from the active electrode to the $CrPS_4$ layer with sulfur vacancies.

Keywords:

2d material, conductive bridge memory, high on/off ratio, ultralow operation voltage, artificial synapse, ultrasensitivity, reproducibility

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F4.01

교육과정 개정의 주요 방향 및 쟁점 그리고 통합과학 속의 물리 콘텐츠

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Abstract:

본 발표에서는 2015 개정 교육과정의 주요 방향과 쟁점, 통합과학 내 물리 콘텐츠, 학교에서 통합과학 운영과 과목 위상에 대해 발표하고자 한다. 2015년에 발표한 교육과정 개정의 배경에는 인문학적 상상력과 과학기술 창조력을 갖추며 바른 인성을 겸비한 창의융합형 인재를 양성하자는 데 있다. 교육과정 개정 내용을 보면 문이과 통합형 교육과정을 취지를 살리기 위해 고등학교 공통과목(통합과학, 과학탐구실험, 통합사회)를 신설하고, 문학.연극.독서 및 소프트웨어 교육을 강화하는 것이 주요 골자로 되어 있다. 또한 단위학교 교육과정 편성의 자율성을 확대하고, 중학교 자유학기제를 정착시키고, 고등학교에서 다양한 선택과목 개설(고교학점제)을 교육과정 개정의 주요 방향으로 설정하고 있다.

2015 개정 교육과정에서 고등학교 교육과정의 편제를 보면, 교과와 창의적 체험활동의 큰 두 줄기 아래 교과에는 보통 교과(주로 일반 인문계고 과목)와 전문 교과(특목고, 특성화고 과목)로 나뉘며, 보통 교과에는 학생들이 필수로 배워야 하는 공통 과목과 학교 및 학생의 자율 선택권을 강조하는 선택 과목(일반 선택, 진로 선택)이 있다. 이번 논의의 중심인 통합과학은 과학탐구실험, 통합사회와 더불어 공통 과목군에 속해있으며, 2015 개정 교육과정이 문이과 통합형 교육과정을 지향하고 있다는 점에서 2015 개정 교육과정에서 매우 중요한 위상을 가지고 있는 과목이다.

2015 개정 교육과정의 핵심 교과목이라는 위상 덕분에 통합과학의 성공적 안착을 위해 교육부는 과목에 적합한 교수학습 및 평가 방법을 제시하고, 관련 교수학습 자료 및 평가 도구를 개발하는 등 다양한 정책적 지원 노력을 해왔다. 특히 통합과학에 대한 별도의 집중 연수 계획을 수립하고 해당 과목의 담당 전문직 및 현장 교원을 대상으로 해당 교과목의 교육과정 및 내용지식에 대한 이해, 융합적 교수·학습 설계 등에 대한 연수를 진행하였다. 전문직 연수는 17개 시 · 도교육청의 통합과학 담당 34명(과목별 각 2명), 핵심교원 연수는 60명씩 30시간 연수로 진행되었으며, 선도교원 연수는 단위학교 1명 이상을 연수 대상으로 선정하여 시행되었다. 이 연수는 통합과학과 같은 맥락상에 있는 통합사회에 대해서도 실시하였으며, 교사 연수는 2016년에 시작하여 2018년까지 온라인과 오프라인 형태를 융합하여 실시하였다.

통합과학은 물질과 규칙성, 시스템과 상호작용, 변화와 다양성, 환경과 에너지라는 4개의 영역에 대해 물질의 규칙성과 결합, 자연의 구성 물질, 역학적 시스템, 지구 시스템, 생명 시스템, 화학 변화, 생물다양성과 유지, 생태계와 환경, 발전과 신재생에너지 등과 같은 9개의 핵심 개념을 중심으로 분과 학문적 지식수준을 넘어 다양한 형태의 통합을 통한 융복학적 사고력 신장이 가능하도록 구성되었다.

통합과학의 내용요소 중 물리 콘텐츠에 해당되는 내용을 정리하면 <표 1>과 같다.

<표 1> 통합과학 단원 구성과 물리 관련 내용

영역(대단원)	핵심개념(중단원)	물리 관련 내용
물질과 규칙성	물질의 규칙성과 결합	*빅뱅 우주론*
	자연의 구성물질	신소재의 활용, 전자기적 성질
시스템과 상호 작용	역학적 시스템	중력, 자유낙하, 운동량, 충격량
	지구 시스템	
	생명 시스템	
변화와 다양성	화학 변화	
	생물 다양성과 유지	
환경과 에너지	생태계와 환경	에너지 전환과 보존, 열효율
	발전과 신재생 에너지	발전기, 전자기유도, 전기에너지, 전력수송, 태양에너지, 핵발전, 태양광발전, 신재생에너지(연료전지, 파력, 조력, 풍력)

<표 1>에서 물질의 규칙성과 결합 단원에 속한 빅뱅 우주론은 지구과학과 내용요소가 공유되는 부분이며, 나머지 요소들은 순수 물리 콘텐츠에 해당되는 내용이다. <표 1>에서 알 수 있듯이 통합과학 내 물리 내용은 역학적 시스템과 발전과 신재생 에너지 단원에 집중된 모

양새이다. 실제 통합과학을 물화생지 교사 4명이 분리하여 가르치는 학교의 경우 이 두 단원을 물리교사에게 집중하여 담당하기도 한다. 최근 조사해본 결과 통합과학의 학교 내 위상은 개정 교육과정이 발표된 2015년도에 비해 달라졌음이 확인되고 있다. 통합과학은 고등학교에서 필수인 보통교과이며 문이과 통합형 교육과정을 지향하는 2015 개정 교육과정의 성패를 좌우할 만큼 중요한 역할을 담당하는 초기 위상에서 일부학교에서는 교사 수업 시간을 분배하기 위한 과목으로 위상이 낮아진 것이 발견되고 있다. 위상 변화의 원인 중 하나는 2022학년도 대학수학능력시험에서 통합과학을 수능 과목에서 배제하기로 한 2018년 8월의 교육부 발표이다. 이에 따라 교사의 평가 부담을 줄여 통합과학의 원래 취지인 활동 중심 교육이 제대로 수행하며 한 명의 교사가 통합과학 전체를 담당하여 학생들의 통합적 사고를 기르게 하는 긍정적 요인도 발생한 반면, 통합과학 수업 단위 수 감축 운영 등 부정적 요인도 발견되고 있다.

Keywords:
통합과학, 2015 개정 교육과정

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F4.02

2015개정교육과정 통합과학 교과 물리영역에서의 학교 현장 수업진행방식 분석

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Abstract:
본 연구에서는 2015개정교육과정에서 1학년 통합과학 교과 물리영역의 비중과 학교 현장에서의 수업진행방식에 대하여 분석하였다. 이전 교육과정에서의 과학 교과에 비하여 물리영역 비중이 대폭 감소하였다. 또한, 과학교사의 전공영역이 통합과학의 교육과정 재구성 과정에서 물리영역의 수업 간소화 혹은 생략에 영향을 미친다. 이러한 교육현장의 상황이 물리학1을 선택하는 학생의 비율을 더욱 감소시킬 수 있을 것이 우려되기에 개정될 교육과정에서의 영역 비율 및 내용 조정이 필요하다고 판단된다.

Keywords:
통합과학, 물리영역, 수업 진행

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F4.03

새로운 물리 교육과정 개정을 위해 고려할 측면들

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Abstract:

본 발표에서는 새로운 교육과정 개정을 위해 고려할 필요가 있는 측면을 다음과 같이 논의하고자 한다. 첫째, 초등과정부터 10학년까지 미래의 진로와 직업에 상관없는 모든 이를 위한 공통 교육과정에서 과학적 소양을 기본 목표로 한다면, 과학적 소양에 대한 구체적인 분석틀에 따라 교육과정에서 제시하는 성취기준들이 과학적 소양을 얼마나 반영하고 있는지를 점검해야 한다. 둘째, 11~12학년에서 선택과목인 물리 I, II 과목은 미래 물리학과 관련된 진로와 직업을 위한 준비과목으로의 성격을 강화할 필요가 있다(예를 들어, 물리 I 과목을 문이과 구별없이 모든 학생을 대상으로 하는 것은 모순이다). 셋째, 최근 강조되고 있는 융합과학은 융합을 이해하고 체험할 수 있도록 하되, 물리 I, II 과목에서는 미래에 여러 세부 전문가들과 협업하는데 필요한 전문 지식과 기능을 갖추는 것을 중심으로 한다. 넷째, 역량중심 교육과정에 따른다면, 역량중심 교육과정의 내용이 실제 교실/실험실 수업에서 구현될 수 있도록 구체적으로 제시될 필요가 있다. 다섯째, 실업계 고등학교와 과학영재학교를 위한 차별화된 물리 I, II 교육과정의 신설이 필요하다. 여섯째, 7학년에서 자유학기제가 시행될 경우, 자유학기제 운영을 고려한 7학년용 교육과정을 별도로 고려할 필요가 있다. 일곱째, 입시에서의 평가방향이 학습에 미치는 되먹임이 강력한 현 상황에서는 초중등 교육과정에서 대학 입시의 기본방향을 함께 제시하고, 이 방향이 수능제도와 대학선발과정에 반영되도록 할 필요가 있다(예를 들어, 물리 I을 선택한 경우 물리 II 과목은 필수 이수하도록 한다. 대학에서는 학과별로 필요한 선택과목을 명시하고 명시된 과목에 대한 수능성적을 반영하도록 한다). 마지막으로 새로운 교육과정으로의 개정을 위해서는 이전 교육과정의 장점과 단점을 분석한 데이터와 증거에 기반하며 충분한 기간을 확보하여 수행되어야 한다.

Keywords:

물리교육과정, 융합과학, 선택과목, 역량중심, 자유학기제, 입시

F4.04

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장 개념을 다루는 새로운 교수방안에 대한 제안

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Abstract:

역사적으로 장 개념은 즉각적인 힘의 전달에 반하는 개념으로 도입되었다. 그런데 물리교육에서 장을 다룰 때 주로 정적인 장(static field)에 대해 많은 논의가 집중되면서, 장을 통해 힘이 전달될 때 힘이 전파되는 속도가 유한하다는 핵심이 잘 다루어지지 않는다. 본 연구에서는 장과 힘의 전달속도 개념을 교수학습에서 다루는 새로운 방안을 제시하고자 한다. 여기서 장을 통한 힘의 전달은 파동의 전파로 비유되어 이해될 수 있다. 또한 힘이 전달속도가 있다면, 뉴턴의 3법칙이 깨지게 되며, 그 효과가 행성의 운동에도 영향을 미친다는 논리적 결론도 도출된다. 이러한 논의들은 교수학습에서 장개념과 힘의 전달속도를 심도 있게 다루는 데 도움을 줄 수 있을 것이다.

Keywords:

장, 힘의 전달속도

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F4.05

고등학생들의 양자역학 기초 개념에 대한 이해

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Abstract:

고도의 과학기술을 기반으로 하는 현대 사회에서 양자역학의 중요성은 재론의 여지가 없으며, 이에 따라 고등교육 뿐만 아니라 중등교육 수준에서도 양자역학 교수학습에 대한 관심과 연구가 지속적으로 증가하고 있다. 한편, 물리학의 전 분야에 걸쳐서 학생의 물리 개념 조사와 이를 바탕으로 하는 물리 교수학습에 대한 연구가 활발히 수행되었으나, 양자역학 교육에 있어서는 고전 물리학과 근본적으로 다른 세계관과 접근을 요구하는 양자역학의 학문적 특성으로 인해 관련 연구가 여전히 부족한 편이다. 특히 고등학생을 대상으로 하는 연구는 더욱 부족한 실정이다. 이에 이 연구에서는 그동안 양자역학에 대한 학생의 물리 개념 연구를 점검하고 이를 바탕으로 고등학생을 대상으로 양자 현상 및 관련된 양자역학 기초 개념에 대한 이해를 조사하고자 하였다. 기존의 양자역학 개념조사 도구들이 주로 학부 수준 이상을 대상으로 개인의 개념 이해 정도를 측정하는 방식으로 수행된 것에 비해서, 이 연구에서는 군집분석(cluster analysis)을 통하여 양자역학 기초 개념과 관련한 진술문에 대한 학생의 이해를 유형별로 분류하는 접근을 적용하였다. 연구 결과를 바탕으로 고등학생의 양자역학 기초 개념에 대한 이해를 군집으로 구분하여 설명하고, 이를 바탕으로 고등학교 수준에서 양자역학 교수학습에 대한 시사점을 논의한다.

Keywords:

양자역학, 개념 이해, 고등학생, 군집분석

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

F4.06

고등학교에서의 현대물리학, 무엇을/어떻게, 가르칠/배울 것인가

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Abstract:
현대물리학은 우리가 자연에 대해 가지고 있는 지식과 관점의 가장 기초를 이루는 학문이다. 따라서 현대물리학을 어떻게 가르치고 배울 것인가는 모든 과정에서 과학교육의 매우 중요한 주제라고 할 수 있다. 현재의 통합과학 교과서는 이러한 현대물리학의 내용과 관점을 보여주기에 다소 미흡하다고 보인다. 이에 현대물리학의 어떤 내용을 고등학교 과정의 교과서에 제시해야 할 것인지를 생각해 보고자 한다.

Keywords:
현대물리학, 통합과학

F5.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Non-Hermitian photonics based on quantum-inspired symmetries

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Abstract:

In this talk I will discuss several symmetries in quantum physics that have recently led to the observations of intriguing optical phenomena and the realizations of novel photonic functionalities. Different from canonical quantum mechanics, these symmetries implies non-Hermiticity that is difficult to realize in high-energy physics or condensed matter systems in a controlled fashion. However, thanks to absorption and radiation loss as well as light amplification, photonics provides an ideal platform to explore the ramification of these symmetries, including parity-time (PT) symmetry and non-Hermitian particle-hole symmetry. PT symmetric photonics [1] is one of the fastest growing fields in the past five years. It requires a judiciously balanced refractive index satisfying , i.e., with a symmetric real index modulation and an antisymmetric imaginary index modulation. I will talk about its spontaneous symmetry breaking [2], the coexistence of laser and anti-laser [3], generalized conservation laws for wave propagation, and anisotropic transmission resonances [4]. Particle-hole symmetry imposes a strong restriction on the underlying system in the Hermitian case, which exists, for example, in superconductors and is related to Majorana zero modes. In photonics however, I will show that particle-hole symmetry is ubiquitous in gain and loss modulated systems with two sublattices [5], such as coupled waveguides and a network of optical cavities. As a consequence, there exist a large set of symmetry-protect zero modes, which can be utilized for building a unique single-mode, fixed-frequency, and spatially tunable laser, potentially useful for spatial encoding of telecommunication signals.

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[5] Qi, B., Zhang, L. & Ge, L. *Phys. Rev. Lett.* 120, 093901 (2018).

Keywords:

non-Hermitian, photonics, symmetries

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F5.02

Anomalous phenomena in non-Hermitian electrical circuits and photonic structures

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Abstract:

Using physical effects for practical device applications, environmental interferences are in general considered as being problematic or at least undesirable for proper operations of physical devices. However, recent development of non-Hermitian physics and photonics has suggested intriguing possibility of using environmental interferences as a key mechanism for remarkably efficient control schemes even beyond conventional closed-system approaches. In this talk, we provide our recent progresses in the development of non-Hermitian electrical circuits and photonic structures. We demonstrate electrical circuit resonators which reveal unique non-Hermitian properties in their parametric eigenvalue spectra and dynamic responses. Considering potential for applications of these properties in practice, we show an intriguing photonic-device architecture that produces topological time-asymmetric operations over an extremely broad optical spectral band. We discuss required further study and future directions of this emerging research topi

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F5.03

Continuum models of non-Hermitian topological edge states

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Abstract:

Recently there has been tremendous interest in topological phases and edge modes occurring in non-Hermitian systems. I will briefly review progress on this topic to date, introducing key ideas such as winding numbers and non-Hermitian degeneracies and using a simple continuum model of a non-Hermitian domain wall [1]. Then I will show how these concepts can be applied to understand a very old problem: surface waves of Maxwell's equations supported by interfaces between two uniform, isotropic, lossless media [2].

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[2] K. Y. Bliokh, D. Leykam, M. Lein, and F. Nori, "Topological non-Hermitian origin of surface Maxwell waves," Nature Communications 10, 580 (2019).

Keywords:

topological phase, non-Hermitian, surface plasmon polariton

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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F5.04

Observation of exceptional points in active non-Hermitian graphene metasurfaces

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Abstract:

In this talk, we demonstrate that exceptional points and phase singularities can be observed in a non-Hermitian metasurface. By designing a metasurface composed of hybrid meta-atoms with anisotropic radiation loss and using graphene to control the intrinsic coupling between the meta-atom components, the polarization eigenstates of the metasurface can be manipulated through variation of radiation frequency and graphene's optical conductivity. We have observed a polarization phase singularity for the first time at an exceptional point in the transmission through an anisotropic metasurface. By analyzing the transmission data of the metasurface, we observe phenomena unique to exceptional points including level repulsion behavior, geometric phase under encirclement of the exceptional point, and asymmetric transmission of circularly polarized radiation.

Keywords:

Metasurfaces, Graphene, Non Hermitian Photonics, Exceptional Points

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F6.01

Application of near ambient pressure X-ray photoelectron spectroscopy to catalysis studies

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Abstract:

Catalysis is significant for energy and chemical industries. A chemical reaction on a thermal catalyst occurs on surface of a heterogeneous catalyst. Chemistry of the catalyst surface is the key for understanding catalytic performance and reaction mechanism at a molecular level. X-ray photoelectron spectroscopy is the important technology to obtain surface chemistry of a catalyst including chemical environment of atoms, atomic ratio of elements, oxidation state of atoms, charge transfer between different atoms. Atoms of a catalyst surface at a catalytic state (called active surface) in terms of working for transforming reactants to products are at a state quite differently from that of an active surface after cooling down to room temperature and purging reactants (called inert surface). To fundamentally understand the catalysis at a molecular level, it is necessary to establish a direct correlation between measured catalytic performance and its corresponding active surface. Thus, uncovering surface of the catalyst during catalysis is the key for interpreting reaction mechanism of this catalysis and designing a catalyst with promoted catalytic activity, selectivity and stability.
Near ambient pressure X-ray photoelectron spectroscopy is a technique to track surface of a catalyst in gas phase of reactants when the catalyst is catalyzing the gaseous reactants. Scientists over the world have pursuit in realizing instrumentation and characterization of surface of materials in gas phase. Our recent instrumentation has focused on realization of studying surface of materials at higher pressure through building new X-ray source and reaction cell which allows to perform catalysis and collection of photoelectrons. In the last decade, my group has extensively used it in characterizations of surface of a catalyst during catalysis. I will present our instrumentations in building our near ambient pressure XPS systems and demonstrate how it can be used for catalysis including thermal catalysis, electrocatalysis and even photocatalysis.

Reference:
Nguyen, L. et al. *Chem. Rev.* 2019, DOI. 10.1021/acs/chemrev.8b00114

Keywords:
NAP-XPS, Heterogeneous Catalysis

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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F6.02

Operando surface science study in energy and catalysis processes under two-dimensional materials

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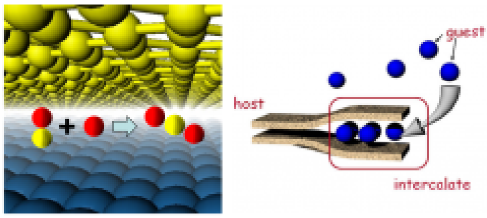
Abstract:

Traditional photoemission spectroscopy and electron microscopy techniques including X-ray photoelectron spectroscopy (XPS) and photoemission electron microscopy (PEEM) are based on ultrahigh vacuum conditions. However, energy processes and catalytic reactions take place under ambient conditions. To bridge the gap, near ambient pressure (NAP) XPS, NAP-SPM, and NAP-PEEM have been developed or built in our lab. Surface and interface processes occurring in the energy and catalysis processes close to real reaction conditions can be investigated using the advanced surface science techniques. Two-dimensional (2D) nanoreactor formed under 2D materials can provide well-defined model systems to explore confined catalysis and energy processes using the NAP surface science techniques. Particularly, the interlayer within 2D materials provides 2D space for ion diffusion and intercalation (Figure), which is the fundamental step of the secondary ion batteries. As an example, Al-ion battery processes under the 2D materials have been investigated by operando XPS, AFM, and Raman. The operando surface and interface studies can unambiguously reveal the battery mechanism, demonstrating the methodology of *surface and interface electrochemistry*.



2D material/metal catalyst   2D material electrode

References:
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[3] H.B. Li, J.P. Xiao, Q. Fu, X.H. Bao, *PNAS*, 2017, 23, 5930
[4] D.H. Deng, K. Novoselov, Q. Fu, N.F. Zheng, Z.Q. Tian, X.H. Bao, *Nat. Nanotechnol.*, 2016, 11, 218;
[5] L.J. Gao, Q. Fu, M.M. Wei, Y.F. Zhu, Q. Liu, E. Crumlin, Z. Liu, X.H Bao, *ACS Catal.*, 2016, 6, 6814.

Keywords:
1) NAP-XPS; 2) NAP-PEEM; 3) NAP-STM; 4) 2D material catalyst; 5) 2D material electrode

F6.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Noble Vanadium Core-Shell Catalysts for Methane Oxidation to Formaldehyde

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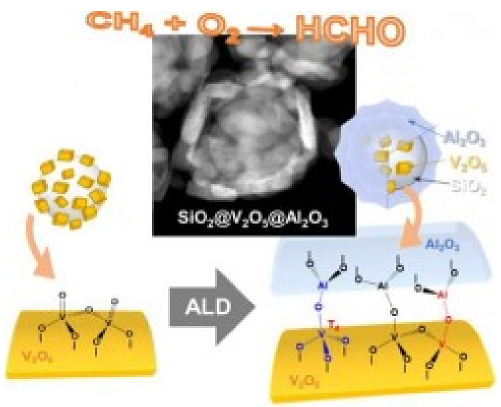
Abstract:



The recent development of hydraulic fracturing technology for collecting shale gases further stimulates to convert abundant methane to a more valuable chemical feedstock by less depending on petroleum resources. Nevertheless, direct catalytic conversion of methane is challenging, because of a stable tetrahedral geometry of methane with high bond dissociation energy. While avoiding the production of carbon dioxide by full oxidation, selective conversion of methane to formaldehyde is important for the purpose of versatile utilization of natural gas. As an efficient and thermally stable catalyst, new $SiO_2@V_2O_5@Al_2O_3$ core@shell nanostructures are designed via hydrothermal synthesis and subsequent atomic layer deposition (ALD) method. In particular, the thickness of Al_2O_3 shells over $SiO_2@V_2O_5$ cores can be controlled by the number of ALD cycles. Through catalytic methane oxidation in a flow reactor operated at 600 °C, $SiO_2@V_2O_5@Al_2O_3$-(50) nanostructures after 50 cycles of ALD is proven to be the best catalyst with 26.5 % of conversion and 47.9 % of HCHO selectivity which is the highest methane conversion never achieved before from any vanadium based catalysts at 600 ^{o}C. With versatile characterizations with TEM, EDS, *in situ* XRD, Raman, H_2-TPR, and diffuse reflectance UV-vis spectroscopy, we find that the Al_2O_3 shell of the $SiO_2@V_2O_5@Al_2O_3$ core@shell catalyst provides new surfaces to create highly dispersed T_d-monomeric species by interactions between the Al_2O_3 and V_2O_5 nanoparticles during the ALD process. It is revealed that the surface Al_2O_3 shell not only protects V_2O_5 nanoparticles against sintering at 600 ^{o}C but also anchors the new T_d-monomeric vanadium species which is responsible for the high conversion in methane oxidation.

Keywords:
vanadium, V2O5, core@shell, methane oxidation, formaldehyde, stable catalyst

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F6.04

Confined-interfacial nanostructure formation on the $Pt_3Ni(111)$ surface at near-ambient pressure

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Abstract:

The unique electronic structure of platinum (Pt)-based transition metal (TM) alloyed surface structure has considered as an origin of high-performance molecular interactions in heterogeneous catalysis. Especially, the tailored Pt-skin/Pt-TM structure shows enhanced catalytic activity for oxygen reduction reaction (ORR) and preferential oxidation of carbon monoxide (PROX) that the geometrically and electronically manipulated nanostructure can provide effective charge exchange sites on the surface at the molecular-level by the Sabatier's principle. However, the sub-surface TM elements are strongly influenced with adsorbate molecules at elevated pressure. In fact, the dissociative oxygen on topmost layer of Pt-skin/Pt-TM structure lifts up the sub-surface TM element. For example, spontaneously occurring adsorbate-driven nickel (Ni) segregations make confined-interfacial Pt-NiO_{1-x} nanostructure on the surface during chemical reaction condition.

In this talk, we explain the formation process of Pt-NiO_{1-x}/$Pt_3Ni(111)$ surface by using near-ambient pressure scanning tunneling microscopy (NAP-STM). In the Torr range pressure of O_2 conditions, partially oxidized Ni clusters are segregated onto $Pt_3Ni(111)$ surface that the time-lapse and pressure-dependent observation results critically indicate the evidence of confined-interfacial nanostructure formation. Furthermore, carbon monoxide (CO) molecules are selectively adsorbed on the sites of Pt elements consisting of Pt-NiO_{1-x} clusters, which leads more efficient chemical reaction pathway for CO oxidation with lowering activation energy barrier. *Operando* near-ambient pressure X-ray photoelectron spectroscopy (NAP-XPS) measurement results of chemical binding energy changes support that the selectively adsorbed CO molecules on Pt atoms easily react with nearby oxygens of NiO_{1-x} species for CO_2 evolution. We will deal with the important relationship of interfacial nanostructures formations and highly-enhanced catalytic activity at elevated pressure and temperature.

Keywords:

NAP-STM; NAP-XPS; Pt-Ni bimetallic catalyst; Surface segregation; CO oxidation

F7.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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TEM Investigation of Various Structures and Dynamics in 2D van der Waals Heterostructures

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Abstract:
Heterostructures composing of two-dimensional (2D) crystals have gained wide interests due to their tuable physical properties emerging from intereaction between differenct components. Here we present studies on various structures and dynamics observed in 2D van der Waals heterostructures using tranmission electron microscopy (TEM). In particular, graphene can serve as an excellent membrae for molecular assembly and TEM imaging. Various inorganic and organic assembly and their dynamical behavior can be monitored at atomic and molecular resolution, providing key information on the energetics and kinetics of assembly process. Moreover, 2D crystals protected by graphene membrane exhibit prolonged stability under e-beam, enabling successful imaging of crystal structure and atomic-scale defects. In situ TEM expeirments, including observation of interlayer stacking modification at high temperatures, will be also discussed.

Keywords:
2D heterostructure, molecular assembly, TEM imaging

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Interaction between charge density wave excitation with electron captured in low dimensional systems

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Abstract:

In most of charge density wave materials, superconductivity emerges when charge density wave phase is suppressed. It naturally implies the connection between them, the possible role of charge density wave fluctuation on superconductivity. This new possible connection is not deeply considered even the competing relation in their phase diagram is relatively well-known, To investigate such new possibility, the first requirement is to search whether electron can couple with charge density wave fluctuation or collective excitation mode.

In this presentation, we report the evidence of such interaction between the electron and the collective excitation mode of charge density wave. We observed kinks, a footprint of bosonic mode coupling, in the electronic structure of 1D ($NbSe_3$) and 2D ($TaSe_2$) charge density wave system and interestingly, it appears only when charge density wave formed. Based on such selective appearance which is not expected in the conventional kink caused by a phonon, we conclude that it is the result of coupling between collective excitation mode of charge density wave. Our new finding can bring new insight to the relationship between charge density wave and superconductivity.

Keywords:

charge density wave, superconductivity, angle resolved photoemission spectroscopy, electronic structure

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F7.03

Anomalous Wannier-Stark insulator

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Abstract:
The Stark effect is well known in the study of atomic energy splitting by external electric field. When a strong electric field is applied to a lattice system, its electronic band structure shows a similar splitting and this is called the Wannier-Stark ladder. The topological character of such systems naturally appears in multi-band systems. We present a static electric-field tuned topological phase transition in a three-dimensional Wannier-Stark insulator. Analogous to conventional quantum Hall systems, the system contains chiral edge modes in its open boundary and their number is reflected in a DC current parallel to the electric field.

Keywords:
Wannier-Stark, topological, strong electric field,

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F7.04*

Universal d=1 flatband generator from compact localized states

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Abstract:
The band structure of some translationally invariant lattice Hamiltonians contains strictly dispersionless flatbands(FB). These are induced by destructive interference, and typically host compact localized eigenstates (CLS) which occupy a finite number U of unit cells. FBs are important due to macroscopic degeneracy and consequently due to their high sensitivity and strong response to different types of weak perturbations. We use a recently introduced classification of FB networks based on CLS properties, and extend the FB Hamiltonian generator introduced in Phys. Rev. B 95, 115135 (2017) to an arbitrary number ν of bands in the band structure, and arbitrary size U of a CLS. The FB Hamiltonian is a solution to equations that we identify with an inverse eigenvalue problem. These can be solved only numerically in general. By imposing additional constraints, e.g. a chiral symmetry, we are able to find analytical solutions to the inverse eigenvalue problem.

Keywords:
flatband, macroscopic degeneracy, band structure

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Interlayer magnetic coupling in bilayer CrI3: A first-principles study

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Abstract:
Recent discoveries of two-dimensional van der Waals (vdW) magnetic materials, especially CrI_3, has accelerated various experimental and theoretical investigations. It has been shown that CrI_3 has the intriguing interlayer magnetic orderings.: In contrast to the ferromagnetic bulk crystal, a bilayer CrI_3 shows an antiferromagnetic coupling between the layers that is hardly computed as magnetic ground states within conventional first-principles computational methods . In this talk, we show that the spin-dependent vdW interactions and the extended on-site correlation are of vital importance in describing the magnetism in a bilayer CrI_3 within ab initio computation schemes.

Keywords:
First-principles, two-dimensional, van der Waals, magnetism, CrI3

F8.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Reliable Simulation of Scanning Seebeck Microscope for the Asymmetric Thermoelectric Images of Carbons in Epitaxial Graphene on 6H-SiC

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Abstract:
Scanning thermoelectric microscope (SThM), which measures atomic-scale local electronic structures at the Fermi level on the sample surface by the applied temperature bias, have successfully provided high imaging contrast at the atomic level of monolayer graphene on 6H-SiC [1]. Recently, we successfully reproduced a thermoelectric image through Scanning Seebeck Microscope (SSM) simulations by using the free-standing monolayer graphene instead of the epitaxial Mono-layer graphene on the 6H-SiC substrate, but the cause of the difference in the asymmetric slope of the thermoelectric voltage measured between A and B sites of carbons could not be explained solely by the SSM simulation results for the constructed free-standing monolayer model. Therefore, we have studied the role of the multilayer and substrate on the origin of the experimental thermoelectric slope, compared to the free-standing monolayer graphene. Here, using only SSM simulation without considering temperature drop, we will show that the oblique slope of the thermoelectric voltage between A and B sites in graphene can be numerically well demonstrated.

[1] Eui-Sup Lee, Ho-Ki Lyeo, and Yong-Hyun Kim, Phys. Rev. Lett. 112, 136601 (2014).

Keywords:
Seebeck effect, First-principle, Epitaxial graphene on SiC

F8.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Two-dimensional $CdPSe_3$ semiconductor as a potential candidate for high-performance thermoelectric material

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Abstract:

Two-dimensional (2D) semiconducting materials have attracted much attention because of their potential applications in nanoscale optoelectronics, phtovoltaics, phtocatalysis, spintronic devices, and so on. In this connection, searching for novel 2D semiconductors with excellent performance is a challenging issue in the field of low-dimensional systems. In the present work, we perform the first-principles electronic structure calculations to investigate the thermodynamic stability, transport, and thermoelectric properties of single-layer (1L-) $CdPSe_3$ which is belong to ternary transition metal phosphorus trichalcogenides (TMPTCs) materials. Consequently, 1L-$CdPSe_3$ is shown to be easily isolated from the bulk counterpart and in addition the thermodynamically stable based on both the first-principles molecular dynamics and phonon dispersion calculations. Simultaneously, using the deformation potential method, an electron and hole mobilities of 1L-$CdPSe_3$ are calculated to be ~390 and ~300 $cm^2\ V^{-1}\ s^{-1}$, respectively, which is comparable to that of 1L-MoS_2. Furthermore, detailed discussion of thermoelectric properties of 1L-$CdPSe_3$ will be given.

Keywords:

two-dimensional materials, first-principles calculation, CdPSe3, thermoelectric properties

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F8.04

Out-plane polarization induced by in-plane trimerization in TMDC monolayer

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Abstract:

Out-plane ferroelectricity in atomically thin film is rare phenomena due to its depolarization field proportional to the inverse of the thickness. Overcoming the depolarization field, distorted 1*T* group-VIB transition metal dichalcogenides (TMDC) monolayer are promising candidate for out-plane ferroelectric materials [1]. It has been reported that the improper coupling [2] between in-plane primary mode and out-plane secondary mode stabilize the polar phase. However, the in-plane primary mode induces out-plane polarization first then the secondary modes cancel polarization, according to our calculation. The charge difference between upper and lower chalcogen atoms explain the out-plane polarization in these materials. As in-plane primary mode applied, the charge transferring to chalcogen atoms change as they prefer orthogonal bonding. This out-plane polarization is robust because the later displacement reducing the magnitude of the polarization make the external electric field hardly penetrate the film. Actually, the transition path calculated using nudged elastic band method shows unique energy-polarization behavior in the systems. On the other hand, we could engineer this polar phase with in-plane strain because Fermi surface is sensitive to the in-plane motion and it is good for device application. We also expect that this new mechanism of stabilizing out-plane ferroelectricity in atomically thin film can be applied to find other 2D materials.

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[2] A. P. Levanyuk and D. G. Sannikov, Usp. Fiz. Nauk. **112**, 561 (1974).

Keywords:

Transition metal dichalcogenides, ferroelectricity, 2D materials, ferroelectric switching

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

F8.05*

First-principles studies of nonlinear flexoelectric effect in corrugated two dimensional materials

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Abstract:

The flexoelectricity, the spontaneous electrical polarization induced by a strain gradient, is one of the very exotic physical phenomena because it can develop huge piezoelectricity even in centrosymmetric materials. Here, by combining density functional theory calculation and mathematical analysis, we find that the great flexoelectricity-related spontaneous out of polarization can be generated in the corrugated two-dimensional materials. The flexoelectricity in 2D materials is highly sensitive to the corrugation strength and tunable by adjusting the curvature at the nm scale. In particular, above critical corrugation strength, nonlinear flexoelectric behavior appears, which is attributed to the unusual change of the Born effective charges with the corrugation strength. The correlation between flexoelectricity, Born effective charges, and resulting out-of-plane polarization will be discussed, and the origin of nonlinear flexoelectricity will be addressed in detail.

Keywords:

flexoelectricity, strain gradient, born effective charge, corrugation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

F8.06*

First-principles determination of quasi-Fermi level profiles across molecular junctions

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Abstract:

While the quasi-Fermi level (or *imref*) is a standard concept in semiconductor physics employed to describe the finite-bias non-equilibrium operations of electronic and optoelectronic devices, its first-principles determination has not been achieved previously. Herein, based on the multi-space constrained-search density functional theory (MS-DFT) formalism we have recently developed [1], we calculate the non-equilibrium electronic structure of molecular junctions under a finite bias voltage and extract the quasi-Fermi level profiles across molecular device systems. Comparing with the conventional non-equilibrium Green's function (NEGF) calculations based on DFT, we first confirm the practical equivalence between MS-DFT and DFT-NEGF. An important feature of MS-DFT that differentiates it from DFT-NEGF is that it relies on the determination of the quasi-Fermi level or *electrochemical* potentials across the channel, which are not explicitly provided within DFT-NEGF unlike their *electrostatic* potential counterparts. Analyzing the spatial profiles of electrochemical potentials of molecular junctions based on different electrode-molecule contact geometries [2] at varying bias voltages, we extract important insights into the nature of nonequilibrium quantum transport at the nanoscale.

References

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Keywords:

Quantum transport, Density functional theory development, Molecular junction, Quasi-Fermi level

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2019-04-24 - 2019-04-26

F8.07*

Comparative study for single defect states in hexagonal boron nitride

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Abstract:

Investigation of single-photon source is a fundamental task for quantum technologies, such as quantum computing. Hexagonal boron nitride (h-BN) is one of the most attractive candidates for single-photon emitters. Even though it has a wide band gap of ~6 eV, it is expected to be a host of single-photon emitters, because its various defect states may appear in the middle of its pristine band gap. To utilize these defect states for single photon sources, it is essential to estimate the energy levels of these states accurately. Although, there have been various studies on these defect states such as a B or an N vacancy, these results are somehow inconsistent one another. To understand such inconsistency, we take into account various computational conditions, such as supercell size dependencies, different types of exchange-correlation functionals, local symmetries of defect structures. For instance, we revealed that boron-vacancy defect requires much larger supercell size than nitrogen-vacancy defect. Another example is Jahn-Teller distortion stabilizing a point defect by breaking three-fold local symmetry. We will present a concise summary of electronic states of various representative point defects existing in h-BN.

Keywords:

hexagonal boron nitride

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

F8.08*

Adsorption of carbon dioxide driven by selective energy transfer through resonance frequency

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Abstract:

These days, the greenhouse gases (GHGs) are one of the important global issue, and many countries have investigated to get rid of these GHGs. The carbon dioxide (CO_2) is the most famous GHG and many researchers are tried to capture or converge this CO_2 gas. Commonly, there are two ways to capturing the carbon dioxide gas, wet and dry process. The wet process occurs at the room temperature and shows high adsorption yield, however the cost of absorbent such as monoethylamine (MEA) is too high. On the other hand, the dry process occurs at the high temperature and the cost is relatively low, although the adsorption yield is not good.

In this study, we suggest the low-temperature dry process by using the resonance frequency of CO_2 bending mode. For the simple model study, we set a metal atom such as Cu, Pt, Fe, and Cr, and a CO_2 molecule in a supercell and calculated the potential energy surface (PES) to find proper metal atom which can has physisorption and chemisorption states. Then, we performed the molecular dynamics (MD) with the alternative electric field where the frequency is adjusted to the CO_2 bending mode. From the MD calculation, we were sure of that the resonance of the CO_2 bending mode can decrease the activation barrier for adsorption, and we designed a metal doped graphene like structure as a catalytic surface to suggest a more realistic condition. To restrict the degree of freedom of CO_2, we applied weak pressure between the metal doped graphene layers by adding several dummy CO_2 molecules. After the PES calculation, we found that the Cr-doped graphene shows the proper property to capture the CO_2 molecule, and we performed the MD calculation with alternative electric field. From that results, we suggest the novel selective energy transfer method through resonance frequency and this resonance phenomenon can be utilized as a molecule capturing mechanism.

Keywords:

selective energy transfer, CO2 adsorption, catalyst, resonance frequency

Wave Packet Spreading with Disordered Nonlinear Discrete-Time Quantum Walks

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Abstract:
We use a novel unitary map toolbox—discrete-time quantum walks originally designed for quantum computing—to implement ultrafast computer simulations of extremely slow dynamics in a nonlinear and disordered medium. Previous reports on wave packet spreading in Gross-Pitaevskii lattices observed subdiffusion with the second moment m2~t^1/3 (with time in units of a characteristic scale t0) up to the largest computed times of the order of 10^8. A fundamental and controversially debated question—whether this process can continue *ad infinitum*, or has to slow down—stands unresolved. Current experimental devices are not capable to even reach 1/10^4 of the reported computational horizons. With our toolbox, we outperform previous computational results and observe that the universal subdiffusion persists over an additional four decades reaching "astronomic" times 2×10^12. Such a dramatic extension of previous computational horizons suggests that subdiffusion is universal, and that the toolbox can be efficiently used to assess other hard computational many-body problems.
Ihor Vakulchyk, Mikhail V. Fistul, and Sergej Flach
Phys. Rev. Lett. **122**, 040501 - Published 30 January 2019

Keywords:
Anderson localization, nonlinear systems, quantum walks, delocalization

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F9.01

Energy level alignment of decoupled dipolar interface layers in organic solar cells and organic-inorganic hybrid perovskite solar cells

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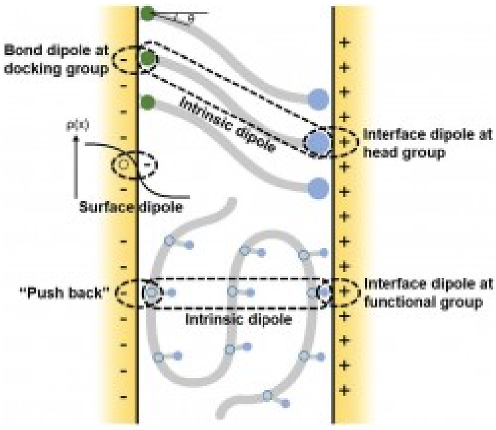
Abstract:

The dipole moment of interface materials has played the key role in efficient charge extraction in organic and hybrid perovskite solar cells, but the mechanisms of the interaction at the interface and of the resulting energy level alignment have not been well established. In this research, the decoupled dipole moments at the interface are investigated and clarified by using both the theoretical and experimental findings, with particular focus on dipolar interface materials and the consequent energy level alignment in organic and hybrid perovskite solar cells. The mechanisms of interface dipole moments in the interface layer are evaluated by using spontaneously and nonspontaneously aligned dipolar molecules, thereby the energy-level adjustment of the dipolar interface layer in the devices are elucidated. The diverse dipolar interface materials (e.g., self-assembled monolayers, conjugated or nonconjugated polymer, neutral molecules or electrolytes, zwitterion based molecules, electrolyte grafted copolymer) are introduced and classified according to their working mechanisms of decoupled dipole moments at the interface. We conclude that an efficient interface material and its particular treatment can be designed and developed by exploring the underlying mechanisms of the decoupled dipole moments.



Keywords:
interface, dipole, decoupled, organic solar cells, perovskite solar cells

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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F9.02

High performance from optoelectronic devices based on metal halide hybrid perovskites

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Abstract:

In our laboratory in Kyushu university, we are investigating metal halide hybrid perovskites for obtaining extremely high performance beyond existing organic- and inorganic-based electronics. Our device applications include solar cells, LED, field-effect transistors, and optically and electrically pumped laser devices. Another purpose in our laboratory is to clarify the basic electrical, optical, and electronic properties of this sort of materials. In the conference, we will talk about our recent results of perovskite-based devices.
Kyushu university demonstrated hybrid perovskite LEDs first in the world [1]. Initial perovskite LEDs reported in 1994 unfortunately showed electroluminescence only at low temperatures. Systematic optimization of the perovskite fabrication conditions and LED architectures by many researchers have increased electroluminescence efficiency even at room temperature. We recently demonstrated high external quantum efficiencies of over 12% by selecting organic molecules with appropriate energy levels for incorporation as an organic segment within the hybrid perovskite lattice [2]. We could fabricate flexible hybrid perovskite LEDs using plastic substrates. Our LEDs based on an emitter of hybrid perovskite quantum dots operated properly [3].
We analyzed why hybrid perovskite solar cells degrade under illumination. By removing degradation sources from films and devices, we obtained highly stable hybrid perovskite solar cells [4,5]. Our recent hybrid perovskite solar cells exhibited power conversion efficiencies higher than 21% and half lifetimes higher than 20,000 h under continuous illumination with 100 mW cm^{-2} [6]. Additionally, we developed lead-free perovskite solar cells with good operational durability [7] and highly thermally stable perovskite solar cells [8].
We prepared two-dimensional tin iodide-based hybrid perovskite films by spin-coating and used these films as the semiconductor in field-effect transistors. By taking advantage of excellent carrier transport associated with inorganic sheets of corner-sharing tin iodide frameworks, we demonstrated very high field-effect hole and electron mobilities of 26 and 4.8 cm^{2} V^{-1} s^{-1}, respectively [9-11]. To our knowledge, this hole mobility is the highest ever reported in any perovskite transistor. Our recent tin-based hybrid perovskite transistors became relatively stable even in air [12].
By controlling dimensionality of hybrid perovskites, we successfully reduced thresholds for amplified spontaneous emission under optical pumping [13]. We observed efficient lasing from hybrid perovskite films embedded into optical resonators under optical pumping [14]. With the aim of realizing electrically pumped hybrid perovskite laser, we investigated how much current can be injected into hybrid perovskite films. We found that injection of high current densities beyond 100 A cm^{-2} is possible [14].
Combining organic and hybrid perovskite materials is interesting. We utilized the chlorine-based hybrid perovskite as a host layer for OLEDs. Use of this host led to a decrease of driving voltage and an enhancement of electroluminescence efficiency, along with very good operational durability [15].

References

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Keywords:

metal halide hybrid perovskite, LED, solar cell, field-effect transistor, laser

F9.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Lifetime and Efficiency of Blue Phosphorescent Organic Light Emitting Diodes

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Abstract:

Organic light emitting diodes (OLEDs) are poised to realize innovative display and high- performance lighting applications in the future. However, the development of suitable blue OLEDs remains a challenge which has impeded the progress of large-scale OLED commercialization for more than a decade. Blue devices are critical components for red-green-blue displays and white lighting but, to date, suffer from short operational lifetimes as well as a lack of efficient deep blue emitting materials. This presentation aims at understanding the physical background of these issues and providing potential solutions.

In the first part of this presentation, we investigate the nonradiative loss mechanism dominant in deep blue emitting phosphorescent materials. We identify that thermal population to metal-centered ligand-field states (3MC states) is a major source of efficiency loss. Thus, we develop tris-cyclometalated Iridium (III) complexes using N-heterocyclic carbene (NHC) ligands that render the energy of 3MC states inaccessibly high and achieve a high quantum efficiency in deep blue. In phosphorescent OLEDs (PHOLEDs), NHC-Ir complexes are used as emitters, as well as electron and exciton blocking components. This multiple use enables deep blue PHOLEDs with very high efficiency, potentially suited to demanding display applications.

In the second part of this presentation, we focus on understanding the short lifetime of blue PHOLEDs. We identify the cause of device degradation as the annihilation between excited states in the emission layer (EML), producing energetically “hot” excited states. If such a hot excited state dissipates its energy on the EML molecule, the bond dissociation ensues and resulting fragmented products permanently deteriorate the device performance. We propose two solutions to this problem: (i) reducing the probability of bimolecular annihilation via distributing the excited state density and (ii) thermalizing hot excited states on the ancillary, protective dopant in the PHOLED EML. The stability of the blue PHOLED employing both strategies is cumulatively improved and a theory is proposed to explain such lifetime enhancement.

Keywords:

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

F9.04

Negative Carrier State of Organic Semiconductors Investigated by *Operando*- Photoelectron Yield Spectroscopy

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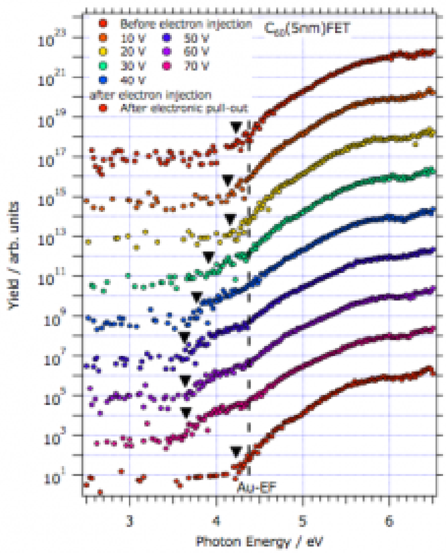
Abstract:



Electron affinity (*A*), which corresponds to the energy difference between a neutral molecule and its anion, is one of the key parameters to construct energy diagram of organic devices. It has been widely estimated as the energy difference between the ionization energy and optical band gap (E_{opt}) from UV-VIS absorption spectroscopy. The obtained value does not give a good estimate of *A* because the binding energy of exciton is neglected. On the other hand, inverse photoemission spectroscopy (IPES) is one of the most suited technique to measure *A*, where the process of $M^0+e^- \Rightarrow M^- + h\nu$ is observed, here M^0 and M^- denote neutral molecule and anion, respectively. In negative carrier (electron) transporting process ($M^0 + M^- \Leftrightarrow M^- + M^0$), the sudden transition not only from relaxed M^0 to M^- but also from relaxed M^- to M^0 is incorporated because the energy relaxation for both processes is different. To investigate the latter case, photoemission measurement for anion state is highly desired to measure the electron detachment energy *D*, which corresponds to ionization energy of anion. Basically, the values of *A* and *D* should be different by reorganization energy (λ), and both are necessary to understand the carrier states with various relaxation effects such as electronic polarization, lattice polarization, and other slower effect. In this presentation, we will report on our recent two techniques to experimentally determine the value of *D* of various organic semiconductors.

Very recently, we have applied high-sensitivity photoemission spectroscopy (HS-PES) using tunable low energy photon to a representative OLED material, tris (8-hydroxyquinolinato) aluminium (Alq_3) film. The film has positive polarization charge at the surface region because the permanent dipole moment of Alq_3 molecule tends to spontaneously align during the vacuum evaporation process. The photoemission from anions captured by the surface polarization charge was successfully observed by HS-PES. The obtained value of *D* was ca. 2.5 eV which was about 1 eV larger than *A* (1.96eV) in Alq_3 by IPES [1]. The similar photoemission from shallow anion states was observed for other OLED-related materials such as TPBi, 4CzIPN, a-NPB. The observed value of *D* is very useful to understand the electronic structure of injected electrons in polarized devices.

To discuss the more realistic carrier states, photoemission measurement of anions which are not bound by counter charge is necessary. One solution is *operando* spectroscopy of OFET structure in which electrons are injected. In the case of conventional photoemission spectroscopy, *operando* measurement of FET structure is not successful because of non-uniform potential at the biased FET surface. In contrast, photoelectron yield spectroscopy (PYS), in which the yield of emitted photoelectrons is measured as a function of hν, can be applied even to sample with non-uniform potential. Even if the energy location of the occupied state and the vacuum level moves depending on the position, the energy separation between them, which corresponds to the onset energy in PYS spectrum, should be constant. Very recently we have demonstrated that *operando*-PYS can be applied to C60 FET structure [2]. Photoemission from negative carrier injected to the FET was directly observed as shown in Fig.1. Similar measurement was also successful for pentacene FET. C60 and pentacene indicated different trend in the relation between *A* and *D*. The difference will be discussed in relation to reorganization energy.

References

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[2] Y. Tanaka et al., *Applied Physics Express*, **11**, 081601 (2018).

Keywords:
Operando-Photoelectron Yield Spectroscopy, Organic semiconductor, LUMO, Anion state, Organic Field Effect Transistor

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F10.01

Synchronization and heat in a large population of coupled oscillators

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Abstract:
In this talk, we revisit a typical model of coupled oscillators that shows synchronization.
We consider thermal noise in the oscillators, and explore how the thermal noise affects the synchronization.
In particular, we pay attention to the heat dissipation when the system reached the synchronized state.
We derive the heat analytically, and investigate its critical behavior near the synchronization transition.

Keywords:
synchronization, coupled oscillators

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Application of Soft-Matter Physics and Biophysics beyond Academics

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Abstract:
Soft-matter physics showing self-assemble hierarchical structures (or conformational changes) and spontaneous information processing, is of direct relevance for biophysics and many industrial applications. In soft-matter physics, theory and experimental techniques of statistical mechanics, such as the effect of entropy, phase transitions and fluctuations, could provide powerful tools for understanding, designing and optimizing the complicated system in biophysics and industry. Here, I would like to introduce some real applications of soft-matter physics in biophysics and cosmetic industry.

Keywords:
Soft-matter physics, Biophysics, Industrial Applications

F10.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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The bases of smell: Modular structure of human olfactory receptor codes

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Abstract:
Olfaction, or the sense of smell, identifies and discriminates different odors that carry distinct behavioral signals. An odor captures the chemical state of the environment in a mixture of smell molecules, called odorants. Olfactory sensing is realized by the selective binding of odorants to a set of olfactory receptors (ORs) in the nose, which in turn activates the corresponding olfactory sensory neurons that transmits the information to higher-level brain circuits. The activity of the ORs in response to an odor, called the receptor code, therefore constructs the brain's first representation of the odor. Recent measurements with human ORs suggest that the odorant-OR interaction is sparse; only a small select fraction of all available pairs interact, generating a specific pattern that determines the receptor code. Viewing the interaction pattern as a network of odorants and ORs, we discover a modular structure inherent in the olfactory receptor code, and discuss the implications of our finding for the basis of olfactory sensing.

Keywords:
odor coding, olfactory receptor code, modular structure

F10.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Evolution of metabolic networks in a growing ecosystem

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Abstract:
Considering that the roles of the cellular metabolism are well-defined and common to all living organisms and that, in contrast, individual metabolic reactions are executing a wide range of different functions, it might look unsurprising that the reaction popularity follows a broad, power-law distribution with exponent one while the number of reactions in an individual species is narrowly distributed. These empirical findings, however, can be a key to understanding the metabolism evolution and speciation in a unifying framework. Here we propose an evolving ecosystem in which the metabolic network of each species grows by recruiting a new reaction or the new reaction replaces an old similar reaction, giving birth to a new mutant species. Though much simplified, the proposed model captures the essential mechanism responsible for the empirical findings mentioned above. Due to the finiteness of external nutrient compounds, the set of recruited metabolic reactions grows exponentially first but then linearly with time, and we show that the latter behavior underlies the empirical power-law distribution of reaction popularity. We present extensive simulation and analytic results of the model and discuss their implications.

Keywords:
Metabolic network, Evolution, Ecosystem

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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F10.05

Biopolymers: statistical physicists' favorite toys and strings of life

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Abstract:
Biopolymers have fascinated statistical physicists for decades for their simplicity and elegance. Despite their simplicity, the physics realized by biopolymers is highly complex and non-trivial, continuously amazing and inspiring a broad range of scientists. In my talk, I will briefly overview our studies on biopolymers.

Keywords:
biopolymers, DNA, nucleic acids, statistical mechanics, single-molecule biophysics

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F11.01

MEMS are becoming 3D and atomically precise

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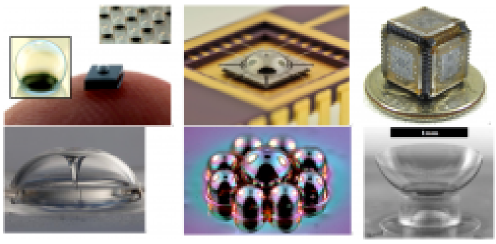
Abstract:

Microtechnology comes of age. Clearly, some significant advances have been made, and we see a footprint of the technology in an ever-growing consumer electronics market full of interactive products enabled by microtechnology. These products include, for example, accelerometers for gaming, gyros for auto safety, resonators for clocks, and more. The questions remain, however: Is the technology really on the level of what we consider to be precision sensing? Is making sensors small necessarily result in degradation of performance? Why do we need the precision of sensing for our daily life and what are the opportunities if we have the precision at our fingertips? I will talk about some of the recent developments in my research group toward precision sensing, including solid-state 3D shell gyroscopes, spin-polarized atomic magnetometers and gyroscopes, and the futuristic concept of the Ultimate Navigation Chip (uNavChip).



Keywords:
Micro-Electro-Mechanical Systems (MEMS), chip-scale atomic sensors, magnetometers, gyroscopes

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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F11.02

알칼리 원자-버퍼가스 셀 제작

김태현*[1], 임신혁[1], 이상경[1], 김재일[1], 심규민[1], 권택용[2], 이성의[3]
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Abstract:
알칼리 원자 증기 및 버퍼가스가 주입된 셀은 원자시계 및 원자 스핀 자이로스코프와 같은 원자센서의 핵심 물리부이다. 본 구두발표에서는 원자 스핀 자이로스코프를 위해서 국내에서 시도되고 있는 다양한 원자증기셀 제작 방법을 소개한다. 특히 국과연-표준연-한국산업기술대학교에서 수행중인 고진공에서의 유리 초자 기술 및 레이저 bonding을 이용한 Rb-Xe-N2가 주입된 셀 제작방법에 대해서 기술하고 제작된 셀로부터 얻은 분광 신호를 소개할 예정이다.

Keywords:
atom spin gyroscope, akali atom vapor cell

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F11.03*

Quantum dynamics of few-body entangled Rydberg atom systems

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Abstract:

We experimentally investigate the coherent dynamics of few atom Rydberg systems up to N=5 with various geometries. We especially analyze the dissipation of coherent dynamics, which arises from interaction with environments. Such experimental imperfections include finite quantum state preparation and measurement errors, spontaneous emission, laser noises, etc. We model the time evolution using Lindblad equation with stochastic parameters. With this model our experimental results are successfully verified with optimal parameters.

[1] W. Lee, et al. "Quantum system dynamics of entangled Rydberg atoms." *arXiv:1901.10896* (2019).

Keywords:

Rydberg atom

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F11.04

Enhancement of MTS spectra via tuning the Zeeman sub-levels in the Cs D2 transition

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Abstract:

Modulation transfer spectroscopy (MTS) provides reliable frequency reference compared to the conventional spectroscopic methods, e.g. polarization spectroscopy and saturated absorption spectroscopy. Especially, its nonlinear character based on four-wave mixing (FWM) process makes MTS practically free from the unwanted change in a Doppler profile due to environmental fluctuations. In this presentation, we report the outcome of frequency stability comparison of two similar MTS systems, which will be referenced by other lasers working at different molecular transitions in EDM/PNC experiments. We also address the role of Zeeman sublevels in MTS process in the context of FWM. Enchancement of MTS process in the lower cyclic transition of Cs D2 line, $6^2S_{1/2}$ F=3-$6^2P_{3/2}$F=2, was observed via tuning the Zeeman sublevels. Numerical calculcations of the governing master equation will also be presented.

Keywords:

Modulation transfer spectroscopy, Four-wave mixing, Zeeman sub-levels, Master equation

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F11.05*

Anderson Localization of Two Interacting Discrete-Time Quantum Walks

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Abstract:
We study Anderson localization in a system of two interacting particles (TIP) whose unitary evolution is efficiently emulated with Interacting Discrete-Time Quantum Walks (IDTQW). Recently a single particle DTQW with disorder was studied. We use these results and compute the dependence of the size of the TIP wave function on the control parameters of the system. We are in particular interested in the scaling of the TIP localization length with the single particle localization length in the limit of large values of the latter. A new qualitatively different limit of large localization length is identified and will be addressed in this talk.

Keywords:
Anderson Localization, Interacting Particles, Quantum Walks

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F11.06

Origin of the plateaus in high-order harmonic generation in solids

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Abstract:

Unlike atoms, multiple plateaus structure appears in the harmonic spectrum generated by the interaction of laser with solids. The Houston states, which are instantaneous eigenstates of the time-dependent Hamiltonian,
are known as an appropriate method to observe the role of bands that contribute to those plateaus. However, as the intensity of laser increases, the number of bands participating in electron dynamics increases,
and thus smaller band gaps between the higher conduction bands make the transition matrix elements in the Houston basis blow up. The blow-up makes the time-dependent Schroedinger equation (TDSE) highly unstable in numerical analysis. For this reason, Wu *et.al.* [1] could not introduce a sufficient number of conduction bands to analyse the multiple plateaus structure in HHG. To solve the TDSE in the Houston basis set, we apply the smooth variable discretization (SVD) method, which is known as a novel approach for Hamiltonian with nonadiabatic couplings between channels. It is demonstrated that application of the SVD method lifts the sharp blow-up of the transition matrix elements between the Houston basis functions. And the origin of the multiple plateaus is revealed for high-harmonic spectra generated by intense laser pulses demanding introduction of many conduction bands.

[1] Wu et.al, Phys. Rev. A 91, 043839 (2015).

Keywords:
HHG in solids, plateau, SVD, Houston states

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F12.01

S-band Accelerating Structure development for PAL-XFEL

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Abstract:
A total of 174 electron accelerator structures are required for the PAL-XFEL 10GeV linear accelerator of Pohang Accelerator Laboratory. In this presentation, I would like to introduce the international cooperation, the development process and the certification process for the procurement of these accelerator structures and the domestic development process of an accelerator structure.

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F12.02

KOMAC 양성자가속기 고주파 가속관 개발

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Abstract:
양성자가속기연구센터의 100 MeV 가속기는 50 keV 입사기, 3 MeV RFQ (Radio Frequency Quadrupole), 100 MeV DTL (Drift Tube Linear Accelerator)로 구성되어 있다. RFQ와 DTL의 운전주파수는 350 MHz 이며, 1개의 RFQ와 11개의 DTL 탱크가 설치되어 있다. 고주파 원으로는 클라이스트론을 사용하고 있고, 냉각수 온도를 조절하여 공진 주파수 제어를 하고 있다. 본 발표에서는 양성자가속기연구센터에서 운영중인 RFQ와 DTL 가속관에 대해 논한다.

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F12.03

Development of the accelerator based Boron Neutron Capture Therapy system for cancer treatment within 1-hour therapeutic time

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Abstract:

The interest of BNCT in Korea has been increased gradually as the number of cancer patients has been increased. An accelerator based BNCT(A-BNCT) system is under development with a goal to use practical cancer treatments within about 1 hour therapeutic time for a hospital based facility in Korea.
To meet the goal we have designed and developed a high power accelerator, a beam delivery system and its target moderator assembly to produce a high epithermal neutron flux of $2x10^9$ n/cm^2 • s. It consists of a 10MeV proton linear accelerator and a high power beryllium target system and a moderator-collimator system under the consideration to reduce residual gamma radiations and fast neutrons.
A-BNCT has a capability of production of higher epithermal neutron flux and lower residual radiation doses than the IAEA BNCT recommendation. This paper focused on the some details of performance verification about the proton accelerator and the neutron generator system in a practical epithermal neutron source for hospital-based uses.
A-BNCT system within about 1 hour therapeutic time in Korea has been developed as scheduled. And this hospital based BNCT system will be convenient and useful for cancer patients.

Keywords:
BNCT, Epithermal neutron

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F12.04

High-Power Conditioning of the RISP RFQ at the Off-site Facility

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Abstract:

A CW radio frequency quadrupole (RFQ) accelerator has been designed and constructed to accelerate from proton to uranium ions for the Rare Isotope Science Project (RISP). The RISP RFQ is a four-vane type with a ramped inter-vane voltage profile to reduce the length and it has 81.25 MHz operational frequency.
RISP RFQ has been installed at the off-site test facility and O+7 ions were accelerated to validate the design, fabrication and tuning results as a preliminary beam test. The designed RF power system is consisted of two sets of 80kW SSPA (Solid State Power Amplifier) and two power couplers. However, high-power conditioning was accomplished only using a set of 80 kW SSPA since there is a limitation of the cooling water capacity at the off-site test facility. Conditioning experiment is in progress and we plan to perform a full power test after the site installation. The experimental results will be reported in detail.

* This work was supported by the Rare Isotope Science Project of Institute for Basic Science funded by the Ministry of Science, ICT (MSIT) and the National Research Foundation (NRF) of Korea (2013M7A1A1075764).

Keywords:

RFQ, heavy ion, RF conditioning, AcceleratorRFQ, heavy ion, RF conditioning, Accelerator

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F13.01

Prospects of flavor physics at Belle II

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Abstract:
With the e+e- B-factory experiments such as BaBar, Belle, and recently LHCb, there have been significant progresses in the flavor physics, in particular with the CKM mechanism of CP violations in the quark sector. Recently some anomalies (so call;ed "R(K*), R(D*) anomalies") have been reported in these experiments, and it is not clear whether these anomalies are real feature of our nature (i.e. New Physics beyond the Standard Model) or some (shared) systematic or statistical effects in the experimental measurements. Moreover, recently many results have appeared in the dark sector and related subjects from these experiments.

In this talk, we briefly review the current status of flavor physics in B hadron systems from the existing B-factory experiments and discuss prospects of the Belle II experiment which starts taking data for Phase 3 run in March 2019.

Keywords:
Belle II, flavor, New Physics

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F13.02

Theory interplay in flavor and energy frontier

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Abstract:
Discrepancies between the experimental results and their standard model predictions have been reported in the flavor frontier. They are candidates for effects of new physics, i.e., physics beyond the standard model. The new physics will be demystified by discovering new particles as well as the flavor signals. Current flavor discrepancies imply that the new physics exists within (multi-) TeV energy scale, and thus, is detectable by high energy collider experiments. We will overview current flavor anomalies, their implications on the LHC experiment, and future prospects.

Keywords:
Flavor, Theory, New Physics

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F13.03

Flavor of theories for B-meson anomalies

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Abstract:
We review some of recent theoretical efforts to explain the violation of lepton flavor universality in B-meson decays observed in BaBar, Belle and LHCb experiments. In particular, new U(1) gauge symmetries or leptoquark scalars with flavor dependent couplings are proposed. We discuss how extra flavor-dependent interactions can be tested by other rare processes and direct searches for new particles in future collider experiments.

Keywords:
B-mesons, Semi-leptonic decays, Extra U(1) symmetries, Leptoquarks

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F14.01

Introduction of GW astrophysics and waveform modeling

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Abstract:

There are eleven direct detections of gravitational wave by LIGO/Virgo collaboration between Sep. 2016 to Aug. 2018 (O1 and O2 observations). This new observational signal from the universe has open a new window for us to gaze into the Universe. In this talk, I will introduce gravitational wave astrophysics and explain in detail how GW is detected with its underlying tools. As Einstein said, GW signal itself is very weak and buried in various environmental noises. Hence it was paramount to invent very sophisticated instrument that can respond to GW efficiently and develop a dedicated signal processing technique. For this technique, we need to model precisely the expected gravitational waveforms according to the targeted astrophysical sources. I will briefly introduce few theoretical techniques generating approximate gravitational waveforms. Finally, I will summarize about previously mentioned detections.

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F14.02

The Unlikely Dawn of Joint Gravitational-Wave and Electromagnetic Astronomy

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Abstract:
On August 17, 2017, the gravitational waves from a neutron star collision were observed for the first time, an event dubbed GW170817. Remarkably, and contrary to all reasonable expectations, this discovery was joined a few hours later by the identification of an optical transient consistent with the afterglow of a neutron star collision in NGC 4993. Since then, nearly every kind of astronomical instrument imaginable has been pointed at the source, in one of, if not the, most extensive studies of a transient astronomical event. GW170817 very nearly went undiscovered. I will describe how we discovered it, and provide a small glimpse into the drama that unfolded around that world that night.

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F14.03

How to identify astrophysical sources detected via GWs?

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Abstract:

Waveform modeling for gravitational radiation from binary coalescences provides a tool for not only detecting out a signal from the noise but also identifying the nature and properties of the source. Physical parameters such as mass, spin, eccentricity, distance, and location are essential information in order to understand the formation and evolution of the sources, for example. Once these pieces of information are statistically determined, they are shared with the astronomical community for follow-up observations. Focusing on binary coalescences or inspirals, I will present a quick summary on how one can identify the nature of GW sources by applying appropriate waveform models and what we have learned about known sources from GW observations. I will also briefly discuss the expectations for future GW detectors in the context of stellar astrophysics.

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F15.01

Cascade of Superconducting domes and magnetism in ultraclean twisted bilayer graphene

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Abstract:
Superconductivity often occurs close to symmetry broken parent states, in particular when doping magnetically ordered states. Flat bands in Moire lattices in twisted bilayer graphene have emerged as a rich and highly tuneable model platform, where superconducting domes were found close to correlated insulating states at ± ½ band filling, raising speculations of an unconventional pairing mechanism. Here we report on the fabrication of highly twist-angle homogeneous devices, which allow to resolve correlated states at all integer fillings ± ¼, ± ½, ± ¾ of the four-fold spin and valley degenerate Moire band, and a gapped insulating state at charge neutrality. We find an enhanced critical temperature of ~ 3 Kelvin of the superconducting dome close to - ½ filling, and strikingly we observe three new superconducting domes at much lower temperatures, when slightly doping the charge neutral point and the ±¼ filled correlated states. Interestingly, the weakly pronounced - ¼ correlated state shows a sharp hysteretic resistance enhancement when a perpendicular magnetic field above 3.6 Tesla is applied, consistent with a field stabilized magnetically ordered state. Overall, our study shows that symmetry broken and superconducting states occur not only around half-filling, but are common across the entire Moire band, including charge neutrality. The co-existence of superconductivity and magnetic order in the - ¼ correlated states points towards a possible pairing mechanism.

Keywords:
Twisted bilayer graphene, superconductivity, moire bands

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F15.02

Atomistic study of electron-hole asymmetry and electron-phonon interaction in magic-angle twisted bilayer graphene

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Abstract:

We report strong electron-phonon coupling in magic-angle twisted bilayer graphene (MA-TBG) obtained from atomistic description of the system including more than 10,000 atoms in the moiré supercell. Electronic structure, phonon spectrum, and electron-phonon coupling strength λ are obtained before and after atomic-position relaxation both in and out of plane. Obtained λ is very large for MA-TBG, with $\lambda > 1$ near the half- filling energies of the flat bands, while it is small ($\lambda \sim 0.1$) for monolayer and unrotated bilayer graphene. Significant electron-hole asymmetry occurs in the electronic structure after atomic-structure relaxation, so λ is much stronger with hole doping than electron doping. Obtained electron-phonon coupling is nearly isotropic and depends very weakly on electronic band and momentum, indicating that electron-phonon coupling prefers single-gap s-wave superconductivity. Relevant phonon energies are much larger than electron energy scale, going far beyond adiabatic limit. Our results provide a fundamental understanding of the electron-phonon interaction in MA-TBG, highlighting that it can contribute to rich physics of the system. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2018-CRE-0097).

[1] Y. W. Choi and H. J. Choi, Strong electron-phonon coupling, electron-hole asymmetry, and nonadiabaticity in magic-angle twisted bilayer graphene, Phys. Rev. B **98**, 241412(R) (2018).

Keywords:

twisted bilayer graphene, electron-phonon interaction, electron-hole asymmetry, superconductivity

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F15.03

Theory of superconductivity on flatlands

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Abstract:

While 2D materials are already exceptionally interesting and fertile in terms of emergent phases, new twist to story arises from the discovery of flatbands in twisted bilayer graphene. The interplay between flatband and strong correlation unlocks 'the pandora box' with many emergent properties such as metal-insulator transition, magnetism, topological bands, and superconductivity. Superconductivity in single layer MoS_2, FeSe on $SrTiO_3$ substrate also turn out to be unique compared to their bulk systems. After a brief survey of these experimental features, I will discuss our theoretical model for understanding the new emergent superconducting features in these compounds. Spin/valley-fluctuations, valence fluctuations, spin-orbit fluctuation all come into play here, giving a platform to obtain new form of pairings such as Wannier pairs, Ising pair, composite pairs, quasiparticle-phonon coupling mediated pairs etc. I will conclude with a generic view on the plethora of correlated phases embedded in flatbands on flatlands.

[1] Wannier pairs in the superconducting twisted bilayer graphene and related systems,
Sujay Ray, Jeil Jung, Tanmoy Das, arXiv:1804.09674
[2] Superconducting dome in MoS_2 and TiSe2 generated by quasiparticle-phonon coupling,
Tanmoy Das, K. Dolui, Physical Review B **91**, 094510 (2015).

Keywords:

Superconductivity, 2D materials

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F15.04

Holstein polaron in the vicinity of superconducting phases in MoS_2

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Abstract:

The interface between chemical dopants and two-dimensional (2D) van der Waals semiconductors is known to host an interesting 2D superconducting dome with the critical temperature as high as 12 K [1,2]. By means of high-resolution angle-resolved photoemission spectroscopy (ARPES), we investigate the spectral function of charge carriers at the interface of alkali-metal atoms and MoS_2. We observed strong band renormalization collectively identified as a hitherto unobserved spectral function of Holstein polarons, a small composite particle of an electron that carries a cloud of self-induced phonons. This short-range nature of electron-phonon coupling in MoS_2 can be explained by valley degeneracy that enables strong intervalley coupling mediated by short-wavelength acoustic phonons. The strong of electron-phonon coupling is found to gradually increase along the superconducting dome [3,4], and its potential relevance to the 2D superconductivity in surface-doped MoS_2 will be discussed.

[1] J. T. Ye *et al.*, *Science* **338,** 1193 (2012).
[2] D. Costanzo *et al.*, *Nature Nanotech.* **11,** 339 (2016).
[3] M. Kang *et al.*, *Nano Lett.* **17,** 1610 (2017).
[4] M. Kang *et al.*, *Nature Mater.* **17,** 676 (2018).

Keywords:
Holstein polaron, Superconductivity, MoS2, ARPES

G1.01

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Project for fast-timing gamma-ray detector system with LaBr3(Ce) scintillators at Rare-Isotope Beam facilities

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Abstract:

The lifetime of a quantum state in an atomic nucleus provides significant information on the many-body quantum system. For instance, the beta-decay half-lives of the unstable nuclei like neutron-rich or proton-rich isotopes, play essential roles on the nucleosynthesis such as the slow neutron-capture process, rapid neutron-capture process, and rapid-proton capture process in the stellar environments to understand the origin of elements. On the other hand, the lifetimes of the excited states in an atomic nucleus are significant in terms of not only the resonances but also the interactions between nucleons.
In the past decade, as the rare-isotope beams could be successfully produced to reach the region near the drip-lines, abundant proton- or neutron-rich isotopes have been identified. From the decay and in-beam spectroscopies, newly observed gamma-ray energies have provided fruitful results on the nuclear structure. However, the measurement of the lifetimes of specific levels in an even-even nucleus is essential as much as the energy measurements to investigate the nuclear structure evolution. Specifically, the lifetime information helps our understanding of the various nuclear structure properties such as the quadrupole deformation, mixiture of configurations, seniority scheme, short-lived isomer, or neutron matter.
The Center for Extreme Nuclear Matters (CENuM) is now planning to lead a fast-timing decay spectroscopy group to investigate the fundamental nuclear structure study on the very unstable nuclei far off the stability region. A gamma-ray detector array composed of 24 fast-timing LaBr3(Ce) scintillators will be constructed in 2019 and 2020. In this talk, the motivation, details on the technical design, and results from the simulation and bench tests will be introduced.

Keywords:

Nuclear structure, Gamma-ray spectroscopy, Decay spectroscopy, Fast-timing measurement, LaBr3(Ce) scintillator, Rare-Isotope beam

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G1.02*

The Absolute Measurement of Radioactivity of Gaseous ^{85}Kr and ^{3}H using Primary Standard System at KRISS

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Abstract:

한국표준과학연구원(KRISS)에서 베타 입자를 방출하는 가스상의 방사성 동위원소 (^{37}Ar, ^{39}Ar, ^{85}Kr, ^{127}Xe, ^{131m}Xe, ^{133}Xe, ^{3}H)의 일차표준기로 길이보상법을 이용한 내부비례계수장치를 개발하고있다. 이 장치는 진공챔버 내에 내경이 25 mm이고 길이가 각각 100 mm (Short), 150 mm (Middle), 그리고 300 mm (Long)인 3개의 비례계수기로 이루어져 있다. 비례계수기 표면 근처에서 붕괴할 경우 이온화율이 낮아져 검출효율도 낮아지므로 최대의 검출효율을 가지기 위해 진공챔버의 압력을 변화시켜 1.8기압 이상에서 효율변화가 없음을 확인하였다. 그리고 2기압에서 HV plateau을 그려 1700 V에서 안정된 계수율를 구할 수 있음을 확인하였다. 전기증착법으로 제작한 ^{55}Fe 선원을 비례계수기의 끝단에 위치시켜 에너지 교정을 하였고 교정값을 통해 문지방 에너지 레벨은 구하였다. 각 채널에 대한 문지방 에너지 레벨은 Long이 0.143 keV, Middle이 0.140 keV, Short이 0.141 keV 이다. ^{85}Kr 가스상 동위원소를 이용하여 시험운용하였으며, 최대 0.70 % (k=1)의 불확도를 갖는 예비결과를 획득하였다. 그리고 본 발표에서 추가적으로 삼중수소에 대한 측정결과와 앞으로 개발예정인 닫힌형태의 길이보상법을 이용한 내부비례계수장치에 대해 논의할 예정이다.

Keywords:
가스상 방사성동위원소, 일차표준기, 내부비례계수기, 85Kr, 3H, 길이보상법, Proportional Counter, Length-compensation, primary system

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G1.03*

전열 교정을 통한 흑연 열량계의 유효 비열(effective specific heat) 측정

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Abstract:

방사선량을 측정하는 방법 중 하나인 열량계법(calorimetry)은 열량계에 방사선을 조사하여 그로 인한 온도 검출부의 온도 증가량을 측정하고, 검출부 물질의 비열로부터 선량을 결정하는 방법이다.

본 연구에서는 전자선형가속기에서 발생하는 고에너지 광자빔의 방사선량을 측정하기 위해 흑연 열량계를 개발했다. 열량계의 구조는 온도 검출부인 지름 10 mm의 원통형 코어를 재킷과 실드라 불리는 두 겹의 재킷이 감싸고 있는 형태이다. 방사선량을 결정하는 요소 중 하나인 코어의 비열은 임의의 전기 에너지를 공급하고 그에 대한 온도 증가량을 측정해 평가하는 방법의 전열 교정을 통해 유효값을 구할 수 있다.

먼저 열량계 제작 단계에서 코어의 질량을 평가했고 이 때 지지대, 써미스터, 에폭시와 같은 구성 요소들의 질량을 함께 측정했다. 코어에 부착된 써미스터, 표준 저항, 전류 소스 그리고 전위계를 이용해 전기에너지를 공급 및 측정하는 회로를 구성하고 LabView 기반의 운영 프로그램을 작성했다. 전열 교정 동안 열량계는 준 단열모드(Quasi-adiabatic mode)로 운영했다.

실드의 온도는 26 ℃로 제어하고 코어와 재킷 사이의 온도는 PID 제어를 통해 8.3 mK으로 유지되도록 했다. 약 0.04 mW의 전력을 200 s부터 100 s 간격으로 5번 공급해 약 7~23 mJ의 전기에너지가 코어에 공급되도록 했다. 전기 에너지와 온도 증가량을 함께 측정했고, 두 측정량 사이의 선형성을 확인할 수 있었다. 두 양 사이의 선형관계로부터 열량계 코어의 유효 비열을 결정했다.

Keywords:
열량계법, 전자선형가속기, 방사선량 측정, 전열 교정

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G1.04*

Development of Water Cherenkov Detector for the J-PARC H-Dibaryon Search Experiment

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Abstract:

We have developed a Water Cherenkov Detector (WCD) for the J-PARC E42 experiment. This WCD is designed to suppress low-momentum protons so that we can reduce the online trigger rate at a manageable level. It will be located behind the TOF array in 2 layers, each consisting of 10 slats, which covers a whole are of the TOF array. Each slat is composed of a 180 cm long acrylic rectangular hollow structure with a sctional area of 24x19 cm^2. The thickness of the acrylic hollow section is 2 cm. The rectangular hollow section is filled with pure water, whose refractive index n = 1.33. Cherenkov light is reflected diffusively on a diffuse reflective sheet, convering the inner wall of the radiator. We use a special type of PMT with Super Bialkali (SBA) photocathode and UV-transmitting glass (UVT) to enhance the probability to detect more Cherenkov photons.

We have performed a cosmic-ray test for a coupe of WCD prototypes with different materials. We will present preliminary results on a long-term performance of the WCD prototypes in comparison with Geant4 simulation on the WCD response.

Keywords:

J-PARC E42, Water Cherenkov Detector, Cherenkov Counter, SBA photocatode PMT

G1.05*

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Development of a threshold aerogel Cherenkov detector for the LEPS2 solenoid spectrometer at SPring-8

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Abstract:

We develop a large array of aerogel Cherenkov (AC) detectors for pi/K particle identification at LEPS2/SPring-8. To an LH2 target located at the center of TPC in the magnetic field of 1 T, Compton backscattered photons are incident with linearly polarization in the energy range from 1.4 to 3.0 GeV. Outgoing charged particles are identified using a time-of-flight information from two RPC arrays located at forward and transverse directions.

However, in the polar angles between 40 and 50 degrees, particles with momentum between 1.0 and 1.5 GeV/c can't be identified by the two RPC arrays. To cover this range, the AC array with 30 detector elements will fill this gap between the TPC and surrounding RPC. We have been prototyping and testing the AC detectors with various configurations of light guide shapes and reflector materials. We modeled the AC detector using Geant4 simulation and studied its response to electrons passing through the radiator box. Preliminary simulation results will be presented and discussed with beam test results.

Keywords:

Aerogel Chrenkov Detector, SPring8, Fine Mesh PMT, LEPS2

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G1.06*

Development of a new trigger counter array with multiple MPPC readouts for J-PARC hadron experiments.

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Abstract:
The Hyperon Spectrometer consisting of superconducting dipole magnet and a time projection chamber (HypTPC) has been recently developed for new hadron experiments at J-PARC. The TPC hodoscope is composed of 32 plastic scintillator slats surrounding the HypTPC. Each scintillator has a dimension of 1 x 7 x 80 cm3. We utilize 8 Multi-Pixel-Photon-Counters (MPPC, Hamamatsu S13360-3050PE) at each end. We devised a new individual biasing method with a summing amplifier for stable multiple MPPC readouts. Each MPPC is biased using an individual power supply and each signal is fed to a differential amplifier. The amplified signals from 8 MPPCs are then summed up through a unity-gain amplifier. We have tested real-size hodoscope prototypes made up with EJ-200, EJ-230, and EJ-232 plastic scintillators. The best timing resolution was measured to be 117 ps using cosmic-ray tests. We will present preliminary results on the basic characteristics of the hodoscope prototypes with special emphasis on the timing resolution.

Keywords:
Scintillator counter, MPPC, HypTPC, E42, E45, E72, J-PARC

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G1.07*

현장 교정 이동형 고감도 라돈 검출기 개발

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Abstract:

라돈침대 사건을 계기로 실내 라돈 농도에 대한 국민의 관심이 높아지면서, 라돈 검출기 수요가 증가하고 있다. 현재 국내 라돈 측정기 교정은 한국표준과학연구원의 저온 입체각 라돈 일차 표준기를 이용하여 수행되어지고 있지만, 라돈 교정에 2개월이 걸려 늘어나는 교정 수요에 따라가지 못하고 있다. 따라서 한국표준과학연구원은 국가 측정 표준 확대를 위해 이동형 라돈 교정 시스템을 구축 중이다. 이 시스템은 라돈 선원, 교정 챔버, 고감도 라돈 측정 검출기로 구성되어 있다. 그 중 고감도 라돈 측정기는 에너지에 따라 핵종을 구분할 수 있으며 민감도 및 정밀도가 높은 Electrostatic 방식의 검출기로 개발하였다. 이는 기준기 급의 상용 라돈검출기인 RAD-7과 민감도 비교 시 35.6 ± 0.2 배 높은 감도를 달성하였다. 이번 발표에서는 라돈 일차 표준기를 이용한 정밀 교정 결과와 이동형 라돈 선원을 이용한 라돈 교정시스템에 대해서 소개할 예정이다.

Keywords:

라돈, 라돈 교정, 라돈 검출, 라돈 측정, 정전기 수집, 검출기 개발

G2.01

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Large Area Growth Technologies of Two Dimensional Transition Metal Dichalcogenides

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Abstract:

그래핀으로부터 시작된 이차원 (2D) 소재에 대한 기대와 관심은 그래핀의 제로 밴드갭 특성 때문에 반도체 특성을 나타내는 칼코겐화 전이금속 화합물들 (transition metal dichalcogenides, TMDC)로 전이되어, 전 세계적으로 TMDC 소재에 대한 연구가 활발히 진행되고 있다. 그래핀과는 달리 TMDC 소재들은 밴드갭 에너지가 스위칭 특성을 얻기에 적합하며, 동시에 고이동도를 기대할 수 있다. 2D 소재들은 한 층 내에서는 구성원소간 결합력이 매우 강한 반면 층간에는 반데르발스 결합력 만이 존재하므로 캐리어들이 산란없이 수송되어 높은 이동도를 얻을 수 있지만, 반도체층-전극 사이에 오믹 접촉 특성을 확보하기 어렵고, 쉽게 박리되는 특성 때문에 기존 반도체 패터닝 공정을 적용하기 어려운 문제들도 가지고 있다.
2D-TMDC 소재를 소자의 대량생산에 활용하기 위해서는 대면적 제조가 가능하여야 하는데, 테이프를 이용한 박리, 작은 crystallites 형태의 성장공정, 또는 성장박막의 전사 등으로는 이를 구현할 수 없으므로, 소자를 제조할 기판 위에 직접 2D 소재 박막을 제조하는 기술들이 최근 많이 연구되고 있다. ETRI에서는 황, 셀렌 증기의 큰 분자를 열크래킹 방법으로 반응성이 크며, 크기가 작은 분자로 잘게 쪼개어 활용하는 방법을 이용하여 2D 소재를 6인치의 대구경 기판 위에 직접 성장하는 기술을 개발하였다. 이 기술에 의하면, 기존의 화학기상증착법에 비해 낮은 온도에서 우수한 특성의 박막을 균일하게 얻을 수 있다[1] 또한, 기존의 테이프 박리와는 달리, 수분산액에서 2D 나노 시트들을 박리하여 나노시트-고분자 복합체를 제조하고 이를 균일하게 도포하여 소자를 제조한 연구 결과도 함께 소개한다 [2].

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Keywords:
이차원 소재, 대면적 성장, 칼코겐화, 나노시트 복합체

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G2.02

Spin metrology at KRISS

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Abstract:
Spintronics is one of the areas which are expected to replace conventional electronics where the charge of an electron plays an important role. In the pursuit of the next generation spintronics, starting from the metallic ferromagnet, we can extend to more emergent materials such as topological insulators. New physical phenomena have been found in these emergent materials systems. One of the main concerns is that characterization of the electron spin is not an easy task, thus characterization of electron spin is one of the challenging issues in experimental condensed matter physics.

Serving as the national metrology institute in Korea, we have built several infra-structures characterizing the electron spin to support the spintronics industry. I will introduce several methods developed so far by KRISS such as secondary electron microscope with polarization analysis (SMEPA), ferromagnetic resonance(FMR), Brillouin light scattering(BLS), and XFMR which is based on synchrotron light source. Furthermore, I will introduce the on-going project for the measurement standards of Dzyaloshinskii-Moriya interaction, which is one of the most controversial parameters in spintronic materials. Finally we will introduce possible science based on our spin probes and use of the spin measurement infra built at KRISS.

Keywords:
spintronics, metrology, spin, SEMPA, XFMR, FMR, BLS

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G2.03

중적외선 양자폭포레이저 개발 및 ppb급 가스센서 응용

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Abstract:
중적외선 광원은 고감도 가스센서 응용, 미사일 countermeasure 등 환경, 의료, 국방 분야에 활용될 수 있는 중요한 광원 중의 하나이다. 반도체의 초격자 구조로 이루어진 양자폭포레이저는 중적외선 광원을 제작할 수 있는 차세대 반도체 광원의 대표라 할 수 있는데 그 동안 국내에서의 연구는 상대적으로 이루어지지 않았다. 본 연구에서는 최근 몇 년간 KIST에서 개발한 MBE에 기반한 중적외선 양자폭포레이저를 소개하고, 이를 이용한 암모니아 및 메탄가스의 ppb급 검출 특성에 대한 연구결과를 소개하고자 한다.

Keywords:
양자폭포레이저, 중적외선 광원, 반도체 초격자, 고감도 가스센서

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G2.04

Organic Semiconductor Materials Development in KRICT

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Abstract:

Since the early effort to control the electrical conductivity of pi-conjugated organic materials, organic semiconductors are nowadays being investigated intensively because of their potential of new form factor, processing flexibility and manufacturing cost effectiveness. Among various kinds of applications of such organic semiconductors, OLEDs (organic light-emitting diodes) have already been successfully commercialized, followed by OPVs (organic photovoltaics). OTFTs (organic thin-film transistors) have also been studied for a long time, and are waiting for the opportunity to enter the niche market. One of the advantages of this organic semiconductor technology is the freedom of materials. Through careful organic synthesis, the structure and property of each of the organic semiconductors can be finely tuned. In this presentation, I will first briefly review the recent developments of organic semiconductor technology from the aspect of materials. Our research experience and results from KRICT including OLEDs and OPVs will also be discussed. More specifically, recent results about arylamine-based p-type organic semiconductors for OLEDs or perovskite solar cells applications will be discussed.

Keywords:
OLED, OPV, Arylamine

G3.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Formation of sub-micron aluminium hydroxide structures using dip-pen nanolithography

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Abstract:

Sub-micron aluminium hydroxide ($AlOH_3$) structures are obtained by dip-pen nanolithography (DPN) with utilizing meniscus between the tip and substrate as a chemical reaction site. In our previous study [1], protruded structures of $AlOH_3$ were obtained on 30 nm gold nanomembrane coated 200 nm thick aluminium layer deposited on a silicon dioxide substrate. Solidification of $AlOH_3$ to form the protruded structures is resulted through pH decrease of the reacting KOH solution occurred in relatively small volume of KOH ink. Here, to investigate the mechanism of the protruded $AlOH_3$ structure formation, DPN is carried out to load small volume of KOH solution on a substrate. Different concentration of KOH solutions are prepared and inked onto one-dimensionally (1-D) parallel DPN tip. The relatively small volume of different concentrated KOH ink are loaded on 20 nm gold nanomembrane coated 100 nm thick aluminium layer deposited on a silicon dioxide substrate. Protruded structure of sub-micron $AlOH_3$ is confirmed by atomic force microscopy (AFM) measurement. In addition, the detailed formation process (etching-filling-protruding) is observed by Kelvin probe force microscopy (KPFM) and optical microscopy. By time-of-flight secondary ion mass spectroscopy (TOF-SIMS) measurement of the DPN carried out samples, the formation of $AlOH_3$ is double confirmed.

Reference

[1] C. M. Oh, K. H. Park, J. H. Choi, S. Hwang, H. Noh, Y. M. Yu, J. W. Jang. Polycrystalline Au Nanomembrane as a Tool for Two-Tone Micro/Nanolithography. *Chem. Mater.* 2017, 29 (9), 3863-3872.

Keywords:
Dip-pen lithography, aluminium hydroxide

G3.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Protective and Selective Oxide-coating for Ionic Conductive Solid Electrolyte Interphase

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Abstract:
To employ Li-based batteries to their full potential in a wide range of energy-storage applications, their capacity and performance stability must be improved. Si is a viable anode material for Li-based batteries in electric vehicles due to its high theoretical capacity and good economic feasibility. However, it suffers from physical and chemical degradation, leading to unstable electrochemical performance and preventing its incorporation in new Li-based battery systems. Herein, we report various simple and effective methods to form the stable Li ionic conductive layers in Si-based LIB anode materials. The protective coating for Si-graphite composite can be applied by mixing a poly(vinyl alcohol)-PO_4 with the Si-graphite composite. The polymer acts as a binder to alleviate the pulverization of Si and the oxide coating reduces the loss of Li_2O, which has high ionic conductivity, during operation, resulting in the formation of a stable solid electrolyte interphase. In the case of selective coating for Si nanoparticle inside the Si-C composite, a tiny amount of Li_2O nanoparticles was mixed with the coal tar pitch carbon source during the fabrication of the composite particles and a stable Li_2SiO_3 phase, known as a good Li ionic conductor, was successfully formed on the Si nanoparticles. The analysis results, such as XPS, XRD, and TEM, will present findings for coating effects. Our findings show that a stable and ion-conducting anode/interphase can be developed by applying a simple protective or selective oxide coating. Therefore, this study provides the direction to enhance the stability of Si-based anode materials for developing high performance LIB.

Keywords:
nano-coating, stable SEI, XPS, LIB, Si anode,

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G3.03*

VIS-UV resonance Raman scattering study of chemical SERS effect

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Abstract:

Surface enhanced Raman scattering (SERS) for the amplification of Raman signals has been studied for several decades. Nevertheless, one of the mechanisms of SERS, the chemical enhancement, has yet to be elucidated. In this study, we have studied the chemical enhancement effect of SERS from 4-MPY molecules adsorbed on well-defined ZnO nanostructures over incident photon energies from 1.7 eV to 5.7 eV.
We observed that the Raman intensities of 4-MPY peaks at 5.14 eV in the UV region is about 20 times larger than that in the visible region, due to resonance transition between the highest occupied molecular orbital (HOMO) and least unoccupied molecular orbital (LUMO) of 4-MPY molecule itself. We also calculated the resonance profile by using the four-photon Green's function for the resonant Raman scattering process and obtained a good agreement with our experimental results. However, the enhancement factor for SERS is still larger in visible excitation range where charge transfer transition between ZnO and molecules suggesting that charge transfer transition is the most important factor for chemical enhancement, even though there are a couple of relevant resonance energy scales. Through this study, we provide a theoretical and an experimental means to study chemical enhancement mechanism for SERS more in detail and in depth.

Keywords:
SERS (Surface Enhancement Raman Spectroscopy), UV, Visible, Charge transfer, Chemical mechanism

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G3.04*

STM studies of single organic molecular magnet on ultrathin insulating film

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Abstract:

Scanning tunneling microscopy and spectroscopy is highly useful tool to investigate electronic and magnetic properties of individual atoms, molecules, and their complexes at atomic scale. Introducing ultrathin insulating film into the system can decouple the properties of atoms and molecules from metallic substrate. In particular, such insulating substrates can be a novel template for understanding interplay between individual atoms and organic molecules. Here, we investigate transition metal (V)- tetracyanoethylene (TCNE) complexes on insulating Cu_2N surface to understand how charge transfer between the metal and the organic molecule influences the evolution of spin states at atomic scale. Our study may help to understand the underlying mechanism of the room temperature organic magnets and to provide an opportunity to study spin exchange through single molecules with atomically precise contacts.

Keywords:

STM, V-TCNE complex

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G3.05*

A study on the relationship between crystallinity of catalytic metal and distribution of dopants on doped graphene.

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Abstract:

We have controlled the crystallinity of the catalytic metal through the pre-annealing process for the designed synthesis of graphene using chemical vapor deposition (CVD). The commercial roll-pressed Cu foils were employed as a catalytic metal for the annealing and synthesis process. Before and after annealing process, the crystallinity of Cu foil was confirmed by electron channeling pattern (ECP) and electron backscatter diffraction (EBSD) mapping inside the scanning electron microscope (SEM).
We investigated the growth of N-doped graphene at specific orientation of copper. We used pyridine as a precursor for nitrogen doped graphene. XPS and Raman analysis were performed to study whether nitrogen doping was affected by the orientation of copper in the growth process. The analysis was performed at the same position before and after transfer onto the 300 nm silicon dioxide substrate from Cu foil. After the analysis, a field effect transistor (FET) device was fabricated and the field effect mobility and charge neutral point (CNP) of the FET device were evaluated by measuring the I-V curve according to the gate voltage. I'll show you more about the results our study in the conference.

Keywords:
Graphene, CVD, Crystallinity, Doping

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G3.06*

Aromatic molecules on transition metal surfaces: chemical analysis of adsorption

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Abstract:

Recently two-dimensional (2D) layered materials are very attractive in various fields because of their interesting properties. For this reason, the study for interaction between catalytic surface and a precursor molecule such as borazine($B_3H_3N_3H_3$) or benzene(C_6H_6) has been one of the intensive topics of low-dimensional materials. Inevitably, experiments for growth of 2D materials have been influenced by surface atom, the atomic structure of surface and a precusor molecules. a computational study of the interaction between molecules and various surfaces can contribute to growth of 2D materials of good quality. In this study, we investigate the adsorption structure of borazine on the copper, platinum, nickel and iron(111) surface using generalized gradient approximation functional (PBE) including dDsC(density dependent dispersion correction)[1] vdW approximation. As a result, the boron and nitrogen atoms of the molecule are strongly adsorbed on the Ni(111) and Fe(111) surface compared to other surfaces. On the Pt(111) surface, the molecule make only Pt-N pairs with surface atoms and this type of bonding maintains the inherent planar structure of the molecule. The Fe(111) surface has different adsorption sites from other surfaces and the Cu surface has very weak bonds with molecules. We present our analysis for the trend and different behaviors depending on surfaces

[1] S. N. Steinmann., J. Chem. Phys. 134, 044117 (2011).

Keywords:

surface, DFT, denstity functional theory, borazine, synthesis, two-dimentional materials, hexagonal boron nitride

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G3.07

Driving mechanism of single atom electron spin resonance (ESR) - STM

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Abstract:
Scanning tunneling microscopy (STM) has been one of highly versatile surface science tools to investigate electronic and magnetic properties of individual atoms and molecules on surfaces. Recently, successful combination of electron spin resonance (ESR) technique and STM has demonstrated electron spin of individual Fe atoms on ultrathin insulating MgO can be coherently driven. In this talk, we show recent progress of benchmarking the ESR-STM which we successfully measure and reproduce spin resonance signal from individual Fe atoms. In addition, with advantage of our vector magnet, we perform the ESR experiments at various external magnetic fields and discuss the driving mechanism of the ESR-STM.

Keywords:
Electron spin resonance, scanning tunneling microscopy, ultrathin insulating film

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G3.08*

Selective $AuCl_3$ doping onto multilayer MoS_2 field effect transistors carried out by dip-pen nanolithography

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Abstract:
Dip-pen nanolithography (DPN) is a scanning probe-based tool of fabrication that utilizes an ‘ink’ molecules-coated AFM tip to print on surface of the sample. DPN is a direct-write lithographic tool that allows soft and hard materials to be printed with high sub-100-nm resolution. Among Two-dimensional (2D) semiconducting transition-metal dichalcogenides (TMDCs), molybdenum disulfide (MoS_2) has been widely studied as a next generation field effect transistors (FETs). Several characteristics are needed to improve the electrical properties MoS_2 devices such as contact resistance, control of the Fermi level and threshold voltage. Such improvements can be achieved by the doping process. Since chemical doping does not damage the lattice of the material, selective doping is possible using the advantages of DPN. In this study, DPN is carried out to execute doping on the MoS_2 surface. The multilayer MoS_2 was transferred from the bulk crystal onto the SiO_2 substrate by mechanical exfoliation. The source and drain electrodes were fabricated using thermal evaporation with Ti/Au (10/100 nm) with stencil masking on the multilayer MoS_2. The electrical properties of multilayer MoS_2 FET were characterized with applying back-gate bias. The surface of MoS_2 was doped by DPN printing *p*-type dopant (2 mM and 10 mM $AuCl_3$). The MoS_2 FETs show *n*-type and *p*-type behaviors. Doping of MoS_2 was confirmed by field emission scanning electron microscope (FE-SEM), energy-dispersive spectroscopy (EDS), and electrical measurements. Finally, it turns out that electrical performance of the multilayer MoS_2 FET can be improved when the proper doping by DPN carried out.

Keywords:
MoS2, field effect transistor (FET), dip-pen nanolithography (DPN)

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When modern physics meets nature of science: Investigating new physics textbooks' representation of nature of science in general relativity using family resemblance approach

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Abstract:

Social reaction to the recent detection of the Higgs boson and gravitational waves provided evidence that public interest in modern physics has reached a high point. Though these modern physics topics are being introduced into the upper secondary physics curricula in a growing number of countries, their potential for teaching various aspects of scientific practice have yet to be explored. This article responds to this call by presenting an analysis of new South Korean high school physics textbooks' representations of nature of science (NOS), particularly as reflected in their general relativity theory section. Chapters from textbooks by five publishers are analysed based on the family resemblance approach (FRA) to NOS by Erduran and Dagher (Reconceptualizing nature of science for science education. Springer, Dordrecht, 2014). Drawing on Wittgenstein's linguistic philosophy, FRA allows for capitalising on the domain-general and domain-specific NOS aspects that are entangled within and across scientific domains. The result indicates that textbooks' references to NOS are concentrated on aspects related to scientific knowledge, scientific practice, scientific methods, and professional activities of scientists, while the various characteristics of science as a social-institutional system are generally underrepresented. In addition to this generic description, we also present a closer inspection of how physics textbooks portray the story of the LIGO-Virgo Collaboration's (LVC) gravitational-wave detection in February 2015 and discuss implications for how the affordances of 'physics in the making' such as general relativity for NOS instruction should be substantiated and supported by textbooks. In doing so, this paper highlights that FRA can point to the curriculum emphases and omissions with respect to the epistemic and social nature of science.

Keywords:

family resemblance, physics textbook, general relativity, science textbook, nature of science

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G4.02*

Challenging the theory-drivenness of experimentation: Exploratory experiments in physics and their educational values

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Abstract:

본 연구는 최근 일부 과학철학자들에 의해 정식화되고 있는 탐색적 실험(exploratory experimentation)의 개념과 사례를 소개하고 물리학 교육과정에 가지는 함의를 논의한다. 논리실증주의의 이론-관찰 이분법에 의존한 전통적인 관점에서 과학실험은 이론으로부터 도출된 가설을 검증하기 위한 목적으로 설계되고 수행된다고 이해되어 왔다. 1990년대 후반 배리언 및 스타인리에 의해 각각 독립적으로 제안된 탐색적 실험 개념은 가설검증기능에 기반한 과학실험의 정의가 현실에서의 모든 실험행위를 포괄하지 못한다는 문제의식에서 출발한 것으로, 과학사 및 현대과학 실행에서 발견되는 많은 실험들이 가설의 검증보다는 이전에 보고된 바 없으며 이론적 설명이 체계화되지 않은 새로운 현상을 관찰하기 위한 '탐색적' 용도로 수행된다고 설명한다. 이 논문에서는 특히 물리학에서 탐색적 실험의 예시로 언급되는 패러데이의 전자기 실험 및 괴테의 색채 실험 사례를 중심으로 탐색적 실험이 이론적재적 가설검증형 실험과 어떻게 구별되는지를 살피고, 초중등학교 물리학 실험교육 및 물리학의 본성 교육 맥락에서의 의의를 검토한다.

Keywords:
exploratory experiments, experimentation, physics curriculum, philosophy of scientific experimentation, nature of science

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G4.03*

A Text Analysis of International Studies on Physics Education : Focused on Semantic Network Analysis and Latent Dirichlet Allocation Topic Modeling Methods using Python

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Abstract:

We report an overview in the field of physics education research through text analysis of a large database of papers published in international journals. We analyzed 2,105 abstracts indexed in the Science Citation Index (SCI) and Social Science Citation Index (SSCI) from the database of Web of Science (WoS). In this study, Semantic Network Analysis (SNA) and Latent Dirichlet Allocation (LDA) topic modeling methods were used to analyze a large text data of abstracts by using Python packages (Networkx, Gensim, and NLTK) for network analysis and topic modeling. The results show characteristics of the words used in physics education by period or region and provided international trends of research topics in this field. SNA and LDA topic modeling of articles using Python packages not only offers an overview of physics education research but also could be helpful for researchers who want to qualitatively analyze a large amount of text data in physics education more efficiently.

Keywords:

Physics education, Text analysis, Python, Data mining, Literature review

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G4.04

2 라운드 물리 문제 해결 과정의 분석을 통한 협력적 지식생성 양상 탐색

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Abstract:
동료는 협업 중에 서로의 학습에서 중요한 역할을 한다. 이 연구에서는 1 라운드에서 학생들의 개인 성과에 기초하여, 2 라운드 물리 문제 해결 세션에서 협력의 유형과 본질을 알아보고자 한다. 142개의 물리 문제에 대한 2라운드 물리 문제 해결 과정을 3개 학기 데이터를 이용하여 분석한다.

Keywords:
동료 토론, 협력, 2라운드, 협력적 지식생성

G4.05

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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일정한 중력장에서 강체구 충돌 모형에 의한 HTML5 기반의 교육용 대기압 시뮬레이션

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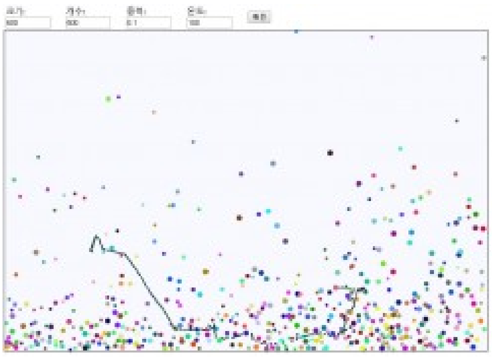
Abstract:
두 강체구의 고전적 탄성충돌 모형을 확대하면 N개의 강체구 충돌을 구현하는 시뮬레이션을 통하여 이상기체의 거동을 모사하는 시뮬레이션을 구현할 수 있다. 이때 초기 조건으로 각 강체들의 질량, 초기속도 또는 온도, 강체구의 거동 공간 크기 등을 설정함에 따라 다양한 이상기체의 거동을 학생들이 이해하도록 도울 수 있다. 이러한 강체구의 충돌 과정에서 각각의 강체구가 일정한 방향의 중력장에 의하여 가속되도록 구속 조건을 부가하면, 이에 따라 중력장 방향에 따른 강체구의 밀도 구배와 이에 따른 강체구의 속도 분포 구배가 형성되어 대기압이 형성되는 과정을 구현하는 시뮬레이션을 구현할 수 있다. 본 연구는 이러한 알고리듬에 따라 HTML5 기반에서 javascript에 의한 대기압 시뮬레이션을 구현하고 그 교육적 시사점을 논의한다.



Keywords:
시뮬레이션, 대기압, HTML5

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G4.06*

일반 물리 실험 수행에서 나타난 오류에 대한 대학생의 자기 인식

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Abstract:

이 연구의 목적은 실험 보고서 분석을 통해 일반 물리 실험 수행에서 나타난 오류 및 그에 대한 대학생의 자기 인식을 알아보는 것이다. 일반 물리 실험 수업 수강생 30명 중 8명의 실험 보고서를 선별하여 각 실험 수행 단계별 오류 유형을 분석하고, 실험 수행에서 나타난 오류에 대한 학생들의 인식과 비교하였으며, 분석한 결과는 다음과 같다.
첫째, 보고서 분석을 통해 드러난 실험 수행 과정의 오류 유형은 측정, 자료 처리, 자로 해석, 결론 도출 단계에서 고르게 나타났으며 학생들은 잘못된 측정값을 측정 뒤, 이에 대한 자료 처리 및 자료 해석, 결론 도출에서 미숙함을 보였다.
둘째, 학생들의 자체 분석에서는 측정, 자료 처리, 자료 해석 단계에서만 오류가 제시되었으며, 실험에 대한 보편적인 신념이 드러났다. 이를 정리하면 학생들은 이론값에 맞추어 인위적으로 자료를 조작하거나 부적절한 해석을 하였음에도 불구하고, 실험 수행에서 나타난 오류는 실험이 가진 본질적 한계라 생각하며 자신들의 수행 상 오류를 제대로 인식하지 못하였다.
셋째, 교사의 보고서 분석과 학생의 자체 분석결과는 다르게 나타났으며, 학생들은 부적절한 실험을 수행할 뿐만 아니라 자신들의 수행 상 오류를 제대로 인식하지 못하였다.

Keywords:

일반물리, 실험보고서, 오류 인식

G4.07*

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고등학생들의 공간과 시간규모에 대한 인식 수준과 논리적 사고력

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Abstract:
이 연구의 목적은 일상에서 우리가 경험하는 세상을 공간과 시간 규모에 대해 인식하는 수준과 관찰한 자연계를 과학적으로 이해하고 설명하는 학습자의 인지발달 수준인 논리적 사고력을 측정하여 둘 사이의 상관관계에 대해 분석함으로써 교육적으로 유용한 정보를 제공하는데 있다. 이를 위하여 서울 소재 고등학교 1,2학년 학생 576명에게 공간 규모 및 시간 규모 질문지(MUST)와 논리적 사고력 검사도구(GALT)를 투입하여 공간 규모에 대한 인식, 시간 규모에 대한 인식과 논리적 사고력의 상호간의 상관관계를 분석하고, 각각의 하위 요소별 영향을 분석하였다. 연구 결과는 다음과 같다. 첫째, 공간과 시간 규모에 대한 인식 수준에 대한 평균을 비교해보면 공간 규모보다 시간 규모에 대한 인식이 더 높음을 알 수 있다. 둘째, 공간과 시간 규모에 대한 인식 수준은 남녀 사이에 공간과 시간 규모에 대한 인식 중 특정한 영역에서의 수준에 통계적으로 차이가 있음을 알 수 있다. 셋째, 논리적 사고력에 대해 12점을 만점으로 했을 때 평균은 5.36임을 알 수 있고, 성별에 따른 통계를 보면 남학생은 5.53점, 여학생은 5.05점으로 남녀 학생의 유의한 차이가 있다는 것을 분석할 수 있다. 넷째, 공간 규모 인식 수준과 논리적 사고력 하위 요소 사이에는 부분적으로 영향력이 있음을 알 수 있으며, 시간 규모 인식 수준과 논리적 사고력은 전체적으로 유의한 상관관계가 있음을 알 수 있다. 따라서 공간과 시간 규모에 대한 개념이 명확할수록 논리적 사고력이 높다는 것이 확인되었다.

Keywords:
공간과 시간 규모, 논리적 사고력

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G4.08*

A Similarity Analysis Between Paper-and-pencil Items and Textbook Objectives in Physics I 'Spacetime and The Universe'

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Abstract:

A valid evaluation must have balance between contents and be matched with learning objectives. This study analyzed items used from 9 high schools and Korea Institute of Curriculum and Evaluation (KICE) about first chapter, 'Spacetime and the universe', of high school Physics I. In order to analyze distribution of items, the items were classified by cognitive level which is knowledge, comprehension and application levels, and by scientific inquiry skill level. As results, application level items were a few, and unbalanced distribution were appeared in items both from school and KICE items. Most for scientific inquiry skill were evaluated the analyzing data skill. Lastly, we analyzed the similarity of objectives between items and textbooks in terms of cognitive level using by ratio difference. Similarity was very high between textbooks and school items. However, there was low similarity between KICE items and both textbook and school items. Finally, we concluded that items were unappropriated to evaluate higher order cognitive ability because of difficulty of Physics I course, and the multiple-choice test format.

Keywords:

Physics Ⅰ, cognitive domain, inquiry skill, textbooks, test items.

G4.09
2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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한국의 역사를 기반으로 한 과학-예술 프로그램의 개발
Development of program for making ScienArt work based on Korean Culture(SAKC)

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Abstract:

열강들에 둘러싸여 있는 우리나라는 험난한 여정에도 불구하고 찬란한 문화를 이룩하였다고 볼 수 있다. 문화예술의 도입은 과학에 대한 흥미와 한국에 대한 자부심을 느끼게 한다고 볼 수 있다(2018, 이수아·박윤배). 특히, 시(詩)는 언어적 도구를 넘어서 학생들의 정서와 가치관 형성에 도움을 준다고 볼 수 있으며 민족시는 우리 민족의 현실을 이야기한다고 볼 수 있다(2019, 이하석). 고려 왕건의 경우, 팔공산에서 참패하여 여덟 명의 충신들을 산속에 묻어야 했으나 그 시련을 디디고 후삼국을 통일하였으며 조선은 일제 식민지를 지배를 극복하고 광복을 맞이하였다. 독립운동가였던 과학자 김용관은 일상생활 속에서 과학 대중화를 통해 강한 조국을 이룩하고자 하였다. 본 연구는 대구지역 중고등학교 학생들을 대상으로 한국의 역사를 기반으로 과학-예술 프로그램을 개발하고 문제해결과정을 나타난 핵심역량을 살펴봄으로써 과학교육의 대중화를 위해 노력하고자 하였다. 연구 결과, 학생들은 다양한 시각에서 시 창작 및 낭송을 하였으며 시간·공간의 개념과 파동의 성질, 연소, 식물의 특성과 같은 과학 영역도 도입한 것으로 나타났다. 또한, 과학적 사고력과 문제해결력, 참여/평생학습능력이 나타났으며 과학적 탐구력과 의사소통 능력은 나타나지 않았다. 독창성과 심미적 감성능력은 두드러진 것으로 나타났다.

Keywords:
과학과 예술, 한국의 역사, 시, 핵심역량

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G4.10

학생참여중심 수업 사례 연구: 파동과 광학을 중심으로

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Abstract:

본 연구에서는 창의적이며 산업현장 적응 능력을 갖춘 고급 전기전자 인재를 양성하는 전문대학에서 전자통신공학을 전공하는 학생 24명을 대상으로 하여 학생참여중심 수업을 진행하였다. 특히 본 수업 형태에서는 파동의 특성과 기하광학에 대한 깊이있는 이해를 얻고 동기 수준이 낮은 학생들도 적극적으로 수업에 참여할 수 있도록 적절한 수업 모형을 설계하였다. 학생들의 수업 참여를 높이고 물리적인 개념의 이해 수준을 향상 시키기 위해 동료 교수법과 릴레이 질문을 바탕으로 팀 활동 수업을 전개하였고 이를 통해 학생들이 수동적인 수업에서 적극적으로 서로 토론하고 협력하여 과제를 수행할 수 있도록 수업을 구성하였다. 매 차시 수업 활동지와 설문지를 수집 분석하였고 필요할 경우 심층 면담을 실시하였다. 연구결과, 전통강의로만 이루어진 기존 교수학습방법과 비교할 때, 학생참여중심 수업을 적용한 학기의 경우 학업성취도가 높게 나타난것으로 분석되었다. 본 연구를 시행하기 이전 3년 동안의 평가점수와 본 연구를 시행한 학기의 점수 분포를 비교한 결과, 학생참여중심 수업을 적용한 학기에서 고득점을 받은 학생 비율은 이전 년도보다 증가하고 저득점을 받은 학생 비율은 현저히 감소함을 확인 할 수 있었다.

Keywords:

광학, 동료교수법, 학생참여중심, 팀 활동 수업

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G5.01

The Aleph and the search for topological states in non-hermitian systems

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Abstract:

The search for topological states has expanded to non-Hermitian lattices (for a review see [1]), systems where non Hermiticity is used to model gains and losses (as in photonic or acoustic systems) or the effect of interactions (such as electron-electron and electron-phonon). Capital to this endeavor is the ability to build a proper bulk-boundary correspondence, a task that has gained much attention during the last year.
In this talk I will focus on recent results that are unique to non- Hermitian lattices and that challenge the usual viewpoint in the theory of topological states. This includes the occurrence of higher-order exceptional points where a macroscopic fraction of the states coalesce at a single point with a geometrical multiplicity of one [2]. At such points it may occur that the system becomes devoid of extended states (even for a pristine lattice) [2]. I will present a scheme to generate such higher-order exceptional points in lattices [3].

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[2] V. M. Martinez Alvarez, J. E. Barrios Vargas, and L. E. F. Foa Torres, Phys. Rev. B 97, 121401(R) (2018).
[3] V. M. Martinez Alvarez, E. Rodríguez-Mena, L. E. F. Foa Torres, to be published.

Keywords:
non-Hermitian, topological states

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G5.02

Wave Chaos in Microwave Networks Simulating GOE & GUE Graphs

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Abstract:
First I will give a brief introduction on aspects of Quantum Chaos, that is, on the study of manifestations of classical chaos in the spectral fluctuation properties of the corresponding quantum system. Then I will report on the investigation of the fluctuations in the spectra of microwave networks simulating quantum graphs with classically chaotic dynamics and preserved or violated time-reversal invariance. Such systems are especially suited for the theoretical and experimental study of various aspects related with wave chaos, random matrix theory and the semiclassical approach. Both closed and open quantum systems with and without time-reversal invariance violation may be designed.

In the experimental spectra approximately 6% of the levels are missing. However, the statistical analysis of the spectral properties of a quantum system and the comparison with those of random matrices from the conventional Gaussian ensembles requires complete sequences of eigenvalues belonging to the same symmetry class. We will present a procedure [1-3], to determine the fraction of missing levels and still unambiguously identify the symmetries from the spectral properties of the corresponding quantum system. Incomplete spectra are actually a problem one has to cope with in real physical systems, like, e.g., nuclei, dielectric and microwave cavities, Thus, such a procedure is a requisite for their analysis.

Finally, I will shortly speak about recent numerical and experimental investigations of quantum graphs with GSE symmetry.

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[3] B. Dietz et al., Phys. Rev. E 95, 052202 (2017).

Keywords:
level statistics, microwave, open system

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G5.03

Topologically robust states in two-fold PT-symmetric systems

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Abstract:

The emergence of topologically robust states has been understood in terms of the bulk-edge correspondence; they appear at the boundary between two insulating systems whose topology cannot be continuously deformed into another. However, is its converse true? We find that at the boundary between topologically trivial non-Hermitian systems, a robust localized state can appear. We provide a new topological identification that two-fold PT-symmetry of the system protects the emergence of such a state against continuous deformations. Moreover, we show the localization length of the topological defect state is insensitive to a wide range of parameters.

Keywords:

Non-Hermitian, topology, PT-symmetry

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G6.01

In-Situ Observation of Catalytic Surface Reactions with Soft X-Ray Core-Level Spectroscopies

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Abstract:

We have been working on understanding of catalytic surface reactions using in-situ soft x-ray core-level spectroscopies. Particularly we have paid attention to observation of active species involved in catalytic processes. For this purpose we built end-stations for in-situ observations of catalytic surface reactions based on wavelength-dispersive near-edge x-ray absorption fine structure (Dispersive-NEXAFS) [1] and near ambient pressure x-ray photoelectron spectroscopy (NAP-XPS) [2] at the Photon Factory (KEK-PF).

With the Dispersive-NEXAFS technique we observed reactive species under UHV conditions via the titration method and sometimes could find a reaction intermediate [3]. However, such a reaction is just one of elementary steps included in the actual catalytic process. To drive whole catalytic cycle, dose of reactant gases at near ambient pressures at elevated temperatures is often effective. We conducted in-situ observations of catalytic reactions under near ambient pressure conditions with NAP-XPS [4-8]. Following two topics concerning well-known catalysts will be presented: (1) automobile catalyst using platinum group metals (PGMs) and (2) silver catalyst for epoxidation of ethylene.

In-situ observations of the automobile catalysts under reaction conditions enabled us to identify active phases of catalysts [4,5] and active species of reactants [6,7]. The surface structure of the PGM catalyst plays a crucial role to determine the active phase and active species. For the silver catalyst, we conducted polarized NAP-NEXAFS measurements under reaction conditions in addition to NAP-XPS measurements. These experiments revealed that a flat-lying carbonate is produced from the reactants (ethylene and oxygen) under the reaction conditions [8], which may play a role in the catalytic epoxidation of ethylene. The carbonate on the silver catalyst could be regarded as a molecular catalyst which induces epoxidation of ethylene and regenerates after the epoxidation by oxygen. The in-situ observations of catalytic surface reactions with soft x-ray core-level spectroscopies provide opportunities to find species essential to the catalysis.

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Keywords:
1) NAP-NEXAFS; 2) NAP-XPS; 3) Platinum group metals

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G6.02

Atomic Structure of Copper Surfaces in the Presence of CO, CO_2 and Methanol Gases

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Abstract:

Using high pressure scanning tunneling microscopy (HPSTM), we show here that the most compact and stable surfaces of Cu undergo massive reconstructions in the presence of CO at room temperature at pressures in the Torr range, and they decompose into two-dimensional nanoclusters, which is a double effect of low cohesive energy of Cu and the high gain in adsorption energy at the newly formed under-coordinated sites.[i][ii][iii] Here we discuss the atomic structure of the nanoclusters as a function of CO pressure, their energetics for formation, and the growth mechanisms, as well as their importance for heterogeneous catalysis. Whilst 19-atom large hexagonal clusters are the building blocks of larger clusters on the Cu(111) surface, linear clusters form on Cu(100) and Cu(110) surfaces. Surface- sensitive spectroscopy techniques such ambient pressure photoelectron spectroscopy (APXPS) and infrared reflection absorption spectroscopy (IRRAS) are used to corroborate the HPSTM results. The surfaces which are broken up into clusters are more active for water dissociation, a key step in the water gas shift reaction. Such a behavior opens a new paradigm, especially for other soft metals like gold, silver, zinc, etc., and it is clear that we need more of such studies. Similar to CO, Cu(100) surface also breaks up into clusters in the presence of CO_2, however at an order of magnitude higher pressures.[iv] Gas-phase CH_3OH, on the other hand, does not cause the break-up of Cu into clusters because methoxy already adsorbs strongly on Cu terraces.[v]

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Keywords:
1) HP-STM; 2) AP-XPS; 3) IRRAS; 4) Copper Catalyst;

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G6.03

8A2 KBSI-PAL AP-XPS Beamline for in-situ and Operando Science

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Abstract:
8A2 KBSI-PAL AP-XPS (Ambient pressure X-ray photoelectron spectroscopy) beamline is about time to finish its comissioning and ready to open. The gaol of 8A2 beamline is the realization the photon energy of 200 ~ 2000 eV and the photon flux of 1 x 10-13 photons/sec with resolving power of 10,000 at the photon energy of 900eV. In this presentation, I'd like to explain the status of 8A2 beamline and AP-XPS experimental system. Also, the future plan of 8A2 beamline for the in-situ and operando science will be introduced and discussed.

Keywords:
APXPS, in situ and operando science, surface and interface

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G6.04

Atomic scale view of degradation and surface inhomogeneity of single crystal $MAPbBr_3$

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Abstract:
Organic-inorganic hybrid perovskite materials, especially methylammonium (MA) lead halides, have received significant attention in solar cells society in the past few years. It is mainly due to high power conversion efficiency and carrier mobility, together with inexpensive and relatively simple fabrication, which makes the hybrid perovskites one of the most competitive options for the next generation light harvesting materials for photovoltaic applications. Despite of the desirable properties of perovskite solar cells, several challenges remain to be commercialized. One of the most critical challenges is the poor stability of the hybrid perovskites against moisture, temperature, and sunlight. The atomic scale mechanism behind the degradation of perovskite materials, however, remains unclear.
Atomic scale surface degradation mechanisms and the surface characterization of $MAPbBr_3$ are studied by ambient-pressure atomic force microscopy (AP-AFM) with simultaneous measurements of friction and conductance [1,2] and by density functional theory (DFT). Single crystal $MAPbBr_3$ grown in solution process is mechanically cleaved in ultra-high vacuum (UHV) chamber in order to obtain atomically clean surface without contamination. Cleaved $MAPbBr_3$ exhibits large terraces with monolayer-height steps. We also observe a partial coverage of low-friction domains that exhibit height variation. A growth of surface $PbBr_2$ clusters are observed as a function of time in UHV chamber ($p \approx 10^{-10}$ Torr). Plausible mechanisms of surface inhomogeneity and the degradation of $MAPbBr_3$ single crystal are discussed.
[1] J. Y. Park and M. Salmeron Chem. Rev. 114, 677-711 (2014).
[2] J. I. J. Choi et al. Rev. Sci. Instrum. 89 103701 (2018).

Keywords:
AFM, AP-AFM, DFT, perovskite, MAPbBr3, friction, solar cells, degradation, stability

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G7.01

Phenomenological theory of quantum spin liquids

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Abstract:
Strong quantum fluctuations in quantum spin liquids realize enormous entanglements without any magnetic ordering. Emergent excitations such as gauge fluctuations and Majorana fermions are predicted and even reported to be discovered. In this talk, we provide phenomenological descriptions of such quantum spin liquids and apply them to obtain characteristic signatures of quantum spin liquids.

Keywords:
Quantum spin liquids, Majorana fermions, emergent photons

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G7.02

Discovery of a new type of magnetic order on pyrochlore spinels

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Abstract:

Frustration in a spin system can give rise to unique ordered states and as a consequence several physical phenomena are expected, such as multiferroics, high temperature superconductors, and anomalous Hall effect. Here we report the “new magnetic orders” induced by anisotropic spin exchanges on pyrochlore spinels as the interplay of spin-orbit coupling and geometrical frustration. Due to complicated superexchange paths of B-site spinels, we claim that anisotropic interaction between next-nearest neighbors play an important role. Based on the systematic studies of the spin model, we argue that several classical spin states can be explored in spinel systems; local XY state, all-in all-out state, Palmer-Chalker state, and coplanar spiral state. In addition, we reveal new types of magnetic phases with finite ordering wave vectors, labeled as *octagonal (prism)* state and *(distorted) cubic* states. When the *octagonal prism* state is stabilized, nonzero scalar spin chirality induces alternating net current in addition to finite orbital current and orbital magnetization even in Mott insulators. Finally, we also discuss the relevance of *distorted cubic* state to the magnetic order of spinel compound GeCo2O4.

Keywords:

frustration, spin orbit coupling, pyrochlore, noncoplanar

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G7.03

Quantum convolutional neural network to recognize a symmetry protected topological phase

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Abstract:
We present a quantum machine learning model inspired by convolutional neural networks (CNNs). After a brief review of classical CNNs, we describe the concrete circuit architecture for quantum CNNs. In particular, we discuss how quantum CNNs can be used to identify quantum phases and present both numerical and analytical results for recognizing an SPT phase in one dimension. We provide a theoretical explanation for the success of quantum CNNs, by relating our quantum CNN model to "renormalization-group" flow using the multi-scale entanglement renormalization ansatz (MERA) combined with quantum error correction. Our results also suggest there exists an non-local order parameter of fractal spatial profile, rather than string, that detects the 1D SPT phase even near criticality.

Keywords:
1D SPT phase, quantum error corrections, tensor networks, MERA, machine learning

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G8.01

Time-resolved X-ray diffraction set-up in BL15XU beamline and piezo-response of PZT films

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Abstract:
We demonstrate the time-resolved X-ray diffraction system for the purpose of study on the piezoelectric material under a temporal electric field at BL15XU NIMS beamline, SPring-8. By synchronizing focused X-rays, applied electric field and 2-dimensional detector with respect to the synchrotron clock signal, we successfully observe the shifts of 222 Bragg peak of 750 nm-thick $Pb(Zr_{0.35}, Ti_{0.65})O_3$ films near the time zero under unipolar rectangular wave at 12 V. It is expected that this system could be used for understanding the domain switching dynamics.

Keywords:
Time resolved X-ray diffraction, PZT films, Piezo-response

G8.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Synthesis of (1-x)BNT-xBKT piezoelectric ceramics and Mn doping effects on their structural and electrical properties

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Abstract:

Recently, lead-free-materials has a great attention to an alternative lead-based materials. Among them, BNT-based materials is one of the candidate owing to excellent electromechanical and piezoelectric properties. The origin of the great properties in BNT-based materials is connected with relaxor properties, which can be changed by temperature or/and electric field. Especially, the property under the electric field will be enhanced due to changing into the ferroelectrics with long-range order. However, the pure BNT has high leakage current and coercive field (E_C). Consequently, we fabricated binary ceramics, BNT-BKT, to compensate these disadvantages. Also, there is two other methods to enhance the piezoelectric property; 1) Morphotropic phase boundary (MPB), and 2) Doping strategy. The enhancement of property in MPB is having a low energy barrier affecting in polarization direction between ferroelectric phases which is able to be easily rotated by external stress or electric field. In BNT-BKT ceramics, there is two kinds of phase, rhombohedral and tetragonal so that the number of direction is more than the pure ceramics'. Another way to enhance the property is doping. We choose the acceptor dopant with Manganese. In the case of Mn^{2+}, defect dipole by oxygen vacancy is the reason to effect on domain stabilization in spontaneous polarization. As a result, we fabricated (1-x)BNT-xBKT with x dependence to check the MPB. The maximum polarization (P_{max}), remnant polarization (P_r) and inverse piezoelectric constant (d_{33}^*) are 36.4 $\mu C/cm^2$, 8.1 $\mu C/cm^2$ and 336 pm/V for x=0.2, respectively. The d_{33}^* is 6.6 times comparing to 51 pm/V at x=0.1. After doping in 0.8BNT-0.2BKT with yMn (wt %), we finally got 8.8 times with 450 pm/V at y=0.25.

Keywords:

Piezoelectrics, Lead-free materials, Mn-doping

G8.03*

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Unconventional Stability of Sub-loop Behavior for Analog Device in Ferroelectric HfO_2

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Abstract:

Ferroelectricity with controllable partial polarization is considered as one of feasible candidate for analog device for neuromorphic device in the form of ferroelectric tunnel junction and ferroelectric transistor. However, in case of conventional ferroelectric materials, complex nature of ferroelectric switching mechanism and/or defect mediated uncertainty hinder deterministic control of ferroelectric subloop switching. Ferroelectric HfO_2 thin film has been investigated intensively as an alternative to conventional ferroelectric materials due to the advantages such as good scalability, compatibility with conventional CMOS process technology.

In this study, we present the unprecedented stability of sub-loop polarization observed in the subloop switching of ferroelectric HfO_2. We suggest that the enhanced stability and accessibility of intermediate states in HfO_2 can be attributed to the large activation field for ferroelectric switching with small critical volume for the ferroelectric nucleation of HfO_2. We measured switching dynamics and temperature dependence hysteresis of HfO_2 thin films. The characteristic switching time and temperature dependence of hysteresis showed that ferroelectric HfO_2 has large activation energy while the critical size of ferroelectric domain volume is small. PFM results showed large domain wall activation energy due to stable small critical volume. Theoretical calculation demonstrated the stable switching energy path of ferroelectric HfO_2 during single dipole flip. Monte-Carlo simulation confirmed the relation between stable accessibility and the small volume of the ferroelectric domain.

Keywords:

FeRAM, ferroelectric, multilevel, HfO2

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G8.04*

Ferroeletric Polarization-Switching Dynamics and Fatigue Behavior in Si-Doped HfO_2

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Abstract:

HfO_2-based ferroelectrics exhibits two regimes of “wake-up” and “fatigue” in which remnant polarization increases and decreases during electric field cycling. These two phenomena are considered as the effect of defect generation and diffusion including redistribution of oxygen vacancies inducing a phase transition in the dielectric layer. Ferroelectric HfO_2 thin film has been focused on the structural transition in the wake-up stage. However, in order to operate a reliable device, it is necessary to understand the ferroelectric characteristics and dielectric properties in wake-up and fatigue processes.

In this presentation, we report on the wake-up and fatigue effect in Si doped HfO_2 ferroelectric film of the metal-ferroelectric-metal structure in terms of the change in the polarization-switching dynamics and the associated defect in the dielectric layer. Compared with a pristine sample, increase of a remnant polarization value was observed during a finite number of external electric field sweeping known as a wake-up effect. Fatigue as a decrease in remnant polarization appeared with further electric cycling after the wake up effect. Dynamics of the polarization switching was analyzed using the nucleation-limited switching model characterized by a Lorentzian distribution of logarithmic domain-switching times. Investigations by various methods including simple current-voltage (I-V) curves, first-order reversal curves (FORCs) and capacity-voltage(C-V) curves have shown that electric cycling affects film conditions involving the defect at these two stages.

Keywords:
HfO2, ferroelectricity, fatigue, defects

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G8.05*

Subsequent Wake-up Effect Behavior in Zr-doped Ferroelectric HfO_2 Thin Films

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Abstract:

Ferroelectric HfO_2 film exhibited an interesting phenomenon as known as the “wake-up effect” in which remnant polarization increases with the external cycling of the electric field. This “wake up effect” has been argued with the fact that the phenomenon of redistribution of oxygen vacancies contributes greatly to the expansion of the ferroelectric domain. Investigations by using transmission electron microscopy have demonstrated that the monoclinic phase and/or tetragonal phase can change to the orthorhombic phase during the field cycling process. Based on this result, the wake-up effect can be explained by the redistributed oxygen vacancies which promote the structural phase transition of HfO_2 film.

In this presentation, we report on the investigation of wake-up effect in Zr doped HfO_2 ferroelectric film of the metal-ferroelectric-metal structure. The systematic change of a remnant polarization value was observed during the sweeping of continuous external electric field on the pristine sample. The saturation behavior of the enhancement of remnant polarization via the wake-up effect exhibited clear temperature dependence. The activation energy for the phase transition was estimated from the temperature dependence of the polarization switching dynamics. The activation value of the tetragonal-to-orthorhombic phase transition was well matched with the extracted activation energy.

Keywords:
Ferroelectricity, HfO2, wake-up effect

G9.01

Control of charge and heat transports by organic molecules for energy harvesting applications

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Abstract:

In recent years, great attention has been placed on the "Internet of Things (IoT)" technologies. To continuously operate electrical circuits put on billions of "things", a good solution is to use waste heat from our body or living environment to harvest electrical power. Development of flexible thermoelectric generators (TEGs) is therefore urgently necessary and studies on organic-based thermoelectric materials have become intensive. In practical operating conditions where ambient air is the only medium for heat dissipation, the efficiency is restricted not only by the thermoelectric figure of merit (*ZT*) but also by the thickness and thermal conductivity of the device, which influence the temperature difference used. A total design of materials, device structure and fabrication process are therefore important to satisfy difficult requirements: (1) sufficiently low thermal conductivity, (2) millimeter-scale thickness, and (3) mechanical flexibility. Organic materials have advantages against them. This talk will mainly focus on the nature of organic materials to suppress heat transport [1] and to utilize a strong interaction between heat and charge [2-4].

A Giant Seebeck Effect (GSE) was first found with pure C_{60} thin-films [2] and eventually confirmed its universality in various organic semiconductors [3]. Fig. 1 summarizes the temperature dependence of Seebeck coefficient and conductivities in some of the organic semiconductors. Irregularly large Seebeck coefficients, > 0.1 V/K, are observed for almost all materials. The Seebeck coefficient is sensitive to temperature as indicated by the connected marks, which is an irregular behavior in this temperature range. From a scientific point of view, the GSE is interesting because the conventional models in condensed matter physics cannot explain their extremely large Seebeck coefficients. A strong charge-vibration coupling in molecular solids is considered to be a driving force of this phenomenon (Fig. 2). Similar hopping rates of molecular vibration (heat) and polaron (charge) may also contribute to the interaction between them [4]. From an application point of view, such a large Seebeck coefficient possibly produces revolutionary simple TEGs (Fig. 3) being free from the series connection of hundreds of p- and n-type blocks.

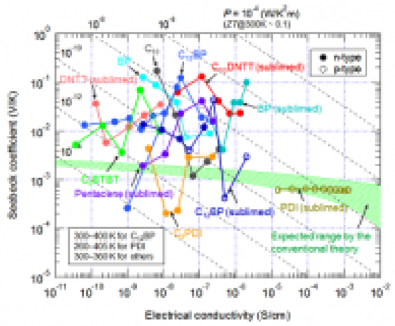

Fig. 1. Temperature dependences of Seebeck coefficient and electrical conductivity in various organic semiconductors.

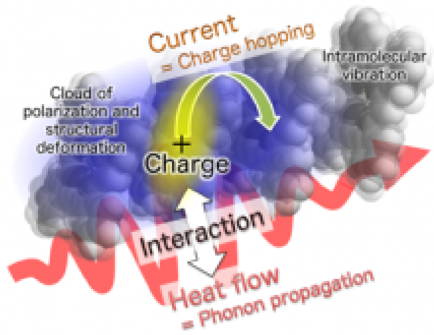

Fig. 2. Conceptual scheme of the Giant Seebeck Effect.

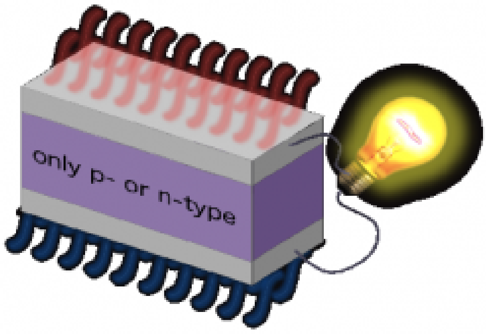

Fig. 3. Revolutionary simple structure of TEG.

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Keywords:
organic semiconductor, giant Seebeck effect, charge-vibration coupling

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G9.02

Artificial Synapses with Short- and Long-Term Memory based on Biopolymer Electrolytes

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Abstract:
Development of electronic devices with the function of biological synapses is crucial step to mimic the capabilities of the human brain. Realization of artificial synapses based on various materials have been done. Among many materials, renewable natural materials have the advantages of being abundant, inexpensive, biodegradable, and ecologically benign. Here, we report biocompatible artificial synapses based on a matrix of the biopolymer. This device emulates several important synaptic behaviors, including analog memory switching behavior, short-term plasticity, long-term plasticity, spike-rate-dependent plasticity, and short-term to long-term transition. A flexible biopolymer-based artificial synapse device could be operated successfully without noticeable degradation under mechanical bending test. These results suggest biopolymer could be a promising key component for artificial synapse. Biopolymer-based artificial synapse could be an important component in future neuromorphic systems and will open a new route to develop biocompatible and implantable devices.

Keywords:
artificial synapses, biopolymers, memory, plasticity, electrolytes

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G9.03

Resonance energy transfer from fluorescence probes to graphene oxide for the study of artificial cell membrane systems

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Abstract:

The lipid bilayer is the fundamental structure of cell membranes, at which the transportation of materials and signals in and out of cell membranes take place. Lateral molecular diffusion, transverse “flip-flop” transition, and domain formation of lipids and membrane proteins in lipid bilayers are key fundamental processes in these cell membrane reactions. Artificial lipid bilayers are applied for the studies of biological and physicochemical processes of the cell membrane reactions. Supported lipid bilayers (SLBs) are a lipid bilayer system at the interface between solid substrates and aqueous solutions. Graphene oxide (GO) is an amphiphilic atomic sheet, in which contains hydrophobic pristine graphene-like domains and hydrophilic oxidized regions mixes on a nanoscale. GO shows unique a fluorescence quenching property through resonance energy transfer, and has been applied to biosensing. We aim to establish a method to obtain a precise location of molecules in a lipid bilayer using the GO quenching. We prepared SLBs on GO, and investigated their physical and quenching properties on single molecule level with fluorescence microscope-based techniques.
SLBs comprising of 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC) and, or of DOPC and polyethylene glycol (PEG)-modified 1,2-disterol-sn-glycero-3-phosphoethanolamine (PEG-lipid) were formed on a thermally oxidized SiO_2/Si substrate by the vesicle fusion method [1]. Single layer of SLB formed on the bare SiO_2 region as reported, but double layers of SLB are also formed on GO. We conjugated quantum dots (Qdots) to lipids in SLB, and observed the diffusion of single Qdot in the SLB on GO under the effect of fluorescence quenching by GO. The SLB of DOPC including 5% PEG-lipid was used to suppress the non-specific adsorption of Qdots onto SLB. The Qdot-conjugated lipids diffusing both GO and SiO_2 regions were tracked, and their fluorescence intensities and diffusion coefficients (*D*) in each region were evaluated. The fluorescence intensities in the GO region were lower than that in the SiO_2 region. The distances estimated from the quenching efficiencies were distributed around 10.7 nm and longer than 17 nm. We attributed these two distributions to the Q-dots on single and double SLB on GO, respectively. We also found that the average value of *D* of the Qdot-conjugated lipids on the GO region was ~70% of that on the SiO_2 region [2]. The atomic force microscope observation showed that PEG-lipid were localized on GO, and it was the reason of the decrease in *D* [3].

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Keywords:
lipid bilayer, graphene oxide, single molecule tracking, fluorescence quenching

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G9.04

Electronic Structure Analysis at the Interface of Organic Materials

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Abstract:

Organic materials have attracted much attention due to its unique nature, such as various synthesis possibility, flexibility for device fabrication and ease of vacuum deposition. Commercial electronic devices, e.g. OLED, have been already appeared in the market and it is becoming a main stream device in display industry. All these devices have many layers between electrodes, and thus there are many interfaces inevitably. These interfaces have crucial role in organic optoelectronic devices because all the charges should be injected from the electrodes and transport through the interface. Therefore, the interfacial electronic structure is the most important factor to determine the device characteristics. In this talk, "electronic structure measurements at organic interface" will be discussed.

Keywords:

organic material, photoelectron spectroscopy, energy level, interface

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G10.01

Functional Brain Network Mechanism of Hypersensitivity in Chronic Pain

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Abstract:
Fibromyalgia (FM) is a chronic widespread pain condition characterized by augmented multi-modal sensory sensitivity. Although the mechanisms underlying this sensitivity are thought to involve an imbalance in excitatory and inhibitory activity throughout the brain, the underlying neural network properties associated with hypersensitivity to pain stimuli are largely unknown. In network science, explosive synchronization (ES) was introduced as a mechanism of hypersensitivity in diverse biological and physical systems that display explosive and global propagations with small perturbations. We hypothesized that ES may also be a mechanism of the hypersensitivity in FM brains. To test this hypothesis, we analyzed resting state electroencephalogram (EEG) of 10 FM patients. First, we examined theoretically well-known ES conditions within functional brain networks reconstructed from EEG, then tested whether a brain network model with ES conditions identified in the EEG data is sensitive to an external perturbation. We demonstrate for the first time that the FM brain displays
characteristics of ES conditions, and that these factors significantly correlate with chronic pain intensity. The simulation data support the conclusion that networks with ES conditions are more sensitive to perturbation compared to non-ES network. The model and empirical data analysis provide convergent evidence that ES may be a network mechanism of FM hypersensitivity.

Keywords:
human brain networks, explosive synchronization, hypersensitivity, chronic pain

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

G10.02

Majority-vote dynamics on multiplex networks with two layers

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Abstract:

Majority-vote model is a much-studied model for social opinion dynamics of two competing opinions. With the recent appreciation that our social network comprises a variety of different "layers" forming a multiplex network, a natural question arises on how such multiplex interactions affect the social opinion dynamics and consensus formation. Here, the majority-vote processes will be studied on multiplex networks with two layers to understand the effect of multiplexity on opinion dynamics. We will discuss how global consensus is reached by different types of voters: *AND*- and *OR*-rule voters on multiplex-network and voters on single-network system. The *AND*-model reaches the largest consensus below the critical noise parameter q_c. It needs, however, much longer time to reach consensus than other models. In the vicinity of the transition point, the consensus collapses abruptly. The *OR*-model attains smaller level of consensus than the *AND*-rule but reaches the consensus more quickly. Its consensus transition is continuous. The numerical simulation results are supported qualitatively by analytical calculations based on the approximate master equation.

Keywords:

Opinion dynamics, Multiplex networks, Majority-vote process

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G10.03

Relational flexibility of network elements based on inconsistent community detection

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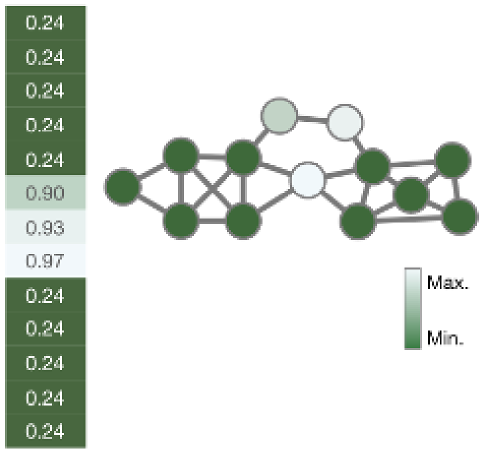
Abstract:

Community identification of network components enables us to understand the mesoscale clustering structure of networks. A number of algorithms have been developed to determine the most likely community structures in networks. Such a probabilistic nature of this problem naturally involves the possibility of ambiguity in resultant community structures.In other words, stochastic algorithms can result in different community structures (community degeneracy) for each realization. In this study, instead of trying to "solve" the community degeneracy problem, we turn the tables by taking the degeneracy as a chance to quantify how strong companionship each node has with other nodes. For that purpose, we define the concept of community inconsistency that indicates how inconsistently a node is identified as a member of a community in regard to the other nodes. With both model and real networks, we show that community inconsistency discloses unique characteristics of nodes, i.e., it is a new type of node centrality. In social networks, for example, community inconsistency can classify outsider nodes who do not have obvious community and promiscuous nodes who have multiple connections to several communities. In infrastructure networks such as power grids, it can diagnose how the connection structure is evenly balanced in terms of power transmission. As we show with the demonstrations, therefore, community inconsistency abstracts individual nodes' intrinsic property on its relationship to a higher-order organization of the network containing the nodes.



Keywords:
community inconsistency, community structure in network, network centrality

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

G10.04*

Rodlike Counterions near Charged Cylinders: Counterion Condensation and Intercylinder Interaction

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Abstract:

We study a system composed of like-charged cylinders and dumbbell-like counterions, with the focus laid on the role of the internal structure of counterions, using Monte Carlo simulations. The dumbbell ions are found to exhibit novel counterion condensation behavior governed by their length. Effective electrostatic interactions mediated between charged parallel cylinders also turn out significantly different from the case of pointlike ions, as a result of the complex interplay between the spatially separated charge distribution in the dumbbell counterions, their orientation, and the curvature of the charged cylinder. We show that at a weak-to-moderate electrostatic coupling strength, where effective like-charge interactions are usually found to be repulsive, the intercylinder interaction can become attractive and display a distinctive sensitivity to the cylinder curvature and dumbbell size, proving the significant effect of ion structure.

Keywords:

Dumbeell-like counterion, condensation, like-charge attraction

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G10.05

Emerging Trends in Neuroscience

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Abstract:
This talk will focus on cognitive & systems neuroscience, a multi-disciplinary field of research attracting considerable attention from physicists, engineers, neuroscientists, and psychologists. It explores a range of topics concerning the mechanisms underlying the activities of neuronal circuits associated with cognitive functions as well as the design and development of innovative computational and experimental technologies. I will also highlights emerging trends and advances regarding the theoretical and computational consideration of real-world neuroscience to make sense of the neural behavioral data, integrating the structural and functional connectome, inferencing the cognitive or brain states based on multi-modal neuronal data, and application of these technologies in the medical domain in the treatment of neural disorders.

Keywords:
Neuroscience, cognitive neuroscience, systems neuroscience

G10.06

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Synchronization, networks, complexity: Wonderful researches of wonder women in Korean statistical physics community

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Abstract:
In this talk, I will introduce wonderful research results of women physicsts in statistical physics community in Korea.

Keywords:
statistical physics, women physicists

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G11.01

An elongated, uniform ^{87}Rb Bose-Einstein condensate in a clipped Gaussian trap

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Abstract:

Regular vortex shedding and its transition to turbulent flow behind a moving obstacle represent a universal characteristic of classical fluid dynamics. A superfluid, which has no viscosity, is expected to show similar universal behavior in the wake response to a moving obstacle [1] and a recent experiment reports the regular vortex cluster shedding and its transition to turbulence in a Bose-Einstein condensate (BEC) [2]. To investigate the universal behavior of vortex shedding dynamics, the BEC with a long obstacle translation distance and a uniform density is definitely essential for allowing multiple events of vortex shedding. In this work, we present an elongated, uniform ^{87}Rb BEC generated by using a clipped focused Gaussian beam [3]. As we truncate a 1070nm trapping beam, the length of the BEC is increased more than twice that with a normal optical dipole trap. Also, we observe that the BEC in the clipped Gaussian trap shows a uniform density region along the trapping beam direction, which is beneficial to investigate the vortex shedding dynamics. In addition, recent progress on the vortex shedding experiments with this atomic sample is discussed.

[1] M. T. Reeves, T. P. Billam, B. P. Anderson, and A. S. Bradley, Phys. Rev. Lett. 114, 155302 (2015)
[2] Woo Jin Kwon, Joon Hyun Kim, Sang Won Seo and Yong-il Shin, Phys. Rev. Lett. 117, 245301 (2016)
[3] Glen D. Gillen, Christopher M. Seck, and Shekhar Guha, Opt. Express 18, 4023-4040 (2010)

Keywords:
Bose-Einstein condensate, 87Rb, a clipped gaussian trap, vortex shedding dynamics

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G11.02*

Kibble-Zurek universality in a strongly interacting Fermi superfluid

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Abstract:

Near a continuous phase transition, systems with different microscopic origins display universal dynamics if their underlying symmetries are compatible. In the Kibble-Zurek (KZ) mechanism, a thermally quenched system reveals such dynamics through the creation of topological defects, whose universal nature is encapsulated in a characteristic scaling exponent that describes the dependence of the defect density on the quench rate. Here, we report the observation of the Kibble-Zurek universality in a strongly interacting Fermi superfluid. A linear temperature quench applied to an oblate sample of ^{6}Li atoms near a Feshbach resonance creates as many as 50 vortices in the superfluid phase, and their counting statistics reveals the characteristic power law scaling of the KZ mechanism. Importantly, as the system's microscopic description is tuned from bosonic to fermionic, the KZ exponent remains constant at a value that is consistent with the inhomogeneous KZ mechanism for a BEC in a harmonic trap, revealing the underlying $U(1)$ gauge symmetry of the system. However, when the quench rate is sufficiently increased, the destructive collisions among vortices limit their densities to a value that is inversely proportional to the interaction dependent area of the vortex cores.

Keywords:

strongly interacting Fermi gas, cold atoms, Kibble-Zurek mechanism, universality

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Entanglement generation of far separated atoms

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Abstract:

We show a distance-dependent entanglement generation at tweezer trap array. The Rydberg atom, highly excited state atom, is one of the major candidates for quantum simulator and quantum computation. The conventional method of entanglement generation via Rydberg atoms use strong dipole-dipole interaction which prohibits doubly excited Rydberg state (Rydberg blockade). In the presentation, we show entanglement generation through weakly interacted (far separated) Rydberg atom pair [1] to distinguish inter-atomic distance. The control of interaction time between two Rydberg atoms makes atom pair entanglement at a specific distance. The experiment performs with single atom tweezer trap array [2]. The experimental results show that the entanglement occurs at a particular interatomic distance. Furthermore, entanglement can be generated at a longer distance pair while separable at a short distance without single addressing.

[1] D. Jaksch et. al. "Fast quantum gates for neutral atoms," Phys. Rev. Lett. 85, 2208 (2000)
[2] H. Kim et. al. "In situ single-atom array synthesis using dynamic holographic optical tweezers," Nat. Commun. 7, 13317 (2016)

Keywords:
Rydberg atom, entanglement

Magnetic sound propagation in a spinor superfluid gas

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Abstract:

We present the observation of magnetic sound propagation in an antiferromagnetic spinor superfluid gas. We introduce a new kind of optical obstacle that can apply a spin-dependent force, which is repulsive for the $m = -1$ spin components and attractive for the $m = 1$ spin components with equal magnitude. By perturbing a condensate in an easy-plane polar state via abruptly switching off this obstacle beam, we observe the generation of a magnetic pulse wave, which is comprised of a density dip of $m = -1$ and a density bump of $m = 1$. The magnetic pulse shows the characteristic of sound wave that propagates non-dispersively towards the outer region of the condensate, demonstrating the linear dispersion of magnon mode in the spinor superfluid system. We also find that its propagation speed is about five times slower than that of a mass-density wave in the same system. This measurement implies that the spin interaction coefficient c_2 is twice larger than the previous result in [PRL 99, 070403 (2007)].

Keywords:

superfluid, spinor Bose-Einstein condensate, sound propagation

G11.05*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Topological Creutz Ladder in a Resonantly Shaken 1D Optical Lattice

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Abstract:

Topological phases such as quantum Hall states and topological insulators represent intriguing physics beyond the conventional Landau paradigm of phase transition. Periodic lattice shaking is one of the successful tools for exploring exotic phases in optical lattices. From the perspective of Floquet band engineering, the lattice shaking method has been extensively discussed even in the resonant regime where the driving frequency is high enough to match the energy gap between two bands. Such strong orbital hybridization may enable access to a broader range of effective Hamiltonians. In particular, it was anticipated that multi-photon inter-orbital resonant coupling could yield a special route to engineer topological states. Thus, it is highly desirable to examine the multifarious scope of Floquet band engineering for the study of topological phases.

We report the experimental realization of a topological Creutz ladder for ultracold fermionic atoms in a resonantly driven 1D optical lattice. The two-leg ladder consists of the two lowest orbital states of the optical lattice and the cross inter-leg links are generated via two-photon resonant coupling between the orbitals by periodic lattice shaking. The characteristic pseudo-spin winding in the topologically non-trivial bands of the ladder system is demonstrated using momentum-resolved Ramsey-type interferometric measurements. We discuss a two-tone driving method to extend the inter-leg link control and propose a topological charge pumping scheme for the Creutz ladder system.

Keywords:

Optical lattice, Quantum simulation, Topological insulator

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2019-04-24 - 2019-04-26

G11.06

Modulation instability associated nonlinear dynamics of spin-orbit coupled Bose-Einstein condensates

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Abstract:
We study pattern-forming nonlinear dynamics starting from a continuous wave state of quasi-one-dimensional two-component Bose-Einstein condensates with synthetic spin-orbit coupling induced by Raman lasers. Modulation instability(MI) can occur even when the miscibility condition due to the interatomic interactions is satisfied. We find that the initial stage of the nonlinear development is consistent with the prediction of MI, where the two primary and secondary instability bands lead to the spontaneous growth of the modulation and the subsequent complicated dynamics of pattern formation. At later stages of the evolution, the wave functions undergo clear separation in the momentum space, reflected in the dispersion of the single particle Hamiltonian.
Ref: J. Phys. B: At. Mol. Opt. Phys. **52**, 045301 (2019).

Keywords:
Bose-Einstein condensation, spin-orbit coupling, modulation instability

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G12.01

ITER 사업 추진 현황 및 물리 기술

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Abstract:
국제핵융합실험로(ITER) 프로젝트는 핵융합에너지 개발에 있어서 전세계가 지난 60여년 동안 연구해 온 결과와 핵심 기술을 종합하여, 2025년 최초 플라즈마의 달성을 목표로 건설 중인 국제공동 프로젝트로서, 현재 공정율은 60% 정도에 이른다. 우리나라는 ITER 장치의 진공용기, 열차폐체, 블랑켓차폐체 등 핵심부품을 조달하고 있으며, 비조달 부분에 대해서도 국내 학계, 연구계, 산업계 등이 기술 추적 및 R&D를 진행 중에 있다. 더불어 국내 최첨단 핵융합 연구장치인 KSTAR를 중심으로 핵융합 플라즈마 실험 연구에 있어서도 두드러진 연구성과 등이 달성되고 있다. 이에 2019년 봄 학술논문발표회 포커스 세션 프로그램을 통하여 ITER 관련 사업 추진 현황 및 연소 플라즈마 물리 연구 성과 등을 소개하고, 향후 연구 방향을 논의하고자 한다.

Keywords:
ITER, 핵융합에너지, 연소 플라즈마, 진공용기

G12.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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The KSTAR research in support to ITER Research Plan

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Abstract:
To begin with, the overall plan of the ITER operation & research will be introduced based on the ITER Research Plan (IRP) which has been developed to provide a guide to the overall research activities which should be undertaken within the framework of the ITER Project. The Staged Approach foresees First Plasma in December 2025, which is succeeded by a progressive upgrade of the capabilities of the ITER tokamak and facility interleaved with two periods of system 'commissioning with plasma' and experimental plasma studies in H and He plasmas. In subsequent experimental campaigns in D-T plasmas, planned on a two-year cycle, the experimental basis for achieving the principal scientific mission goals of the ITER project are developed: a demonstration of $Q \geq 10$ for burn durations of 300 - 500 s and the development of long-pulse, noninductive scenarios aiming at maintaining $Q \sim 5$ for periods of up to 3000 s. In this talk, firstly, the main objectives of IRP will be introduced for each stage and urgent research issues will be clarified to achieve the milestones. Subsequently, the contribution of KSTAR, a korean superconducting tokamak, will be addressed emphasizing the unique role of KSTAR which has many components in common with ITER, i.e., superconducting magnets, control coils, and the plasma heating systems. Utilizing these potentials, the research activities of KSTAR will be introduced in support to IRP addressing several critical issues to minimize uncertainty for IRP milestones, i.e., physics mechanism in suppression of the edge localized mode, long-pulse noninductive H-mode operation, development of ITER baseline/advanced scenarios and will be summarized with a brief future plan in support for IRP.

Keywords:
KSTAR, ITER, tokamak

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G12.03

ITER 열차폐체 제작 및 은도금 기술

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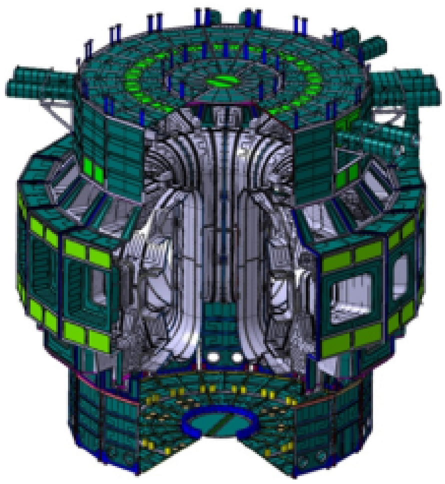
Abstract:

The role of the ITER thermal shield (TS) is to minimize the radiation heat load transferred from the warm components to the superconducting magnet operating at 4.5K. Silver-coated TS panels which have welded cooling tubes are cooled by 80K of gaseous helium. The main material of the TS is stainless steel 304LN and the total weight is about 900 tons. Fabrication of the TS is ongoing. Silve coating of an huge structure like TS panel was one of the technical challenges to be solved at the beginning of the project. After dedicated efforts on the process development by R&D, the coating process has been established and applied on the TS products. Silver coating of the LCTS (Lower Cryostat TS) cylinder was completed already and the coating of the VVTS (Vacuum Vessel TS) is ongoing now. Due to the complicated shape of the TS panels, several non-coated surfaces were detected locally and repaired with silver-coated patch. This paper describes the manufacturing progress and the silver-coating technology applied on the TS.



Keywords:

ITER thermal shield, silver coating

G12.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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ITER 중성자방사화 시스템 개발

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Abstract:
ITER 중성자방사화 시스템은 ITER 플라즈마에서 발생하는 핵융합 중성자의 일차벽 플루언스를 측정하여 핵융합 출력을 평가하기 위한 진단 장치이다. 캡슐에 담긴 시편을 플라즈마 부근의 조사점까지 공압 이송하여 핵융합 중성자에 조사시킨 후, 이를 다시 측정실로 공압 이송하여 시편의 감마선 스펙트럼을 측정한 뒤 시적분된 중성자속을 평가하는 방법으로 운전된다. ITER 표준 모델을 이용한 중성자 수송 해석 결과 중성자방사화 시스템은 ITER 플라즈마의 모든 핵융합 중성자 발생 조건에서 높은 정밀도의 측정 결과를 제공할 수 있음을 확인하였다. 4 군데의 폴로이달 위치에 총 12개의 조사점이 설치될 예정이며 시편 공압 이송을 위한 전송선이 조사점과 측정실 사이에 설치된다. 2019년 현재 최초 플라즈마 운전 이전 설치 완료를 위해 전송선에 대한 최종 설계가 진행중이며, 핵해석, 전자기해석 등 공학해석을 통해 전송선이 ITER에서 요구하는 구조 건전성 요건을 만족하는지 여부를 확인하였다. KSTAR에 ITER 중성자방사화 시스템 시제품을 설치하고 플라즈마 진단 실험을 실시함으로써 본 진단장치에 대한 설계, 제작, 설치, 운전, 데이터 분석 경험을 습득하였다. KSTAR 진단실험 및 중성자 해석을 통한 데이터 분석 결과, 2018년 KSTAR 플라즈마에서 약 10^{13}-10^{14}n/sec의 총 핵융합 중성자가, 약 10^{10}-10^{12}n/sec의 삼중수소 연소 중성자가 발생함을 확인하였다.

Keywords:
ITER, 중성자방사화 시스템, 중성자, KSTAR

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G12.05

Status of ITER VUV spectrometers design and development

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Abstract:
Three VUV spectrometers systems are under development by KODA for ITER: VUV core survey spectrometer and divetor VUV spectrometer in equatorial port 11, and VUV edge imaging spectrometer in upper port 18. The primary role of VUV spectrometers are to monitor impurity species and profile as well as to monitor impurity influx at the divertor region. Among them, VUV core survey spectrometer is one of the first plasma diagnostics. ITER VUV spectrometers are at the final design phase, and detailed engineering design is on-going focusing on the safety components which can satisfy the safety regulations in ITER related with its envisaged radiation environment. Various R&Ds are on-going as well such as the first mirror protection experiment and post-processing algorithm development. Status of ITER VUV spectrometer design and development will be presented.

Keywords:
ITER diagnostics, VUV spectrometers

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G13.01

Prospects of hadron spectroscopy at Belle II

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Abstract:

In the last 15 years, there has been a significant progress in the field of hadron spectroscopy, mainly driven by the B-factory experiments. A large number of hadrons which can not be understood as ordinary mesons or baryons, so-called the exotic hadrons are discovered. Understanding the nature of exotic hadrons leads us to the new insight for the strong interaction.

SuperKEKB/Belle II is next generation B-factory experiment which aims to discover the physics beyond the Standard Model with 50 times more statistics compared with its predecessor, KEKB/Belle. The huge statistics will enable us to perform precise measurement of these exotic hadrons. In this talk, review on the current status of the exotic hadron studies and prospects at Belle II will be given.

Keywords:
exotic hadrons, Belle II, hadron spectroscopy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G13.02

Search for the $K_L \longrightarrow \pi^0\nu\bar{\nu}$ decay at the J-PARC KOTO experiment

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Abstract:

The KOTO experiment at J-PARC aims to observe the $K_L \longrightarrow \pi^0\nu\bar{\nu}$ decay and measure its branching ratio. The Standard Model prediction for the mode is 2.4 x 10^{-11} with a small theoretical uncertainty. The rare “golden” decay is ideal for probing for new physics beyond the standard model. The signature of the decay is a pair of photons from the π^0 decay and no other detected particles. For the measurement of the energies and positions of the photons, KOTO uses a Cesium Iodide (CsI) electromagnetic calorimeter as the main detector, and hermetic veto counters to guarantee that there are no other detected particles. KOTO has collected data since 2013. With the data collected in 2015, we set an upper limit of 3.0×10^{-9} for the branching fraction of $K_L \longrightarrow \pi^0\nu\bar{\nu}$ at the 90% confidence level, which improved the previous limit by almost an order of magnitude. Recently, we completed significant hardware upgrades and started taking additional physics runs since 2018. This presentation will recap the efforts of KOTO with a special emphasis on the recent results and its sustained pursuit of detecting $K_L \longrightarrow \pi^0\nu\bar{\nu}$ toward the sensivitiy of O(10^{-11}).

Keywords:

Kaon rare decay ; KOTO ; J-PARC

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G13.03

Muon g-2/EDM Experiment at J-PARC

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Abstract:

A new precise muon g-2/EDM measurement is planned at J-PARC. The recent experiment at BNL measured muon g-2 at 0.54 ppm but there is a discrepancy from the Standard Model expectation by more than three standard deviations. The experiment at J-PARC aims to measure muon g-2 with a different method from BNL or another experiment ongoing at FNAL and also to improve a sensitivity to muon EDM. We use a novel technique of muon beam thermalization, accelerate muons to 300 MeV/c, inject and store them in high precision MRI-type magnet with the storage orbit diameter of 66 cm and 3 T field and focuses with weak magnetic field. Positron tracks from muon decays are reconstructed by the silicon strip detector. By using different approaches from BNL and FNAL, J-PARC experiment will provide a independent measurement. The overall design and its preparation status will be presented.

Keywords:

muon g-2, EDM, J-PARC

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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G13.04

COMET experiment

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Abstract:
The COMET experiment is seeking to measure the neutrinoless, coherent transition of a muon to an electron (μ−e conversion) in the field of an aluminum nucleus. The facility for the experiment is J-PARC Hadron Hall at Tokai village in Japan. The J-PARC main ring can provide high intensity 8-GeV proton beam to the Hadron Hall, and the generated pions are captured by the surrounding capture solenoid and will decay to muons in the curved transport solenoid which is connecting to the detector part. With these system, the muon intensity will be the world highest, thus the sensitivity of the experiment could reach to the branching ratio to test the several beyond the standard models which predict the neutrinoless muon to electron conversion process.
In the COMET Phase-I, we will search for the μ-e conversion process with a single event sensitivity of ~10^{−15}, corresponding to the factor 100 improvement from the past search done by the SINDRUM-II experiment at PSI. After the Phase-I, the transport solenoid and detector part will be extended and modified, and the sensitivity will be ~10^{−17}.The COMET Phase-I is now under construction. I will report on the status of Phase-I and prospects for the Phase-II.

Keywords:
COMET, J-PARC, mu-to-e conversion

G14.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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The Need for High-Precision Gravitational Waveforms

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Abstract:

The observation of gravitational waves from coalescing binary black holes and a binary neutron star with LIGO and Virgo detectors is providing us, for the first time, the opportunity to unveil the nature of gravity and matter under extreme conditions. After reviewing the theoretical groundwork that allows us to identify and interpret those gravitational-wave signals, I will discuss some theoretical challenges in the solution of the two-body problem in General Relativity that would need to be addressed and solved to build highly accurate waveform models, and take full advantage of upcoming, more sensitive gravitational-wave detectors.

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G14.02

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Gravitational waveform and electromagnetic counterparts modeling for binary neutron star mergers

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Abstract:

Recent detection of gravitational waves from a binary-neutron star merger (GW170817) and the subsequent observations of electromagnetic counterparts provide a great opportunity to study the physics of compact binary mergers. While more and more detections of neutron star binary mergers are expected in the near future, theoretical modeling for gravitational waveforms and electromagnetic signals is an urgent task to maximize the physical information which can be extracted from the observation. In this talk, I briefly review the current understanding of neutron star binary mergers, and present our recent works for modeling gravitational waves and optical and near-infrared electromagnetic counterparts based on the latest numerical-relativity and radiative transfer simulations.

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G14.03

Systematic errors due to inaccurate GW waveform modeling

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Abstract:

In gravitational wave (GW) data analysis, accurate modeling of waveforms is very important. In the GW parameter estimation, the recovered source parameters can be biased from the true parameter values, and such the systematic errors depend on how exactly the wave function mimics real gravitational waveforms. In order to describe gravitational waveforms from merging compact binary systems, one should consider various physical parameters, e.g. masses and spins of the binary. If a waveform model neglects some physical parameters to simplify the wave function, the parameter estimation analysis would give wrong results. In this talk, I will briefly describe how the parameter estimation can be affected by inaccurate waveform models and show some examples.

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G15.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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한석봉과 캐러비안의 해적이 물리를 알았더라면

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Abstract:

역사, 자연과 경제/문화의 상관관계, 그리고 생활주변을 새로운 시각으로 바라볼 수 있게 되는 눈을 가지게 되는 것은 자연과학을 배우는 가장 큰 장점들 중 하나가 아닌가 합니다. 해외여행에서 그 나라의 풍경과 문화를 보는 것은 큰 즐거움입니다. 하지만 더 좋은 것은 그 나라 사람들과 만나서 이야기를 나누는 것이 아닌가 합니다. 연사는 자연과학자로서 역사, 자연, 문화, 생활주변에 대한 이야기들을 주제로, 해외여행 중 만난 외국인들에게 다양한 이야기들을 나누었습니다. 지난 10여년간 이러한 대화들을 통해서 연사가 스스로 만들어 낸 많은 이야기들 중에 특히 한석봉과 캐러비안의 해적을 물리학적 관점에서 풀기 시작해서 정치 경제까지 이어지게 한 이야기들이 여행 중 만났던 사람들에게서 가장 좋은 반응을 얻었던 것 같습니다. 국내에 돌아와서도 몇몇 자연과학자들과 주변 벗들에게 이야기를 하고서 그들의 격려를 힘입어서 대중강연을 통해서 더 많은 청자들을 만나 보려고 합니다. 한국에서 사회문제로 대두되는 애완견 문제, 평균수명 연장과 노인 복지 문제에서도 고체물리실험 전공의 물리학자의 관점에서 새로운 관점을 제시합니다.

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H1.01

Optical transfer of orbital angular momentum on nonresonantly pumped polariton superfluid

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Abstract:

Exciton-polariton (Polariton) is a new type of bosonic quasi-particle arising from strong coupling in a semiconductor microcavity. This hybrid state of half matter (exciton) and half photon can transit to a collective coherent state very close to Bose-Einstein condensate in a driven-dissipative system. Manipulating orbital angular momentum can be used to explore superfluidity in comparison to cold atoms and superfluid helium. It also provides a platform for various quantum technologies in polaritons, optics and photonics systems. Here, we used orbital angular momentum of nonresonant optical pump to create and control polariton quantum fluid. Based on advanced optics technique, imaging and PL spectroscopy, transfer of orbital angular momentum from non-resonant pump beam were shown to control chirality and topological charge of vortices even through large energy relaxation. Quantized rotation of the coherent polaritons could be maintained robustly without having large dependence on size and shape of optical pump. Quantized vortices were easily generated and maintained in the pumped potential guided by transferring optical orbital angular momentum in polariton condensate. Energy structure of the generated vortices in polariton fluid revealed the nature of multi-state condensates, a unique property of non-equilibrium quantum fluid. This study can provide novel methods for all-optical control of topological charge in polariton simulator, sensing, switch and information processing.

Keywords:

exciton-polariton, condensates, orbital angular momentum, quantum fluid

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H1.02*

Recombination Processes of All Inorganic Halide Perovskite : $CsPbBr_3$ Single Crystal

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Abstract:

Halide perovskite semiconductors have attracted significant attention for superior optical properties and relevant applications. All-inorganic halide perovskites ($CsPbX_3$: X = Cl, Br, I) are particularly promising materials for light emitting diodes (LEDs) because of their high photoluminescence(PL) quantum yield and cost-effective fabrication with bandgap tunability. Fundamentally, it is important to know the recombination dynamics of unbound electron-hole pair or exciton for LED application. But, these processes of perovskites are not completely understood yet. In order to address the issue, we investigated optical properties of a bulk (3D) single crystal $CsPbBr_3$ grown by the Bridgman technique. The PL relaxation dynamics was also investigated, under pulsed excitation (30 ps). With increasing the laser intensity (I), the PL intensity continuously varied from I^2 to I where the corresponding carrier density (n)- ranges from 10^{18} to 10^{20} cm^{-3}. This nontrivial PL intensity dependence was analyzed by numerically solving the rate equation which does not need any excitonic phase. This is indeed in contrast to the Saha model, which predicts that the excitonic phase is dominant at $n>10^{17}$ cm^{-3} at room temperature. We believe that electron-hole plasma is dominant within our experimental range considering the Mott transition density of $6.0 * 10^{17}$ cm^{-3}. Therefore, the underlying mechanism for the PL is essentially bimolecular together with three-body Auger recombination. We found that the extracted bimolecular coefficient and the Auger coefficient of $CsPbbBr_3$ are similar to the values obtained from $MAPbBr_3$.

Keywords:
Perovskite, Recombination dynamics, Photoluminescence

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Optical sectioning in optical resolution photoacoustic microscopy

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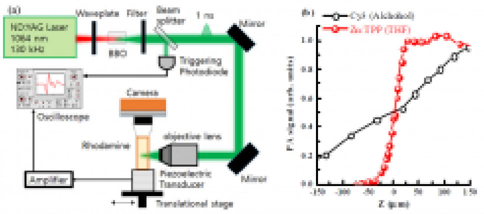
Abstract:



We report a novel optical resolution photoacoustic microscopy concept to obtain an axial resolution only by optical methods. The photoacoustic signal is generated through a non-radiative relaxation from a level that is populated by excited state absorption and reverse saturable absorption. This two-step excitation process of a single laser enables to achieve an optical sectioning without any acoustic selectivity, whereby a full optical resolution photoacoustic microscopy is obtained. We bring a proof of this concept using Rhodamine and Zinc Tetraphenylporphyrin dyes known for their efficient excited state absorption process. Under moderate laser fluence, we have measured an optical sectioning exceeding two to three times the Rayleigh length for simple ESA system while an efficient RSA system presents sectioning capabilities in the range of the Rayleigh length.

Keywords:
Photoacoustic, Imaging, resolution

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H1.04*

Numerical study of spin-polarized transport of electrons in a quasi-1D wire with Rashba dots

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Abstract:
A numerical study on the spin-polarized transport properties in a quasi-one-dimensional wire having a different number of Rashba quantum dots is presented. The ballistic spin transmission probability and spin density profiles are obtained based on the Quantum Transmitting Boundary Method. We analyze the Fano-Rashba effect on the spin transmission and the oscillation of its transmission as a function of the Rashba spin-orbit coupling strength and incident energy.

Keywords:
Rashba effect, quasi-1D system

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H1.05*

Raman scattering study of methylammonium lead halide perovskite single crystals

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Abstract:

For several decades, many researches about solar cells have been carried out and tremendous effort has been exerted to improve the efficiency of solar cell devices. In this research, we focus on structural characteristic, especially structural phase changes in methylammonium (MA) lead halide perovskite ($CH_3NH_3PbX_3$, X - I, Br and Cl) materials with respect to temperature change. The perovskite materials have different properties depending on the halogen element so the temperature at which the phase transition occurs is also different for different compounds. For example, $CH_3NH_3PbBr_3$ shows a structural phase transition from cubic to tetragonal structure at ~235K and $CH_3NH_3PbCl_3$ shows the same phase transition at ~177K. We measured temperature dependent Raman spectra from single crystal $MAPbBr_3$ and $MAPbCl_3$ samples, and observed abrupt change in the spectra at ~ 140K for bromide and at ~160K for chloride samples. Our results show that contributions to the phase transition from each atomic/molecular vibration are different for different compounds. From our result it can be seen that Raman scattering spectroscopy is a very effective research mean to observe any small changes in phonon spectra that reflect microscopic environment and configurations, thus can be a sensitive monitoring tool for studying structural phase transition.

Keywords:

Raman, scattering, spectroscopy, temperature, phase, transition, change, perovskite, methylammonium, halogen, materials, single crystal

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H1.06*

Multiphoton-absorption-induced multiexciton generation in perovskite micro-crystallites: $MA_{0.2}FA_{0.8}PbI_3$

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Abstract:

Recently, organic-inorganic hybrid halide perovskites have gained much attention on their excellent optoelectronic properties, especially for solar-cell applications. Also, one can readily tune the bandgap of this material by modulating the halide ratio. In this work, we have prepared $MA_{0.2}FA_{0.8}PbI_3$ by inverse temperature crystallization, which has an ideal bandgap, 1.3 eV. Interestingly, this bulk perovskite exhibits so-called above-the-gap emission, in which the photoluminescence (PL) appears above the bandgap. We employed fine-scale PL excitation (PLE) spectroscopy in order to clarify the bandgap of this unusual perovskite under one, two and three photon absorption (PA). The series of our spectroscopic data indicate that the 2PA-induced PL peak appears at 855 nm and the 3PA-induced PL peak does at 840 nm, respectively. Based on the excitation power dependence across the 2PA and 3PA edge, we found evidence for the multiexciton generation under multiphoton absorption. Also, 2PA and 3PA coefficients and the corresponding damage thresholds were precisely determined.

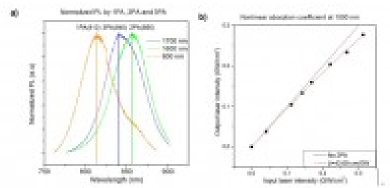

Figure 1 a) Normalized PL under 1PA, 2PA and 3PA at room temperature.
b) Input laser intensity vs. output laser intensity.

Reference :

[1] F. O. Saouma, C. C. Staumpos, M. G. Kanatzidis, Y. S. Kim, J. I. Jang, J. Phys. Chem. Lett. **2017**, 8, pp 4912.

Keywords:

#perovskite #MPA #MEG

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Light Soaking Phenomena in Organic-inorganic Mixed Halide Perovskite Single Crystals

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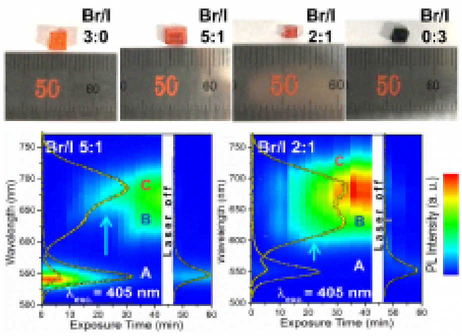
Abstract:

Recently, organic-inorganic mixed halide perovskite ($MAPbX_3$; MA = $CH_3NH_3^+$, X = Cl^-, Br^-, or I^-) single crystals with low defect densities have been highlighted as candidate materials for high efficiency photovoltaics and optoelectronics. Here we report the optical and structural investigations of mixed halide perovskite ($MAPbBr_{3-x}I_x$) single crystals. Mixed halide perovskite single crystals showed strong light soaking phenomena with light illumination conditions which were correlated to the trapping and detrapping events from defect sites. By systematic investigation with optical analysis, we found that the pseudocubic phase of mixed halide perovskites generates light soaking phenomena. These results indicate that photo-induced changes are related to the existence of multiple phases or halide migrations.



Keywords:

perovskite, single crystal, photoluminescence, light soaking effect

H2.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Enhanced performance of perovskite light-emitting diodes by surface engineering

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Abstract:

Organic-Inorganic hybrid perovskite materials have attracted the interest of many researchers due to their promising properties such as low cost, solution processable fabrication, their excellent optical and electrical properties. One of promising approach to improve device performance is defect passivation, which suppress ion migration across interface and prevent electrode corrosion. Here, we report the significant beneficial effects using defect passivation and proper hole transport layer, resulting in improved efficiency and long-term stability of perovskite light-emitting diodes (PeLEDs).

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H2.02

Preparation of Highly Luminescent Organic-Inorganic Multi-Dimensional Perovskites and Their Application as Light Emitting Diodes

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Abstract:

In this talk, I will talk about the preparation of highly luminescent organic-inorganic perovskites and their application as light emitting diodes. More details, two topics will be introduced. The first topic is the effects of polar solvent treatment on optical properties of the perovskite thin film and second topic is enhancement of color purity and environmental stability of perovskite quantum dots (QDs) by embedding them in polymeric 3D photonic crystal.

We confirmed that polar solvent treatment leads to luminance enhancement of organometallic halide perovskite through two simultaneous processes; recrystallization and conversion of unreacted and remaining precursors into perovskite. Also, the correlation between crystal grain size of perovskite and SVA solvent properties, polarity and vapour pressure, has been systematically investigated and discussed. As both polarity and vapour pressure of SVA solvent increase, PL intensity of perovskite increase due to high crystallinity and small crystal grain size through recrystallization of microscale crystal grains into nanosized grains. The water (H_2O) is the most suitable solvent for SVA process of halide perovskite which resulted in outstanding PL intensity enhancement (~100 times brighter luminance and ~5.6 times higher crystallinity confirmed by XRD) as well as its abundant and eco-friend properties. Our finding clearly shows that optical properties of perovskite can be controlled by adjusting polarity, vapour pressure and exposure time of post annealing solvent and paves the way for realizing organometallic halide perovskite based lighting emitters with high luminance and proper colour.

The down-conversion organic-inorganic hybrid perovskite LEDs with a high color purity and a large viewing angle were realized by utilizing perovskite NP-embedded 3D PCs. The diameter of the copolymer particles was precisely controlled by varying the ratio of two monomers, MMA and 4-VP, and the total amount of the monomers. The stiff and hydrophobic properties of MMA sterically stabilized the copolymer particles as well as enhanced the environmental stability of the embedded perovskite NPs. Nonbonding electrons of 4-VP attracted $PbBr_2$ NPs to adhere to the p(MMA-co-4-VP) chain. The embedded $PbBr_2$ NPs were converted to blue, green and red perovskite NPs via VASP. The resonance induced light extraction at the PB edge of the 3D PCs shifted the PL emission peaks and narrowed the FWHM. In addition, an enhancement in PL intensities was also observed. The angle-dependency of PL emission from perovskite NPs embedded in 3D PCs was significantly improved compared to that of perovskite NPs without photonic structures due to non-directional Bragg scattering induced by the polycrystalline structure of the PC. Furthermore, the perovskite NPs embedded in polycrystalline 3D PCs showed enhanced environmental stability. The improved opto-physical properties of perovskite NP-embedded 3D PCs open a new opportunity for the application of perovskite LEDs to next generation displays.

Keywords:
Multi-Dimensional Perovskites, Light Emitting Didoes, Crystallinity, Grain Size, Environmental Stability

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H2.03

Improving electroluminescence efficiency of polycrystalline perovskite light-emitting diodes

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Abstract:

Metal halide perovskites (MHPs) have been developed as emitting materials in perovskite light-emitting diodes (PeLEDs) because of their advantages of high color purity, easy color tunability, and low material cost. However, polycrystalline MHPs have intrinsic limitation in electroluminescent (EL) efficiency including low exciton binding energy, long electron-hole diffusion length, and severe exciton quenching at the interface and in the bulk of MHP layer. Here, we present the efficient strategies for high-efficiency polycrystalline PeLEDs through the stoichiometry control, nanocrystal pinning method, and core-shell-mimicked nanograin. First, we suggest the high-efficiency in polycrystalline MAPbBr3 PeLEDs by fine stoichiometry control, decreasing grain size, and improving surface coverage of MAPbBr3 layer. From these strategies, the efficiency of 42.9 cd/A was achieved. Moreover, by unravelling the additive- based nanocrystal pinning method, EL efficiency limitations in PeLEDs was investigated; we achieved an external quantum efficiency of 8.79% ph/el. In addition, making small nanograins is one of the issues while healing the defective grain boundary region. We developed organic-shielded nanograins mimicking core-shell nanoparticles. The polycrystalline organic-shielded nanograins caused improved photoluminescence and electroluminescence properties, so achieved an external quantum efficiency of 21.81% ph/el with hemisphere lens. Our strategies will provide efficient ways for high-efficiency polycrystalline PeLEDs.

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Park, M.-H.; Jeong, S.-H.; Seo, H.-K.; Wolf, C.; Kim, Y.-H.; Kim, H.; Byun, J.; Kim, J. S.; Cho, H.; Lee, T.-W. Unravelling Additive-Based Nanocrystal Pinning for High Efficiency Organic-Inorganic Halide Perovskite Light-Emitting Diodes. Nano Energy 2017, 42, 157- 165.
Kim, Y.-H.; Cho, H.; Heo, J. H.; Kim, T.-S.; Myoung, N.; Lee, C.-L.; Im, S. H.; Lee, T.-W. Multicolored Organic/Inorganic Hybrid Perovskite Light-Emitting Diodes. Adv. Mater. 2015, 27 (7), 1248-1254.

Keywords:
PeLEDs

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H2.04

A strategy for high performance perovskite light-emitting diodes

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Abstract:

Metal halide perovskites are promising candidates for use in light emitting diodes (LEDs), due to their potential for color tunable and high luminescence efficiency.

While recent advances in perovskite-based light emitting diodes (PeLEDs) have resulted in external quantum efficiencies exceeding 20.3% for the green emitters, and infrared emitters based on QD light-emitting device with the alkyl ammonium iodine salt perovskites have exceeded 21.3%.

A critical issue to date is creating highly emissive and stable perovskite emitters with the desirable emission band gap to achieve full-color displays and white LEDs.

Moreover, the optimization of the devices via balanced charge injection is certainly required for high performance PeLEDs.

Here, we report the simple methods including facile synthesis of stable and highly luminescent nano-crystals, and effective charge transport layers for high performance PeLEDs.

Keywords:

perovskite, LED, charge transport

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H3.01*

Investigating micro-neuronal network using multi-electrode arrays

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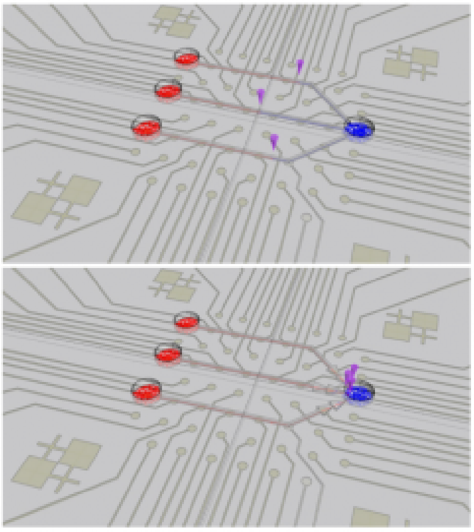
Abstract:

Due to recent development of bioengineering, extracellular electrophysiological recording using multi-
electrode arrays(MEAs) are helpful in understanding various function of neuron in nerve systems. In vitro
reconstitution of the brain circuits is helpful to investigate underlying cell to cell interactions. To investigate the
dependence of neural activities on the structure of neural networks, we have fabricated directional neural
networks using spin on PDMS lithography method and measured spontaneous and evoked electrical signals using multi-electrode arrays. Depending on the structure of neural networks, different activities are observed and they are analyzed in terms of synaptic and dendritic learning.



Keywords:
Micro neuronal network, Neuron Guidance, Multi-electrode Arrays(MEAs), Synaptic Learning, Dendritic Learning, Spin on PDMS Lithography(SPL)

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H3.02

Inertial focusing and separation in flexible 3D curved triangular channels

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Abstract:
Inertial focusing offers passive and high-throughput manipulation methods for cells and microparticles within microfluidic flows without aids of external forces. In previous research, unique inertial focusing behavior was observed in accordance with Re, apex angle, and a/H (a = particle diameter, H = hydraulic diameter) and separation of microparticles and cells were demonstrated using triangular microchannels. Here, we devised the 3D curved triangular channel with high-flexibility using a thin PDMS film to achieve the controllability of the radius of curvature and the curving direction. Using the 3D curved triangular channel, we investigated the alteration of stable focusing positions by changing De, Re and the curving direction. In straight triangular channels, particles are normally focused into the top (one or two positions depending on a/H and Re) and bottom (almost one regardless of conditions). In case of curved channel, the additional Dean flows changes the stability of the focusing positions. Here we show the modulation of the curving direction and radius of curvature allows novel methods for control the stability of the focusing positions.

Keywords:
Inertial focusing, Triangular microchannel, Microparticle separation

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H3.04*

Rapid antibiotic susceptible test by measuring bacterial growth in real-time

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Abstract:

To prevent spread of infection and antibiotic resistance, fast and accurate diagnosis of bacterial infection and subsequent administration of antimicrobial agents are important. However, conventional methods for bacterial detection and antibiotic susceptibility testing (AST) require more than two days, leading to delays that have contributed to an increase in antibiotic-resistant bacteria. Here we report an aptamer immobilized capacitance sensor which can measure bacterial growth in real time. By measuring the real-time capacitance, the sensor can monitor the bacterial growth curve in real-time. In addition, when the time-dependence of capacitor is differentiated with respect to time, a peak was observed in 6 hours, which indicates a phase transition from lag-phase to log-phase of bacteria. The peak is observed also when the bacteria are treated with antibiotics under the minimum inhibitory concentration (MIC). On the other hand, the peak is not above the MIC. These results demonstrate that rapid and accurate ASTs can be performed by aptamer immobilized capacitance sensor and derivative curve of real-time capacitance.

Keywords:

aptamer, capacitance sensor, bacteria, antibiotics, AST

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H3.05*

Cell separation from undiluted whole blood using inflection point focusing

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Abstract:
The detection and analysis of circulating tumor cells (CTCs) are important due to early prognoses and appropriate treatment for patients. Prior to the detection and analysis, isolation and sorting of the CTCs from whole blood are significant requisites for the efficient detection, which has been widely studied in microfluidic fields. Generation of inflection points in velocity file can lead to formation of stable inertial focusing positions by sole effect of the shear gradient lift forces. The velocity profiles with the inflection points can be generated by changes in the channel cross-sectional shape or co-flows of two liquids having different viscosities. Here, we generated the inflection points with combined effects of channel geometrical change and co-flows, and applied this system to particle/cell separation from undiluted whole blood.
First, we investigated focusing pattern in the combined system using microparticles. As the particle size increased, the focusing efficiency was increased due to the particle size effect. However, as the flow rate increased, the focusing efficiency was decreased because of flow disturbance by fluid inertia. Co-flow of whole blood (viscosity ~3-4 cp) and DPBS allowed increased shear gradient lift force and high efficiency to inflection point focusing. Separation efficiencies were as high as 92.7% and 85.2% for particles and cells, respectively. The throughput of blood sample processed was 50 μl/min.

Keywords:
Inertial microfluidics, Inflection point, Cell separation, Whole blood

H4.01*

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리튬이온 이차전지 음극용 산화주석/그래핀 나노복합소재 합성

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Abstract:

이차전지와 관련된 전기자동차 및 모바일 디바이스의 수요가 급증함에 따라 Lithium Ion Battery(LIBs)의 안정성 및 효율을 증진시키기 위한 연구가 활발히 진행되고 있다. 현재 상용 LIBs의 음극물질로 사용되고 있는 Graphite는 372 mAh/g의 낮은 이론적 전기용량 특성을 가지고 있기 때문에 Graphite를 대체할 수 있는 저가의 안정적인 음극소재의 개발이 필요한 상황이다[1]. 저가이면서 환경친화적인 Tin Oxide 나노소재는 LIBs 음극소재로 주목을 받고 있다. 특히 SnO는 이론적 전기용량이 875mAh/g으로 783mAh/g의 전기적 용량을 갖는 SnO_2보다 많은 용량을 갖지만, 대면적으로 균일하게 합성하기 어렵다는 단점으로 인하여 다양한 구조에 대한 전지특성평가가연구되지 않았다[2]. 또한 Tin Oxide 나노소재는 Tin 특유의 물리적/화학적 반응으로 인한 변형으로 전지의 성능이 떨어지는 문제점이있다. 이러한 문제점을 해결하기 위하여 Carbon과 복합소재 형태로 음극을 제작하는 것이 유리하다고 알려져 있다[3]. Wide Band Gap Semiconductor로 잘 알려진 Tin Oxide의 경우 성장 조건에 따라 전혀 다른 표면형상을 갖는 나노구조물로 성장하는 것이 보고되어 있다[4]. 따라서 본 연구에서는 Chemical Vapor Deposition (CVD) 시스템으로 균일하고 넓은 면적의 Graphene을 합성하고, 그 위에 직접 Tin Oxide 나노구조물을 성장시킴으로써 Tin Oxide/Graphene 복합소재를 합성하였고, LIBs 음극소재로의 특성을 조사하였다. 특히 SnO 나노구조물은 Single Layer Graphene(SLG) 위에서 높은 표면적을 갖는 Free-Standing 구조로 성장됨을 확인하였다. SLG의 품질과 SnO 나노구조물의 결정학적 특성은 Raman Spectroscopy로 분석하였고, SnO 나노구조물의 표면형상 및 표면적 특성은 FE-SEM, AFM으로 분석하였다. Ar 분위기의 Glove Box 안에서 LIBs를 제작하였고, Cyclic Voltammetry(CV)와 Charge-discharge(CD)를 평가하여 SnO/Graphene 복합소재의 이차전지 음극 특성을 평가하였다.

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Keywords:
Nanostructures, Graphene, Tin oxide, Nanomaterials, Free-standing, Nanocomposites, Lithium ion battery.

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H4.02

Diamond spin qubit coupled to shear strain of mechanical oscillator

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Abstract:
Nitrogen-Vacancy (NV) center in diamond is a solid-state spin-qubit that can be coupled to various fields such as magnetic, electric, and strain field. In this talk, we present strain-mediated coupling between diamond NV center and diamond mechanical oscillator. Particularly, we focus on T-shaped diamond mechanical oscillator which possesses both flexural and torsional mechanical modes. By utilizing the multiple mechanical modes, one can manipulate all strain components and realize effectively controls of the NV spin states via strain fields. We also present spin population inversion induced by strain field which can provide higher spin flip fidelity in NV ensemble measurements compared to traditional microwave spin flip.

Keywords:
quantum defect, diamond NV center, qubit

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H4.03*

Development of gate-tunable SiO_x memristive synapse inspired by rod-to-rod bipolar synapse of the biological visual system

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Abstract:

Memristor, which consists of a simple metal-oxide layer sandwiched between two conductors, is being greatly envisioned as a technical platform to imitate the principal of biological synapse system due to its nonlinear and dynamic electrical characteristics depending on the history of applied electrical programming [1]. In this study, we fabricated a vertical form of a gate-tunable memristor using a SiO_x memristor in combination with graphene barristor at room temperature and utilized the device as an artificial synapse [2]. The device can exhibit a high ON-OFF ratio (> 10^6) and excellent endurance cycles and retention time, where switching is based on the transition between two Si phases (α-Si and Si nanocrystal). Moreover, the electrostatic gating from a graphene barristor can greatly improve the switching performances of the SiO_x memristor in terms of the programming voltage and energy. Based on the switching and the gate-tunability, the device successfully mimicked the unique synaptic functions of rod-to-rod bipolar synapse in human visual system such as binary state and shift of threshold. Using the controllable ON probability in the SiO_x memristor, we utilized as a probabilistic synapse and investigated the recognition accuracy, and the learning efficiency (energy and time consuming) of the fashion images according to different ON probability based on supervised learning simulation. From this study, we rather think that the switching uncertainty in a filament-type binary memristor may be good for the mimicking of artificial probabilistic synapse. As a result, the probabilistic binary synapse could provide a non-conventional and another route toward the learning, energy and time-efficient neuromorphic computing technology.

References
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Keywords:
Silicon oxide, Gate-tunable memristor, Graphene barristor, Neuromorphic computing, Probability

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Graphene/hBN Barristor : tuning a tunneling barrier height by controlling fermi energy level of Graphene

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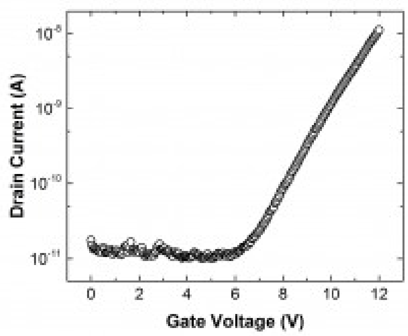
Abstract:

A tunneling barristor, switching Fowler-Nordheim tunneling current through vertically-staked graphene/hBN/metal, will be presented in this poster. Graphene is a 2-dimensional plane of carbon with one-atom thick of graphite. Because of its low density of states near the Dirac point, its Fermi level can be modulated with the accumulated charge by 0.5~0.6 eV from charge neutral point [1]. Hexagonal boron nitride, the tunneling barrier, is composed of boron and nitrogen, and has the same structure with graphene. However, it is an insulator, whose breakdown voltage and dielectric constant are similar to those of SiO_2, which is ~0.8 V/nm and 4 respectively [2].



The current is modulated by tuning the barrier height between h-BN and Graphene like the barristor [3]. Interestingly, depending on gate voltage. While the former depends on the density of states, and modulates I_{on}/I_{off} ~ 100, the latter depends on the barrier height, and modulates I_{on}/I_{off} ~ 10^6. Therefore, our device can be switched by the barrier-height modulation. In this work, we achieved 10^6 of I_{on}/I_{off} ratio with 50 nm thick hBN at 300 K and 10^3 with 32 nm thick hBN at 1.78 K.

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Keywords:
Barristor, Graphene, Hexagonal Boron Nitride, Fowler-Nordheim tunneling

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H4.05

Theoretical study of 'buckling-to-flipping' nonlinear transition for an elastic cantilever

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Abstract:

We present a mechanical model for the buckled tip, and derive the governing equation that describes the `buckling-to-flipping nonlinear transition of the tip motion. Our minimal mechanistic model fully captures the velocity-dependent flipping phenomena, in which the tip position of the tip varies with the speed of the surface motion, as consistently observed in previous experiments. The present study could be applicable for sensitive detection of the directional surface motion such as the seismic waves.

Keywords:

sensor, bifurcation, nonlinear dynamics

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H4.06

Gate-tunable photodetector and ambipolar transistor in graphene/$MoSe_2$ barristor

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Abstract:

실리콘 기반의 반도체 소자의 한계가 드러남에 따라 이를 대체할 수 있는 미래 전자 소자의 개발이 이미 십여 년 전 부터 이슈가 되고 있다. 최근 단결정 실리콘보다 100배 이상 전자를 빠르게 이동시킬 수 있고 구리보다 100배 이상 전기가 잘 통하며 늘리거나 구부려도 전기적 성질을 잃지 않는 그래핀이 차세대 소자용 소자로 많은 주목을 받고 있다. 높은 전기 전도도와 투명성 유연성 등의 특성으로 인해 그래핀을 전극으로 활용하고자 하는 연구들이 수없이 진행 되어왔으나 최근에는 그래핀을 전극으로서의 역할이 아닌 반도체 소재로서의 연구들이 활발히 진행되고 있다. 이러한 연구들은 대부분 밴드갭이 없는 그래핀에 도핑, 구조 변화 등의 방법으로 밴드갭을 생성하여 반도체 소자로 사용하려는 방법들이 대부분이다. 그래핀과 다른 물질과의 접합을 이용해 쇼키 장벽을 만들고 소자에 순방향, 역방향의 게이트 전압을 걸어줌에 따라 장벽의 높이를 조절하는 방법으로 전류가 흐르게 하거나 차단시킬 수 있어 '0'과 '1'의 디지털 신호를 만들 수 있다. 이러한 소자를 트랜지스터 소재로 활용함에 따라 현재 사용되고 있는 실리콘 기반의 소자의 한계를 극복한 새로운 반도체 소재를 개발 할 수 있다.

본 연구에서 제작되어진 그래핀/$MoSe_2$ 배리스터 소자는 이온겔을 게이트 절연물질로 사용함에 따라 높은 유전율로 인한 효과적인 게이트 전압 인계 효과를 가져왔으며, 그래핀의 Fermi-level을 효과적으로 조절해줌에 따라 높은 전자 이동도(247 cm^2/sV)와 온오프비(10^5)을 보이는 성과를 가져왔다. 또한 외부 전압을 통해 p-타입과 n-타입 모두의 특성을 보이는 양극성 또한 확인 할 수 있었다. 광전류 측정을 통해 이러한 양극성 특성을 직접적으로 확인할 수 있었으며, 그래핀과 $MoSe_2$ 접합부에 형성되어진 쇼트키 배리어의 제어를 통해 발생되어지는 광전류를 획기적으로 증폭 시킬 수 있었으며, EQE(24%)와 responsivity(103mA/W) 또한 증폭 시킬 수 있었다. 이러한 제어 가능한 광학적 특성은 광입력에 대한 광출력을 제어할 수 있음을 보여주었다. 이러한 성과들로 인해 그래핀/$MoSe_2$ 배리스터 소자는 높은 전자이동도와 온오프비를 가지는 차세대 양극성 트랜지스터와 제어 가능한 광전 소자, 이미지 센서, 포토 트랜지스터 등 향상된 광학 소자로의 사용 가능성을 확대하는 성과를 기대할 수 있을 것이다.

Keywords:
그래핀, MoSe2, 배리스터, 이온겔

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H4.07*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Spectroscopic Gyroscope Experiments: Building an Intrinsic Angular Momentum Sensor

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Abstract:

Intrinsic angular momenta of condensed matter systems are known to exist for quite some time, however, direct measurement of them have not been widely performed other than some special cases [1]. Systems with intrinsic angular momentum include time reversal symmetry broken phases such as ferromagnets or chiral topological superconductors. The absolute magnitude of these angular momenta, however, has been too minute to reliably measure until the recent development of the microelectromechanical systems (MEMS) gyroscopes. Even with the advent of the highly sensitive MEMS gyroscopes, the detection scheme has been limited to amplitude sensing of mechanical oscillation. Here, we show that spectroscopic measurement can be carried out on these gyroscopes. Angular momentum sensitivity can be improved with this new technique even in the presence of imperfection in the fabrication process.

[1] G. G. Scott, Reviews of Modern Physics 34, 102 (1962).

Keywords:
MEMS gyroscope

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H4.08

Enhanced room-temperature NO_2 gas sensing properties of plasmonic gold nanoparticles decorated ZnO nanowires

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Abstract:

Semiconducting metal oxides are promising candidate materials for gas sensing devices. We have attached Au nanoparticles (NPs) onto ZnO nanowires (NWs) with and without self-assembled monolayers (SAMs) of (3-Aminopropyl)triethoxysilane (APTES). At room-temperature, highly selective NO_2 gas response under green light is observed in Au NPs decorated ZnO NWs, owing to the localized surface plasmon resonance (LSPR) effect. Electron transfer from Au NPs to ZnO and hole accumulation in Au NPs are revealed from the Kelvin probe force microscopy (KPFM) measurements. In addition, photocurrent measurements are carried out and discussed to identify the gas absorption/desorption mechanism of ZnO NWs.

Keywords:

ZnO nanowires, Gas sensor, Localized surface plasmon resonance effect

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H4.09*

Al_2O_3 박막을 성장시킨 MoS2 소자의dielectric screening효과를 통한 mobility 증가

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Abstract:
Al_2O_3 박막을 MoS_2 Field Effect Transistor(FET) 위에 atomic layer deposition (ALD)을 이용하여 성장시키고 transistor 특성을 조사하였다. MoS_2 FET에 Al_2O_3를 성장시킨 경우MoS_2 FET의carrier mobility증가와 hysteresis감소를 확인했다. 이는 유전상수가 큰 Al_2O_3에 의해 MoS_2 FET 표면에 존재하는 charged impurity의 영향을 감소시키는 dielectric screening 효과로 생각된다. 또한 Al_2O_3가 덮인 MoS_2 FET의 경우 상온에서 2 K로 온도를 내릴 때 carrier mobility가 80 $cm^2V^{-1}s^{-1}$에서 670 $cm^2V^{-1}s^{-1}$까지 증가한 것을 확인하였다. 이는 저온에서 homopolar phonon, surface optical phonon 등에 의한 전자 산란이 제한되었던 것으로 생각된다. 다른 한편으로 Al_2O_3가 덮인 소자를 공기중에 노출시켜 11개월 후에 carrier mobility를 측정하였을 때 2 K에서 550 $cm^2V^{-1}s^{-1}$의 값을 보였다. 이는 Al_2O_3가 산화에 민감한 MoS_2 소자에 안정성을 유지하는데 도움이 된다는 것을 보여준다.

Keywords:
MoS2, Al2O3, dielectric screening

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H5.01

Simple, Cost-effective, Bio-inspired Fabrication of Highly-ordered Dynamic Plasmonic Nanostructures Utilizing M13 Bacteriophage

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Abstract:

An ability to self-assemble highly ordered and hierarchically organized nanostructures had generated significant interest in the method of bio-inspired fabrication in recent years. In fabrication ways, self-assembly is simple, non-complex, and reproducible nanostructures were mass-produced at low cost which is a crucial difference when compared with existing methods. As a future smart material with characteristics of self-evolve, self-replicate and self-assemble, M13 bacteriophage (phage), a virus bio-material, stands as a good choice. In this work, we introduce a drop-cast fabrication method involving M13 phage for dynamic plasmonic nanostructures. By exploiting the natural evaporation kinetics happening at the meniscus when the virus solution dropped on the substrate, two key nanostructures in high order are formed in a single attempt. Two types of nanostructures are formed as a function of distance: single or bundled nanowire networking structures and islands or dots structures. Tunable scattering and SERs characteristics can be shown by interplaying with M13 phage (Wild type, WHW, 4E) solution concentration. By implementing different humidity variations, the M13 phage based nanowires/dots exhibited excellent dynamic structural changes in the resolution of 1 nm - 2 nm, resulting in excellent plasmonic gap mode on/off properties. Please note that making such tiny sub-nm scale structures using lithography or other methods requires numerous attempts, which makes our fabrication method outstanding. The genetic engineering of M13 phages helps to modify its surface according to the application requirements or even target molecules binding, which makes it an excellent candidate for highly selective and sensitive biosensors. The dynamic property of M13 phage provides a solution for a unique platform of plasmonic color printing within the single structure. With such above important characteristics, our employed drop cast method involving M13 phage will find interesting applications in the field of biosensors, dynamic color printing, photonic devices, and so on.

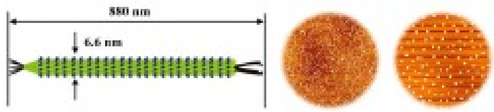

Figure. M13 bacteriophage geometry information. The AFM images on the right show the self-assembled nanostructures formed using drop-cast fabrication method.

References:
1. Nat. Commun. 5, 3043 (2014).
2. ACS Appl. Nano Mater. 6, 2851(2018).
3. Nanomaterials 8, 582 (2018).

Keywords:
M13 Bacteriophage, Dynamic Plasmonics, Self-assembly, Biomaterial, Biosensor

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H5.02*

용액형 메타물질 디자인 및 가시광선 대역 극한 굴절률 달성

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Abstract:
광학적 메타물질이란 전기적 유전율과 자기적 투자율이 모두 음의 값을 가져 결과적으로 음의 굴절률을 가지게 되는 인공적 물질을 지칭한다. 메타물질의 기본 단위가 되는 메타원자들은 현재까지 일반적인 리소그래피 공정으로 제작되고 있기 때문에 수 마이크로미터 이상 크기를 가지고 있다. 따라서 메타물질이 동작하는 파장대역 또한 수 마이크로미터 이상으로 제한되어 왔으며, 구조가 비등방성을 가지기 때문에 특정 입사각과 편광을 가지는 빛에만 반응할 수 있다. 최근, 금속 콜로이드를 고리 모양으로 잘 조립한 클러스터에서 비자연적인 자기 반응이 가시광선대역에서 나타날 수 있음이 제안되었고, 금속 콜로이드의 합성 및 조립 기술 또한 상당한 수준으로 발달되었다. 이러한 연구 흐름에서 우리는 금속 콜로이드를 용액상에서 조립하고 정제하여 제작된 용액형 메타물질이 가질 수 있는 굴절률의 한계를 이론적으로 계산하였다. 이를 통해 가시광선 대역에서 동작하며 편광 의존성이 없는 용액형 메타물질을 디자인하여 제안한다.

Keywords:
metamaterial, metamolecule, plasmonics, effective medium theory

H5.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Nanoscale substructure imaging in photo-induced force microscopy

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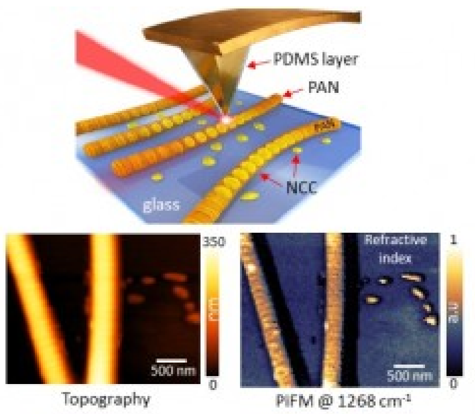
Abstract:

The opto-mechanical force response from light-illuminated nanoscale materials has been exploited in many tip-based imaging applications to characterize various heterogeneous nanostructures. Such a force can have two origins: thermal expansion and induced dipoles. The thermal expansion reflects the absorption of the material, which helps to chemically characterize a material at their absorption resonance. The induced dipole interaction reflects the local refractive indices of the material underneath the tip, which is useful to characterize a material in the spectral region where no absorption resonance occurs as in IR inactive region. Unfortunately, the dipole force is relatively small, and the contrast is rarely discernible for most organic- and bio- materials, which only show a small difference in the refractive indices of their components. In this letter, we demonstrate that the refractive index contrast can be greatly enhanced with the assistance of a functionalized tip. With the enhanced contrast, we can visualize the substructure of heterogeneous biomaterials, such as a polyacrylonitrile-nanocrystalline cellulose (PAN-NCC) nanofiber. From substructural visualization, we address the issue of the tensile strength of PAN-NCC fibers fabricated by several different mixing methods. Our understanding from the present study will open up a new opportunity to provide enhanced sensitivity for substructure mapping of nanobio materials, as well as local field mapping of photonic devices, such as surface polaritons on semiconductor, metal and van der Waals materials.



Keywords:
photo-induced force, substructure imaging, semiconductor, near-field, tip-enhanced force, microscopy and spectroscopy

H5.04*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Exploiting optical phase conjugation for reference-free single-point holographic imaging

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Abstract:

Holographic imaging, measuring both the amplitude and phase information of a sample, is an essential physical experimental method, with applications in metrology, materials, nanotechnology, and biophotonics. However, the realizations and applications of holographic imaging are limited to the wavelengths at which digital image sensors are available. Furthermore, the conventional holographic method requires a reference-based interferometer, which significantly limits the usage and application of holographic imaging.

Here, we propose and experimentally demonstrate a new scheme for holographic imaging without the need for a reference field and an image sensor, by exploiting optical phase conjugation. The basic principle of our method is based on the time reversal reciprocity. When a plane wave impinges onto a sample, the plane-wave illumination results in a scattered field. If we rewind the scattered field back to the sample in a time-reversed manner, then the scattered field will be converted to a plane wave. On the contrary to conventional forward imaging, reference-free single-point holography is realized by exploiting this time-reversal symmetry. To emulate the time-reversal propagation of the scattered field, the phase conjugation of the scattered field can be displayed by a spatial light modulator. Then, the rewound plane wave can be detected by a point detector.

In order to demonstrate the proposed method, wide-field holographic imaging consisting of 128x128 spatial modes is realized in a visible wavelength, using a digital micromirror device and a point detector. Furthermore, we demonstrated the broadband applicability of our method by realizing two-dimensional holographic imaging at the wavelength of 1.55 um.

Keywords:

holography, optical phase conjugation, bidirectional transducer

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H5.05*

Kramers-Kronig digital holographic microscopy

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Abstract:

The space-bandwidth product (SBP) of an imaging system determines the total amount of information that can be delivered. Despite the fact that the SBP of a modern microscope reaches up to tens of Megapixels, the SBP is bottlenecked by a detector. As a result, a great portion of the field-of-view or the resolution of images are sacrificed, which becomes an important issue in high-throughput large field-of-view imaging. Here we propose a novel method for digital holographic microscopy for an enhanced SBP. Exploiting the Kramers-Kronig relations, the proposed method efficiently utilizes the interferogram bandwidth. The analyticity condition of the Kramers-Kronig relations enables a correct reconstruction of complex amplitude even when the first order image is completely overlapped with the zero-order image. As a result the SBP of the proposed method is significantly improved compared to that of the conventional off-axis method. Importantly, the proposed method requires a single off-axis interferogram and the image of a reference beam, without imposing any condition on a sample. To demonstrate the capability of the proposed method, microscopic samples including a USAF resolution target and a polystyrene bead are imaged and then compared with the conventional off-axis method. Furthermore wide field-of-view imaging of a mouse brain tissue and a human breast tissue is demonstrated.

Keywords:

digital holographic microscopy, quantitative phase imaging

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H5.06

Time-Energy Entangled Photon Pairs from Doppler-Broadened Atomic Ensemble via Collective Two-Photon Coherence

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Abstract:

We experimentally demonstrate two-photon interference between a time-energy entangled photon pair generated from Doppler-broadened cascade-type 87Rb atoms using an unbalanced Michelson interferometer. In our system, the CW-mode time-energy entangled photon-pair sources are generated via the SFWM process and the collective two-photon coherence effect of a Doppler-broadened cascade-type atomic ensemble. The coherence time of the two-photon state from the Doppler-broadened atomic ensemble is more than 100 times longer than that of the single-photon state. We investigate two-photon interference (TPI) by means of highly time-resolved coincidence detection and determine the two-photon coherence length of a photon pair from the Doppler-broadened atomic ensemble. We observed fourth-order interference with visibility as high as 97% with the time-energy entangled CW-mode photon pairs from the atomic ensemble for the first time.

Keywords:

Quantum entanglement, Quantum optics, Quantum interference, Collective two-photon coherence effect, Sperradiance,

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H6.01

Transport Spectroscopy on Bilayer Graphene

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Abstract:
The talk will introduce a non-local direct chemical potential measurement technique using double bilayer graphene heterostructures, which consist of two parallel bilayer graphene separated by a hexagonal boron nitride dielectric. The measured chemical potential vs density characteristics show signatures of electron-electron interactions and an electron-hole asymmetry. The talk will then discuss quantum Hall (QH) effect in bilayer graphene, presenting spin-to-valley polarized phase transitions, interaction-driven negative compressibility, and novel QH phases, which are predicted to possess a coherent superposition of two different electronic states. Gate-tunable resonant tunneling and negative differential resistance in the interlayer current vs voltage characteristics will be also breifly addressed.

Keywords:
Transport Spectroscopy, Bilayer Graphene, Quantum Hall Effect, Electronic Structure, Negative Compressibility

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H6.02

4π-periodic supercurrent through surface states in $(Bi_{0.81}Sb_{0.19})_2Se_3$ nanowire-based Josephson junctions

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Abstract:
Topological insulator (TI) nanowire combined with conventional s-wave superconductor is expected to provide the topological superconducting state for hosting the Majorana fermion, which is essential for the topological quantum computation. Here, we report the experimental evidences of the topological supercurrent through surface states in $(Bi_{0.81}Sb_{0.19})_2Se_3$ TI nanowire-PbIn superconductor Josephson junctions. When an axial magnetic filed is applied, the Josephson supercurrent oscillates, and their period is consistent with the Aharonov-Bohm (AB) oscillations of normal conductance, indicate that the supercurrent is caused by the topological surface states. Furthermore, when we applied microwaves to the junctions, anomalous Shapiro steps with the first step missing are observed at around 300 mK. In the topological superconducting state, the supercurrent has a 4π-period and is expected to show doubled Shapiro steps, so called the fractional Josephson effect. Therefore, our anomalous Shapiro steps can be caused from the topological supercurrent, and it is also verified by numerical calculations. To the best of our knowledge, our experimental results are for the first time in the world to simultaneously demonstrate the surface supercurrent AB oscillations and fractional Josephson effect in a topological nanowire.

Keywords:
topological insulator nanowire, topological surface states, topological supercurrent, fractional Josephson effect

H6.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Circuit cavity electromechanics with semiconducting InAs nanowires

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Abstract:

One of the crucial aspects in circuit cavity electromechanics is to achieve strong coupling that enables cooling a mechanical oscillator into its ground state and thereby measuring its motion at the quantum level. These have been realized by exploiting a typical optomechanical coupling originating from the geometric capacitance of a metallic, mechanical oscillator coupled with a superconducting microwave cavity. Though abundant quantum mechanical phenomena has been shown using this platform, engineering intrinsic material properties of mechanical oscillators has been rarely attempted in the past. A cavity electromechanical system with semiconducting oscillators could present unprecedented phenomena possibly arising from the electronic structures of the semiconductors.

Here, we fabricate a novel platform where a semiconducting InAs nanowire is embedded in a superconducting microwave cavity. We study cavity electromechanics of a suspended InAs nanowire and a microwave cavity. The coupling behavior could be both dispersive and dissipative in this system. The results we present here will pave the way for novel optomechanical devices made of semiconductors.

Keywords:

Cavity electromechanics, InAs nanowire mechanical resonator

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

H7.01

Rich quantum phases in 3*d*-5*d* double perovskite oxide heterostructures

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Abstract:
Rich quantum phases are expected in 3*d*-5*d* oxide double perovskites, where both strong electron-electron correlations in 3*d* orbitals and the relativistic spin-orbit coupling in 5*d* orbitals play cooperative roles. Here, we have demonstrated new electronic and magnetic ground states in 3*d*-5*d* double perovskite Sr_2FeReO_6 by using heterostructure engineering. In the first part of presentation, we will show observation of a highly insulating ferromagnetic state, which are required for spintronic applications, in 3*d*-5*d* double perovskite $Sr_2Fe_{1+x}Re_{1-x}O_6$ ($-0.2<x<0.2$) epitaxial films. Beyond the original ferromagnetic metallic ground state in a stoichiometric film, Fe-rich films showed innately rare ferromagnetic insulating states with three orders of higher room-temperature resistance than that of the metallic film, a high Curie temperature about 400 K, and a large saturated magnetization about 1.8 uB/f.u. In the second part of presentation, we will show the evolution of electronic and magnetic ground state of Sr_2FeReO_6 with reducing dimensionality. While the original ferromagnetic ordering is survived even down to monolayer Sr_2FeReO_6, the enhancement of strong electron correlation in a quasi-two-dimensional geometry of $[SrTiO_3]_8/[Sr_2FeReO_6]_1$ superlattices induced the Mott-like metal-insulator transition. The origin of the metal-insulator transition with polarized spin states will be discussed based on optical spectroscopy and the first principle calculations.

Keywords:
Ferromagnetic insulator, Two-dimensional ferromagnetism, oxide heterostructures

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H7.02*

Magnetic-field-induced superconductor-to-insulator transition in the thickness controlled cuprate thin films

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Abstract:
Magnetic-field-induced superconductor-to-insulator transition in disordered $La_{1.85}Sr_{0.15}CuO_4$ thin films is investigated. The disorder effect is severe, as decreasing the film thickness, leading to suppression of the superconductivity. Our electronic transport measurement reveals the bosonic insulator behavior with the emergence of resistance peak preceding the onset of the transition at T_c = 6.9 K, which is consistent with the Bose-glass model. Finite-size scaling is performed by tuning magnetic field near the quantum phase transition regime. The critical resistance is measured as R_c = 6.10 kΩ which is close to the universal quanutm resistance of the Cooper pair, $R_q = h/4e^2$. Moreover, we experimentally determine the product of spatial and temporal critical exponents, zν =1.36, indicating the percolative threshold is the origin of the superconductor-to-insulator transition.

Keywords:
Superconductivity, Superconductor-to-insulator transition, oxide thin film

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H7.03

Two-dimensional hole gas in oxide heterostructures

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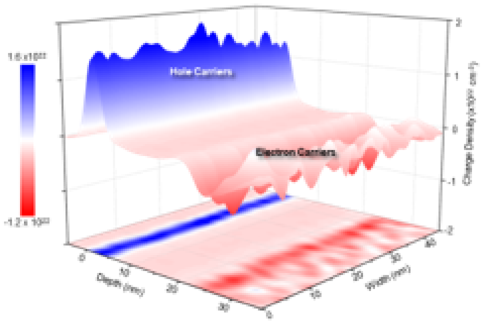
Abstract:

Extensive studies of two-dimensional electron gas (2DEG) at complex oxide interfaces have revealed a plethora of new phenomena not present in conventional semiconductors, becoming a focal point of novel device applications. Its counterpart, two-dimensional hole gas (2DHG), has long been expected to complement the 2DEG. However, although the 2DEG has been widely observed, the 2DHG has proved elusive so far. In this talk, I will introduce a highly-mobile 2DHG in epitaxially-grown $SrTiO_3/LaAlO_3/SrTiO_3$ heterostructures. By electrical transport measurements and in-line electron holography, I provide direct evidences of a 2DHG that coexists with a 2DEG at complementary heterointerfaces in the same structure. We found that the precise control of interfacial atomic structure and the removal of point defects are prerequisites to realizing 2DHG at oxide heterointerfaces. First-principles calculations, coherent Bragg rod analysis, and depth-resolved cathodoluminescence spectroscopy consistently support our finding. The coexistence of a 2DEG and a 2DHG in a single oxide heterostructure provides a novel platform for the exciting physics of confined electron-hole bilayers and for developing applications.



Keywords:

Two-dimensional hole gas, Two-dimensional electron gas, Interfacial transport, Polarity Discontinuity, Oxide Heterointerfaces

H7.04*

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Nonreciprocal charge transport in noncentrosymmetric oxide interfaces

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Abstract:

The electrons confined at the interfacial quantum well of a $LaAlO_3/SrTiO_3$ display various exotic condensed matter phases and rich spin-orbitronic functionalities associated with broken inversion symmetry. This 2D polar conductor may exhibit directional propagation of itinerant electrons, i.e. the rightward and leftward currents differ from each other, when the time-reversal symmetry is further broken by applying a magnetic field. This potential rectification effect in general was shown to be very weak due to the fact that kinetic energy is much higher than energies associated with symmetry breakings producing weak perturbation. Here, we present large gate-tunable nonreciprocal magnetoresistance in $LaAlO_3/SrTiO_3$ conductive interface, where the electrons are confined at two-dimension with low Fermi energy. The coefficient γ representing the strength of magnetochiral anisotropy, was measured to be as high as ~ 56 $T^{-1}A^{-1}$, which is about 2 order of magnitude higher than those estimated for typical noncentrosymmetric conductors. The observed directional charge transport shows linear dependence on the applied current, while it exhibits higher order dependence on the applied magnetic field. The behavior of directional response in $LaAlO_3/SrTiO_3$ is associated with comparable energy scales among kinetic energy, spin-orbit interaction, and magnetic field, which opens a new route to enhance nonreciprocal response and its functionalities in the emerging spin-orbitronics.

Keywords:

Oxide heterointerface, Nonreciprocal response, Rashba spin-orbit interaction, spin-orbitronics.

H7.05*

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Formation of electret patterns in $LaMnO_3$ thin films by electrochemical amorphization

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Abstract:

Electrets, materials that retain quasi-permanent electric charges or dipole moments and generate electric fields, have been intensively studied due to a wide range of applications [1-3]. So far, two groups of electret materials have been introduced, i.e., polymer-based organic electrets and SiO2-based electrets [3-6]. In this study, we introduce the electret formation in a transition metal oxide by electrochemical solid-state amorphization. Highly-stabilized charged patterns have been successfully demonstrated in $LaMnO_3$ thin films. Surface charge density is estimated as ~400 nC/cm2 and injected charges persist for more than a year. Interestingly, the charged patterns show additional volume expansion at ambient condition. The temporal volume expansion of the charged patterns can be understood based on the diffusion-drift-reaction model of the charged particles under space-charge-induced electric field within thin films. Our finding will not only offer novel electrets in transition metal oxides but also clarify the origin of the height change.

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Keywords:
Electrets, amorphization, LaMnO3

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H8.01

Current status of the CXI instrument at PAL-XFEL

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Abstract:
We have established the single-shot imaging instrument at the NCI (Nano-crystallography and Coherent Imaging) experimental station, PAL-XFEL. This instrument consists of a sample chamber and a detector chamber including the MPCCD (Multi-port charge-coupled device) detector. The sample chamber is widely utilized with tightly focused X-ray pulses and optimized for single-shot based experiments. Tightly focused X-ray pulses by the Kirkpatrick-Baez mirrors (KB mirror) with ~ 5.96 m long focal length is delivered to the sample chamber. Samples are supplied to the X-ray interaction region using thin Si3N4 membranes mounted on high speed piezo stages. Coherent diffraction patterns are collected by the MPCCD detector with 30 Hz repetition rate.

Keywords:
PAL-XFEL ultrafast dynamic imaging coherent diffraction imaging

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H8.02*

Three dimensional structure determination of a core-shell nanoparticle by single particle 3D imaging at PAL-XFEL

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Abstract:

Single particle imaging is a novel x-ray imaging technique that utilizes the extremely high brilliance and spatial coherence of X-ray Free Electron Laser (XFEL) to capture the complete 3D structure of non-crystalline sample. It enables high-resolution 3D imaging of non-crystalline biological specimens without staining, fixation, and sectioning. We established a hard x-ray fixed-target coherent diffraction imaging set-up at PAL-XFEL NCI beamline and recorded 2D diffraction patterns from sphere core-shell nanoparticles with trisoctahedral gold core. We reconstructed 3D image with two different approaches. One is to reconstruct the 3D reciprocal volume from the 2D diffraction patterns via EMC algorithm, and acquire 3D structure from phasing of reciprocal volume. The other is construct the 2D images first by phasing the single 2D diffraction patterns, followed by 3D image reconstruction from the 2D image sets which is a common scheme in cryo-EM. Clear core-shell structure in nanoscale and heterogeneity was observed in the reconstruction. Detailed analysis and comparison of both reconstruction would be discussed.

Keywords:

XFEL, single particle imaging, nanoscopy

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2019-04-24 - 2019-04-26

H8.03*

Ultrafast resonant X-ray scattering investigation of non-thermal melting using XFELs

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Abstract:

Ultrafast melting transitions in noble metals and semiconductors irradiated by femtosecond IR laser have been reported with signatures of lattice disorder in less than a picosecond timescale, which is faster than electron-phonon energy transfer rates. With this mysteriously fast reaction of crystal lattice, the interest in unveiling the fundamental energy transfer mechanism has been intense with extensive research effort using ultrafast electron diffraction, time resolved X-ray diffraction, etc. By employing time-resolved resonant X-ray scattering, we have investigated the ultrafast lattice melting with femtosecond IR laser irradiation synchronized to the X-ray laser pulses from PAL-XFEL. Experimental evidence on the electron transition driven lattice disorder has been obtained, supporting the bond softening explanation on the nonthermal melting in covalent bonding crystals. IR laser fluence dependence of the melting time suggests essential role of electrons in bonding orbitals in causing the crystal melting.

Keywords:
Ultrafast melting, Time-resolve X-ray scattering, XFELs

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H8.04*

3D-mapping of grains and strains in polycrystalline specimen using X-ray microdiffraction

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Abstract:

X-ray microdiffraction(XMD) set up at 4B beamline of Pohang Light Source (PLS) is designed for observing lattice strain in a small localized region of a specimen. The lattice strain can be calculated from the recorded Laue pattern on CCD. However, when the grain size of the polycrystalline specimen is smaller than or comparable to the size of the X-ray beam, Laue patterns from different grains appear overlapped because the penetration of the X-ray is usually bigger than typical grain size. In this case, it is necessary to isolate the Laue pattern from a single grain from the overlapped image in order to calculate the lattice strain. Such a Laue pattern identification method is possible by analyzing characteristic spatial intensity profiles (changes of peak intensities at the beam position) in a Laue image and the analysis algorithm has been developed through our previous works. Through the above described method, it is possible to obtain grain-specific lattice strain map in polycrystalline specimens. However, the grain-specific data were still two-dimensional data. In this study, we have developed a method to provide three-dimensional map information by adding depth direction information to grain-specific data of polycrystalline specimens. For 3D map construction, additional measurements are needed to obtain the depth positions of the grains along with the 2D area measurements. 3D lattice strain information will be helpful for studying various properties of polycrystals.

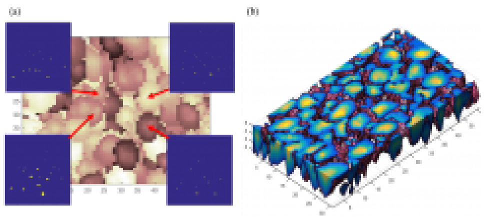

Figure 1 (a) The 2D grain map from the Grain identification algorithm. Colors assigned randomly on each grain. The inset images indicating the Laue patterns of the grains pointed by arrow. (b) The sample image of 3-D visualized map from new method

Keywords:
X-ray microdiffraction, polycrystal, grain analysis

H8.05

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Design and Fabrication of an Atomic Force Microscope Scan Head with Photothermal Excitation

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Abstract:
An atomic force microscope (AFM) scan head should be compact and easy to use while offering the versatility required to operate the AFM in various measurement modes. Dynamic mode AFM measurements require the use of an oscillating microcantilever. Among the methods used to oscillate AFM cantilevers, photothermal excitation is relatively easy to implement and provides clean and stable oscillations. In this work, we present our initial design and fabrication of a compact AFM scan head with physical provisions for photothermal excitation of a cantilever. A commercial scanning probe microscope (SPM) controller (Anfatec Instruments AG) is used to conduct imaging experiments with the scan head in contact mode, non-contact mode, and tapping-mode. Further development is ongoing to combine the scan head with an inverted optical microscope.

Keywords:
Atomic force microscope photothermal excitation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H9.01

Multi-space constrained-search density functional formulation for nonequilibrium quantum transport

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Abstract:

In the effort to develop advanced electronic, optoelectronic, energy, and bio devices based on functional nanomaterials, first-principles or *ab initio* simulations are playing an increasingly important role by providing atomistic information that are not easily accessible in experiments. For this purpose, a key ingredient that is still immature and should be further developed is the capability to treat non-equilibrium open junction systems under finite bias in a first-principles manner. In this talk, I will discuss the limitations of the standard nonequilibrium Green's function (NEGF) foramslim combined with density functional theory (DFT) in simulating the finite-bias nonequilibrium electronic structure in nanoscale junctions and introduce the novel multi-space constrained-search DFT (MS-DFT) formalism that we have recently developed. The MS-DFT formulation is based on, rather than the standard Landauer picture, a microcanonical picture that maps the quantum transport process to the space-resolved (drain-to-source) optical excitation one, and goes beyond the standard DFT-NEGF in several aspects. As an application example, I will consider graphene-based two-dimensional (2D) vertical heterosturcture tunneling transistors, which are a promising platform to realize next-generation "More Moore" and "More than Moore" devices [1]. An important feature of MS-DFT that differentiates it from DFT-NEGF is that it relies on the determination of *electrochemical* potentials or quasi-Fermi levels across the left electrode-channel-right electrode, which are not explicitly provided within DFT-NEGF unlike their *electrostatic* potential counterparts. Analyzing the spatial profiles of electrochemical potentials for different molecular channel cases, we extract important insights into the nature of nonequilibrium quantum transport in nanoscale devices. To the best of our knowledge, this is the first *ab initio* calculations of quasi-Fermi distributions across nanoscale junctions [2].

References
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Keywords:
first-principles calculations, non-equilibrium, quantum transport

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H9.02

DFT+DMFT method for correlated materials: choice of local orbitals and correlated subspace

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Abstract:

The development of theoretical formalism and numerical methods to simulate realistic materials with strongly correlated electrons is a central challenge. One of the successful approaches is the dynamical mean-field theory (DMFT) combined with the DFT [1]. We implemented DFT+DMFT based on OpenMX, a pseudo-atomic orbital basis DFT code [2,3]. In our implementation, hybridization function is defined over a wide range of the energy window, in which ligand orbitals, e.g., oxygen p orbitals, are included. The correlated subspace is defined by the projection method based on the natural atomic orbitals (NAOs) [4]. With this NAOs-based projector, we found that the d-p hybridization can be reasonably described. We also show that the NAOs basis provides a useful way to disentangle strongly correlated orbitals from the moderately correlated ones for which we adopt perturbative solver.

References

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Keywords:

DMFT, Natural atomic orbitals, Correlated subspace

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H9.03

An open-source software package for Slater-Koster tight-binding parameterization and calculation

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Abstract:
We introduce a newly developed open-source toolkit [1] for reliable fitting energy bands obtained from *ab initio* electronic structure calculations using two-center Slater-Koster tight-binding parameters. The new toolkit has the genetic algorithm and the Levenberg-Marquardt nonlinear least square fitting algorithm to compute various hopping parameters between any given set of atoms. Moreover, advanced material parameters such as topological invariants can be computed readily using the Wannier charge center method. Using the code, we report a new tight-binding parameter set of bulk Bi crystals up to the sixth nearest neighbor hoppings. We contrast two distinct parameter sets showing seemingly same electronic energy bands with different topological properties of bulk Bi. This highlights that the topological index or parameter needs to be treated carefully for proper parameterizations of first-principles energy bands of topological materials.

[1] H.-J. Kim, Tight-binding parameter fitting package for slater-koster method, URL *https://github.com/Infant83/TBFIT.*

Keywords:
Tight-binding approximation, Slater-Koster, Wannier charge center, Levenberg-Marquardt, Genetic algorithm, Bismuth

H9.04*

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Complex bandstructure calculation for the ferroelectric tunneling junction current

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Abstract:

Owing to the recent advances in the oxide growth technology, ferroelectricity has been stabilized even in a few nm-thick films, which makes it possible to realize the oxides-based ferroelectric tunneling junction (FTJ) governed by the quantum-mechanical tunneling phenomena. Recently, the theoretical framework has been built to predict the expecting tunneling probability in TiN/HfO_2/TiN FTJ combining with analytical approximations. However, the theoretically estimated tunneling current is extremely smaller than the experimentally reported tunneling current. Here, we will show that the effective mass of tunneling electron is more closely related to the complex band structure rather than the typical real band structure.

Keywords:

Ferroelectric Tunnel Junction, HfO2

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H10.01*

Shift of synchronized frequency of coupled oscillators induced by asymmetric dynamic interaction

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Abstract:

Interacting dynamic agents can often exhibit synchronization. It has been reported that the rhythm all agents agree on in the synchronized state could be different from the average of intrinsic rhythms of individual agents in applause and music performance like finger tapping. Hinted by such a real-world behavior of the interaction-driven change, we propose a modified version of the Kuramoto model, in which the ith oscillator of the phase ϕ_i interacts with other oscillator j only when the phase difference $\phi_j - \phi_i$ is in a limited range $[-\beta\pi, \alpha\pi]$. From numerical investigations, we conclude that the asymmetric dynamic interaction characterized by $\beta \neq \alpha$ leads to the shift of the synchronized frequency with respect to the original distribution of the intrinsic frequency. We also perform and report our computer-based synchronization experiment, which exhibits the expected shift of the synchronized frequency. In analogy to interacting runners, our result roughly suggests that agents tend to run faster if they are more influenced by runners ahead than behind. We verify the observation by using a simple model of interacting runners.

Keywords:

Coupled oscillator, Kuramoto model, Synchronization

H10.02

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Nearly synchronous clusters of symmetry-induced intertwined cluster set with parameter mismatches

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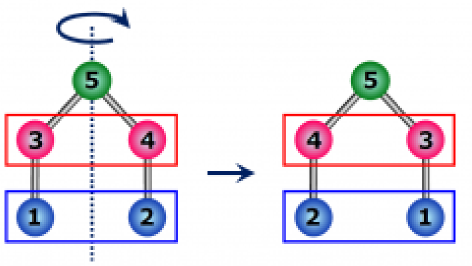
Abstract:



Cluster synchronization (CS) is a phenomenon where oscillators in a given network are partitioned into synchronous clusters. It has been recently shown that diverse CS patterns can be found using network symmetry when oscillators are identical. For a symmetry-induced CS pattern, subsets of clusters so-called intertwined clusters can exist, where every cluster in the same subset should be synchronized or desynchronized concurrently. In this work, we consider networks composed of nearly identical oscillators by reflecting the existence of noise in real systems. We show that every cluster in the same intertwined cluster set is nearly synchronized concurrently when the nearly synchronous CS of the set is stable. We also consider an extreme case where only one cluster of an intertwined cluster set is composed of nearly identical oscillators but every other cluster in the set is composed of identical oscillators. In this case, deviation from synchronous state of every cluster in the same set increase as the magnitude of parameter mismatch within the cluster of nearly identical oscillators. We confirm these results by numerical simulation.

Keywords:
cluster synchronization, symmetry, intertwined clusters

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2019-04-24 - 2019-04-26

H10.04

Dynamical Glass and Ergodization Times in Josephson Junction Chains

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Abstract:

Models of classical Josephson junction chains turn integrable in the limit of large energy densities or small Joseph-son coupling strength. Close to these limits, the Josephson coupling between superconducting grains induces a short range network. We compute distributions of finite-time averages of grain charges and extract the ergodization time which controls their convergence to ergodic delta distributions. We relate ergodization time to the statistics of the fluctuations in time of the grain charges, which are dominated by fat tails. The ergodization time grows anomalously fast upon approaching the integrable limit as compared to the Lyapunov time - the inverse largest Lyapunov exponent. The microscopic reason for the observed behavior - which we labeled dynamical glass - is rooted in a growing number of grains evolving over long time in a regular fashion due to low probability of resonant interactions with the neighboring ones. We conjecture that the observed dynamical glass is Josephson junction networks irrespective of their dimensionality.
Ref: Phys.Rev.Lett. 122 054102 (2019).

Keywords:

Nonlinear dynamics, chaos, ergodicity, glass

H10.05*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Density Resolved Wave Packet Spreading in Disordered Gross-Pitaevskii Lattices

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Abstract:

We report on the first density resolved wave packet spreading study, in the disordered Gross-Pitaevskii (GP) lattice. GP wave spreading is controlled by the two conserved quantities-energy and norm. This removes ambiguity from previous attempts and greatly improves the possibility to observe different spreading regimes. We give direct evidence for the first observation of the regime of strong chaos sub-diffusive spreading, and reconfirm the regime of weak chaos sub-diffusive spreading. We further quantify the ground state, which is impacted by the finite strength of the disorder. Close to the ground state, wave packets fragment and get trapped in a disordered phase of disconnected insulating puddles of matter. Based on our analysis, for the first time, we identify a Bose-glass phase which shows a significant slowing down of sub-diffusive spreading.

Keywords:

nonlinear dynamics, disordered nonlinear lattice, wave packet spreading, weak chaos, strong chaos, self-trapping, discrete nonlinear Schrodinger equation

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H10.06

Quantum Themalization after Quench

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Abstract:
The eigenstate thermalization hypothesis postulates the nonintegrable quantum systems are thermal in the sense that the energy eigenstate expectation value of a local observable is equal to the statistical ensemble average. Recently, it is reported that some nonintegrable systems display a nonthermal behavior after a sudden quench. We show that the nonthermal behavior is originated from the energy fluctuations introduced by the sudden quench.

Keywords:
quantum thermalization, eigenstate thermalization hypothesis, quench, energy fluctuation

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H10.07

Studying Fractional Quantum Hall Effect from Non-equilibrium Point of View

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Abstract:

Hall resistivity curve and quasi-particle energy gaps in fractional quantum Hall effect have not been reproduced theoretically. Recent experiments tell us that Hall current flows through incompressible regions formed in both edge and bulk of a Hall bar. We consider how the Hall current flows at non-equilibrium steady state and construct a model Hamiltonian which is easily diagonalizable. Then, Hall resistivity can be calculated using the obtained energy eigenvalues. In constructing the Hamiltonian, we reveal that a quasiparticle comprising an electron and its image replacing the confining potential of an incompressible strip is formed, and many-body interaction induces multi-quasiparticle correlations. Both plateau widths and energy gaps are governed by degrees of multi-quasiparticle correlation. We restrict our interest to lowest Landau level, and reproduce experimentally observed Hall resistivity and quasi-particle energy gaps for the region of filling factor less than unity.

Keywords:

fractional quantum Hall effect, Hall resistivity, quasi-particle energy gap, multi-particle correlation

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H10.08

Effects of magnetic field induced symmetry breaking in open quantum systems

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Abstract:
Controlling nonequilibrium properties of quantum systems is the key to many promising quantum technologies. Here I'll introduce the power of symmetry as a resource to manipulate quantum NonEquilibrium Steady States (NESS) [1] and elaborate on the effect of an external magnetic field to break open system symmetries. In the absence of a magnetic field the Fermionic simple cubic lattice preserves symmetries that modulate the NESS based on the symmetry decomposition of the initial state. The presence of a magnetic field breaks symmetries in preferential directions with all symmetries broken only in the presence of an anisotropic field. This preferential breaking of symmetries causes the nonequilibrium steady-state properties like currents to be manipulated by the field direction. These results demonstrate the importance of symmetry not only as an organizing principle in physics but also as a tool to control quantum systems [2].

[1] J. Thingna, D. Manzano, and J. Cao, Sci. Rep. **6**, 28027 (2016).
[2] D. Manzano and P. I. Hurtado, Adv. Phys. **67**, 1 (2018).

Keywords:
Open quantum systems, Nonequilibrium steady states, Symmetries

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

H10.09

진동하는 하모닉 포텐셜 중심에 의해 유도된 비평형 운동

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Abstract:

콜로이드 입자의 트랩 조화포텐셜의 중앙을 일정 진동수로 변화시킬 때 주기적 변화를 나타내는 비평형 상태를 조사한다. 우선 랑주뱅 방정식(Langevin Equation)을 이용하여 전산 모의실험을 진행한다. 시간에 따른 일률의 평균을 계산하고 이론 계산과 비교한다. 기존의 오일러 방법(Euler Method)에서 발생하는 이론 계산 결과와의 오차를 고차 룽게-쿠타 방법(Lunge-Kutta Method)으로 충분히 감소시킬 수 있음을 확인한다. 일의 확률분포를 구하여 일에 대한 요동정리를 확인한다. 외부 추진 진동수가 조화포텐셜의 내적인 진동수와 같을 때 정상상태에서 발생하는 일률이 최대가 되는 공명(resonance) 현상이 나타남을 확인한다. 최대 일률 공명진동수는 콜로이드 입자 진동의 최대 진폭 공명진동수와 달리 유체의 점도 계수에 무관한 점에 주목한다. 일의 공명현상에 대한 물리적인 설명을 찾고 있는 중이다.

We investigate the periodic non-equilibrium steady state of a colloid driven by an oscillation with a constant frequency of the trap harmonic potential center. We carry out the computer simulation subject to the Langevin equation. We find the average rate of work in the periodic steady state and compare it with the theoretical calculation. By using the higher-order Lunge-Kutta method, we are able to sufficiently reduce a considerable error resulted from the Euler method. We confirm the fluctuation theorem for work by computing the work distribution function. We find a resonance where the average work rate in the steady state is maximized, which occurs as the driven frequency is equal to the internal frequency of the harmonic potential. We note that the maximum-work-rate resonance frequency is independent of the viscosity coefficient of the liquid medium unlike the maximum-amplitude resonance frequency for the oscillation of the colloid. We pursue a physical explanation for the resonance phenomenon for work.

Keywords:

비평형 상태, 요동 정리, 확률 분포, 전산 모의실험, 공명

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H11.01

Electrically tunable artificial magnetic field for polaritons

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Abstract:

Neutral particles subject to artificial gauge potentials can behave as charged particles in magnetic fields. This fascinating premise has led to demonstrations of one-way waveguides, topologically protected edge states and Landau levels for photons. In ultracold neutral atoms, effective gauge fields have allowed the emulation of matter under strong magnetic fields leading to realization of Harper-Hofstadter and Haldane models. In this presentation, we show that application of perpendicular electric and magnetic fields effects a tunable artificial gauge potential for two-dimensional microcavity exciton polaritons. For verification, we perform interferometric measurements of the associated phase accumulated during coherent polariton transport. Since the gauge potential originates from the magnetoelectric Stark effect, it can be realized for photons strongly coupled to excitations in any polarizable medium. Together with strong polariton-polariton interactions and engineered polariton lattices, artificial gauge fields could play a key role in investigation of non-equilibrium dynamics of strongly correlated photons.

Keywords:

Exciton-polaritons, Quantum Optics, Artificial Gauge Potential, Semiconductor Heterostructure, AlGaAs

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H11.02*

State Tomography of Superconducting Multi-Qubits in Circuit QED

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Abstract:
It is a challenge to identify the quantum state with high fidelity as the quantum system size becomes large. The larger system size requires more parameters to be calculated and hence more measurement and more time. For example, 16 and 64 parameters are needed to express two and three qubit state in density matrix, respectively. Here each parameter is determined by the quantum state tomography (QST) after the initial state is prepared by performing simple single gate operations and/or two qubit CNOT gate. This enables us to determine the state fidelity of the given state preparation.

Keywords:
Superconducting Transmon Qubit, Multi-Qubit, Fidelity, Tomography

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H11.03

Fundamental building block for photonic scalable quantum networks

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Abstract:

Major obstacles against all-optical implementation of scalable quantum communication are photon losses during transmission and the probabilistic nature of Bell measurements causing exponential scaling in time and resource with distance. To overcome these obstacles, while conventional quantum repeaters require matter-based operations with long-lived quantum memories, recent proposals have employed encoded multiple photons in entanglement providing an alternative way of scalability. In pursuing global scale quantum networks, naturally arising questions are thus whether or not any ultimate limit exists in all-optical implementations, and whether and how it can be achieved. Motivated by these questions, we derive the fundamental limits of the efficiency and loss tolerance of the Bell measurement with multiple photons, restricted not by protocols but by the laws of physics, i.e. linear optics and no-cloning theorem. We then propose a Bell measurement scheme with linear optics, which enables one to reach both the fundamental limits: one by linear optics and the other by no-cloning theorem. The quantum repeater based on our scheme allows one to achieve fast and efficient quantum communication over arbitrary long distances, outperforming previous all-photonic and matter-based protocols. Our work provides a fundamental building block for quantum networks towards reaching the ultimate limits of all-optical scalability.

Keywords:

Quantum communication, Quantum repeater, Quantum network, Bell measurements

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H11.04*

A classical-quantum hybrid architecture for noisy intermediate-scale quantum advantage without quantum random-access memory

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Abstract:

Quantum algorithms are powerful, yet it would be impractical to enjoy full quantum speed-up in noisy intermediate-scale quantum (NISQ) computer. Most of all, many quantum algorithms are enabled by and utilizes quantum parallelism, embedding large (or 'big') classical data into quantum states. However, such a work can cost a lot of computational resources, e.g., by implementing quantum random-access memory (QRAM). Thus, here a classical-quantum hybrid architecture is considered in which the classical data can remain classical and relatively small assistant quantum devices are employed, and hence is applicable in NISQ settings without using QRAM. This approach is applied to solve a problem, called "Boolean oracle identification", with an oracle designed in the aforementioned way of hybridization. On the basis of our theoretical and numerical analysis, it is shown that the success rates of oracle query can be improved so that one is able to explore a much larger candidate space depending on the errors and problem size. This advantage also leads to much lower learning sample complexity, establishing the link to the quantum machine learning speed-up.

Keywords:

Quantum Machine Learning; Quantum Computation; Noisy Intermediate-Scale Quantum;

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H11.05

Quantifying non-Gaussianity of quantum-state correlation

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Abstract:

Non-Gaussianity, i.e., deviation from Gaussianity, is a notion of keen interest in many branches of science. Particularly for continuous variable (CV) quantum informatics, the competition between Gaussianity and non-Gaussianity has been addressed as a critical issue from fundamental and practical aspects as no-go theorems in a Gaussian regime necessitate non-Gaussian resources. To rigorously understand the role of non-Gaussianity in quantum science, it is desirable to characterize the non-Gaussianity in a quantitative manner. However, the non-Gaussianity measures proposed so far [1-5] are inadequate to characterize the correlation aspect.

In this presentation, we consider how to quantify non-Gaussianity for the correlation of a bipartite quantum state by using various measures such as relative entropy and geometric distances. We first show that an intuitive approach, i.e., subtracting the correlation of a reference Gaussian state from that of a target non-Gaussian state, fails to yield a non-negative measure with monotonicity under local Gaussian channels. Our finding clearly manifests that quantum-state correlations generally have no Gaussian extremality. We therefore propose a different approach by introducing relevantly averaged states to address correlation. This enables us to define a non-Gaussianity measure based on, e.g., the trace-distance and the fidelity, fulfilling all requirements as a measure of non-Gaussian correlation [6],

[1] M. G. Genoni, M. G. A. Paris, and K. Banaszek, Phys. Rev. A 76, 042327 (2007).
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[6] J. Park, J. Lee, S.-W. Ji, and H. Nha, Phys. Rev. A 96, 052324 (2017).

Keywords:
non-Gaussianity, mutual information

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H11.06*

Sequential state discrimination of coherent states

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Abstract:

It is well known that coherent state is an information carrier robust to a noisy environment. Hence, sequential state discrimination for coherent states can be applied to implement realistic multiparty QKD. We propose optical models that performs optimal sequential state discrimination for binary c-oherent states. Furthermore, we analyze our models in a realistic situation involving photon loss. Also, we compare our strategy with probabilistic quantum cloning strategy. We show that optimal s-uccess probability of sequential state discrimination is larger than probabilistic quantum cloning. Besides, since sequential state discrimination can be implemented using linear optics, our model is much easier to be implemented than probabilistic quantum cloning.

Keywords:

quantum state discrimination, sequential state discrimination, quantum key distribution, multiparty, coherent state, linear optics

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H11.07

Quantum secure training-data sampling

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Abstract:

Establising a new, novel, keyword "secure quantum machine learning (SQML)", here we present a protocol for the task of secure training-data sampling in which a learner would try to generate training-data samples from an oracle located at a distant place. The protocol is designed with a classical-quantum hybrid oracle which consists of a large-bit classical I/O channels and a single qubit. In analyzing the security, it is shown that any illegitimate learner can be noticed. We argue that our protocol can be realized in the noisy intermediate-scale quantum (NISQ) devices.

Keywords:

Secure Quantum Machine Learning; Quantum Machine Learning; Quantum PAC learning

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H12.01

Development of sensitive radon detector for KNO

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Abstract:
There has been interesting development of a high sensitivity Rn detector for KNO (Korea Neutrino Observatory). One of major backgrounds in the water Cherenkov detector such as KNO is produced by the radon dissolved in the water. Radon emanating from surrounding rocks contaminates water and air of the detector. A precise measurement of radon concentration in air and water is necessary for lowering the energy threshold. We have designed and assemble the high sensitive radon detector. In this presentation, we report the status of the detector development and its calibration.

Keywords:
randon detector, Korea Neutrino observatory, low energy background, cherenkov

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H12.02

Development of low threshold light detectors for a rare event experiment

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Abstract:

Low-temperature detectors (LTD) are developed to observe the low energy of phonons at mK temperatures. LTDs improve the detection sensitivity for rare events, such as direction dark matter detection or neutrinoless double beta decay. They can be implemented for simultaneously measurement of heat and light signals by measuring excess phonons in the target material and scintillation light. The light (photon) signals can be measured by additional light detector composed of a Si or Ge wafer and a sensitive temperature sensor. Based on different quenching in scintillating procedure, the events types can be identified enabling an efficient background rejection capability. The light signals are normally much smaller than the phononic ones because only small portion of total deposit energy convert to scintillation photons in a scintillating crystal. Using the Neganov-Luke amplification may improve the light-detection threshold when using a semiconductor wafer as an absorber in light detection. The signals can be amplified by applying an electric potential across the wafer.

We developed a Neganov-Luke amplification light detector connected to metallic magnetic calorimeter (MMC) served as a sensitive thermometer. In this talk, measured low temperature ($<$ 40 mK) characteristics of one of the surface electrode type and the PIN diode type of 1 cm^2 light detector with phonon amplification by Neganov-Luke effect. In this light detector, the electron-hole pairs generated by light absorption in silicon drift toward the electrodes while creating Luke phonons. A phonon collector film evaporated on the back side of the wafer is thermally connected to a thermometer. Clear amplification on the light signals was measured with a voltage applied to the electrodes without change on heat signals.

Keywords:
Low temperature detector, Direct dark matter detection experiments, Neganov-Luke effect, light detector

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H12.03

A search for the rare decay of ^{180m}Ta using an array of fourteen HPGe detectors

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Abstract:

^{180m}Ta is an isomer of tantalum with a natural abundance 0.012%, and its formation is particularly an interesting part of the nucleosynthesis puzzle. It is the rarest stable nuclide in nature and the only effectively-stable excited nuclear state. However, an upper limit on the half-life of ^{180m}Ta is reported, because its decay has never been observed.

We recently conducted an experiment to measure the half-life of ^{180m}Ta using the HPGe array system, which has been constructed and is operating at the Yangyang underground laboratory by the IBS Center for Underground Physics. The setup and analysis result of the experiment will be reported in this presentation.

Keywords:
HPGe detector, 180mTa

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H12.04

The pilot phase of the Advanced Mo-based Rare process Experiment and its background modeling

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Abstract:

The Advanced Mo-based Rare Process Experiment (AMoRE) campaign is a search for neutrinoless double beta decay of Mo-100 in calcium molybdate ($CaMoO_4$) crystals using cryogenic detectors at tens of millikelvin temperature. Commissioning runs with six $CaMoO_4$ crystals with a total mass of 1.9 kg have operated at the Yangyang underground laboratory the last few years as the pilot phase (AMoRE-pilot). In order to identify possible background sources, background measurement results of recent commissioning runs were compared with Monte Carlo simulations of radioactive sources in materials, of gammas from rocks, and of gammas from neutrons. Throughout the runs, we achieved reductions of background levels by replacing detector components and adding the neutron shield. In this presentation, the AMoRE-pilot status and background data modeling will be presented.

Keywords:

Neutrinoless double beta decay

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H12.05

Metallic magnetic calorimeter optimization for AMoRE experiment

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Abstract:
Metallic Magnetic Calorimeter (MMC) is used in the AMoRE (Advanced Mo-based Rare-process Experiment) project, which is an international experiment aimed at searching for the neutrinoless double-beta decay of ^{100}Mo. This MMCs are developed as a high sensitivity low temperature thermometer for heat and light detection from scintillation crystal with dc-SQUID for reading its signal. A light detector measure the phonon from light absorbing in 2-inch Ge wafer and a heat detector measure the phonon from the Incident energy in target crystal, $CaMoO_4$.
The current version of MMCs in light detection showed a nice performance, temperature independent rise time, a good energy resolution, 545 eV of FWHM with ^{55}Fe source, and 87 eV and 30 eV of RMS noise at 40mK and 10 mK respectively. In this talk, we introduce the heat and light detector and how we achieve these performance. And also discuss about the MMC optimization for improved MMCs in sensitivity and detection time of light detector for AMoRE project.

Keywords:
Low temperature detector, light detector, AMoRE(Advanced Mo-based Rare-process Experience), MMC(Metallic Magnetic Calorimeter)

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H12.06

Background study of AMoRE-pilot detector

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Abstract:

AMoRE (Advanced Mo-based Rare process Experiment) is an experiment, searching for neutrinoless double beta decay of Mo-100. A pilot experiment, AMoRE-Pilot, has operated with six 40Ca100MoO4 (CMO) crystals of total mass ~1.9 kg, in a low-temperature cryostat at the Yangyang Underground Laboratory (Y2L), with a minimum overburden of 700 m. Recent two major improvements of configuration have taken place to reduce the background level of the experiment. The first one is replacements of detector components with high radio-activities. The second is installation of polyethylene (PE) blocks were installed outside of the muon detectors together with borated rubber sheets inside the muon counters and outside of the lead shield to reduce external neutron backgrounds. We will present the studies of backgrounds of the detector before and after improvements.

Keywords:

neutrino, beta decay, neutrinoless, background, crystal

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H12.07*

Detector Design for AMoRE-I

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Abstract:
Advanced Mo-based Rare process Experiment (AMoRE) is an international collaboration project to search for neutrinoless double beta decay ($0\nu\beta\beta$) of ^{100}Mo using Molybdenum-based crystals. AMoRE aims at operating the detector in zero-background condition to maximize the sensitivity. As the Pilot phase of AMoRE, we completed several consecutive runs in which many background sources have been identified and reduced. Currently, we plan to upgrade the detector system for AMoRE-I, the next phase experiment of the project which will host 18 molybdate crystals with a total mass of about 6 kg. We present the design details and concerns of AMoRE-I operating at milli-Kelvin temperatures.

Keywords:
Neutrinoless double beta decay, AMoRE, Detector

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H12.08

Stabilization heater for AMoRE

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Abstract:
AMoRE (Advanced Mo-based Rare process Experiment) is a large-scale low temperature detector to search for neutrinoless double beta decay (0νββ) of 100Mo. The project employs MMC readouts for simultaneous phonon-scintillation detection from scintillating crystals containing 100Mo elements. Because heat capacities of the detector components and MMC sensitivity vary with temperature, signal amplitudes drift over a long time period as the base temperature fluctuates. This effect degrades the energy resolution of the calorimetric detection at low temperatures. By installing a Joule heater attached to the detector to inject periodic and controlled amount of heat, we produce reference signals that can be used for gain stabilization. We report on the fabrication and the characterization of Joule heaters together with test results for AMoRE application.

Keywords:
AMoRE, Stabilization heater, MMC

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H12.09*

Analysis upgrade for AMoRE-Pilot runs.

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Abstract:
Advanced Molybdenum-based Rare-process Experiment (AMoRE) searches for neutrinoless double beta decay($0\nu\beta\beta$) of Mo-100 using scintillating crystals through simultaneous detection for phonon and scintillation signals at milli-kelvin temperatures. The AMoRE project aims to run the detector at zero-background to maximize the detection sensitivity. It is essential to identify and minimize the background sources. In the presentation, we summarize a series of Pilot runs with their background levels and sensitivities. We also present the analysis tools and results on the Pilot runs.

Keywords:
AMoRE

H13.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Drell-Yan differential cross section measurement at 13 TeV

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Abstract:
Measurements of the differential and double differential cross sections for the Drell-Yan process in the dilepton channels are presented. They are based on proton-proton collision data at 13 TeV recorded with the CMS detector at the LHC. In addition to the differential cross section measurement performed on the data corresponding to an integrated luminosity of 2.8 (2.3) fb^{-1} in the dimuon (dielectron) channel, the study of the double differential cross section measurement based on full 2016 dataset with 35.9 fb^{-1} integrated luminosity is also discussed including background estimation and various corrections.

Keywords:
Drell-Yan, cross section, CMS

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H13.02

Search for flavor-changing neutral current interaction of the top quark and the higgs boson decaying into bb bar at sqrt[s] = 13 TeV with CMS Run2 data

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Abstract:
In this presentation, the results of searching for Higgs-mediated flavor-changing neutral current interaction of top decay modes are presented. Large Hadron Collider (LHC) has accumulated proton-proton collision data corresponding to an integrated luminosity of 140 fb^{-1} at a center-of-mass energy of 13 TeV with the CMS detector during Run2. Using these datasets, the search is performed with the events of the final state of one lepton, three jets, and two b jets.

Keywords:
flavor changing neutral current, Higgs boson, top quark

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H13.04*

A study of initial state radiation on the Drell-Yan events at sqrt(s) = 13 TeV

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Abstract:

We present a study of initial state radiation (ISR) on the Drell-Yan events from pp collision at LHC with sqrt(s) = 13 TeV, 35.9 fb-1 CMS data. ISR from hardron collisions plays an important role in the jet physics, which has an impact on the precision measurements and searches for new physics. We develope a systematic way to study the ISR effect using the dielectron and dimuon channel of the Drell-Yan events. The truncated mean of the dilepton transverse momentum distribution is found to have a logarithmic slope as a function of dilepton invariant mass square. This logarithmic slope can be used to control ISR effect in the SM processes and new physcis processes.

Keywords:

CMS Standard Model

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H13.05*

Measurement of the top-quark mass in $\bar{t}t$ events with semi leptonic channel at CMS

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Abstract:

The measurement of the top quark mass by using charmed mesons within b-quark jet is known as an alternative solution. We measured the top quark mass by using a sample of tt candidate events with one electron or muon and at least four jets in the final state. This method can reduce the jet energy uncertainties, because it does not use the jet energy measurement when extracting the top quark mass. During the selection of charmed mesons, machine learning was used to improve the effectivity.

Keywords:
top quark mass, deep learning

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Search for excited leptons in llɣ final states in proton-proton collisions at the HL-LHC

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Abstract:

A search for excited leptons (electrons and muons) is presented, using simulated samples of the upgraded CMS detector under the High-Luminosity LHC (HL-LHC) at a center of mass energy of 14 TeV and corresponding to an integrated luminosity of 3 /ab. Excited leptons are predicted by many theories beyond the standard model (SM) where quarks and leptons are not elementary but instead are made of more fundamental constituents. Excited leptons ($l^* = e^*, \mu^*$) in llɣ ($l = e, \mu$) final states where the excited lepton decays to a SM lepton and a photon ($l^* \rightarrow l\gamma$) are studied. The analysis is optimized for HL-LHC conditions and allows for an extension of the discovery potential for excited leptons. This presentation indicates that 5σ discovery of excited leptons is possible for masses up to 5.1 TeV and excited leptons with masses below 5.8 TeV could be excluded at 95% confidence level.

Keywords:

excited lepton, HL-LHC

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H13.07

Search for RPV SUSY at CMS

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Abstract:

Results from a search for physics beyond the standard model in proton-proton collisions at a center-of-mass energy of $\sqrt{s}$ = 13 TeV will be discussed. The search uses a signature of a single lepton, large jet and bottom quark jet multiplicities, and high sum of large-radius jet masses, without any requirement on the missing transverse momentum in an event. The data sample corresponds to an integrated luminosity of 35.9 fb^{-1} recorded by the CMS experiment at the LHC. No significant excess beyond the prediction from standard model processes is observed. The results are interpreted in terms of upper limits on the production cross section for R-parity violating supersymmetric extensions of the standard model using a benchmark model of gluino pair production, in which each gluino decays promptly via $\tilde{g} \rightarrow tbs$.

Keywords:
SUSY, RPV, CMS, LHC

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H13.08*

Search for a right-handed W and a heavy neutrino at 13 TeV using CMS detector

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Abstract:
We present the status of search for a right-handed W and a heavy neutrino which is based on the left-right symmetric model. The final objects are 2 leptons and jets where jets are both decay particles of heavy neutrino. For cases where the mass of right-handed W and that of heavy neutrino have a big difference, heavy neutrino is likely to get boosted and as a result, merged topology can be observed. For Run 2 analysis, we focus on the cases where heavy neutrino's decay products are merged together.

Keywords:
CMS, LHC, heavy neutrino, left-right symmetry

H13.09*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Search for heavy neutrinos and Z' with the dilepton plus jets channel with CMS at 13 TeV

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Abstract:
We present a status of search for heavy majorana neutrinos (N) and an additional neutral gauge boson (Z') based on the left-right symmetric
(LRS) extension of the Standard Model (SM).
Not only for the opened question about source and mechanism for masses of neutrinos established by discoveries of neutrino oscillations, the see-saw mechanism and LRS extension of the SM can also provide answers for matter/anti-matter asymmetry and left handedness of the universe.
The analysis is targeting to search for pair production of N via Z' while each N decays into a lepton and two jets.
For the cases when m(Z') >> m(N), decay products from boosted N merge. Handling this kind of boosted signature is the most important part of the analysis to have good searching sensitivity over all phase space on m(N) VS m(Z') plane.
The search is being performed using data taken by the CMS during 2016 and 2017 from proton-proton collision of LHC at 13 TeV of center of mass energy which is corresponding to 35.9 /fb and 41.3 /fb of data respectively.

Keywords:
CMS, LHC, heavy neutrino, LRSM

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H14.01*

Performance Status and e/p Separation of Top and Bottom Counting Detectors of CREAM Experiment at the International Space Station

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Abstract:

Cosmic Ray Energetics And Mass for the International Space Station (ISS-CREAM) is an experiment for investigation of high-energy cosmic rays. The ISS-CREAM instrument was launched on 14th of August 2017 to ISS aboard the SpaceX-12 Dragon spacecraft. The Top and Bottom Counting Detectors (TCD/BCD) are parts of the ISS-CREAM instrument and designed for studying the physics of cosmic electrons and gamma-rays. The TCD/BCD can separate electrons from protons by utilizing the shape difference between electromagnetic and hadronic showers in the high energy region. We checked the status of TCD/BCD from launching to Jan. 2019. The 85% channels of TCD/BCD are working well. The TCD/BCD show less noise signal measured on the ISS than measured in the ground test. We used Monte Carlo simulation data from 100 GeV electron with -3.0 spectral index and from 300 GeV proton with -2.7 spectral index for studying e/p separation. In this presentation, we will present the performance status and e/p separation capability of TCD/BCD on the ISS.

Keywords:

ISS-CREAM, TCD/BCD, e/p separation, Cosmic rays

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H14.02*

Multi-channel YSO scintillator crystals for the application of low energy X-rays detection in space

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Abstract:

We developed an X-ray detector which consisted of 36-multi-channel Yttrium OxyorthoSilicate (Y_2SiO_5: Ce,YSO) scintillator crystals and 36-Multi-Anode PhotoMultiplier Tubes(MAPMTs) to observe Gamma-ray bursts(GRBs). The reason for choosing YSO scintillator crystal is that it has several advantages in X-ray detection compared to other scintillators. First, it has no intrinsic backgrounds which are crucial to detecting low energy X-rays. Next, it has high light yield and fast decay time. We applied the YSO scintillator crystal X-ray detector to the space mission, which is called Ultra-Fast Flash Observatory (UFFO) /Lomonosov, launched into space on Apr. 2016. Unfortunately, this mission was stop but we confirmed that its stable operation in space to detect X-rays and its low energy sensitivity in ground by 2nd set. We will present its performances on the detection of low energy X-rays and its possibility to observe high red shift GRBs in the future space mission.

Keywords:

X-ray detector, Low energy x-ray detection, YSO, Scintillator crystal

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H14.03

Cosmic-ray charge and energy measurement with ISS-CREAM

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Abstract:
The Cosmic Ray Energetics And Mass experiment for the International Space Station (ISS-CREAM) is a direct cosmic-ray detection experiment on the ISS. It aims to reveal the source, acceleration, and propagation of cosmic rays by observing individual elemental spectra at energies in the TeV - PeV range. The ISS-CREAM measures cosmic-ray charges from protons to iron nuclei with a charge resolution of 0.1 - 0.3e using the Silicon Charge Detector. It also measures the cosmic-ray energy by sampling the shower energy deposit of incident particles with the Calorimeter. We present the preliminary analysis results of the cosmic-ray charge and energy measured with the ISS-CREAM.

Keywords:
cosmic ray, ISS-CREAM, International Space Station

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H14.04*

On-orbit performance and charge measurement on the ISS-CREAM SCD

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Abstract:
The Cosmic Ray Energetics And Mass for the International Space Station (ISS-CREAM) experiment is designed for precision measurements of energy spectra and elemental composition of cosmic rays. It was launched and installed on the ISS in August 2017. The Silicon Charge Detector (SCD), placed at the top of the ISS-CREAM payload, consists of 4 layers with a total of 10,752 silicon pixels which have 1.37 x 1.57 cm^2 size each. The ISS-CREAM SCD 4-layer configuration was chosen to achieve the best precision in measuring the charge of cosmic rays from proton to iron nuclei with a charge resolution of 0.1 - 0.3e. We will present its on-orbit performance and preliminary charge analysis on the ISS-CRAM SCD.

Keywords:
cosmic ray, ISS-CREAM, SCD

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H14.05*

Deploying Surface Detectors for the Telescope Array x4 experiment to study of UHECR

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Abstract:

The Telescope Array(TA) experiment has observed the energy spectrum and anisotropy of Ultra High Energy Cosmic Rays(UHECRs) since 2009 from hybrid detection of Fluorescence Detectors(FDs) and Surface Detectors(SDs). TAx4 was suggested to broaden detection area 4 times by increasing the number of SDs. 260 SDs have been built in Japan and Korea, and assembled with battery, electronics and antena for the data acquisition in Utah. Finaly, the deploy has been done from Jan. to Mar. of this year. We will present here the Korean activities for the deploy of SDs and expected improvement of TAx4.

Keywords:
Cosmic Ray, Ultra High Energy Cosmic Ray, UHECR, Telescope Array, TAx4

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H14.06

새로운 중력파 검출을 위한 이론적 계산 III

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Abstract:
현재 구상 중인 새로운 형태의 우주 실험 중력파 검출장치의 설계와 관련하여, 이 장치를 pulsar timing array (PTA) 실험에 응용할 경우, 중력파 검출에 대한 response function 및 sensitivity curve와 아울러 해당 중력파원에 따른 characteristic strain 등을 이론적으로 계산하여 보이고자 한다. 2018 봄, 가을 물리학회 발표에 이은 후속 연구에 관한 보고이다.

Keywords:
중력파, pulsar timing array, response function, sensitivity curve, characteristic strain

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H14.07*

Search for Energy Spectrum Anisotropy of Ultra-high Energy Cosmic Rays in Equatorial Coordinates with Telescope Array Surface Detector

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Abstract:
The Telescope Array (TA) is an experiment to observe the Ultra-high energy cosmic rays (UHECRs) located in Utah, USA, operating since 2008. TA investigates the extensive air showers that occur when UHECRs enter the atmosphere by using Surface Detector (SD) array and Fluorescence Detector (FD). If there are point sources like Hot Spot which reported by TA, the energy spectrum around the source direction can differ from that of other areas. We study energy spectrum anisotropy of UHECRs on Field of View (FOV) of TA, using 9-years data of TASD. The FOV of TA in the equatorial coordinates was scanned with a circle with fixed angular size, The energy spectrums of events inside the circles were fitted with 4 parameters of broken power-law spectrum. The break points of these energy spectrums from small FOV were compared with that of the energy spectrum from full FOV and the probability observing the energy spectrums from small FOV was computed to identify whether there is an energy spectrum anisotropy of UHECRs or not.

Keywords:
Telescope Array, Cosmic rays, Anisotropy, Energy Spectrum

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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H14.08

Trajectories of ultra-high-energy cosmic rays in the magnetized cosmic web

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Abstract:
An excess of ultra-high-energy cosmic ray (UHECR) events, so-called a hotspot, was observed by the Telescope Array experiment, but the origin has not yet been explained. We proposed that the magnetized cosmic web of the local universe could be responsible for it, suggesting a model that UHECRs, produced inside the Virgo cluster, are confined by the cluster magnetic fields for some time and then escape to and propagate along the filaments of galaxies attached to the cluster. We further explored the model by calculating the trajectories of UHECRs in the simulated cosmic web of clusters and filaments of galaxies. In this presentation, we describe the first results and discuss the implications.

Keywords:
ultra-high-energy cosmic rays, cosmic web, magnetic fields

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H15.01

Terahertz Electrodynamics of Superconducting Nb Films in External Magnetic Field

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Abstract:

We studied the terahertz electrodynamical properties of niobium (Nb) thin films under a magnetic field applied parallel and perpendicular to the film surface at 1.5 K. The optical conductivity was extracted from the transmission coefficient by using terahertz time-domain spectroscopy. The magnetic field dependent superconducting gap was determined from the real conductivity data. The penetration depth was also obtained from the imaginary conductivity. Superconducting Nb thin films indicate different behaviors for in-plane and out of plane magnetic fields.

Keywords:

Superconductivity, Niobium, Terahertz Spectroscopy

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The influence of strain on the superconducting transition in Nb films

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Abstract:

A niobium (Nb) thin film was deposited on a silicon (Si) substrate using a DC magnetron sputtering system and the film thickness was controlled by changing the deposition time. As the film thickness decreases, 2θ of the Nb (110) peak moves at an angle lower than the angle of the uniform bulk Nb, which exhibits the same effect as increasing the strain of the Nb films. The uniform strain caused by the lattice mismatch between the Nb and the substrate lowers the superconducting critical temperature (T_c). To find the strain effect on T_c, we performed the theoretical calculation of electron-phonon coupling for different in-plane lattice constant. Both compressive and tensile strain lower the T_c, the main cause of which is a reduction in density of states (DOS).

Keywords:

Niobium thin films, Strain effect

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H15.03

Thermally activated phase slips in spin-triplet superconducting wires

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Abstract:

When large current is injected into superconducting thin wire, the Langer-Ambegaokar-McCumber-Halperin theory explains that energy cost of uniform phase winding can be saved by *phase slips*, the jumps of the phase winding along the wires by 2π. In the spin-triplet superconducting wire, the picture is complicated by the spin-ordering of the Cooper pairs, parametrized by the d-vector. In this case, the spin current bias can induce phase slips in the d-vector; in addition, either the spin current or the charge current bias can induce *half* phase slips in both the superconducting phase and the d-vector. We demonstrate here that when the easy-plane spin-triplet superconducting thin wire is biased by a spin-polarized current, there will be both the voltage drop and the spin torque along the wires and the dominant phase slip mechanism will be determined by the spin-polarization.

Keywords:

spin-triplet superconductor, thin superconducting wire, spin current

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H15.04

Edge currents as a probe of the strongly spin-polarized topological noncentrosymmetric superconductors

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Abstract:

Recently the influence of antisymmetric spin-orbit coupling has been studied in novel topological superconductors such as half-Heusler compounds and artificial heterostructures. We investigate the effect of Rashba and/or Dresselhaus spin-orbit couplings on the band structure and topological properties of a two-dimensional noncentrosymmetric superconductor. For this goal, the topological helical edge modes are analyzed for different spin-orbit couplings as well as for several superconducting pairing symmetries. To explore the transport properties, we examine the response of the spin-polarized edge states to an exchange field in a superconductor-ferromagnet heterostructure. The broken chiral symmetry causes the unidirectional currents at opposite edges. We propose the existence of a substantial charge current parallel to the interface between a noncentrosymmetric superconductor and a metallic ferromagnet. Our analysis focuses upon two complementary orbital-angular-momentum pairing states of the superconductor, exemplifying topologically nontrivial states which are gapped and gapless in the bulk, respectively. We derive an expression for the interface current a long with a systematic study of the current considering the qualitative differences between the gapped and gapless superconductors, which reflect the very different underlying topological properties. We argue that the interface current provides a novel test of the topology of the superconductor, and discuss prospects for the experimental verification of our predictions.

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Keywords:
Topological superconductivity, Noncentrosymmetric superconductors, Spin-orbit coupling, Helical edge modes, Chiral edge modes

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H15.05

Mixed-pairing superconductivity in 5d Mott insulators with antisymmetric exchange

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Abstract:

We study the symmetry of the potential superconducting order parameter in 5d Mott insulators with an eye toward hole-doped Sr_2IrO_4. Using a mean-field method, a mixed singlet-triplet superconductivity, d+p, is observed due to the antisymmetric exchange originating from a quasi-spin-orbit coupling. Our calculation on ribbon geometry shows the possible existence of the topologically protected edge states, because of the nodal structure of the superconducting gap. These edge modes are spin polarized and emerge as zero-energy flat bands, supporting a symmetry-protected Majorana state, verified by evaluation of the winding number and Z_2 topological invariant.

Keywords:

strontium iridate, mixed singlet-triplet superconductivity

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H15.06*

Topological d+s wave superconductors in a multi-orbital quadratic band touching system

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Abstract:

We consider the interacting Luttinger model, where j=3/2 multi-orbital electrons form a quadratic band touching at the Brillouin zone center. [1-3] We consider a realistic situation of finite chemical potential, which induces breaking of the particle-hole symmetry. Performing exact decoupling of electron interactions into pairing channels, we adopt the Landau theory of complex tensor order parameters including both s-wave and d-wave pairings, and study the Landau free energy functionals in terms of invariants under SO(3) symmetry. [1] Remarkably, in the absence of particle-hole symmetry, the system energetically favors particular d-wave superconducting states where subdominant s-wave pairing is always accompanied; (i) uniaxial nematic phase with subdominant s wave pairing (d(3z2-r2)+s), where time-reversal, inversion and rotational symmetry along z direction are preserved. (ii) time-reversal-symmetry broken phase with subdominant s wave pairing (d(3z2-r2,xy)+id(x2-y2)+s), where only inversion and two-fold rotation along z axis are preserved. Both of these superconductors have gapless Bogoliubov quasiparticles and furthermore have topological invariants for each nodal line or Bogoliubov Fermi pocket and related surface states.[4,5]

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Keywords:
Topological superconductors, Multi-orbital system, Interacting Luttinger model, Landau theory

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H15.07*

Superconducting Sr_2RuO_4 thin film grown by pulsed laser deposition

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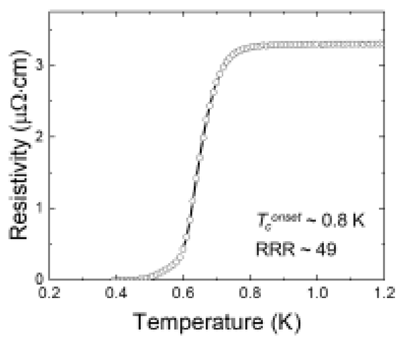
Abstract:

The layered perovskite superconductor Sr_2RuO_4 (bulk T_c ~ 1.5 K) has been studied intensively since it is considered as a strong candidate for *p*-wave superconductor with chiral gap function ($p_x \pm ip_y$) [1,2]. The possible topological superconductivity of Sr_2RuO_4 are interesting with not only the physical advances, but also providing fruitful device application such as quantum-computing circuits [3]. In this respect, Sr_2RuO_4 thin film has been highly required in order to enable Josephson junction for revealing odd-parity of Sr_2RuO_4 as well as realizing micro-fabricated devices. However, superconducting Sr_2RuO_4 film growth has been limited since the superconductivity of Sr_2RuO_4 is extremely vulnerable to structural impurity and stoichiometry. Especially, the Ru stoichiometry plays a crucial role to the superconducting transition temperature (T_c) of Sr_2RuO_4 film [4].



In this presentation, we will explain our superconducting Sr_2RuO_4 films growth by pulsed laser deposition (PLD) technique. To compensate the Ru loss during the growth, we used $Sr_3Ru_2O_7$ as a PLD target. We succeed to achieve epitaxial Sr_2RuO_4 films with high crystallinity, confirmed by synchrotron X-ray diffraction and transmission electron microcopy. Our Sr_2RuO_4 film exhibits superconductivity up to 0.8 K, which is comparable to the previously reported superconducting Sr_2RuO_4 films. Our work suggests a new method to obtain superconducting Sr_2RuO_4 film by PLD.

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Keywords:
superconductivity, Sr2RuO4, thin film, pulsed laser deposition

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H15.08*

Microscopic Mechanism of Room-Temperature Superconductivity in Compressed LaH_{10}

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Abstract:

Room-temperature superconductivity has been one of the most challenging subjects in modern physics. Recent experiments reported that lanthanum hydride LaH_{10}±x (x <1) raises a superconducting transition temperature T_c up to ~260 (or 250) K at high pressures around 190 (170) GPa. Here, based on first-principles calculations, we reveal that compressed LaH_{10} has the symmetry-protected Dirac-nodalline states, which split into hole-like and electron-like bands at the equivalent high-symmetry points near the Fermi energy (E_F), thereby producing a van Hove singularity (vHs). The crystalline symmetry and the band topology around the high-symmetry points near E_F are thus demonstrated to be important for room-temperature superconductivity. Further, we identify that the electronic states at the vHs are composed of strongly hybridized La *f* and H *s* orbitals, giving rise to a peculiar characteristic of electrical charges with anionic La and both anionic and cationic H species. Consequently, a large number of electronic states at the vHs are strongly coupled to the H-derived high-frequency phonon modes that are induced via the unusual, intricate bonding network of LaH_{10}, therefore yielding a high T_c. Our findings elucidate the microscopic mechanism of the observed high-T_c BCS-type superconductivity in LaH_{10}, which can be generic to another recently observed high-T_c hydride H_3S.

Keywords:

Superconductivity, Dirac nodal line, van Hove singularity,

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H15.09*

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Superconducting properties of the high entropy alloy superconductor $Ta_{1/6}Nb_{2/6}Hf_{1/6}Zr_{1/6}Ti_{1/6}$

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Abstract:

We report the superconducting properties of the new composition of high entropy alloy (HEA) superconductor, $Ta_{1/6}Nb_{2/6}Hf_{1/6}Zr_{1/6}Ti_{1/6}$. We had synthesized the HEA by arc melting and confirmed the body-centered cubic structure with lattice parameter a=3.38 Å by XRD measurement. The electrical transport, magnetization, and specific heat measurement reveal that $Ta_{1/6}Nb_{2/6}Hf_{1/6}Zr_{1/6}Ti_{1/6}$ is a type Ⅱ bulk superconductor. We obtained the superconducting parameter such as the critical temperature ($T_c \approx 7.85$ K), the zero-temperature limit upper critical field, coherence length, lower critical field, specific heat jump $\Delta C/\gamma T_c$, and the critical current density J_c. The J_c estimated from the M-H curve using the Bean model and the superconductivity gap estimated from a specific heat jump. The normalized flux pinning force density $f_p(h)$ curves are well fitted using the double exponential model. This is significant data because of the first $J_c(H)$ and $f_p(h)$ value reported in HEA materials.

Keywords:

superconductivity, hight entropy alloy, critical current density

I1.01*

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Synthesis of $MoWS_2$ on Flexible Carbon-Based Electrodes for High-Performance Hydrogen Evolution Reaction

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Abstract:

We report the direct synthesis of $MoWS_2$ nanosheets on conductive carbon nanotube yarn ($MoWS_2$/CNTY) and carbon fiber cloth ($MoWS_2$/CC) through a fast and low-temperature thermolysis method, in order to fabricate flexible catalyst-electrodes for high performance in the hydrogen evolution reaction. Small Tafel slopes of 41.8 and 46.7 mV dec^{-1} are achieved for $MoWS_2$/CC and $MoWS_2$/CNTY, respectively, by optimizing the density of exposed active edge sites of vertically aligned $MoWS_2$ on CNTY and CC. Furthermore, the catalyst-electrodes show good electrocatalytic stability over 36 h. The results of this study illustrate a more accessible and faster process to fabricate high-performance, binder-free, and flexible catalyst-electrodes compared to conventional methods.

Keywords:

electrocatalysts, hydrogen evolution reaction (HER), molybdenum tungsten disulfide (MoWS2), carbon nanotube yarns, carbon cloths

I1.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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기계적 에너지 수확용 에틸 셀룰로오스/MWCNTs 기반 마찰 전기 나노 발전기

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Abstract:
마찰 전기 나노 발전기 (Triboelectric nanogenerator: TNG)는 다양한 휴대용 전자 장치의 구동 및 자체 전원 공급을 위해 기계 에너지를 전기로 변환하는 유망한 기술 중 하나이다. 일반적으로 TNG의 전기 출력 성능은 플라즈마 처리, 특수 구조의 에칭, 적절한 마찰 전기 접촉 쌍 및 화학적 기능화에 의한 표면 개질에 의해 향상되지만 이러한 방법은 대규모 생산을 위해 다소 복잡하고 구현하기가 어렵다. 이러한 문제를 피하기 위해 multi-walled carbon nanotubes embedded 에틸 셀룰로오스 (에틸 셀룰로오스 /MWCNTs) 복합 필름으로 설계된 유연한 TNG를 성공적으로 시연했으며 MWCNTs를 사용한 복합 필름의 내부 저항을 최적화하여 상당한 출력 성능을 달성했다. TNG의 출력 성능에 대한 복합막 두께 및 MWCNTs 비의 발전 메커니즘 및 효과가 연구되었다. 이 소자는 또한 장기간 pushing cyclic 동작에 대한 심각한 degradation없이 안정한 전기적 출력을 나타냈다.

Keywords:
에틸 셀룰로로스, 탄소나노튜브, 나노 발전기

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I1.03

리튬 이온 배터리용 SnO_2/탄소 복합재의 합성

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Abstract:

최근에, 3차원 플렉서블 전극은 우수한 기계적 특성 및 전기 화학적 특성으로 인해 리튬이온 배터리 (lithium-ion batteries)에 큰 관심을 끌고 있다. 여기에서, 우리는 한 단계의 solvothermal 방법을 통해 3차원 SnO_2/탄소 섬유 복합체를 고안하였다. 탄소 섬유상의 SnO_2 나노 구조의 균일한 분포는 주사형 전자 현미경 및 투과 전자 현미경 측정에 의해 확인되었다. 새로 설계된 3차원 네트워크 SnO_2/탄소 섬유 복합 구조는 리튬이온 배터리를 위한 매우 유연하고 바인더 없는 양극으로 사용될 수 있다. 3차원 SnO_2/탄소 섬유 복합 전극은 현저한 속도 능력으로 100 사이클 후에 우수한 가역 용량을 보였다. 얻어진 우수한 전기 화학적 결과는 새롭게 설계된 3차원 SnO_2/탄소 섬유 복합 전극이 고성능 리튬이온 배터리를 위한 잠재적인 양극 재료임을 시사한다.

Keywords:

SnO2, 탄소, 리튬이온 배터리

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I1.04

Ultrafast Energy Transfer Dynamics in Conjugated Polymer and Dyes-labeled Aptamer Complex

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Abstract:

Förster resonance energy transfer-based optical sensing is of interest in various optical sensor applications due to the potential for energy harvesting and a broad view of molecular dynamics as a spectroscopic ruler.[1] Recently, we have demonstrated high sensitive detection array photo-sensitizing potassium ion (K^+) based on Förster resonance energy transfer.[2] As a successive study to quantitatively understand the energy transfer process in conjugated polymer and two dyes (6-Carboxyfluorescein (6-FAM) and 6-carboxytetramethylrhodamine (6-TAMRA))-labeled aptamer complex, we have investigated the fluorescence decay dynamics in terms of the

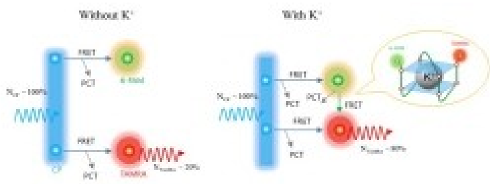

Figure 1. Two-step resonance energy transfer mechanism in conjugate polymer and two-dyes-labeled aptamer complex in the absence and the presence of potassium ion (K^+).

exciton population and energy transfer efficiency. In the presence of K^+ ion, the fluorescence intensities of conjugated polymer and 6-FAM were significantly quenched compared to that of the complex without K^+ ion. The fluorescence decay curve was also changed from single exponential to multi-exponential shape. However, the fluorescence decay time of TAMRA never changed regardless of the presence of K^+ ion, while the fluorescence intensity was four-folded enhanced. In particular, the transient fast energy transfer efficiency (~ 300 %) occurs within ~ 0.5 ns and the steady transfer efficiency (~ 230 %) remains afterward. Therefore, we found that the conformational change due to the G-quadruplex secondary structure with guanine (G)-rich aptamer provides a new decay pathway for the efficient two-step resonance energy transfer (Figure 1).

References

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Keywords:
FRET, Time-resolved PL, Energy harvesting

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I1.05*

Physics of band offsets at $Cu(In,Ga)Se_2/Zn(O,S)$ interfaces with variable elemental ratio

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Abstract:
Chalcogenide $Cu(In,Ga)Se_2$ (CIGS) compound have been studied for several decades as a light absorber material for thin-film solar cells. Though CIGS-based thin-film solar cells have recently gained high power conversion efficiency (PCE) of nearly 23%, the replacement of CdS buffer for sustainable and eco-friendly solar cell development. In this study, we employed sputtered-Zn(O,S) as a buffer layer. By varying the O_2 percentage during the buffer deposition (1.0, 1.3, and 1.6%), we obtained different Zn(O,S) buffer layers having different band offset properties. To figure out how the elemental ratio affected the junction properties at CIGS/Zn(O,S), we exposed the layered structure of the CIGS solar cell devices, and utilized micro-Raman scattering spectroscopy and Kelvin probe force microscopy (KPFM), which are surface-sensitive characterization tools, for local scale investigation. Resultingly, we observed the surface potential changes at the interfaces, indicating either spike-like or cliff-like conduction band offset (CBO). Therefore, the optimized spike-like CBO and enough high hole barrier were obtained with the 1.3% O_2 percentage, yielding the best PCE of 11.24%.

Keywords:
CIGS thin-film solar cells, Kelvin probe force microscopy (KPFM), Mico-Raman spectroscopy

I1.06*

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PEDOT:PSS와 그래핀 양자점이 혼합된 투명전극을 이용한 실리콘 태양전지 연구

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Abstract:

최근에 고효율 및 저비용을 달성할 수 있는 전도성 고분자/실리콘 이종접합 태양전지에 대한 연구가 활발히 이루어지고 있다. 다양한 전도성 고분자 물질 중에서, poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS)은 용액공정이 가능하고, 전기적 특성이 우수할 뿐만 아니라 가시광선 영역에서 높은 투과도를 보이기때문에 차세대 투명전극의 조건을 잘 만족시키고 있다. 그래서 최근까지도 PEDOT:PSS는 Si 기반 이종접합 태양전지 구조에서 가장 널리 사용되고 있는 전도성 고분자물질로서, Si 만으로 이루어진 태양전지에 비교하여 광전변환효율 (power conversion efficiency, PCE)을 크게 향상시킨 바 있다. 그러나, PEDOT:PSS 물질은 에너지 띠간격이 3 eV 이하로 가시광선 영역대에서 빛을 흡수하기 때문에 특유의 색을 띄며, 대기 중에서는 산화속도가 빨라서 안정성에 대한 확보가 필요하다. 이러한 문제점을 극복하기 위해 전도성 고분자 물질에 다양한 물질을 첨가하여 안정성을 향상시키는 연구가 이루어지고 있다. 최근에는 PEDOT:PSS에 그래핀 양자점 (graphene quantum dots, GQDs)을 첨가함으로써 에너지 띠간격을 조절하여 유기 태양전지의 효율을 향상시켰을 뿐만 아니라 안정성도 향상시킨 바가 있다. 본 연구에서는 PEDOT:PSS에 그래핀 양자점을 혼합하여 제작된 PEDOT:PSS-GQDs 하이브리드 투명전극을 이용하여 PEDOT:PSS-GQDs/Si 이종접합 태양전지를 제작하였다. PEDOT:PSS-GQDs/Si 이종접합 태양전지의 PCE는 그래핀 양자점을 포함하지 않는 태양전지의 PCE (PEDOT:PSS/Si: ~4.18 %, Au 전극/Si: ~2.34 %)와 비교하여 상대적으로 높은 효율 (5.47 %)을 나타냈다. 그래핀 양자점의 첨가가 PCE를 증가시키는 이유는 전도성 고분자와 Si 계면에서 전자와 정공의 재결합을 억제함으로써 상대적으로 shunt 저항이 증가하고 다이오드 이상계수가 감소하기 때문으로 해석할 수 있다. 발표에서는 실험결과를 바탕으로 보다 자세한 물리적 메커니즘에 대해서 논의한다.

Keywords:

실리콘, 태양전지, PEDOT:PSS, 그래핀 양자점, 투명전극. 안정성

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2D dimensional van der walls heterojunction diode for Multiband photo detection

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Abstract:

2D layered nanomaterials for semiconductor channel have recently been attracting great attentions from researchers in many possibilities of future applications such as high speed electronics, flexible electronics, and immunity of short channel effects in scale-down transistors. In particular, the nature of dangling-bond-free surfaces in 2D vdWs materials enables the formation of heterojunction without the constraint of atomic lattice match. Among many 2D materials molybdenum disulfide (MoS2) is known as a pacesetting material, since it has displayed excellent carrier mobility, a high on/off current ratio, and a good subthreshold swing in a field-effect transistor (FET) form as a 2D n-type channel. In contrast to MoS_2, $MoTe_2$ is p-type 2D nanoflake and it has an appropriate bandgap for both visible and infrared light photodetection. In general, PN junction diodes are as important as field-effect transistors (FETs), which can be basic building blocks for electronic or optoelectronic systems.

Here, we have fabricated 2D $MoTe_2/MoS_2$ multilayers van der Waals heterojunction PN diode and its application for visible-near infrared broadband multi-detection. The $MoTe_2/MoS_2$ PN diode shows excellent performance with an ideality factor of 1.7 and high rectification (ON/OFF) ratio of over 10^4. This PN diode exhibits spectral photo-responses from ultraviolet (405 nm) to near infrared (1310 nm) with obvious photovoltaic behaviors. In addition to the static behavior, photocurrent switching behaviors are clearly observed under periodic illuminations at up to 100 KHz. The device shows a linear response within optical power density range from 10^{-5} Wcm^{-2} to 1 Wcm^{-2}.

Keywords:

2D semiconductor, heterojunction, diode,photo detector

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I2.02*

Modulating the Functions of $MoS_2/MoTe_2$ van der Waals Heterostructure *via* Thickness Variation

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Abstract:

Various functional devices including p-n forward, backward, and Zener diodes are realized with a *van der Waals* heterostructure which are composed of molybdenum disulfide (MoS_2) and molybdenum ditelluride ($MoTe_2$) by changing the thickness of the $MoTe_2$ layer and common gate bias. In addition, the available negative differential transconductance of the heterostructure is utilized to fabricate a many-valued logic device that exhibits three different logic states (*i.e.,* a ternary inverter). Furthermore, the multi-valued logic device can be transformed into a binary inverter using laser irradiation. This work provides a comprehensive understanding of the device fabrication and electronic-device design utilizing thickness control.

Keywords:

transition metal dichalcogenides, multifunctional heterostructure, tunneling diode, van der Waals heterostructure, multi-valued logic

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van der Waals homojunction devices with WSe_2

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Abstract:

Recently, transition metal dichalcogenides (TMDCs)-based electronics attract a great attention due to its various unique properties. To make van der Waals(vdW) P-N structure, heterojunction is required because effective doping method to convert the carrier type in TMDCs has not been realized so far. However, heterojunctions have significant interface defects due to lattice mismatch between TMDCs.

Here, we fabricated a vdW homojunction electronics composed of elementally Au-doped n-type WSe_2 (donor concentration ~$10^{17}/cm^3$) and Nb-doped p-type WSe_2 (acceptor concentration~$10^{17}/cm^3$). We passivated a hexagonal Boron Nitride (h-BN) layer between SiO_2/Si substrate and the TMDCs for minimize strain effect, and trap state caused by SiO_2 surface. In our structure, n-type and p-type WSe_2 were realized by doping. Rectification ratio and curvature coefficient were obtained about 100 and 24, respectively.

Keywords:

TMDCs, van der Waals, Homojunction

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I2.04*

반도체 양자점 발광의 편광 제어를 위한 타원형 나노구조 제작

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Abstract:

양자점은 구성하는 물질과 크기에 따라서 파장을 결정할 수 있으며 cascade 과정에 의해서 항상 엑시톤 준위의 광자 하나만을 얻을 수 있다는 장점 때문에 단광자광원으로써 좋은 후보이다. 하지만, 반도체 양자점의 경우, 방출된 빛은 반도체/공기 경계면에서 높은 굴절률 차이로 공기 밖으로 대부분 빠져나오지 못하고 신호가 매우 약하기 때문에 메타물질이나 표면플라즈몬을 이용한 나노구조 등에 접목하여 성능을 높이는 연구들이 활발히 진행 중이다. 이러한 구조들은 특정 편광에 의존하도록 설계되기 때문에 양자점 발광의 불필요한 편광 성분들로 인해 실제 사용되는 빛은 최대 50%의 손실을 갖는다. 이를 극복하기 위해 본 연구에서는 금속에 둘러싸인 타원형 메사 형태의 단일 양자점 나노구조를 제작해 양자점 발광의 편광 특성을 제어할 수 있는지에 대한 가능성을 검토하였다. MBE(Molecular beam epitaxy)로 자발 성장된 InAs/GaAs 양자점 시료에 전자 빔 리소그래피 방법과 CAIBE(Chemically Assisted Ion Beam Etching) 방법으로 타원형의 기울어진 GaAs 메사 구조를 제작하고, Si3N4와 금속 반사면을 증착한 뒤 기판을 제거하는 방식으로 최종 소자를 제작하였다. 이렇게 제작된 타원 모양의 단일 양자점 메사 구조를 액체질소 온도인 77 K에서의 μPL 측정을 통해 실제로 구조 내의 양자점 발광의 편광 특성이 어떤 경향을 보이는지 살펴보았다. 더 나아가 실험 도중 나타나는 여러 가지 외부요인들을 줄이기 위해 양자점 안에 quasi-resonant pumping하여 μPL 측정을 통해 얻은 단일 양자점의 편광 의존도 특성을 조사한 후, non-resonant puming의 경우와 비교하였다.

Keywords:

단광자광원, 반도체 양자점, 집광효율, 광소자

I2.05*

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Development of Backward Diode with Few-layer $ReS_2/MoTe_2$ Heterostructure

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Abstract:

Conventional p-n diode structure with two-dimensional metal dichalcogenides (TMDC) is applied to many applications such as photovoltaic and rectifier. However, conventional p-n diode has low rectification ratio and limited to use in the low temperature. To overcome these problems, the tunneling process is needed.
This study presents the realization of backward (Zener) diode with few-layer $ReS_2/MoTe_2$ heterostructure. The p-n diode and backward diode characteristics occur depending on the applied gate bias. As a result, the rectification ratio was 10^2 in the p-n diode and 10^3 in the backward diode at the room temperature. Furthermore, we analyzed temperature dependent rectification ratio. At 100 K, our device shows high rectification ratio ($4X10^5$) in the positive gate bias regime. Additionally, the negative differential resistance is observed in the negative gate bias regime. From these results, it is expected that few-layer $ReS_2/MoTe_2$ heterostructure will be a promising candidate for next-generation nanoelectronics.

Keywords:

few-layer TMDC, ReS2, MoTe2, TMDC heterostructure, backward diode, p-n diode

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I2.06*

Hybrid ZnON-Organic Light Emitting Transistors with Low Threshold Voltage <5 V

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Abstract:
The electrical and optical properties of inorganic-organic hybrid light emitting transistors (HLETs) are investigated, which are fabricated using the n-type semiconductor zinc-oxynitride (ZnON) as an electron transporting layer and the poly(p-phenylene vinylene)-based copolymer, Super Yellow (SY), as the light emitting layer. Additionally, the influence of various source (S)-drain (D) electrodes (Al, Ag, and Au) with different work functions (WFs) (4.1, 4.6, and 5.1 eV, respectively) on the performance of HLETs is studied. In order to increase the rate of hole injection from the metal electrodes and increase hole accumulation at the emissive layer, the use of a molybdenum oxide (MoO_x) interlayer is also investigated. As a result, optimized devices using MoO_x/Au hole injecting electrodes yield high brightness of up to 3.04×10^4 cd·m^{-2} at a low threshold voltage of 4.79 V. This study provides valuable information about the role of the WF of S-D electrodes in HLETs, which may be exploited to improve the device performance of optoelectronic devices in the future.

Keywords:
light emitting transistors, low threshold voltagle, super yellow, work function, zinc-oxynitride

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I2.07

First-principles investigation of electron transport in Ga_2O_3

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Abstract:

Ga_2O_3 is a wide-gap semiconductor with a band gap of 4.8 eV. Owing to the high carrier mobility and large band gap, it has attracted a great attention for use in high power electronics and transparent conductors. Despite its potential for adoption in these applications, an understanding of carrier transport properties of Ga_2O_3 is still lacking. In this study we employ first-principles calculations to compute the electron scattering rates in Ga_2O_3. Scattering due to ionized impurities and polar longitudinal-optical (LO) phonon is considered. We find that the electron mobility is nearly isotropic, despite the low-symmetry monoclinic structure of Ga_2O_3. At low carrier densities (~10^{17} cm^{-3}), the mobility is limited by LO phonon scattering. Scattering by ionized impurities becomes increasingly important at higher doping levels. This type of scattering is enhanced when compensating native point defects are present; in particular, gallium vacancies, which are triply negatively charged, can have a strong effect on mobility. These effects explain the downturn in mobility observed in experiments at high carrier densities.

Keywords:
Ga2O3, electron transport, first principles

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I3.01*

Atomic-Resolution TEM Imaging of Phosphorene Protected by Graphene

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Abstract:

Phosphorene, a single layer of black phosphorus (BP), is an elemental two-dimensional material with unique properties, such as tunable band-gap and high charge carrier mobility, and exotic in-plane anisotropic physical properties. Atomic resolution imaging of phosphorene, including various atomic-scale defects and edge configurations, is of critically importance but has been elusive due to its degradation under ambient exposure as well as electron-beam-irradiation. To overcome these challenges, we prepared graphene/BP sandwich structures to preserve pristine quality of BP. We study the stability of BP samples under electron-beam-irradiation. Comparison between three different configurations of samples, 1) three-layer BP, 2) three-layer BP/graphene, 3) graphene/three-layer BP/graphene, indicates that graphene lamination results in increased tolerance toward e-beam irradiation by one order of magnitude. We also observed that graphene protection from only one-side induces the controlled thinning of BP sample. Using this controlled thinning process, a pristine single-layer phosphorene was fabricated and atomic-resolution imaging was performed.

- This work was mainly supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF - 2017R1A5A1014862) and the Institute for Basic Science (IBS-R026-D1).

Keywords:
2D material, Phosphorene, Transmission Electron Microscopy, Atomic scale imaging

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I3.03*

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Synthetic Study on Lead-free Double Perovskite Halide Single Crystals

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Abstract:

For the last decades, lead-based perovskite halides have been one of the promising materials in the large variety of research fields (e.g. photovoltaic solar cells, x-ray detectors, light emitting diodes, and so on) due to the excellent physical properties and the multi-functionality. Owing to the global regulation of the toxic lead Pb element, an alternative material, which does not contain a divalent Pb^{2+} ion at the perovskite B-site and is eco-friendly, is now under intensive exploration. Currently, lead-free double perovskite halides, where the divalent Pb^{2+} ions are replaced with monovalent Ag^{+} and trivalent Bi^{3+} ions, are of enormous interest. Despite the intriguing earlier studies of the fascinating physical properties in the lead-free double perovskite halides, a synthetic study on their single crystals has been rare. In this presentation, we will systematically demonstrate how the crystallinity of lead-free double perovskite halides changes relying on the ambient chemical environment during the single crystal growth.

Keywords:

lead-free, double perovskite halide, single crystal, synthesis

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I3.04*

Study on the growth of Bi-incorporated α-In_2Se_3 films

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Abstract:

Ⅲ - Ⅵ group semiconductors have been researched for various application such as an electric, optical, optoelectric, thermoelectric, and phase change devices using their outstanding properties. Among them, α-phase In_2Se_3 has a great attention after recent revealing of its 2D-ferroelectricity. Although there are some growth methods using furnace and CVD, it is hard to establish the nano-sizing, large-scaled, thickness controllable growth, because In_2Se_3 is polymorphic in which there are many phases of α, β, ɣ, δ, κ. Among them, α and ɣ phase are most stable phases: α-phase is rhombohedral structure consisting quintuple atomic bonds of Se-In-Se-In-Se with van der Waals gap between each quintuple layer and ɣ-phase is defective wurtize structure consisting randomly distributed In-vacancy. Here, we studies on the large-scaled and thickness-controllable growth of α-In_2Se_3 film. We verify the roles of Bi atoms for stable growth of α-In_2Se_3 by analyzing basic properties of crystalline and electronic structure of the films grown under various growth conditions. Finally, we verified the stable and direct growth of heterostructures such as Bi_2Se_3/In_2Se_3 and Mo_2Se_3/α-In_2Se_3, to verify the possibility for the ferroelectric application.

Keywords:

2D ferroelectric, In2Se3

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I3.05*

Finite-difference time-domain (FDTD) simulation study of chemical enhancement in Surface-Enhanced Raman Spectroscopy (SERS)

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Abstract:

There have been large number of theoretical and experimental studies of Surface-Enhanced Raman Spectroscopy (SERS) over the last few decades. Huge enhancement factors of up to over 10^{10} is known to be mainly due to surface plasmon resonance between substrate materials and incident laser light. In this study, however, we focus on less pronounced, or less studied effect in SERS of chemical enhancement and its mechanism. Chemical enhancement is responsible for selective enhancement of Raman response of different analyte molecules adsorbed on the same substrate materials. We calculated electric field intensity and absorption profile of our systems while varying design of models by using finite-difference time domain (FDTD) simulations . We also compared FDTD results to our experimental results observed in adsorbed molecules on micro- and nano-structured semiconductor substrates. We discuss crucial factors for attaining large enhancement factors. Based on our theoretical and experimental results, we suggest optimization conditions for chemical enhancement in SERS.

Keywords:

Raman, SERS, FDTD, Chemical enhancement

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I3.06

Atomic-Scale Degradation Mechanisms of Hybrid Halide Perovskites: An *Ab Initio* Study

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Abstract:

In the rapidly developing field of organic-inorganic halide perovskite solar cells (SCs), $CH_3NH_3PbI_3$ ($MAPbI_3$) and $CH_3NH_3PbBr_3$ ($MAPbBr_3$) have emerged as attractive material candidates due to their excellent photovoltaic properties. However, so far, there exists no systematic study on the surface properties together with degradation mechanisms of these materials, which are vital information in achieving high-performance SCs. Herein, carrying out density functional theory calculations, we explore (001) surface of tetragonal $MAPbI_3$ and cubic $MAPbBr_3$ with various terminations by considering the developments of unstable surfaces into the degraded stable counterparts in the controlled environmental conditions. We find that MAI and MABr surfaces in addition to their vacant analogues are the most stable surface structures. Moreover, we predict that a flat PbI_2 and $PbBr_2$ surfaces can also be maintained by keeping a PbI_2- and $PbBr_2$-rich environment. We next present plausible degradation pathways from the several unstable surfaces into these stable surfaces under dry, H_2O-, OH- and O_2-rich conditions. Additionally, we investigated the unexplored defect engineering at different $MAPbBr_3$ surface terminations and find MABr surface as a good host for deep level defects compared to $PbBr_2$-flat surface that prefers to remain defect free due to high defect formation energies. Interestingly, the electronic structure of the stable defect-free surfaces in $MAPbBr_3$ revealed the absence of midgap states similar to their bulk structural form, which will prevent the non-radiative recombination processes and improve the SC performance. Clarifying the atomistic details of the degradation of perovskite surfaces, our work will contribute to the design of advanced hybrid halide perovskite SCs.

Keywords:

Halide Perovskite, surface stability, degradation mechanism

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2019-04-24 - 2019-04-26

I4.01*

Trap-Assisted High Photoresponsivity of a Phototransistor using Bi-Layer $MoSe_2$ Grown by Molecular Beam Epitaxy

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Abstract:

The transition metal dichalcogenides (TMDs) have great optical absorption and mobility in a subnanometer thickness. The $MoSe_2$ among TMDs has attracted tremendous interests as an active layer in optical devices because it is superior to other TMDs in light absorption. Herein, we investigated the mechanism and characteristics of phototransistors using bi-layer $MoSe_2$ film grown by molecular beam epitaxy. In order to study of the interaction between the Al_2O_3 as the gate oxide and $MoSe_2$, X-ray photoelectron spectroscopy and ultraviolet photoelectron spectroscopy were conducted. The results showed that energy-band bending in the $MoSe_2$ was observed because of the electron doping during the atomic layered deposition process and the charged defects with gate oxide. The optical devices exhibited well-controlled performance of the phototransistors depending on gate bias (V_{gs}) and power of illumination (P), resulting in ultra high photoresponsivity (R) of 242 A/W. The mechanism of the R with P and V_{gs} was fully explained by the change in quasi Fermi levels, the defect states, mobility, and metal contact. In addition, the photocurrents with temperature demonstratedthe mechanism of the persistent photocurrents, which were not observed at the low temperature. Finally, the performance of photo-inverter system composed of the $MoSe_2$-devices showed its applicability to future photo-sensing systems. The high performance of the phototransistor and photo-inverter indicates the promising $MoSe_2$ grown filmfor next-generation devices and the mass-production fabrication process.

Keywords:

molybdenum diselenides, phototransistor, inverter, molecular beam epitaxy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I4.02*

Solution-processable and Cost-effective Strategy to Synthesize Well-dispersed and Large Area Monolayer RGO Sheets in Water for Gas Sensing Applications

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Abstract:
Development of highly sensitive and selective Gas sensing devices, as powerful tools for detection and quantification of biomarkers of various diseases, hazardous gasses and VOCs (Volatile Organic compounds), is one of the most growing challenges to the sustainable progress of human civilization. Recently, 2D material Graphene has been widely explored for the fabrication of gas sensors because of their atom-thick two-dimensional conjugated structures, high conductivity and large specific surface areas, and excellent gas capturing properties. However, harnessing the exceptional chemical/ physical properties of graphene often requires well dispersed (into aqueous media), highly reduced and well-connected single atomic layers. Here, in this work we synthesized large area and atomically thin RGO sheets using a scalable and simple wet chemical approach to connect the gas sensor electrodes. The main advantageous observations of our work are (1): The synthesized well dispersed RGO solutions can be used on arbitrary substrates for sensing applications (2): Very simple approach to easily transfer graphene sheets on sensing area. The synthesized single layer RGO sheets were confirmed by XRD, UV-Vis, and Raman characterizations. AFM analysis confirmed the ≤1nm thickness of sheets. The optical and SEM results revealed the large area ≈110*u*m of RGO sheets. The

conductivity of the RGO sheets was analyzed using I-V measurements which was observed ≈ 1.97×10^{5} $S.cm^{-1}$. We believe that the as-prepared RGO sheets can be used as a good gas sensing material for detection hazardous gasses in laboratories.

Keywords:
Solution-processable, Well-dispersed and Large area Monolayer RGO Sheets, Gas Sensing Applications

I4.03

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Easy to fabricate multilevel resistive memory devices based on QDs:PVK / ZnO layer

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Abstract:

This study is about write-once-read-many-times (WORM) with multilevel resistive memory device based on using CdSe@ZnS quantum dots (QDs) : Poly(9-vinylcarbazole) (PVK) blending solution. WORM memory is permanently stored once data is written[1] and multilevel resistive memory device can store more than 2 bits in one cell.[2] There are two quantum wells that can store the charge in this device. One is between the QD core and the shell and the other is the interface formed by the difference in HOMO level of ZnO, PVK, QD shell. Current -voltage curves for the Al/[CdSe/ZnS QDs:PVK]/ZnO/indium-tin-oxide(ITO) device at room temperature showed WORM characteristics with an ON/OFF ratio is 10^5 at 0.5 V. The ON state currents remained 10^{-2} A, and the OFF state currents maintained 10^{-8} A. Those devices maintained the same on/off ratios for retention time more than 50 hours.

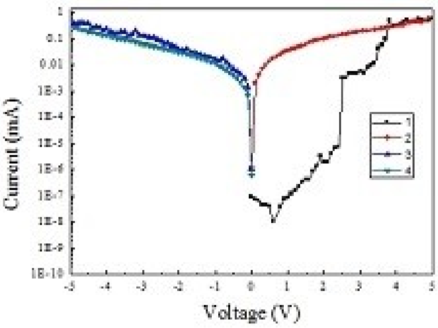

Figure. 2. The I-V characteristic of fabricated memory devices(log scale)

Acknowledgements
This work was supported by a National Research Foundation of Korea (NRF) grant funded by the Korea Government (MSIP) (No. NRF 2017R1D1A3B03032042) and samsung electronics

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[2] Yuanyuan Liu, Jinghua Yin, Xiaoxu Liu, Xiaofeng Zhao, Minghua Chen, Jialong Li, He Zhao, Congcong Zhu and Bo su, "Fabrication of polymer composite films with carbon composite nanofibers doped MWNTs-OH for multilevel memory device application", ScienceDirect, Compisites Part B, 156, pp. 252-258, 20

Keywords:

Write-once-read-many-times(WORM); Memory ; Multilevel resistive memory ; Quantum Dots memory ; ZnO ; Poly(9-vinylcarbazole) (PVK)

I4.04

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

In-situ oxidation/reduction reaction measurements of PdRu solid solution nanoparticles under exhaust gas condition: Rh-free catalyst

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Abstract:

Rhodium (Rh) is one of the most important metals in the industry, which is used as a catalyst for exhaust gas in automobiles. Because Rh is a rare and expensive element, the development of Rh alternatives composed of abundant elements is desirable. Pd and Ru are located on the right and left sides of the Rh of the periodic table, but the combination of these elements is immiscible in the bulk state. Kusada *et al.*, have successfully synthesized Pd-Ru solid solution nanoparticles. Here, we report Pd-Ru solid-solution alloy nanoparticles catalysts which exhibit three-way catalysts under the exhaust gas environment, using the *in-situ* energy dispersive X-ray absorption fine structure technique.
This work was partly supported by ACCEL, Japan Science and Technology Agency (JST) under Grant No. JPMJAC1501. This work was also partly supported by the Ministry of Education, Culture, Sports, Science, and Technology of Japan (OS:18K04868).

Keywords:

Rh-free catalyst, energy-dispersive X-ray absorption fine structure, Pd-Ru solid solution nanoparticles

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I4.05*

Self-power Energy Harvesting and Photo-sensing Circuit through Integration of n-$MoTe_2$ Field Effect Transistor and $MAPbI_3$ perovskite photovoltaic cell

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Abstract:
In this study, we have integrated a molybdenum ditelluride ($MoTe_2$) field effect transistors (FETs) with a perovskite photovoltaic solar cell for self-powered photo-sensing circuit. Among many transition metal dichalcogenide (TMD) semiconductors, $MoTe_2$ is selected because of less light-sensitivity and stable electrical properties compared to the other representative 2D TMD semiconductors: MoS_2, $MoSe_2$, WSe_2, etc. The few nm-thin n-type $MoTe_2$ FET operating at a low voltage is fabricated on a glass substrate as back-to-back bonded to the other glass which has perovskite PV cell. As the PV cell has large open circuit voltage (V_{OC}) over 0.9 V under artificial sun (AM 1.5) or visible photon illumination, we simply have used a red light emitting diode (LED) to generate ~1 V of photovoltage. Surprisingly, two operation modes in circuit are possibly observed depending on the light intensity of red LED: self-power current/voltage source and photosensor mode. Interestingly, despite of small output current and voltages in the circuit, 940 nm near infrared (NIR) is also sensitively detected.

Keywords:
Perovskite, MoTe2 FET, Self-power, Photovoltaic, Photosensing

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I4.06

Rectifying devices based on ballistic transport of encapsulated graphene

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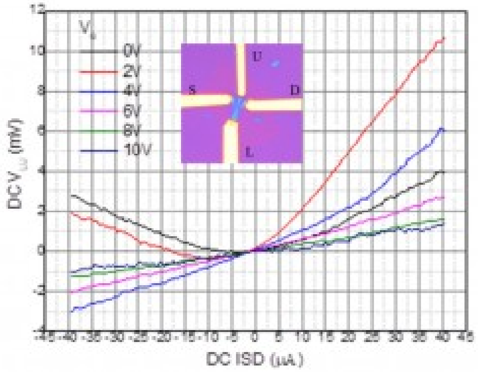
Abstract:

In our work, we developed a dry-transfer method to fabricate encapsulated graphene with hBN to achieve a high purity graphene. The ratio of Raman intensities of 2D and G peaks show over 10, and full width at half maximum at 2D peak of our samples are around 15 cm^{-1}. G peak positions are from 1577cm^{-1} to 1580 cm^{-1}, and Dirac points are around +2V, confirming the pure graphene with high quality by means of our transfer method. In addition, in rectifying operation, the graphene device shows good performance with low threshold operation in a few mV, promising for application as a rectifier for energy conversion. One of advantages of the ballistic rectifier based graphene is its high speed, which was measured up to 9 MHz. (Figure caption: the d.c current input between S-D and d.c voltage output different between L-U at different gate voltages. The insert shows the optical image of rectified device.)



Keywords:
Rectifying device; ballistic transport; encapsulate graphene

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I4.07

Inverted diamond nano-cone structure for bright single photon sources

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Abstract:

A single photon source with high efficiency is necessary to study quantum computing, communication, and cryptography. It is possible to realize an ideal single photon source by using spontaneous emission from an isolated point defect in solids. A well-known example is the nitrogen-vacancy (NV) center in diamond. However, the photon collection is inefficient because the emission direction of single photons from the point defect cannot be controlled and most of the photons are reflected at the solid surface due to the high refractivity. To improve the efficiency, various optical structures have been fabricated such as nano-wire, nano-pillar, bullseye grating and solid immersion lens. In this study, we demonstrate diamond inverted nano-cone structures embedding an NV center to improve photon collection efficiency. The inverted nano-cones are fabricated by using oblique-directional plasma etching with a cone-shaped Faraday cage. By analyzing the second order autocorrelation of photon emission statics, we confirm a single NV color center is embedded inside each nano-cone structure. We also report the improved photon collection efficiency by more than 10 times compared to the single NV center without the nano-cone structure. Because this structure can be optimized for other single photon emitters in high-refractive index materials, such as SiV in diamond and vacancy-related color centers in silicon carbide, the presented structure can be widely used to improve efficiency of various applications including quantum metrology as well.

Keywords:

Single photon source, Inverted nano-cone structure, NV color center, Diamond

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I5.01

Quantum optical sensing/imaging with single photons: sub-shot noise limit

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Abstract:
We investigate the use of quantum states of light to overcome the classical limit on the detection sensitivity. Combined with surface plasmon platforms the optical detection capability could be further improved. The general concept of quantum optical sensing will be discussed by introducing several strategies with different quantum states of light. In addition, we will discuss our current progress on the single photon generation using single fluorescent emitters.

Keywords:
quantum optical sensing single photons

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I5.02

Temporal evolution of cross correlation function and entanglement of photon pairs generated from atomic three-level cascades

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Abstract:
Entangled photon pairs are the core of diverse quantum optical applications such as quantum computing, communication, teleportation, and cryptography. Polarization-entangled photon pairs generated through spontaneous parametric down conversion in nonlinear crystals, four-wave mixing in atomic vapors, and exciton-biexciton generation in semiconductor nanostructures were successfully verified by Bell's inequality using time-delayed two-photon correlation measurements. In theoretical aspect, exactly modelling experimental observables in fully quantum mechanical regime is always a non-trivial task. For instance, quantifying spectrally entangled photon pairs in experiments is still hardly available due to the lack of appropriate observable.
In this contribution, we theoretically investigate the possibility of the cross correlation function of two photon densities at zero delay time $g^{(2)}{}_{12}(t)$ as an observable for verifying the spectral entanglement of two photons. We focus on photon pairs generated by single electrons during the optical transitions in a three-level atomic cascade system and investigate temporal evolution of $g^{(2)}{}_{12}(t)$ depending on the degree of entanglement. The incoherent photon pair generated by spontaneous radiation of an initially excited electron are not entangled inherently, but their bunched and anti-bunched properties can be found in $g^{(2)}{}_{12}(t)$, depending on the radiative lifetimes. The entanglement of two photons can be established only in the coherent excitation regime where only atomic polarizations are predominantly prepared by two pump pulses. Super bunching behavior converging to a constant, irrespective of the lifetimes, is demonstrated in $g^{(2)}{}_{12}(t)$.

Keywords:
Second order photon correlation function, entanglement, three-level atomic systems

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Hong-Ou-Mandel 간섭계를 이용한 빛 흡수 측정

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Abstract:
우리는 spontaneous parametric down conversion을 통해 생성된 810 nm 파장의 광자쌍 광원과 Hong-Ou-Mandel 간섭계를 이용해서 황산구리수용액 시료의 흡수도를 측정했다. 광자쌍이 시료를 통과하는 과정에 대한 분석을 통해서 Hong-Ou-Mandel 간섭계의 간섭패턴에서 동시계수 null 지점의 visibility 비가 시료의 투과율에 해당함을 발견했다. 고전적인 분광계를 이용한 흡수 실험 결과와 비교하여 우리의 분석이 타당함을 입증했다.

Keywords:
광자 흡수도, Hong-Ou-Mandel 간섭계

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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I5.04*

Helical transport in coupled resonator waveguides

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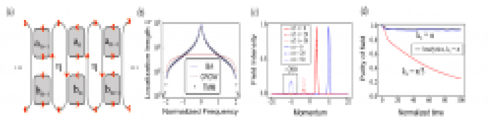
Abstract:

We design a disorder-resistant coupled resonator optical waveguide (CROW) using synthetic pseudospin-momentum coupling. At critical energies, the optical field exhibits a pseudospin-momentum locking that suppresses disorder-induced backscattering. We quantify this resistance to disorder in two ways: First, we calculate the disordered eigenmodes' Anderson localization length ξ, obtaining an order of magnitude enhancement under typical device parameters. Second, we perform time-domain simulations of wavepacket propagation in the presence of disorder, finding that the pseudospin-momentum locking maximizes the wavepacket purity.



Keywords:

Helical transport, Disorder-resistant, Anderson localization, Dephasing

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

I5.05*

Quantum interference using photon pairs generated in a silicon waveguide

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Abstract:
Quantum interference is vital to implement quantum information technologies such as quantum computing and quantum communications. Silicon has excellent potentials for quantum nanophotonics due to its large nonlinear behaviors, good optical properties, and complementary metal-oxide-semiconductor (CMOS) compatibility. Here, we conduct experimental research on quantum interference using photon pairs by spontaneous four-wave mixing generated in a silicon waveguide. The waveguide is pumped by a continuous wave light at 1550 nm. The generated photon pairs have excellent properties of a maximum coincidence to the accidental ratio (CAR) of about 4000 using superconducting nanowire single-photon detectors (SNSPD). Quantum interference of photon pairs from a silicon waveguide is observed in the fiber-based Michelson interferometer, achieving high visibility more than 90%. The results show that the photon pairs from a silicon waveguide can be useful as a quantum light source which is essential for quantum information technologies.

Keywords:
silicon photonics, photon pair, quantum interference

I6.01*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Multiplexed 2D charge stability scanning platform toward high-throughput quantum dot array calibration

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Abstract:

We report raster scan multiplexed charge-stability diagram measurements for tuning multiple gate-defined quantum dots in GaAs/AlGaAs heterostructures. We evaluate the charge sensitivity of the quantum point contact (QPC) in both radio frequency (rf)-reflectometry and direct current (dc)-transport modes, where we measure the signal-to-noise ratio (SNR) of 40 for rf-QPC with integration time per pixel of 10 ms, corresponding to 685 μs for resolving single electron transition in few electron regime. The high SNR for reasonable integration time allows fast two-dimensional (2D) scanning, which we use to facilitate double and triple quantum dot tuning process. We configure highly stable raster scan multiplexed quantum dot tuning platform using a switching matrix and transformer-coupled alternating current (ac) ramp sources with software control. As an example of high-throughput multiple quantum dot tuning, we demonstrate systematic triple quantum dot (TQD) formation using this platform in which a multiplexed combination of 2D scans enables the identification of few electron regime in multiple quantum dots in just a few minutes. The method presented here is general, and we expect that the tuning platform is applicable to more complex multiple quantum dot arrays, allowing efficient quantum dot system Hamiltonian parameter calibration.

Keywords:

Quantum dot, Fast scanning, RF-reflectometry, Multiplexed calibration

I6.02*

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2019-04-24 - 2019-04-26

Fraunhofer pattern of a Josephson junction on a topological insulator

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Abstract:

We theoretically study the magnetic-flux dependence of the critical current in Josephson junction formed by two s-wave superconductors on a three-dimensional topological insulator. We focus on the regime where the magnetic flux perpendicular to the junction is smaller than the flux quantum. The Fraunhofer pattern is different from the conventional form, showing fast decrease near the zero flux and nonzero critical current at the single flux quantum. These features are attributed to the Majorana fermions emerging in the junction.

Keywords:

Fraunhofer pattern of Josephson junction, Majorana fermion, TI Josephson junction

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I6.03*

Graphene Johnson Noise Thermometer for Manipulation and Measurement of Nitrogen-Vacancy Centers in Diamond

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Abstract:

Abstract— We propose a graphene Johnson noise thermometer integrated with nitrogen-vacancy centers (NV center) toward realizing sensitive measurement of spin states in diamonds. Utilizing graphene's unique property for sensitive thermometer combined with highly efficient energy transfer, weak electron-phonon interaction, and high electron mobility, we show that the proposed platform can enable fast and precise electronic read-out of the spin states.

I. Introduction

A pair of electrons in NV centers in diamond form two particle spin singlet or triplet state, where two of ground state triplet states can be regarded as a qubit consisting of spin quantum number m_s=0 and m_s=-1 states. Since the discovery of spin dependent fluorescence and related optically detected magnetic resonance (ODMR), NV centers in diamond have shown remarkable coherence at room temperature and attracted much attention for constructing quantum information platform. Moreover, NV electron spins interact with nearby nuclear spin states through hyperfine interaction, providing a route to manipulate and measure multiple spins in diamond.[1]
The photon-counting method reads out spin states of NV centers by measuring fluorescent light with, for example, single photon counters. This, however, is inherently inefficient and slow due to significant photon loss in conventional confocal microscope-based photo-detection scheme, posing a significant limit on high throughput quantum measurement of this spin system.
Here we propose a graphene Johnson noise thermometer for fast electronic measurement of NV centers.

II. Result and Discussion

The proposed device has hBN/graphene/nano- diamond/graphene/hBN stack on SiO_2/(doped)Si substrate, and graphene is connected to two gold electrodes via edge contact. A waveguide for microwave emission is next to nano-diamonds as well. (see also Fig.1a)
The device operates with the following principle. Non-radiative energy transfer (NRET) from photo-excited spin states in NV centers to electrons in graphene makes an electron-hole pair in graphene. Fig.1 This energy transfer efficiency is almost 100% if the NV center with m_s=0 state is within 10 nm away from the surface of graphene. But this energy transfer efficiency is also known to be spin dependent, having lower probability of energy transfer for m_s=-1 state.[2] Therefore, the difference of the average transferred energy via ODMR indicates the spin state of NV centers.
Graphene has exceptionally small electron-phonon coupling so that excited electrons due to energy transfer form hot electrons for 10^1~10^4ps time scale. Plus, strong electron-electron interaction makes a locally excited electron to more quickly heat up other electrons in wide graphene.[3] Johnson noise results from the spontaneous thermal fluctuation of charges in dissipative electrical elements at finite temperature. Its time averaged mean-square voltage is approximately proportional to the electron temperature of the resistance.[4] These enable electronic measurement of electronic temperature change by Johnson noise thermometry. Furthermore, clean graphene's high mobility exceeding $10^5 cm^2/V^{-1}s^{-1}$ results in short electronic response time and further improves the signal. We also apply cross-correlation technique to minimize uncorrelated noise where the signal is split before amplification and mixed again before time averaging as shown in Fig.1b[4].
We estimate the signal as follows. Suppose a photon from 532nm laser(1.9eV) hits an NV center about 10nm away from 10μm^2 graphene with 1.67*$10^{12}cm^{-2}$ of charge carrier concentration at 4K. Upon NRET, the electron temperature of the graphene rises to 9.30K[3]. Then, the calculated RMS voltage of noise is 26uV for 30MHz of bandwidth after 21.5dB amplification [4] (see also Fig.1b). Unwanted noise power (occurring mainly after splitting the signal) can be experimentally reduced to 1/30 the original value by cross-correlation technique.[4] Photocurrent resulting from laser directly absorbed by graphene can be avoided by time-resolved measurement technique using, for example, gated averaging.
In this presentation, we estimate in detail the expected SNR for the proposed graphene Johnson noise thermometer. We

also present preliminary experimental efforts on realizing a sensitive device.

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Keywords:
NV center, graphene, Johnson noise, thermometry

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I6.04*

Strong polarization of weakly interacting arbitrary nuclear spin using nitrogen-vacancy center in diamond

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Abstract:

We report experimental demonstration of high degree polarization of ^{13}C nuclear spins weakly interacting with nitrogen-vacancy (NV) centers in diamond. Using recursive sequence of energy level selective pi pulses and chopped optical illumination, high degree nuclear polarization is achieved at room temperature for weakly interacting ^{13}C nuclear spins exhibiting hyperfine interaction with NV centers around 500 kHz. With the aid of numerical simulation, we show that the observed efficient nuclear polarization is enabled when the nuclear Zeeman energy is equal to the hyperfine coupling strength parallel to the NV axis where the nuclear quantization axis is perpendicular to the NV axis so that the spin dependent transition rates are maximized.

Keywords:
spin qubit, nv center, nuclear spin polarization, initialization, hyperfine coupling

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I6.05*

Machine Learning Approach for Efficient Spectral Decomposition of Spin Resonance and Nuclear Spin Detection in Diamond

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Abstract:

We present a novel machine learning approach to detect individual nuclear spins in diamond. Localizing individual nuclear spins in solid state spin ensemble is the essential step to build coherently controllable spin resisters, which can enable a robust base for quantum network, quantum simulation platform, or quantum memory. So far, to find these nuclear spins, researchers have analyzed spin resonance spectrums manually so that there is no guarantee to fully find those existent spins and to obtain accurate coupling parameters, especially due to the experimental noise. Here we introduce machine learning algorithm to automatically denoise and decompose the spectral data to identify the location and to specify the characteristic of nuclear spins in diamond.

Keywords:

nitrogen - vacancy centers, machine learning, automated decomposition, nuclear spin detection

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I7.01

Majorana bound states emergent in the field-induced phase of Kitaev magnet

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Abstract:

α-$RuCl_3$ has garnered intense experimental and theoretical interest as the Kitaev honeycomb model and its rich phenomenology encompasses Majorana fermions with Dirac nodes, coupled to a static Z_2 gauge field, and the creation of non-Abelian gapped spin liquids with distinct Chern numbers of the Majorana fermions in an external magnetic field. In zero applied magnetic field there is a magnetic continuum that is controversially discussed in terms of fractionalized excitations vs anharmonic multimagnons. In an intermediate magnetic field of B ~7-9 T recent thermal Hall measurements have shown a thermal Hall effect and its half quantization arising from the Majorana chiral edge mode. A missing piece of information is a landscape of low-energy quasiparticle excitations in the putative topological spin-liquid phase. Herein, we present Raman spectroscopic signatures of Majorana bound states in a singlet sector (ΔS_Z=0), which appear by the application of a magnetic field above B_c=7 T. The magnetic field acts as a confinement potential between two Majorana fermions, which turns the fractionalized excitation continuum to quantized excitation spectra. A detailed temperature and field dependence unveils the existence of isosbestic points, at which the magnetic excitations are independent of an external field and temperature. However, it is an open question whether Majorana bound states are linked to the notion of non-Abelian anyons.

Keywords:

Kitaev spin system, Majorana bound state, topological spin liquid

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I7.02

Signature of topological transitions in Kitaev material α-$RuCl_3$

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Abstract:

We investigate topological transitions between Z_2 quantum spin liquids that appear in a modified Kitaev model targeting α-$RuCl_3$. The signature of the transitions can be shown as a characteristic behavior of thermal Hall conductivity, even though the transitions are well-defined at zero temperature. We show the path integral and the parton mean-field analysis and discuss experimental relevance of our calculation by comparing computed response functions. The results indicate that the temperature dependence of the thermal Hall conductivity can be explained solely based on spin Hamiltonian, neglecting phonon contribution. In addition to the analysis based on the effective spin-Hamiltonian, we also perform the dynamical mean-field calculation on top of the tight-binding Hamiltonian constructed by density functional theory to clarify the electronic structure realizing the spin-Hamiltonian under the external magnetic field.

Keywords:

Z2 spin liquid, Kitaev material, dynamical mean-field theory

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I7.03*

Field induced anisotropy in the quasi-two-dimensional weakly anisotropic antiferromagnet $[CuCl(pyz)_2]BF_4$

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Abstract:

We measured NMR and magnetic susceptibility for the quasi-two-dimensional, weakly XY-like, spin-1/2 square-lattice Heisenberg antiferromagnet $[CuCl(pyz)_2]BF_4\}$ (pyz=pyrazine=$N_2C_4H_4$) near the critical temperature. The Neel temperature T_N and the order-parameter critical exponent β were obtained from the NMR line broadening as a function of temperature. As the applied field strength (H || c) was increased, T_N increased and β decreased. This behavior indicates that the field effectively enhanced XY anisotropy. The susceptibility as a function of temperature showed minima for both H || c and H || ab, where the minimum features disappeared for $\mu_0H > 2$ T. Similar behavior has been reported in the literature for other quasi-two-dimensional square-lattice antiferromagnets and attributed to the crossover from the Heisenberg to XY (H || c) or Ising (H || ab) anisotropy on cooling, where the susceptibility-minimum temperatures lie slightly above T_N. On the other hand, in the present compound, the minima occured slightly below T_N.

Keywords:

Quasi-two-dimensional Heisenberg s-1/2 square lattice antiferromagnet, Crossover, phase transition

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Defect Behavior of Oxygen Vacancy in SrTiO3

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Abstract:

$SrTiO_3$ exhibits a huge variety of physical phenomena/properties not only from itself but also by doping with defects. Among them, self-doping by oxygen vacancies is of great importance because the oxygen vacancy has critical impacts on the wide spectrum of phenomena including the superconductivity at low temperature, magnetoresistance, magnetism and thermoelectricity. However, studies on the behavior of oxygen vacancies in the oxide were insufficient in spite of the decisive role of oxygen vacancies in oxide materials. Following the previous theoretical study[1], we verified the presence of defect behavior of oxygen vacancy as a linear cluster and their orientation along a specific crystallographic direction in $SrTiO_3$, a representative of a perovskite oxide. In this presentation, we describe experimental verification of these phenomena[2]. The presence of the linear clusters was revealed by an electronic structure represented in the increase in the Ti^{2+} valence state or corresponding Ti $3d^2$ electronic configuration and transport measurement. The orientation of the linear clusters along the [001] direction in $SrTiO_3$ was verified by further X-ray diffuse scattering analysis.

Keywords:

oxygen vacancy, lenear clustering, perovskite oxide

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I8.02*

Thickness Distribution of the Electrocatalytic Activity Sites in Epitaxial $La_{1-x}Sr_xMnO_3$ Thin Films

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Abstract:

Transition metal oxides (TMOs) show the strong coupling between the charge, spin, lattice, and orbital degrees of freedom. Its strong correlation affects their structural, electrical, magnetic, and chemical properties. Especially, TMOs show the excellent electrocatalytic activities to be utilized for the water-splitting catalyst. However, the design of the nano-crystalline TMOs for the electrocatalytic activity is rather limited, as most of the studies focus on the efficiency with a large surface-to-volume ratio, obtained for the samples with poor definition of the crystal lattice. Unlike most of the common research direction, we are searching for an intrinsic mechanism of the electrocatalytic activity using single crystalline epitaxial thin films samples [1].
In this study, we try to answer the question: *"How deep within a sample does the electrocatalytic active occur?"* This is a fundamental question for the understanding of the intrinsic electrocatalytic activity, which is closely related to the electronic structure including charge transfer, epitaxial strain, and electronic/ionic movement near the surface. More importantly, this is a question that could be answered by employing the thin film geometry. We prepared the high-quality epitaxial $La_{1-x}Sr_xMnO_3$ (LSMO) thin films with x = 0.0, 0.3, 0.5, and 0.8, using the pursed laser epitaxy (PLE). A large variation of the electrocatalytic activity was observed as the water splitting overpotentials varied from 0.47 to 0.69 V, at the current density of 70 μA/cm^2. This large variation is caused by the modification of the electronic structure with the portion between the Mn^{3+} and Mn^{4+} oxidation state. In addition, the room temperature electric resistivity contributes to the electrocatalytic activity. By increasing the thickness of LSMO thin film from 2 to 5, 7, 15, and 30 nm for the x = 0.3 samples, the current density varied from 138.5, 169.4, 232.6, 538.9, and 173.8 μA/cm^2 at a potential of 1.8 V vs. RHE, respectively. The activity increases up to 15 nm, then decreases, indicating that the active site is distributed with a depth of 〉10 nanometers. Our results provide a basic concept of characterizing the depth of the electrocatalytic active, and LSMO epitaxial thin film is a suitable model system to understand the origin of the oxygen catalytic activity.

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Keywords:
Transition metal oxide, Thin films, La1-xSrxMnO3, Electrocatalytic reaction

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I8.03*

Unusual dielectric anomaly near the magnetic transition temperature in La-substituted $BiFeO_3$ thin films

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Abstract:

$BiFeO_3$ as a canonical multiferroic has ferroelectricity (T_C ~ 1100 K) and antiferromagnetism (T_N ~ 640 K) [1]. Under a compressive misfit strain, highly elongated tetragonal-like $BiFeO_3$ and distorted rhombohedral-like $BiFeO_3$ coexsit forming the strain-driven morphotropic phase boundary (MPB) [2]. The tetragonal-like $BiFeO_3$ has attracted much attention for magnetoelectric applications. In tetragonal-like $BiFeO_3$, ferroelectric and antiferromagnetic transitions occur concurrently [3]. Around the transition temperature, capacitance anomaly occurs when the antiferromagnetic order disappears [3]. However, the two concurrent transitions bifurcate by substituting La into Bi over 10 % [4]. Specifically, La20%-substituted $BiFeO_3$ has G-type antiferromagnetic order as confirmed by neutron diffraction below ~350 K, while the capacitance anomaly is diffusive around 250 K. In this presentation, we report that the similar ferroelectric-antiferromagnetic concurrent transition can still exist in the mixed phase area. We have found that only thick samples to show mixed phase areas show dielectric anomaly depending on thermal cycles. We observe no dielectric anomaly at the magnetic transition temperature in thin films without the mixed phase areas. This finding provides a new pathway into magnetoelectric coupling.

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Keywords:
Dieletrics, magnetic transition

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I8.04*

Metal-to-insulator transitions in Epitaxial Nickelates Films Grown by Pulsed Laser Deposition: Effect of Crystallinity in Ceramic Targets

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Abstract:
Perovskite rare-earth nickelates, of which the generic formula is $R\mathrm{NiO_3}$ (R = La, Nd, Pr, ⋯), are a promising candidate for exploring exotic physical phenomena which do not exist in nature. To tune their physical properties elaborately, rare-earth nickelate thin films have been fabricated on the underlying substrates epitaxially. A pulsed laser deposition (PLD) technique has been mostly used for the film growth. In PLD, the plasma ions generated by the laser ablation of the ceramic target straightly move to the opposite side and then, adhere to the surface of a heated single-crystal substrate forming an epitaxial film layer finally. During this deposition process, the crystallinity of the as-prepared ceramic target directly affects the physical properties of the as-grown films. In this presentation, we will systematically demonstrate how the electrical transport properties (e.g. metal-to-insulator transitions) in rare-earth nickelate thin films vary relying on the crystallinity of the ceramic target in PLD.

Keywords:
Metal-to-insulator transition, Oxide, Thin film, Pulsed laser deposition

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I8.05*

Orthorhombic impurity phase in hexagonally stabilized (Lu,In)FeO_3

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Abstract:
Hexagonal LuFeO3 has attracted much attention as a promising candidate for room-temperature multiferroics. Due to the instability of the hexagonal phase in bulk crystals, most studies focused on $LuFeO_3$ thin-film which can be stabilized by strain using substrates [1]. Recently, there was a report showing that the hexagonal phase of LuFeO3 can be stabilized in bulk crystals by the In-substitution into the Lu-site [2]. It was claimed that the magnetic hysteresis due to the weak ferromagnetism also appears in hexagonal (Lu,In)FeO_3 below the magnetic ordering temperature (T_N) at around room-temperature. However, our recent neutron powder diffraction study revealed that the magnetic ordering of hexagonal (Lu,In)FeO_3 system occurs below 200 K. We will discuss the study on the extrinsic magnetic behavior due to the structural impurity phase in hexagonal (Lu,In)FeO_3 bulk samples. Our study will provide useful information for understanding the intrinsic magnetic properties of doped hexagonal $LuFeO_3$ related systems.

[1] W. Wang et al. Phys. Rev. Lett. **110**, 237601 (2013).
[2] J. Liu *et al*. Adv. Funct. Mater. **28**, 1706062 (2018).

Keywords:
Multiferroics, Hexagonal ferrites, LuFeO3, Magnetism, X-ray diffraction, Neutron diffraction

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I8.06*

Piezoelectric response at ferroelastic twin walls in epitaxial WO_3 thin films

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Abstract:

Piezoelectric responses at ferroelastic twin walls are observed in epitaxial WO_3 thin films at room temperature. Electromechanical vibrations in response to applied ac electric fields are detected at the ferroelastic twin walls of centrosymmetric WO_3 materials. It is most likely due to the flexoelectric polarizations induced by shear strain gradients across the twin walls. We visualize alternatingly antiparallel lateral-piezoresponses of flexoelectric polarizations at twin walls by using angle-resolved piezoresponse force microscopy. In addition, lateral electric fields generated by the spontaneous flexoelectric polarizations are observed based on scanning transmission electron microscopy. Furthermore, we demonstrate the twin wall alignment can be manipulated by AFM tip scanning. These findings provides useful insight into nano-mechanical properties at the twin walls.

Keywords:

ferroelastic twin wall, piezoelectric response, flexoelectric polarization, WO3, epitaxial film

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I9.01

Time-reversal symmetry and circularly-polarized perturbation

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Abstract:

Topological states have commonly been cited as a new classification of materials, and global properties immune to local perturbations have been suggested as topological non-trivial attributes. Actual computations of the topological quantities of real materials have been obtained through the theories of linear responses over the static ground electronic structure. Here, we propose an alternative way by considering the time-evolution of the Hamiltonian, which lets the pumping parameter run periodically through the geometric space of the Hamiltonian. As test examples of this method, we present a trivial insulator, a spin-frozen valley-Hall system, a spin-frozen Haldane-Chern insulator, and a quantum spin-Hall insulators. In later part, we also demonstrate the spin precession dynamics of MoS_2, in which the spin is strongly coupled to the optical phonon. This dynamical spin state can be resolved into discrete Floquet-phononic spectra, and once the phonon is pumped so as to break time-reversal symmetry, the resulting spin-Floquet structures induce net out-of-plane magnetizations in the otherwise non-magnetic 2D material.

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I9.02

Maximally-localized Wannier functions from first principles:Merging tight-binding models and computing spin Hall conductivities

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Abstract:

이 강연에서 우리는 제일원리로부터 얻은 maximally-localized Wannier function 을 이용한 계산 방법론을 두 가지 논의한다. 먼저 요즘 많은 위상 물질의 연구에 사용되고 있는 surface tight binding model 을 만드는 방법을 제시한다 [1]. semi-infinite 한 성질 때문에 bulk tight-binding model 과 surface 에서의 model 을 결합해야 하는데, 이를 잘 결합하지 않으면 표면 상태의 연결성 등이 어긋날 수 있음을 계산을 통해 보이고 잘 연결하는 방법을 제시한다. 두 번째로는 스핀홀 전도도를 계산하는 방법을 설명하고 대표적인 물질들에 대한 계산 결과를 논한다 [2].

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[2] Ji Hoon Ryoo, Cheol-Hwan Park, and Ivo Souza, "Computation of spin-Hall conductivities from first principles using maximally-localized Wannier functions," submitted.

Keywords:
maximally-localized Wannier functions first-principles calculation tight-binding model spin-Hall conductivity

I9.03

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기계학습과 결합된 연속시간 양자몬테칼로 방법 (Continuous time quantum Monte Carlo method in combination with Machine Learning)

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Abstract:

연속시간양자몬테칼로 방법 (Continuous time quantum Monte Carlo methdo)은 강상관계 물질의 전자구조를 연구 할 수 있는 제일원리방법과 결합된 동역학평균장 이론 (Density functional theory plus dynamical mean field theory (DFT+DMFT))의 양자 불순물 해결도구로 매우 확장적으로 사용되고 있는 반면에 양자몬테칼로 방법의 계산비용은 상당히 높은편이다. 따라서, 양자몬테칼로 방법의 계산속도를 증가 시키는 일은 강상관계물질연구 커뮤니티에서 중요한 일 중에 하나이다. 양자몬테칼로 방법의 대부분의 계산은 섭동 차수에 의해 나타나는 역행렬을 계산하는것과, 섭동 차수 행렬과 마추바라 진동수의 행렬의 곱 계산이다. 본 연구는 양자몬테칼로 방법의 속도를 증가 하기 위하여 기계학습 방법을 도입하여 섭동 차수 행렬과 마추바라 진동수의 행렬곱의 계산을 줄일수 있다는 것을 확인하였으며, 기계학습과 결합된 연속시간 양자몬태칼로 방법이 거의 정확한 결과를 얻을 수 있다는 것을 확인하였다.

"Accelerated Continuous time quantum Monte Carlo method with Machine Learning", Taegeun Song, Hunpyo Lee, arXiv:1901.01501 (2019)

Keywords:

Continuous time quantum Monte Carlo (CTQMC), Dynamical mean field theory (DMFT), Machine learning, Density functional theory plus dynamical mean field theory (DFT+DMFT)

I9.04

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Jx: An open-source software to calculate magnetic coupling constant and matrix

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Abstract:

We present our newly-developed open-source program, named by **Jx**. Based on the magnetic force theory (MFT), the exchange interaction parameters are calculated within the linear response level. The **Jx** code provides a user-friendly and efficient tool to calculate magnetic exchange interaction ***J*** in solids and molecules [4-5]. Our code is well-parallelized based on Julia language and is integrable with several DFT codes, e.g. OpenMX, VASP, Wien2K, Quantumespresso and ecalj [6]. Following the merits of the response theory, the **Jx** code calculates ***J*** in momentum space and all the short- and long-range interactions are obtained without supercell and multiple magnetic phase calculation. Further, it is also possible to calculate an orbital resolved matrix form of magnetic couplings. Additionally, our code supports local axis definition for orbital resolution in distorted structure [7, 8].

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Keywords:
DFT, Heisenberg J, Magnetic force theory, linear response, code development

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I10.01

어느 방향에서 소리가 들리는가를 인간의 귀는 어떻게 인식하는가?

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Abstract:
인간은 두 귀를 이용해서 소리가 오는 방향을 알아낸다. 두귀에 도착하는 시간 차이는 밀리세컨드 정도로 뉴런 스파이크의 간격 정도이다. 소리가 전기 신호로 변환되는 청각 유모세포의 신호 변환 지연시간과도 비슷한 크기이다. 그럼에도 불구하고 인간은 특정 방향에서 오는 말소리를 잘 이해 하는 특별한 능력을 가지고 있다. 딥러닝 모델을 이용하여 인간 청각의 방향성 인식을 모사하여 학습에 의해서 오차를 극복할 수 있는 능력을 구현한다. 유모세포 시냅스에서 벌어지는 신경전달 물질의 동력학 모델을 도입하여 청각 유모세포가 시간 정보 정확도를 어떻게 높이는 지도 제안한다.

Keywords:
Hearing, Hair cell, Deep learning

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I10.02*

딥러닝 오토 인코더와 오디오 빔포밍 기법을 이용한 인간 두귀 청각 모델 구현

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Abstract:

인간은 소음이 심한 환경에서도 대화할 수 있다. 이것이 어떻게 가능하며 이러한 기능을 어떻게 구현해 낼 것인가에 대한 문제는 '칵테일 파티 문제'로 알려져 왔다. 이는 보청기나 인공지능 스피커 그리고 무선 이어폰 등의 성능과 직결되므로 반드시 해결되어야 할 과제다. 앞서 언급한대로 "칵테일 파티 문제"는 인간의 청력에서 훌륭하게 해결된다. 따라서 우리는 인간의 인지능력을 모사하여 "칵테일 파티 문제"를 해결하는 연구를 진행하였다. 먼저 두 개의 귀는 소리의 시간차를 통해서 음원의 방향정보가 포함된 신호를 감지한다. 그리고 각각의 귀로 전달된 소리는 뇌의 신경망을 거쳐 특정한 음성에서의 의미만을 구분해 낸다. 이를 근거하여 우리는 두가지 기술을 접목하였다. 하나는 두개의 마이크를 이용하여 특정 방향의 신호만을 수신하는 빔포밍 기술이고 다른 하나는 뇌의 신경망을 모방한 뉴럴 네트워크 음성강화 모델이다. 기존의 뉴럴 네트워크 음성강화 모델은 방향성이 없는 1채널 데이터를 학습하였다. 하지만 우리의 모델은 여러 개의 음원으로부터 생성된 소리를 양쪽 귀와 같이 2채널로 처리함으로 방향 정보를 함께 학습시켰다. 이러한 접목은 기존의 방향성 정보를 훈련하지 못한 모델의 음성강화 지표를 전반적으로 상승시키는 결과를 가져왔다.

Keywords:

뉴럴네트워크,빔포밍,청각,칵테일파티문제

I10.03
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Effect of Interpopulation Spike-Timing-Dependent Plasticity on Synchronized Rhythms in Neuronal Networks with Inhibitory and Excitatory Populations

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Abstract:
We consider clustered small-world networks (SWNs) with two inhibitory (I) and excitatory (E) populations. This I-E neuronal network has adaptive dynamic I to E and E to I interpopulation synaptic strengths, governed by interpopulation spike-timing-dependent plasticity (STDP) [i.e., I to E inhibitory STDP (iSTDP) and E to I excitatory STDP (eSTDP)]. In previous works without STDPs, fast sparsely synchronized rhythms, related to diverse cognitive functions, were found to appear in a range of noise intensity D for static synaptic strengths. Here, by varying D, we investigate the effect of interpopulation STDPs on diverse population and individual properties of synchronized rhythms that emerge in the I- and the E-populations. Depending on values of D, long-term potentiation (LTP) and long-term depression (LTD) for population-averaged values of saturated interpopulation synaptic strengths are found to occur, and they make effects on the degree of population synchronization. In a broad region of intermediate D, the degree of good synchronization (with higher spiking measure) becomes decreased, while in a region of large D, the degree of bad synchronization (with lower spiking measure) gets increased. Consequently, in each I- or E-population, the synchronization degree becomes nearly the same in a wide range of D (including the intermediate and the large D regions). This kind of ``equalization effect'' is found to occur via cooperative interplay between the average occupation and pacing degrees of synchronized rhythms. Furthermore, such equalization effect is much more enhanced in the presence of combined I to E and E to I STDPs when compared with each case of I to E and E to I STDPs. We note that the equalization effect in interpopulation synaptic plasticity is in contrast to the Matthew (bipolarization) effect in intrapopulation (I to I and E to E) synaptic plasticity where good (bad) synchronization gets better (worse). Moreover, emergences of LTD and LTP of interpopulation synaptic strengths are intensively investigated via a microscopic method based on the distributions of time delays between the pre- and the post-synaptic spike times.

Keywords:
Equalization Effect, Interpopulation Spike-Timing-Dependent Plasticity, Fast Sparsely Synchronized Rhythm

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I10.04

A first-passage approach to the thermal breakage of a discrete one-dimensional chain

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Abstract:
Using the first passage method for a Markov process, we theoretically study the fragmentation rate of a discrete one-dimensional chain (Rouse model). The fragmentation occurs due to thermal fluctuations. Assuming equilibrium initial conditions, we obtain an expression for the fragmentation rate of the one-dimensional filament as a function of the number of monomers, the position of the breaking point along the filament, the ratio of the bond energy to the thermal energy, and the Rouse relaxation time. We also obtain the fragmentation rate for a fixed initial configuration of the chain by numerically solving a Volterra equation. Our results reduce to those of previous theoretical studies at the appropriate limits, and spell out the role of the relevant time scales. The prediction of our model for the fragmentation rate of insulin fibrils under optimal growth conditions for the solution appears to be consistent with experimental data from other studies.

Keywords:
thermal fragmentation, fibrils, first passage time

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I10.05

Label-free detection of nanoscopic objects using the iSCAT microscopy

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Abstract:

The Brownian motion of suspended particles is due to their interaction with surrounding solvent molecules and one can obtain rich information about the particles and local environment by simply monitoring their random, diffusive motions. The diffusion coefficient of a particle can be calculated by measuring time/ensemble-averaged squared-displacement of the particle from its real-time trajectory acquired by single particle tracking. Thus, single particle tracking is a powerful experimental approach to extend physical understanding of biological phenomena by directly determining physical characteristics of biological molecules and complexes and intercellular or membrane-bound protein mobility. Besides, the knowledge gained from single particle tracking is critical to practical applications such as developments of drug and gene delivery systems. Although the fluorescence-based single particle tracking technique is still the best way to capture the position of a single biomolecule, its limited photon budget makes long-term observation and fast tracking difficult. An alternative method recently developed to overcome such limitations is the interferometric-scattering(iSCAT) microscopy technique. The iSCAT microscopy can detect individual unlabeled proteins of several nanometers in size and track them with very high spatial and temporal resolutions. It was even reported that the mass of an individual protein molecule was quantitatively measured with iSCAT. Here, we describe our recent developments in this field that open up new possibilities for the study of individual molecules and internal structures of cells. We then envisage that results from our experimental work would be useful in understanding molecular systems from the statistical mechanics viewpoint.

Keywords:

iSCAT(interferometric scattering) microscopy, Label-free detection, Single-molecule tracking

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I12.01

First Results from CAPP's Pilot Axion Cavity Experiment (CAPP-PACE)

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Abstract:
The Pilot Axion Cavity Experiment of the Center for Axion and Precision Physics (CAPP-PACE) is searching for dark matter axions using the haloscope method first proposed by P. Sikivie. Haloscope detectors employ a microwave cavity immersed in a high magnetic field at low temperatures. The axions are expected to compose our galactic dark matter halo; these dark matter axions passing through the detector are converted into microwave frequency photons which resonate with the TM010 mode of the cavity. The signal from the cavity is then picked up by an antenna and transmitted via a low-noise electronics readout chain before being recorded with a spectrum analyzer. After overcoming many challenges in the tuning system, calibration methodology, cavity performance optimization, and DAQ efficiency, PACE has been taking physics data successfully since the beginning of 2018. In this talk, I will briefly describe the overall analysis methodology and present the first results of the experiment.

Keywords:
axion, haloscope, dark matter, strong cp

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I12.03*

Exploiting high-order resonant mode for axion haloscopes

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Abstract:

The axion haloscope is one of the most sensitive approaches to the QCD axion physics within the region where the axion is considered as a dark matter candidate. Current experimental sensitivity, relying on the lowest fundamental mode, TM010, is limited to relatively low mass regions. Exploiting higher-order resonant modes would be beneficial because it enables us to extend the search range to higher frequency regions with higher quality factor and no volume loss. However, this approach has been discarded mainly due to the significantly degraded form factors and difficulty in frequency tuning. We introduce a new concept of tuning mechanism, which enhances the form factors and yields reasonable frequency tunability. An experimental demonstration verifies that this design is suitable for high mass axion search.

Keywords:

axion, cavity, RF, particle physics

I12.04*

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High Quality Factor High Temperature Superconducting Microwave Cavity Development for the Dark Matter Axion Search in a Strong Magnetic Field

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Abstract:

The IBS Center for Axion and Precision Physics Research Center (CAPP) in Korea is searching for axions using a tunable resonant cavity in a high magnetic field based on a scheme called haloscope by P. Sikivie. The extremely feeble signal from the axion-to-photon conversion could be enhanced by improving the Q-factor of the resonant cavity, especially in a hostile environment like a high magnetic field. CAPP has been pursuing an R&D of utilizing superconducting material in constructing our cavity which should not be influenced by the existing magnetic field. Recently, we fabricated a cylindrical test cavity made of 12 vertically sliced pieces whose inner surface was covered by high temperature superconducting (HTSC) YBCO tapes. Those tapes are a perfect candidate for our purpose because they have an extremely small surface resistance in low temperature and very high critical field ($H_{c2//}$ ~ 100T) and also good texture. We present the measurement of the Q factor of the TM010 mode of the YBCO cavity under the magnetic field up to 8 T. No significant Q factor degradation was observed.

Keywords:

High Q Cavity, High-Temperature Superconductor, Dark Matter, Axion

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I12.05

The current status of CAPP18T axion dark matter search experiment at IBS/KAIST

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Abstract:

The presence of dark matter had profound consequences on the evolution of the Universe. The Standard Model does not accommodate a suitable dark matter candidate. Therefore, the existence of dark matter is a crucial phenomenological evidence for physics Beyond the Standard Model. The pressing goal of current and future dark matter experiments is to answer the question of whether dark matter interacts with normal matter other than gravity; i.e. if dark matter is detectable. Among the plethora of dark matter candidate particles, the Weakly Interacting Massive Particles (WIMPs) and the Axions are the most outstanding contender. In this talk, we will present the current status of the dark matter axion search projects at the Center for Axions and Precision Physics Research at CAPP/IBS in KAIST, especially focused on the CAPP18T axion dark matter search experiment which utilizes a 18T High Temperature Superconducting solenoid magnet, resonant cavity, dilution refrigerator, linear amplifier system, and DAQ.

Keywords:

dark matter, axion, CAPP, 18T

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Exploring high mass regions for axion dark matter search at IBS/CAPP

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Abstract:
The Center for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS) in South Korea aims to run several axion dark matter search experiments in parallel targeting at different mass ranges. An experiment utilizing a He-3 cryogenic system and a 9 T superconducting magnet with a 127 mm bore diameter has been under preparation. By employing a new cavity design, dubbed 'pizza cavity', this experiment will explore high mass regions between 10 and 30 μeV (equivalent frequency regions between 2.8 and 7 GHz) for axion dark matter. We update the status of the experiment and discuss the future plans.

Keywords:
Axion, dark matter, haloscope, multiple-cell cavity

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I12.07

Status of COSINE-100

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Abstract:

There is strong evidence for the dark matter from astrophysical observations. The DAMA/LIBRA collaboration has claimed an annual modulation signal consistent with being induced by the dark matter interactions in NaI(Tl)crystals. The COSINE-100 is an experiment to detect the dark matter induced recoil interactions in NaI(Tl) crystals in order to test the DAMA/LIBRA collaboration's claim. The COSINE-100 detector operates in the Yangyang Underground Laboratory located 700 meters underground. The detector consists of eight low-background NaI(Tl) crystals with a total mass of 106 kg, 2000 L of liquid scintillator, and radiation shielding that is surrounded by cosmic-ray muon detectors. Data taking started in September of 2016, the detector has been running stable for two and half years. In this presentation, we report the status of COSINE-100 as well as plans for its next phase, COSINE-200.

Keywords:
dark matter, COSINE-100, NaI(Tl) crystal

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I12.08

Investigating results from DAMA/LIBRA phase-2 and COSINE-100 in a dark matter scattering model

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Abstract:
DAMA/LIBRA recently released their phase-2 results on their WIMP annual modulation signal. However, since it is not well explained by WIMP-nucleon spin-independent interactions, there is a growing interest in interpreting their results in the context of other possible interactions. COSINE-100 has been performing the dark matter search using the same NaI(Tl) target material as DAMA/LIBRA's, and reported no sign of WIMPs. In this talk, the compatibility of DAMA/LIBRA phase-2 and COSINE-100 results for dark matter scattering that considers various types of WIMP-nucleon interactions will be presented. As well, the interpretation using recently measured quenching factors for NaI will be covered.

Keywords:
WIMP, COSINE-100, NaI(Tl)

I12.09*

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Lowering the analysis threshold and a revised background assessment for the COSINE-100 experiment

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Abstract:
COSINE-100 is a direct detection dark matter search that uses low-background NaI(Tl) scintillation detectors to test DAMA/LIBRA's claim for a dark matter observation. Using the first 59.5 days data with a 2 keVee analysis threshold, we observe no excess of events above COSINE-100's background model, allowing us to rule out the spin-independent interpretation of the DAMA signal. Lowering the analysis threshold to 1 keVee and using ~2 years of data will improve the sensitivity around DAMA preferred region of parameter space. In this presentation, techniques used to achieve a 1 keVee energy threshold along with an improved understanding of the background will be presented.

Keywords:
Dark Matter, WIMPs, COSINE-100

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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I12.10

Status of the annual modulation analysis using the COSINE-100 Data

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Abstract:

The COSINE-100 experiment is dedicated to a direct dark matter search with ~106 kg of low-background NaI(Tl) detectors submerged in a veto counter with 2 tons of liquid scintillator. One of signatures of the dark matter is the annual modulation of the event rates due to the relative motion of the Earth around the Sun. The physics run began in September 2016 with a background rate of ~3 counts/kg/keV/day in the energy region of 2 - 6 keV with a very stable operation of the detectors. In this talk, status of the annual modulation analysis with COSINE-100 data taken over 585 days will be presented.

Keywords:
COSINE-100 experiment, direct detection, annual modulation of dark matter

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Search for a light charged Higgs boson decaying to c b-bar in pp collisions at sqrt(s) = 13 TeV

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Abstract:

We present the search result of charged Higgs boson in top quark pair events using the CMS data from pp collisions at 13 TeV. In this search where charged Higgs bosons are lighter than top quark, they can appear in top quark decays as like t->H+b. In particular, the branching ratio of charged Higgs decay into c b-bar can be enhanced in type-Y two Higgs doublet model.

In the lepton+jets channel of the Standard Model top pair events, the final state has one lepton, four jets (two b-jets and two light jets), and missing transverse energy. If the charged Higgs is produced from top decay, three b-jets are expected in the final state. Thus, a search for the light charged Higgs at two & three b-jets channel is performed using 36.4/fb of the data.

Keywords:

Higgs, Light Charged Higgs, 2HDM, CMS, LHC

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Search for a light charged Higgs boson decaying to a W and pseudoscalar Higgs boson pair in proton-proton collisions at 13 TeV using the CMS detector

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Abstract:

A search for a light charged Higgs boson (H^+) decaying to a W and pseudoscalar Higgs (A) boson pair is performed using data from proton-proton collisions at 13 TeV. The data were recorded by the CMS detector at the LHC in 2016, corresponding to an integrated luminosity of 35.9 /fb. In the search, it is assumed that the H^+ boson is produced in decays of top quarks, and the A boson decays to two opposite-charge muons. A range of signals for H^+ boson masses between 100 and 160 GeV and A boson masses between 15 and 75 GeV is investigated.

Keywords:
CMS, charged Higgs boson, pseudoscalar Higgs boson, top

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I13.03

Local reconstrution and noise rejection for CMS Hadron Calorimeter

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Abstract:

Hadron Caloriemter (HCAL) is a crucial sub-detector in CMS that measures the energy of hadrons. The momentum of dark matter (DM) candidates produced at the CMS interaction point is measured by a vectorial sum of all particle momenta. The majority of these particles are hadrons, so measuring their energy precisely is very important in search for DM. HCAL has some intrinsic anomalous signals that can mimic the signature of DM. I will describe the characteristics of those signals and the algorithms used to suppress them. Energy of hadrons deposited in HCAL scintillator tiles is extracted by a template fit called MAHI. It is designed to extract the energy from in-time-collisions only. I will discuss the motivation of the method, the description of the fit procedure, and its performance.

Keywords:
CMS, HCAL, local reconstruciton, noise rejection

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I13.04*

Reducing the beam dynamics systematic errors for the Muon g-2 experiment at Fermilab

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Abstract:
The anomalous magnetic dipole moment of the muon, a_μ, was measured at the Brookhaven National Laboratory (BNL) in 2001, which turned out to have a 3.7σ deviation from the Standard Model expectation. The Fermilab muon g-2experiment aims to measure a_μ with a 140 parts-per-billion precision, which corresponds to four times better sensitivity than the BNL experiment. Muons are injected into a storage ring with a diameter of 15 m and a homogenous magnetic field of 1.5 T in which the muon spins precess with the frequency ω_a≃q/m a_μ B. 24 calorimeters around the ring measure the positrons decaying from the muons with a time-delayed lifetime which is around 64 μs. The Coherent Betatron Oscillations (CBO) refers to the transverse muon beam motion relative to the detectors, where it modulates the positron signals and causes a significant systematic error as the detector acceptance is affected by the CBO amplitude. We have developed a novel method to reduce the CBO systematic error by an order of magnitude using an RF electric field. The RF system has been installed and tested in 2018, and is ready for commissioning.

Keywords:
Muon g-2

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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I13.05

Search for a new heavy gauge boson in final states with one lepton and missing transverse momentum with the ATLAS detector

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Abstract:

The Standard Model (SM) has been an extremely successful theory in describing nature from the fundamental particles and their interactions. Despite the successes of the SM, there are phenomena which cannot be explained by the SM such as dark matter, neutrino mass, and gravity. Hence, various extensions to the SM have been developed during the last few decades, and several theoretical models predict the existence of additional heavy gauge bosons. A search for a new heavy gauge boson in final states with one lepton (electron or muon) and missing transverse momentum is presented using the dataset of proton-proton collisions at a center-of-mass energy of 13 TeV, which were recorded in 2015, 2016, and 2017 by the ATLAS detector at Large Hadron Collider at CERN. No deviation from the Standard Model prediction is observed, and hence exclusion limits on the production cross section times branching ratio, and on the Sequential Standard Model W' boson mass are derived exploiting the Bayesian approach. Masses for W' bosons up to 5.6 TeV are excluded by the combination of the electron and muon channels. This marks the most stringent exclusion limit obtained in the W' searches by any collider experiment so far.

Keywords:

BSM, W', ATLAS

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I13.07*

Systematic error studies of the proton EDM experiment in a hybrid ring

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Abstract:

The storage ring method is a relatively new technique for electric dipole moment (EDM) experiments of fundamental particles. It benefits from high statistics and a precise control of systematics in an accelerator. With its strong coupling with magnetic dipole moments (MDM), magnetic fields become a major systematic error source in every EDM experiment. Therefore, eliminating the magnetic fields inside the experimental region is the natural solution. Typically this is done by shielding, measurement and active compensation. In an accelerator however, strong magnetic focusing fields can eliminate the external magnetic fields automatically. This relaxes the measurement and active compensation limits by several orders of magnitude. We have recently designed a hybrid ring lattice with electric deflectors and magnetic quadrupoles. This talk summarizes the systematic effect studies regarding the hybrid ring.

Keywords:

Dipole moment, proton dipole moment, storage ring, precision, systematics

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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I13.08

Search for Elementary Magnetic Monopole in Electron-Positron Annihilation-in-flight

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Abstract:
From the era of Faraday and Maxwell to now, the effort to search the magnetic monopole has been made. Most of experiments have searched the magnetic monopole predeicted by Dirac and haven't found any evidence of the existence. Based on the experimental results for last 150 years, we assume that the magnetic monopole have low mass and low magnetic charge. In this talk, I will introduce the experimental design to search the low mass and low charge magnetic monopole.

Keywords:
Magnetic monopole

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I14.01*

Lyman Alpha Blobs and Monte Carlo Imaging Polarimetry of Ly$₩₩alpha$

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Abstract:

Lyα is one of the prominent emission lines in star-forming galaxies and active galactic nuclei. Observational evidence points out that Lyα observed in Lyα emitters (LAEs) and Lyα blobs (LABs) are scattered many times in a neutral region before reaching the observer. As the name suggests, LABs exhibit spatially extended images, of which the origin is proposed to be due to an extended ionized source or scattering process involving neutral hydrogen. In the former case, most of the directly escaping photons will be unpolarized. In the latter case, the scattering of Lyα is best described as diffusion in both the frequency and position space (or the phase space), during which the emergent Ly$₩alpha$ may get polarized dependent on the anisotropy of the scattering geometry and kinematics. We introduce the radiative transfer of Lyα in the phase space to compare observational data of LABs.

Keywords:

Radiative Transfer Lyα Polarization Scattering Lyman Alpha Blobs

I14.02*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Parameter Estimation of Tidal deformability in nonspining BNS mergers

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Abstract:
After the detection of binary neutron star (BNS) merger event (GW170817), interest in the tidal deformability which depends on the neutron star equation of state has been increased. In this presentation, we introduce first the post-Newtonian (PN) gravitational waveform model in which tidal deformability contribution emerges at 5PN order. Next, we introduce Fisher matrix (FM) method with which one can get the measurement errors much faster than those of practical parameter estimations that use Markov Chain Monte-Carlo method. We calculated the measurement errors of parameters with FM and obtained result that the measurement error of tidal deformability becomes about 3/4 if tidal deformability contribution is considered up to next leading order.

Keywords:
Gravitational Wave, Neutron Star Equation of State, Parameter Estimation

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I14.03

A new interpretation for the brightest quasar ever "J043947.08+163415.7"

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Abstract:

Recently, NASA observation team led by prof. X. Fan at the Univ. of Arizona
discovered, in terms of the 'Hubble Space Telescope (HST)',
the brightest quasar ever which is as bright as 600x10^9 solar luminosity !
In Astronomy, a quasar is identified with a galaxy powered by a supermassive black hole that is extremely heavy and luminous attracting surrounding gas and dust. The brightest quasar at hand, named, "J043947.08+163415.7" is as old as 128x10^8 years [which is quite old as the age of the universe is 137x10^8 years !]
In their paper published in Astrophysical Journal Letters (ApJL),the NASA observation team attributes the over luminosity of the discovered quasar to the conventional gravitational lens effect.
In the meantime, our research group (that consists of prof. Hongsu Kim and Uicheol Jang, his student) would like to suggest a totally different interpretation/identification of the brightest quasar at hand, named, "J043947.08+163415.7" that can be briefly summarized as follows : As proposed first by B. Paczynsky and P.J. Wiita long ago in a Journal publication [A&A 88, 23-31 (1980)], the over luminosity of the discovered quasar should rather be attributed to the super critical accretion rate and as a result, the super critical, Eddington luminosity which is as large as L_{Edd}~ 10^38 erg/sec.
Generally, the disk luminosity, according to the standard Shakura-Sunyaev 'alpha - disk model' is given by L = (height/width) L_{Edd}.
As a result, provided the inner portion of the cccretion disk is so "thick" and narrow that the height/width >1 we may have ; L > L_{Edd} !
as opposed to the thin &wide entire ordinary disk for which height/width <<1and hence, usually one expects ; ; L << L_{Edd}.
To conclude, provided the accretion disk surrounding the supermassive black hole
which is the power engine for the brightest quasar at hand, named, "J043947.08+163415.7" is indeed "thick" and narrow enough, its luminosity would be L = (height/width) L_{Edd} = (height/width) 10^38 erg/sec. that could be as bright as 600x10^9 solar luminosity as the solar luminosity is given by 10^33 erg/sec. provided (height/width) ~10^7(if the supermassive black hole is of solar mass), 10(if the supermassive black hole is of M = 10^6 M/sun) which seems available for the accretion disk surrounding the supermassive black hole which is the power engine for the brightest quasar!
In short, as an alternative to the he NASA observation team's interpretation, namely, the conventional gravitational lens effect, We (prof. Hongsu Kim and Uicheol Jang, his student) would like to suggest
that the over luminosity of the discovered quasar might be due to the "thick" and narrow inner part of the accretion disk surrounding the supermassive black hole which is the power engine for the brightest quasar at hand, named, "J043947.08+163415.7 rather than the interpretation by the NASA observation team led by prof. X. Fan at the Univ. of Arizona, that is, the conventional gravitational lens effect !!

Keywords:
Accretion disk,

I14.04

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Preinflation with negative temperature

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Abstract:

Despite the success of the inflationary paradigm, the initial conditions for inflation are still being debated in modern cosmology. Especially, the initial inhomogeneity might prohibit the onset of inflation. This problem might be solved if there exists the preinflation before the usual cosmic inflation is ignited. We show that this can be achieved from the negative temperature component which is achieved in the present condensed matter laboratory.

Keywords:

Inflation, Negative Temperature

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I14.05

Towards the Understanding of the Growth and Evolution of Supermassive Black Holes at Galaxy Centers

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Abstract:

As computational resolution of modern cosmological simulations reach ever so close to resolve individual star-forming clumps in a galaxy, a need for "resolution-appropriate" physics for a galaxy-scale simulation has never been greater. To this end, we introduce a self-consistent numerical framework that includes explicit treatments of feedback from star-forming molecular clouds and massive black holes. We perform a state-of-the-art cosmological simulation of a quasar-host galaxy at z~7.5, and demonstrate that previously undiscussed types of interplay between galactic components may hold important clues about the growth and impact of quasar-host galaxies.

Keywords:

galaxy formation, galaxy evolution, star formation, supermassive black hole, active galactic nuclei, numerical simulation

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I14.06

Baryonic Tully-Fisher relation from Ultra-light Scalar Dark matter

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Abstract:
We show that ultra-light scalar dark matter (fuzzy dark matter) in galaxies has a quantum mechanical typical acceleration scale about $10^{-10}₩,₩mbox{ms}^{-2}$, which leads to the baryonic Tully-Fisher relation. Baryonic matter at central parts of galaxies acts as a boundary condition for dark matter wave equation and influences stellar rotation velocities in halos. This model also explains the radial acceleration relation and MOND-like behavior of gravitational acceleration found in various type of galaxies without any modification of gravity or mechanics. This analysis can be extended to the Faber-Jackson relation.

Keywords:
dark matter, Tully-Fisher relation

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I14.07

Weak Cosmic Censorship and Scalar Field in Kerr-(Anti-)de Sitter Black Hole

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Abstract:

We investigate the weak cosmic censorship conjecture in Kerr-(anti-)de Sitter black holes under the scattering of a scalar field. We test the conjecture in terms of whether the black hole can exceed the extremal condition with respect to its change caused by the energy and angular momentum fluxes of the scalar field. Without imposing the laws of thermodynamics, we prove that the conjecture is valid in all the initial states of the black hole (non-extremal, near-extremal, and extremal black holes). The validity in the case of the near-extremal black hole is different from the results of similar tests conducted by adding a particle because the fluxes represent the energy and angular momentum transferred to the black hole during the time interval not included in the tests involving the particle. Using the time interval, we show that the angular velocity of the black hole with the scalar field of a constant state takes a long time for saturation to the frequency of the scalar field.

Keywords:

black hole; cosmic censorship

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Twisting and Stretching van der Waals Bilayers: an Atomic-Scale View

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Abstract:
With the magic of scotch tape, it has now become possible to create artificial layered materials with unique electronic properties. An example of this is a twisted bilayer, where two single layer sheets of a layered material can be stacked together to create a bilayer, but with a controllable twist between the layers. Such structures have new single-electron and many body properties that each of the individual layers may not exhibit. I will discuss two such materials in this talk. The first of these is twisted bilayer graphene, a material which displays interesting new electronic phases including insulating behavior, superconductivity and magnetism. I will discuss scanning tunneling microscopy measurements of this material from my laboratory where we can visualize the atomic structure and measure the excitations of this unique material. The second material I will discuss is heterostrained transition metal dichalcogenides. I will show that strain applied to one layer relative to the other can create new atomic structures termed "strain solitons". I will discuss the formation, manipulation and electronic properties of these solitons.

Keywords:
Twisted bilayer graphene, STM spectroscopy, strain solitons, superconductivity, magnetism

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I15.02

Electronic theory of twisted bilayer graphene

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Abstract:

Twisted bilayer graphene (TBG) is a pair of graphene layers overlapped with the interlayer twist angle, and it exhibits dramatic twist-angle dependent phenomena such as the flat band formation and emergent superconductivity. Here I introduce a theoretical framework to reduce this complex system with huge number of atoms into a simple effective lattice model by constructing the localized Wannier orbitals.[1] The resulting model can be utilized to describe the anybody physics in TBG. I also argue about the 30-degree rotated twisted bilayer graphene, which has completely different electronic nature from the low-angle TBGs. Here we demonstrate that 30-degree TBG has the 12-fold quasicrystalline electronic states with nearly flat bands, which can be well captured by the quasi-band picture.[2]

[1] M. Koshino, N. F. Q. Yuan, T. Koretsune, M. Ochi, K. Kuroki, and L. Fu, PRX 8, 031087 (2018).
[2] P. Moon, M. Koshino, Y.-W. Son, arXiv:1901.04701.

Keywords:

Twisted bilayer graphene, Wannier functions, quasicrystals

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I15.03

Electron interaction effects in twisted bilayer graphene: low-energy models and beyond

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Abstract:

The exciting sequence of many-body ground states in twisted bilayer graphene systems poses a formidable challenge to theory. In this talk we first present examples how functional renormalization group calculations can be used to elucidate the leading ground state ordering tendencies in low-energy 'flat-band‘ effective models for these systems, showing an interplay of density-wave formation and unconventional superconductivity. Then we will explore how the impact of the remnant spectrum outside the low-energy window and the primary instabilities of the untwisted bilayer system are changed by the twisting, but still influence the low-energy physics. Using a susceptibility analysis we show that this allows an alternative approach to understand a sequence of insulating states. We discuss how these two scenarios might be distinguished experimentally.

Keywords:

functional renormalization group, ordered phases

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I15.04

2D Materials Tunneling Spectroscopy

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Abstract:
Electron tunneling spectroscopies are versatile experimental methods to investigate not just detailed electronic structures of low-dimensional condensed matter systems at varying energies but also collective excitations such as phonons, magnons and plasmons and their interactions with tunnel electrons. In particular, it has proven that planar tunnel junctions that employ two-dimensional (2D) insulators like hexagonal boron nitride (*h*-BN) or wide energy-gap semiconductors such as WSe_2 and $MoSe_2$ as tunnel insulating materials enhance spectral resolutions of tunnel electrons in energy at varying external electric and magnetic fields, charge densities, temperatures, and others. In this talk, I will present electron tunneling spectroscopy measurements on single- and bi-layer graphene on high quality *h*-BN layers, and the energy gaps formed in high magnetic fields and graphene superlattices. Moreover, I will discuss experimental approaches to accurately address quasiparticle and optical energy gaps, exciton binding energies and atomic defect states of monolayer Mo- and W-based transition metal dichalcogenides. Finally, the vibrational modes of 2D crystal lattices; phonons, and layer-dependent electron-phonon interactions in 2D van der Waals heterostructures measured through planar tunnel junctions will be discussed.

Keywords:
2D materials, tunneling spectroscopy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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T1.01

Wide-bandgap 반도체 소자 기술

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Abstract:

Wide-bandgap 반도체(SiC, GaN)는 기존 Si 이나 GaAs에 비해 에너지 밴드갭이 3배 가까이 넓어서 이에 따른 고온동작, 고항복전압, 낮은 누설전류의 특성과 함께 자외선 영역의 단파장 발광 및 감지가 가능한 소재이다. SiC는 주로 고전력 스위칭 소자로 연구개발 되어 2000년대 들어 고효율 고전력 반도체 소자로 상용화를 이루었으며, GaN는 90년대 중반 청색 발광다이오드의 성공적 개발 및 이후 RF 고출력 증폭기 소자에 대한 시장이 형성되었고 최근에는 고전압 고효율 전력반도체 소자로 그 영역을 넓히고 있다. 본 강연에서는 다양한 wide-bandgap 반도체 소자 응용에 대하여 소개하고 특히 전력반도체 소자에서 SiC와 GaN의 기술적 차별성 및 시장 동향과 기술 수준을 분석한다. 그리고, GaN 전자소자의 두 축을 형성하고 있는 통신용 RF 고출력 소자 및 전력전자용 스위칭 소자에 대한 기술 수준과 향후 해결해야할 기술적 문제점을 다룸과 동시에, GaN의 새로운 응용분야로 고려되고 있는 고온동작 전자소자, 내방사선 소자, 초저전력 소자 등 그 가능성에 대하여 논의한다.

Keywords:

wide bandgap semiconductor, gallium nitride, RF power, power switching

T2.01

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Introduction of Multi-Dimensional Organic-Inorganic Hybrid Perovskite : Preparation and Opto-Electronic Application

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Abstract:

In this tutorial, I will talk about the preparation of multi-dimensional organic-inorganic hybrid perovskite materials and their application as opto-electronic devices. More details, three topics will be introduced. The first topic is the preparation of perovskite quantum dots (QDs, 0D), thin film (2D) and single crystal (3D) by precipitation method, spin casting and inverse temperature crystallization, second topic is enhancement of photoluminescence quantum yield (PLQY) and carrier mobility of organic-inorganic hybrid perovskite quantum dots (QDs) through crystallinity control and solid-state ligand exchange, and third topic is their application as opto-Electronic devices.

Keywords:

Multi-Dimensional Perovskites, Light Emitting Didoes, Crystallinity, Grain Size, Environmental Stability

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

T3.01

Skyrmions in Chiral Magnets: a Review

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Abstract:

The physics and technology of skyrmions realized in chiral magnets - a class of magnetic materials that inherently or artificially lack certain inversion symmetries - have witnessed explosive growth in the past 10 years since its discovery in 2009. On the theoretical side the dynamics of skyrmions shares many features in common with that of vortices in superfluids, for which concrete theories have evolved over many decades. In this review, I discuss aspect of skyrmion dynamics with emphasis on parallels between the two topological objects in condensed matter systems. In the second part of the talk I discuss experimental and technical progress made in recent years and try to present a loose outlook on where the field might be headed in the next few years. In the concluding part I present some interesting developments on skyrmion research that have taken place at laboratires in South Korea.

Keywords:

skyrmions, vortex dynamics, theory and experiment

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Y1.01

Gravitational Waves: A New Tool for Observing the Universe

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Abstract:

The detection of gravitational waves from binary black holes and neutron stars constitutes a major scientific discovery, as it permits a new kind of observation of the cosmos, quite different from electromagnetic and particle observations. In this talk I will review the gravitational-wave observations and discuss how these new astronomical messengers can unveil the properties of the most extreme astrophysical objects in the universe, and inform us about the nature of gravity in the highly dynamical space-time regime.

Keywords:

Gravitational Waves

포스터발표논문

Poster session abstracts

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.001

Computational simulation of plasma dispersion effects in silicon waveguides for optical modulators

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Abstract:
Optical phase modulators are used in various fields of optical communications, interconnection, and quantum key distribution system, etc. The effective index of an optical waveguide can be controlled by thermal effects or plasma dispersion effects. Thermal effects of an optical waveguide have a slow response time from millisecond (ms) to micro-second (us) scale but, electrically driven plasma dispersion effects can achieve high-frequency modulation above 100 GHz. We performed numerical calculations of a phase modulator in silicon waveguides using plasma dispersion effects. The depletion type and current type modulators are simulated and compared to each other. Under our geometrical condition (1-um width), the depletion type modulators have larger insertion loss or longer length than the current type modulator. One of the simulation results shows that a phase modulator with a length of 0.83 mm and V_pi of 0.9 V can achieve a low insertion loss of 1.34 dB. The proposed phase modulator design has low loss and a reduced number of fabrication processes as the propagating region is doped with only p-type dopant.

Keywords:
modulator, plasma dispersion effect, simulation

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.002

Dose enhancement factor(DEF) and Synthesis of synchrotron radiation-induced gold nanoparticles as radiosensitizer in radiotherapy

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Abstract:

This study investigated the feasibility and dose enhancements factor(DEF) of synthesizing GNPs using synchrotron radiation X-ray for use as a radiosensitizer in radiotherapy, and examined the morphology of the GNPs. Different concentration ratios of 4-mM gold precursor aqueous solution and 4-mM $NaHCO_3$ were mixed. This gold precursor aqueous solution was continuously irradiated with synchrotron radiation in the 4B X-ray microdiffraction beamline of Pohang Light Source (PLS)-II in Korea. The SEM, EDS, TEM, and XRD spectra of the GNPs synthesized using the synchrotron radiation were investigated. The GNPs synthesized using the synchrotron radiation were nanocrystals predominantly in the (111) direction of the face-centered cubic structure. We found that the shape of the gold nanoparticles was icosahedron at the molar concentrations of 0.25 mM:0.25 mM and 0.5 mM:0.5 mM mixed with 4mM $HAuCl_4 \cdot 3H_2O$ and 4mM $NaHCO_3$ solutions. In addition, DEF was measured according to each concentration using in-house developed phantom.

Keywords:

gold nanoparticles (GNPs), radiosensitizer, synchrotron radiation, radiotherapy, Dose enhancement factor(DEF)

P1-ap.003*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Polarized photoluminescence studies of anisotropic 2D material ReS_2

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Abstract:

Rhenium disulfide (ReS_2) is one of semiconducting van der Waal (vdW) materials. Due to the weak vdW interaction along the *c* axis, it can be exfoliated into atomically thin films. While other semiconducting vdW materials such as MoS_2 and WS_2 have a hexagonal crystal structure, ReS_2 has a distorted 1T (1T′) phase with triclinic symmetry. Due to this triclinic symmetry, ReS_2 shows optically biaxial properties and anisotropic in-plane polarization responses.[1] In addition, few-layer ReS_2 has a direct bandgap and its energy is strongly dependent on the number of layers.[2] We conducted polarized photoluminescence (PL) measurements on bulk and few-layer ReS_2 at room and low temperatures. We compared polarization dependence of PL spectra and the crystal orientation of ReS_2, which is determined from measuring polarized Raman spectra.[3] In addition, we studied the temperature and thickness dependences of the PL spectra.

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[3] D. A. Chenet *et al.*, *Nano Letters* **15**(9), 5667-5672 (2015).

Keywords:
Polarized photoluminescence measurement, ReS2, Rhenium disulfide

P1-ap.004*

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Monolithic 2D Oxide/Semiconductor Superlattice for Efficient Light Emitters

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Abstract:

Semiconducting transition metal dichalcogenides (TMDCs) have been attracted enormous attention because of exceptional optical properties such as large exciton binding energy and direct bandgap transition at the monolayer limit. Such remarkable properties make them promising for high-performance light-emitting devices such as LEDs, LASERs, and single-photon quantum emitters. However, highly efficient luminescence in the two-dimensional (2D) semiconductor heterostructures is inherently limited due to the indirect band-gap transition at the multilayer regime as well as low quantum yield of constituent monolayers.

Here, we propose a new approach to fabricate a high-efficiency luminescent 2D superlattice by monolithic phase engineering and van der Waals stacking. To achieve that, first, the bilayer WSe_2 was converted to the WO_x/WSe_2 heterolayer by the layer-by-layer oxidation. Then, by multiple stacking the monolithically-phase-engineered WO_x/WSe_2 building blocks, we successfully achieve the 2D oxide/selenide superlattice structure. Unlike the case of stacking monolayers only, the photoluminescence (PL) characteristic was not quenched in this stacked heterostructure. As the number of the stacked WO_x/WSe_2 structures increases, PL intensity increases several times more than the simple sum of the single WO_x/WSe_2. This is presumably because the WO_x layer acts as a decoupling layer between two adjacent monolayers, allowing to preserve the direct bandgap nature of monolayers even in the staked heterostructure. Our work suggests a new approach to fabricate 2D-based quantum heterostructures for high-performance light emitters.

Keywords:

TMDCs, Monolithic, Heterostructure, luminescence

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P1-ap.005

$MoTe_2$ Transistor with Ionic Liquid Gating

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Abstract:

우리는 Ionic Liquid Gating을 이용한 이텔루륨화 몰리브데늄($MoTe_2$) Field Effect Transistor (FET)를 제작하여 그 전기적 특성을 연구하였다. Si Back Gate를 이용할 때와는 달리, 높아진 Gate Efficiency로 인하여 $MoTe_2$ FET는 Ambipolar 특성을 보인다. 우리는 $MoTe_2$ FET의 특성이 시간의 경과에 따라 어떻게 변해가는지를 조사함으로써, Ionic Liquid가 소자의 특성 및 안정성에 미치는 영향을 확인하였다.

Keywords:

MoTe2, Ambipolar, Ionic Liquid, Air stability

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P1-ap.006*

Unveiling Degradation Mechanism of Black Phosphorus by Scanning Probe Microscopy and Theoretical Modeling

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Abstract:

Fast degradation remains one of the most significant challenges facing black phosphorus (BP) since the discovery of black phosphorus as a new two-dimensional (2D) material. To offer an ultimate solution for BP degradation, the complete understanding of the degradation mechanism is necessary. Despite this importance, the degradation mechanism is still lack due to the difficulties of correlating experimental measurements with the underlying physics. In this regard, we studied the degradation mechanism by using a scanning Kelvin probe microscopy and a theoretical model combining the Marcus-Gerischer theory and GW calculations. Our results demonstrate that there is an intrinsic correlation between the layer-dependent electronic structure and degradation. It provides not only a fundamental understanding of degradation but also the new strategy for improving the stability of BP.

Keywords:
black phosphorus, scanning probe microscopy, degradation

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P1-ap.007*

그래핀/그래핀 산화물 이종 접합 구조에서의 전자기적 특성 연구

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Abstract:

지난 10 년간, 그래핀은 대단히 높은 유연성, 높은 열 전도성, 높은 전자 이동도 및 긴 스핀 확산 길이 등 놀라운 물리적 및 전자기 특성으로 인해 많은 연구가 이루어지고 있다. 특히 스핀 수명과 스핀 확산 길이를 이용한 연구가 스핀트로닉스 분야에서 광범위하게 연구 되고 있다. 그러나 낮은 스핀 -주입 효율 (~ 1%)은 스핀트로닉스 소자제작의 실현에 있어 장애물이라고 할 수 있다. 최근 연구결과에 따르면, 강자성 전극과 그래핀 사이에 절연성 산화막을 사용하거나, 강자성 전극과 그래핀 사이에 Ni (111)와 같은 그래핀의 육방 격자 상수가 비슷한 재료를 사용함으로써 이 문제가 극복되는 것으로 알려져 있다.[1] 또한, 그래핀에 인접한 자기 절연체에 의해 유도된 MEF(magnetic exchange field)는 물질의 구조적 특성을 손상시키지 않으면서 2D 기반 소자에서 로컬 스핀 생성 및 스핀 변조를 효율적으로 제어 할 수 있는 것으로 알려져 있다.[2]
본 연구에서는 자외선 (UV) 빛을 이용한 산화 기술로 그래핀 산화물(graphene oxide, GO)을 제조하고, 그래핀 (G) / 그래핀 산화물 (GO) 이종접합구조 소자를 제작 하였다. 자외선을 이용한 산화 방법은 소자제작 과정에서 쉽게 생성 될 수 있는 그래핀 표면의 손상 및 오염을 최소화하여 대면적으로 그래핀 산화물을 만들 수 있는 방법이다. 이 방법으로 제작된 그래핀 산화물은 균일하게 최상부에만 에폭시 작용기가 달라붙어있게 된다.[3] 따라서, 우리는 G/GO 이종접합 소자를 제작하여 제작된 GO가 채널층인 그래핀에 작용하는 근접 효과를 조사하였다. 이 접합소자에서 일반적인 CVD(Chemical vapor deposition) 그래핀보다 Weak localization과 Shubinikov-de Haas oscillations가 더 크게 나타나는 것을 확인하였으며, MR(magnetoresistance)측정 결과 저온에서 negative MR이 나오는 것을 확인하였다. 이것은 GO가 갖는 강자성 특성이 그래핀의 Spin-orbit coupling을 향상시키는 것으로 예상된다. 따라서, G/GO 소자에 나타난 근접 효과는 향후 양자 정보 처리에서 떠오르는 2D 재료들을 기반으로 하는 스핀 로직 및 메모리 디바이스로 제작될 수 있는 핵심적인 기능성을 제공할 것으로 예상된다.

References

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Keywords:
Spintronics, Graphene, Graphene oxide, proximity effect

P1-ap.008

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A study of synthesis conditions for quantum-well-shell structured quantum dots and photoanodes fabricated by a sono-chemical SILAR.

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Abstract:

성장온도 조절 및 multi-layer 양자점 합성이 어려운 기존의 hot-injection synthesis의 단점을 대체하고자 개발한 one-pot snythesis를 이용하여 quantum-well-shell 구조의 InP 기반 양자점을 합성하였다. 해당 구조는 zinc sulfide를 core와 shell layer로 하며 indium phosphide를 well layer로 갖는 ZnS/InP/ZnS의 core/well/shell 구조이며 양자점 합성과 관련하여 적정 원자 비율(atomic ratio), 초음파 파워, 그리고 성장시간에 대해 연구를 진행하였다. 또한 초음파 연속 이온층 흡착법(Sono-chemical Successive Ionic Layer Adsorption Rreaction, SC-SILAR)을 적용하여 quantum-well-shell 구조의 양자점을FTO/TiO_2 기판에 흡착시켜 태양전지 하판(photoanode)을 제작하고 그 특성을 X선 회절 분석(XRD), 제한시야회절(SAED) 투과 전자 현미경(TEM), 자외선-가시광 흡수도(UV-Vis absorption) 및 광 발광(Photoluminescence)을 기반으로 조사하였다.

Keywords:

Nanomaterials, Quantum dots, Sono-chemical SILAR, Quantum-well-shell structure

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P1-ap.009*

Second harmonic generation spectroscopy on transition metal dichalcogenides

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Abstract:

Second harmonic generation (SHG) spectroscopy is a fascinating experimental method to investigate exciton states in 2-dimensional materials. Fixed wavelength SHG is commonly used to determine the crystallographic orientation in transition metal dichalcogenides (TMD). Additionally, the electronic states can be investigated by measuring the SHG signal while varying the wavelength of the excitation source. Using photoluminescence excitation (PLE) which is another useful method to investigate the energy states, only s-exciton states can be measured due to the selection rule. In contrast, both s- and p-exciton state resonances are observed in the SHG spectroscopy, although the signal only occurs in structures with broken inversion symmetry [1].

For measuring the SHG spectroscopy on 2-dimensional materials, a tunable-wavelength ultrafast pulsed laser is needed. We combined a supercontinuum laser excitation source with a microscopic measurement system. Using the system, micron-scale 2-dimesional samples can be measured with various excitation wavelengths from 420 to 1700 nm. In this work, we measured SHG spectroscopy on 4 representative TMDs (MoS_2, $MoSe_2$, WS_2 and WSe_2) to check the performance of the system [2].

[1] G. Wang *et al.*, Phys. Rev. Lett. **114**, 097403 (2015).
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Keywords:

Second harmonic generation, Second harmonic generation spectroscopy, transition metal dichacogenides

P1-ap.010*

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Correlation between defects of Bi_2Te_3 topological insulator nanowires and their transient photocurrent

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Abstract:

Three-dimensional topological insulators (TIs) host surface states with linear dispersion, which manifest as a Dirac cone. The photoresponse of visible light in the topological insulator with the state of TSS was greatly improved. However, defects in the topological insulator contribute to non-ideal behavior in the transport characteristics. In this regard, the electronic structure of materials can be effectively regulated through defect engineering. Thus, the correlation between defects and the properties of a material has attracted extensive attention. Here, we have investigated the relationship between defects and photocurrent characteristics of Bi_2Te_3 nanowires represented by topological insulator materials and photodetector materials. We synthesized single-crystal Bi_2Te_3 nanowires by using a vapor-liquid-solid (VLS) method and formed defects in a subsequent annealing processes in a vacuum atmosphere. As a result of the structural analysis by TEM measurement, it was confirmed that defects were increased with increasing annealing temperature. In addition, we have studied photoresponse in the defective Bi_2Te_3 nanowires and observed that, unlike single-crystal nanowires, the transient photocurrent is generated under the illumination of visible (520nm) light. The characterized transient photocurrent spectrum demonstrates that the photocurrent values closely correlate with the concentrations of the defects. The results of this study suggest new ways to design and apply nanostructured materials with excellent optoelectronic properties.

Keywords:
Topological insulator, photocurrent, nanowire, defect, transient photocurrent

P1-ap.011*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Observation of interlayer interaction in $WSe_2/MoSe_2$ heterostructure

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Abstract:

Heterostructures of 2-dimensional transition metal dichalcogenides (TMDs) show interesting properties such as interlayer exciton, and the Moiré pattern. Although the features and effects of interlayer excitons in heterostructures have been intensively studied so far, they are not fully understood yet. We investigated the excited states of the interlayer excitons in $WSe_2/MoSe_2$ heterostructures by using photoluminescence excitation (PLE) spectroscopy.

We fabricated heterostructures of monolayer WSe_2 and $MoSe_2$ on SiO_2/Si substrates by the dry transfer method. The samples were encapsulated by hBN layers for excluding extrinsic effects. We performed PLE and reflectance spectroscopy on the heterostructures at room temperature and low temperature using a collimated broadband light combined with a monochromator as an excitation source.

Keywords:

TMDs, heterostructure, PLE, Photoluminescence

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.012*

TEM and Raman investigations of crystalline red phosphorus

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Abstract:

Red phosphorus, an allotrope of phosphorus which is usually known to be amorphous, has several types of crystalline phases. The atomic structures and electrical properties of crystalline red phosphorus, however, have not been studied in detail. According to previous studies, there are five types of phosphorus phases and the crystal structures of type II and type III phases are yet to be discovered. The crystal structures of type IV (fibrous red phosphorus) and type V (Hittorf 's phosphorus) were revealed, showing complex crystal structures. Here we investigate the crystal structures and electrical properties of crystalline red phosphorus. Using chemical vapor transport method, we synthesized crystalline red phosphorus. Using Raman spectroscopy, electron diffraction, and X-ray diffraction measurements, we confirmed that synthesized red phosphorus is a mixture of type IV and other crystalline phases. The observed strong photoluminescence at around 1.9 eV and theoretical calculations of the bandstructure suggest that crystalline red phosphorus has great potential for optoelectronic applications.

Keywords:
red phosphorus, nano material, TEM, Raman, device

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2019-04-24 - 2019-04-26

P1-ap.014*

Surfactant-Assisted Wafer-Scale Growth of High Quality Tungsten Disulfides using Metal-Organic Chemical Vapor Deposition

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Abstract:

Atomically thin transition metal dichalcogenides (TMDs) have recently attracted tremendous scientific and technological interests as an emerging semiconductor because of their exceptional electrical and optical properties. For practical device applications, the wafer-scale and uniform growth of TMDs with large grain sizes is surely required. In this research, we will present the wafer-scale growth of monolayer tungsten disulfides (WS_2) using metal-organic chemical vapor deposition(MOCVD). By optimizing the growth conditions such as temperature, pressure and molar ratio of precursors, first of all, monolayer WS_2 was grown uniformly on 2-inch SiO_2/Si wafer. We investigated the optical properties of MOCVD-grown thin films using photoluminescence and Raman spectroscopy, exhibiting high optical quality comparable to that of
the exfoliated single crystal counterpart. To further improve the quality of WS_2 thin films, the spin-coated NaCl was employed as a surfactant during the MOCVD growth. We found that the NaCl-assisted WS_2 films had much larger grain sizes and improved optical characteristics than those of normally-grown films. This is presumably due to suppressed nucleation and promoted lateral crystal growth aided by the surfactant. The detailed growth mechanism and the role of NaCl are still under investigation.

Keywords:
MOCVD, WS2, TMDs, Growth

KPS 한국물리학회 The Korean Physical Society

P1-ap.015

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Hexagonal boron nitride covered semiconductor devices for passivation layer

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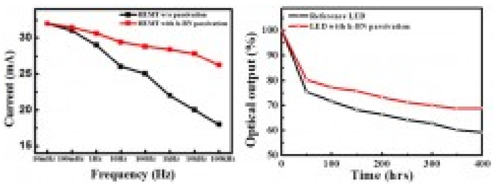
Abstract:



GaN 기반 반도체 소자의 개발로 solid state 광 산업의 발전과 전자소자의 발전에 박차를 가할 수 있게 되었다. 3족 질화물 반도체 성장과 소자 제작이 지속되어옴에도 불구하고 고품질 GaN 박막의 성장이 이슈가 되고 있다. 박막의 품질을 향상시키기 위한 동정 기판 성장은 기판의 높은 가격에 의하여 실제 사용되어지기 어려운 단점이 존재한다. 고품질의 GaN 박막의 성장을 위하여 가장 많이 사용되고 있는 이종기판인 c축 방향 사파이어는 가격이 저렴하다는 장점이 있다. 하지만 큰 열팽창계수 차이와 격자상수의 차이는 2축 압축 스트레스를 형성하게 되고 이로 인하여 높은 밀도의 스레딩 전위를 형성시킨다. 이러한 스레딩 전위는 광소자의 경우 비 발광성 재결합 센터로서 작용하여 광소자의 내부양자효율 및 동작 특성을 크게 저하시키며 온도를 향상시켜 소자의 수명이 짧아지게 된다. 고속전자소자의 경우 스레딩 전위에 의하여 채널 내부 또는 소자 표면에 전자가 트랩되어 소자의 gain 특성을 저하시키며 전류붕괴현상을 야기한다. 이렇게 GaN 기반 반도체 소자의 동작 특성을 저하시키는 스레딩 전위를 해결하기 위한 방안으로 GaN 박막 성장시 수평성장기법, 패터닝된 사파이어 사용, 나노구조등을 이용하는 Bottom up 방식이 있으며, 소자의 표면을 비전도의 물질인 SiNx, AlNx, SiO2 등을 패시베이션 하는 Top down 방식이 존재한다.
육각 붕소 질화물 (hexagonal boron nitride, h-BN) 은 고온의 안정성, 휨 특성, 높은 열 전도성 및 절연 특성과 같은 뛰어난 물성으로 인하여 많은 주목을 받고 있는 물질이다. 본 연구에서는 h-BN을 각각 광소자와 고속전자소자에 적용하고자 하였다. 고온에서의 플라즈마 화학기상증착법을 적용해야 하는 SiO2와 달리 상온에서 트랜스퍼 방식을 이용하여 소자의 표면에 패시베이션이 가능하여 소자의 열화를 방지할 수 있는 h-BN은 간단한 공정을 통해서 소자의 보호 및 동작 특성의 향상을 가능하게 한다.
Fig.1. Device performances after h-BN passivation of high electron mobility transistor and light emitting diodes

Keywords:
h-BN, Passivation, HEMT, LED

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Optical fibers/Black TiO_2 nanotubes for Trace Contaminant Control System

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Abstract:
The concentration of volatile organic compounds (VOCs) that are off-gases from instruments as well as from the human metabolism are significantly considered when designing of spacecraft and spacesuit for long period mission such as planet exploration because they derive diseases such as central nervous disorder, irritation of mucosa and arrhythmia. As present VOCs control system that are composed a charcoal bed for adsorption, a sorbent bed(2kg of LiOH/day-person, LiOH affects irritation of eyes) and a catalytic oxidizer(operated at 400°C) is heavy and complex, thus, development of compact and efficient VOCs control system is important. As a results, we suggested that TiO_2 nanotubes enable to reduce weight of present VOCs control system and hazardous LiOH replacement. In this study, TiO_2 nanotubes were used for decomposition of VOCs that confined at inside and outside tube walls to protect astronauts against VOCs. TiO_2 nanotubes were prepared by alkaline based hydrothermal reaction in convection oven and subsequently it was processed on TiO_2 nanotube ink. VOCs for decomposition test were considered based on spacecraft maximum allowable concentrations table from NASA. Their efficiency of VOCs decomposition in both TiO_2 nanoube-coated optical fibers and transparent glass sheets will be investigated and evaluated in the trace contaminant system of spacecrafts.

Acknowledgement
This research was supported by space Core Technology Development Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education Science and Technology(MEST) (2017M1A3A3A02016666)

Keywords:
Trace Contaminant Control System, Optical fibers, Black TiO2, VOC

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P1-ap.017

Study of CVD graphene based gas barrier by interfacial control

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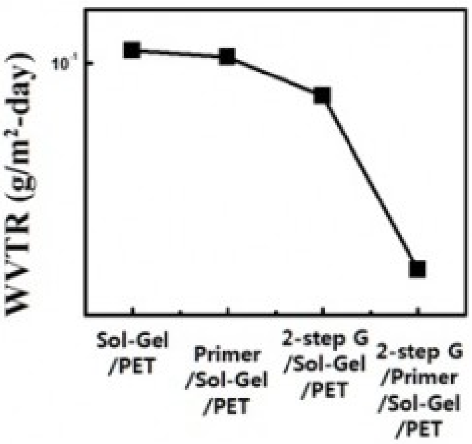
Abstract:

그래핀은 탄소 원자들이 sp2 결합으로 육각형 구조를 이루고 있는 2차원 물질로서 높은 캐리어 이동도, 유연성, 투명성 등을 모두 갖춘 신소재입니다. 또한 이 육각형 구조의 크기는 제일 작은 원자인 수소 원자보다 작아 완벽한 그래핀을 만든다면 가스 배리어로서 최적의 물질이 됩니다.



현실적으로 완벽한 그래핀을 만들기 어렵지만 상대적으로 결함이 적은 그래핀을 만드는 것은 가능합니다. 그래핀 성장에서 초기 핵 생성 밀도가 결과적으로 결함과 관련이 있습니다. 저희는 그래핀의 결함을 줄이는 방법으로 1 step이 아닌 2 step으로 그래핀을 성장하였고 그로 인한 배리어 특성이 향상되는 것을 확인하였습니다. 또한 그래핀 다층구조에서 배리어 특성이 레이어 개수에 비례하여 향상되지 못하다는 것을 발견하였으며 이러한 이유는 그래핀 레이어 사이의 반데르발스 결합이 약하기 때문입니다. 이 결합을 증대시키기 위해 플루오르화 처리를 통해 반데르발스 결합이 강하게 만들었으며 그로 인해 배리어 특성 또한 향상시켰습니다.

그래핀을 배리어로서 활용을 하려면 얇은 PET 필름 위에 전사를 해야 합니다. 하지만 PET 필름의 특성상 표면의 균일도가 떨어짐에 따라 개선방안으로 PVDC 코팅을 활용하였습니다. 그 결과 부착력과 배리어 특성이 모두 좋아지는 것을 확인할 수 있었습니다.

마지막으로 유무기-하이브리드 구조의 배리어를 만들었으며 배리어 측정 결과 위 방법들보다 상대적으로 뛰어나다는 것을 확인할 수 있었습니다. 하지만 부착력이 상대적으로 떨어져 이에 대한 개선 방법으로 primer 처리를 도입하였습니다. 그 결과 primer층으로 인한 배리어 특성이 개선되는 것을 확인 할 수 있었습니다.

Keywords:
Graphene,Barrier,WVTR

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Cu NRs/$CaFe_2O_4$ photo-cathode for CO_2 photo-conversion

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Abstract:

Research of CO_2 fuel conversion selectivity have been critical issue because products are mixed during CO_2 photo-conversion. Some of metal oxide catalysts to improve conversion selectivity have been available for different products. In this study, $CaFe_2O_4$ photo-cathode was prepared by polyol method, chemical bath deposition and oxidation after electrodeposition using FTO glass. Grown heterojunction nano-structures were confirmed by means of both FESEM (field emission scanning electron microscope) and TEM (transmission electron microscope). CO_2 to CH_3OH conversion selectivity test was conducted using three electrode system under visible light that of intensity 100mW/cm^2. Products of CO_2 reduction was collected by micro-syringe and subsequently transferred to the NMR (nuclear magnetic resonance) and Raman spectroscope to identify inside solution composition. Quantitative measurement of CH_3OH was evaluated by GC-MS (gas chromatography-mass spectrometer) and stability of $CaFe_2O_4$ also was studied.

Acknowledgement
This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education Science and Technology(MEST) (2018R1D1A1B07040352)

Keywords:
Cu NRs, CaFe2O4, CO2, Polyol method

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Two-dimensional Electron Gas at Thin Film Oxide Heterostructures Using Atomic Layer Deposition

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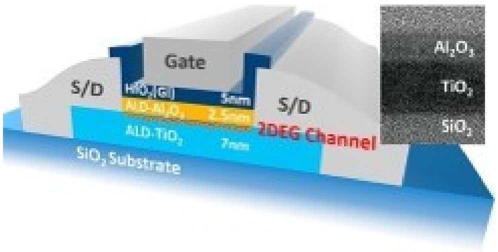
Abstract:



Two-dimensional electron gas (2DEG) at oxide heterostructures has received intense attentions owing to their unique physical properties. The model system is an epitaxial interface of $LaAlO_3/SrTiO_3$ heterostructure. 2DEG has been realized only at the atomically abrupt and sharp interface of $LaAlO_3/SrTiO_3$ heterostructure in which $LaAlO_3$ layer is grown epitaxially on single crystalline $SrTiO_3$ substrate. Unfortunately, the fabrication scheme for the 2DEG creation is not suitable for practical use because of their high cost in the production of the oxide single crystal and epitaxial layer.
In this presentation, we show a creation of 2DEG at Al_2O_3/TiO_2 thin (<15 nm) film heterostructure using atomic layer deposition (ALD) at low temperature (<300°C). It was observed that high density electrons up to (10^{13}~$10^{14}/cm^2$) were confined at the interface of Al_2O_3/TiO_2 heterostructure which electron density is 100 times higher than that of the conventional semiconductor heterojunction. Interestingly, the electron density can be tailored by the ALD process parameter. With the Al_2O_3/TiO_2 thin film heterostructure, a transparent thin film transistor (TFT) was fabricated which outperforms conventional TFTs. A high on-current (I_{on}, > 12 mA/mm), high on/off current ratio (I_{on}/I_{off} > ~10^8), low off-current (I_{off}, ~10^{-8} mA/mm), and low sub-threshold swing (SS, ~100 mV/dec.) are achieved. In addition, the application of 2DEG to gas senor will be introduced in the presentation. After all, the creation and control of 2DEG at thin film oxide heterostructure using ALD, and their applications to thin film transistor and gas sensor will be introduced in the presentation.

Keywords:
Two-dimensional electron gas; Atomic layer deposition; Field-effect transistor; Titanium oxide; Aluminum oxide

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Pulsed wire evaporation based $Cu/Al_2O_3/Cu_2O$ for CO_2 to CH_3OH selectivity and high yield

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Abstract:

Ongoing research of the precise CO_2 to fuel conversion selectivity became important issue because products are mixed during CO_2 reduction. In order to improve conversion selectivity, some of metal oxide catalysts are available for different products. In this study, Cu_2O was vertically grown on FTO glass by chemical bath deposition instead of dominant chemical vapour deposition. And grown Cu_2O nanorods were confirmed by means of both FESEM (field emission scanning electron microscope) and TEM (transmission electron microscope). Al_2O_3 NPs were comparatively studied by three different methods that of pulsed wire evaporation/electrodeposition/oxidation process and SILAR (successive ionic layer adsorption and deposition process process). CO_2 to CH_3OH conversion selectivity test was conducted using three electrode system under visible light that of intensity $100mW/cm^2$. Products of CO_2 reduction was collected by micro-syringe and subsequently transferred to the NMR (nuclear magnetic resonance) and raman spectroscope to identify inside solution composition. Quantitative measurement of CH_3OH was also conducted by HPLC (high performance liquid chromatography).

Keywords:

Pulsed wire evaporation, Cu, Al2O3, Cu2O

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P1-ap.021

Understanding the Interfacial Electronic Structure of WSe_2/C_{60}

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Abstract:

The junction between two-dimensional materials and organic materials has received considerable attention for optoelectronic devices. While most transition metal dichalcogenides (TMDCs) shows n-type characteristics, tungsten diselenide (WSe_2) shows an ambipolar or p-type characteristics with high carrier mobility. Because of these properties, WSe_2 has been the most widely used as p-type material for the van der Waals heterojunction. On the other hand, fullerene (C_{60}) has been mostly used as an electron acceptor in organic photovoltaics due to a high electron affinity and mobility. This is why the WSe_2/C_{60} is the most representative p-n junction to understand organic-2D interface. Despite this potential, it is not yet fully understood what will happen at their interface through the van der Waals interaction. In this regard, direct observation on the interfacial electronic structure of WSe_2/C_{60} would give critical information for the charge transfer and chemical interaction between them.

In this study, we prepared clean WSe_2 single crystal with cleaving. Then, C_{60} was deposited on WSe_2 to from the van der Waals interface. We performed in-situ ultraviolet photoelectron spectroscopy and x-ray photoelectron spectroscopy with gradual increase of the C_{60} thickness on bulk WSe_2. Our measurements show that the WSe_2/C_{60} interface forms a type-II heterojunction.

Keywords:
tungsten diselenide, organic material, electronic structure, photoelectron spectroscopy

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P1-ap.022*

TEM Imaging and Electron Diffraction of Vertically Stacked Graphene/h-BN with Fine Control of Twist Angle

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Abstract:

Vertical heterostructures incorporating two-dimensional (2D) atomically-thin crystals have attracted significant research interest owing to their novel physical properties arising from interlayer interaction. The twist angle between neighboring layers in a vertical stack is a degree of freedom which strongly influences the various properties. The process to build vertical structure with fine control of twist angle is therefore of critically importance. We fabricated graphene/h-BN stacks with 0.0º interlayer twist angle by mechanical exfoliation and transfer by visualizing the crystal orientations of various hexagonal 2D crystals using AgCN microwires. The uniform moiré pattern over the observed region indicates that 2D interface between graphene and h-BN is pristine. We suggest a reliable angle-controlled stacking method which can be extended to build heterostructures using various 2D crystals, including transition metal dichalcogenides (TMDCs).

Keywords:

crystallographic orientation, AgCN, angle-controlled structure

P1-ap.023

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2019-04-24 - 2019-04-26

Analysis of VO_2 nanosphere's dynamic properties using Photon Correlation Spectroscopy

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Abstract:

전이금속산화물은 일반적으로 다양한 조성과 이에 따른 특이한 결정구조로 되어 있으며 금속 및 반도체 특성부터 절연체 특성까지 전반적인 물리적 특성을 지니고 있다. 그 중 산화물(V_2O_5, VO_2, TiO_2 등)들은 온도, 압력, 또는 불순물의 농도 등이 변함에 따라 결정구조 변화를 수반한 상전이와 함께 금속에서 절연체로 변하는 MIT(Metal-insulator transition)특성을 나타낸다. 이들 중 VO_2는 다른 전이금속 산화물에 비해 상온에 근접한 340 K에서 금속-절연체 전이가 일어나며, 급격한 광학적, 전기적 특성의 변화를 수반하여 온도센서, 광스위칭 장치 등과 같은 다양한 곳에서 응용성이 입증되고 있다.
본 연구에서는 PCS(Photon Correlation Spectroscopy)를 사용하여 금속-절연체 전이 전, 후 VO_2 nanosphere의 동역학적 특성을 비교 분석하였다. VO_2 파우더를 3차증류수와 에틸렌 글리콜에 각각 분산시켰으며, 분산된 용액의 농도를 10 nM로 조절하여 VO_2 nanosphere의 광자신호를 얻었다. VO_2 nanosphere에서 얻어지는 광자신호를 상관함수의 형태로 분석하였으며, 열원을 사용하여 MIT 현상 전, 후 VO_2 nanosphere의 동역학적 특성을 비교 분석하였다.

Keywords:

VO2, MIT, PCS

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.024*

Fabrication of metal gratings with E-beam lithography; dose and development time dependence

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Abstract:

E-beam lithography is the technique for generating a custom pattern by scanning a focused electron beam emerging from a SEM onto a substrate coated with an electron beam resist material(ER). This technique uses electron beams, the amount of electrons exposed to the substrate, called dose, has a great influence on the quality of the sample. Also, the development time to remove the ER exposed to the electron beam depends on the dose.

In order to confirm the pattern quality according to the dose, ER was coated on the glass substrate to a thickness of about 200 nm and a grating structure having a period of 500 nm was fabricated. The higher the dose, the better the quality of the pattern. However, at over a certain dose, the overdose phenomenon was observed in which the pattern was not formed due to excessive exposure to electrons. To confirm the dependence of the dose and development time, we experimented with changing the development time of the grating structure made with the same dose. As a result, it was confirmed that the pattern quality was improved as the higher the dose, shorter development time.

Keywords:

E-beam lithography, Dose, Development time

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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P1-ap.025*

Two Dimensional Molybdenum Diselenide Field Effect Transistor with Polymer-Brush/Channel Interface for Touch Sensor Applications

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Abstract:

Being implemented as an active component in the circuits, two dimensional (2D) transition metal dichalcogenide (TMD) transistors have two types of difficulties. Firstly, regardless of carrier type,

threshold voltage (V_{th}) of TMD 2D field effect transistors (FETs) is located far away from 0 V. Second, gate bias induced hysteresis exists in general 2D TMD transistors, causing an unstable operation of FET.

Here, we have fabricated stable n-channel $MoSe_2$ FETs with a relatively small V_{th} of -5 V and minimized-hysteresis of 0.5 V. And we have checked the stable operation by integrating a smart touch sensor circuit composed of piezoelectric P(VDF-TrFE) polymer, the MoSe2 FET, and organic light emitting diode (OLED). To minimize the Vth and gate voltage hysteresis of 2D FET, we inserted ultrathin (8.46 nm)

polystyrene (PS)-brush layer between $MoSe_2$ channel and 50 nm-thin Al_2O_3 dielectric. Our $MoSe_2$ FET

has showed a maximum drain-current (I_D) of ~9 μA at V_{DS} of 1 V along with a high linear mobility of

11.2 cm^2/V s. In the analogue touch sensor circuit gated by piezoelectric film of large scale Al/50 μm-thick P(VDF-TrFE)/ITO/glass, the $MoSe_2$ FET exhibites high ON/OFF ratio and ON-state ID which quite well demonstrated OLED pixel operation.

Keywords:
hysteresis, interface, MoSe2 FET, polystyrene-brush

P1-ap.026

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Magnetic anisotropicity of core-shell Au@FeCo, solid-, and hollow-type FeCo

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Abstract:

In this study, solid, core-shell, and hollow-type iron-based magnetoplasmonic (MagPlas) nanoparticles (NPs) were produced via the thermolysis synthesis route. Different magnetic behaviors of the magnetic NPs in the presence of plasmonic material are experimentally observed by monitoring blocking temperature. Compared with hollow FeCo and solid FeCo, anisotropy of Au@FeCo decreased. This change may come from the overlap or interaction between the “d” orbitals electrons of Fe(3d6)Co(3d7) and the “s” orbital electron from Au (6s1), resulting in lowering the magnetic anisotropy of the Au@FeCo sample.

Keywords:

Magnetoplasmonic nanoparticles, ferromagnetic nanocrystals, magnetic anisotropy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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P1-ap.027*

Flexible Deep-Ultraviolet Photodetectors using Amorphous Gallium Oxide Thin Films Grown by Atomic Layer Deposition

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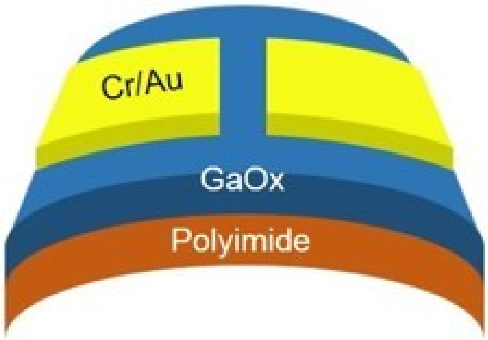
Abstract:



Deep-ultraviolet (DUV) wavelength light has been considered for the detection of biological molecule, missile tracking, water or air purification. However, DUV light is dangerous and harmful to human body because of its high energy (>4eV). So, a high-performance DUV photodetector is necessary to use the DUV light safely. Unfortunately, most of existing DUV photodetectors show a low performance in the DUV detection despite the use of an epitaxial film such as AlGaN. Even with the use of epitaxial beta-Ga_2O_3 films, the photodetector shows a slow response speed with low responsivity.
Here, we show high-performance DUV photodetectors using amorphous gallium oxide thin films (GaO_x) grown by atomic layer deposition (ALD) at a low growth temperature of <250℃. The photodetector using 30-nm-thick amorphous GaO_x film shows a fast response (rise time is as short as ~3us) with high responsivity (~45 A/W at λ = 253 nm) which outperforms conventional DUV photodetectors. The cut-off wavelength is ~ 300 nm which does not respond to visible lights. It should be noted that general substrates such as a glass and quartz can be used for the DUV photodetector due to the amorphous phase of GaOx film, implying a practical application of the process/fabrication protocol. Finally, we demonstrate a flexible DUV photodetector fabricated on polyimide substrate which showed a reliable detection of DUV with the repetitive bending cycles at a bending radius of <10 mm. This process scheme will provide an economically useful solution for the development of DUV photodetector.

Keywords:
Photo detector, Atomic Layer Deposition, Amorphous, Gallium Oxide, Flexible

한국물리학회 The Korean Physical Society

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Transparent hydrogen gas sensor using two-dimensional electron gas at oxide heterostructure

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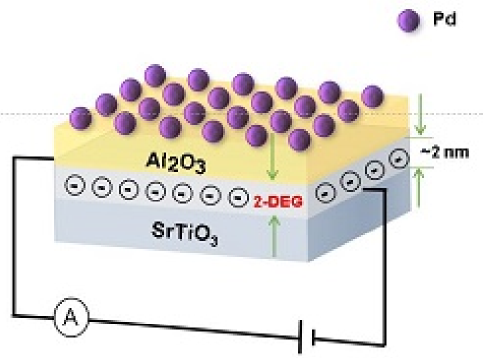
Abstract:

Hydrogen (H_2) is a clean and environmentally-friendly energy source owing to its low ignition energy and high heat of combustion of which the combustion product is H_2O. Recently, H_2 has been considered to be the energy source for the operation of electrical vehicles. However, H_2 is flammable and explosive in the concentration of 4-75%, and its colorless and odorless properties make the detection of H_2 by human beings impossible. Therefore,

sensitive H_2 gas sensor is required for the safety.

In this presentation, we report high-performance H_2 gas sensors

using two-dimensional electron gas (2DEG) at the interface of $Al_2O_3/SrTiO_3$ heterostructure using atomic layer deposition. Palladium (Pd) or platinum (Pt) catalysts are used on top of the $Al_2O_3/SrTiO_3$ heterostructure. We will show a sensitive H_2 gas



sensor performance using 2DEG at the interface of $Al_2O_3/SrTiO_3$. The H_2 gas sensors can detect H_2 gas sensitively (5ppm-1%) with fast response even at room temperature. Adsorbed H_2 gas changes the resistance of underneath 2DEG, and detailed detection mechanism will be introduced in the presentation. The oxide heterostructure has a wide bandgap which allows a fabrication of transparent gas sensor.

Keywords:

Hydrogen Sensor, Two-dimensional electron gas(2DEG), SrTiO3(STO), Atomic Layer Deposition(ALD)

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.029

A computational study of black phosphorus-based van der Waals p-n diode

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Abstract:
Recently, two-dimensional (2D) materials have been actively studied in various fields. It is known that graphene, one of the 2D materials consisting of carbon atoms, has excellent electron mobility and permeability. Despite these excellent properties of graphene, one drawback in use of graphene in the electronic devices is that electron mobility of graphene is considerably reduced when the band gap is generated. To overcome such drawback, diverse 2D semiconducting materials have been investigated, including transition metal dichalcogenides (TMDs) and black phosphorus (BP). Layered structures such as TMDs and BP show the variations in electronic structure depending on the number of layers: As the number of layers increases, their band gaps are decreased. Here, we have studied atomic and electronic structures of p-n heterostructures based on BP such as BP/WS_2 and BP/IGZO(indium gallium zinc oxide), using density functional theory (DFT) calculations. Especially, we investigate the effect of external applied electric fields on their electronic structure and band alignment.

Keywords:
BP, TMD, IGZO, p-n diode, DFT, band alignment, electric fields

P1-ap.030*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Simulational studies using finite element method to analyze plasmonic properties of self-assembled Ag@Fe3O4 nanoparticles

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Abstract:

Magneto-plasmonic nanostructures were have been interested because of its novel physical properties which can be applied in optics, electronics, and bio-engineering. 0D plasmonic nanoparticle's optical properties can be explained with the concept of localized surface plasmon resonance. Its optical properties were changeable when these nanoparticles were assembled into the 1-3D structure because of plasmonic coupling. On the other side, many researchers tried to fabricate metamaterials, the structure which shows abnormal optical property because of its permittivity and permeability which can be tuned by the periodic structures. We tuned optical responses by changing the inner structure of nanoparticles and moreover, by self-assembling nanoparticles into 1-3D suprastructures. Additionally, we simulated absorption and scattering spectra of self-assembled suprastructure of Ag@Fe3O4 nanoparticles by using finite element method (FEM). We solved time-harmonic electromagnetic field distributions based on Maxwell's equation. We integrated energy loss on the surface and the volume of nanoparticles to plot extinction, scattering, and absorption. Optical properties of single Ag@Fe3O4 nanoparticle in different condition was simulated. Moreover, 1-3D and chiral self-assembled structure of single nanoparticle were also simulated.

Keywords:

Magneto-plasmonic; nanostructures; self-assembly; suprastructure; metamaterial; finite-element-method (FEM)

P1-ap.031*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Growth of High-k Thin Films on Graphene Surface Using Atomic Layer Deposition

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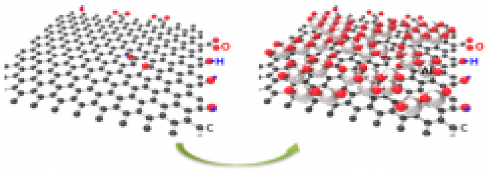
Abstract:

Graphene has received considerable interests for nano/opto electronics because of its unique band structure. Especially, graphene is an emerging channel material for high-performance metal-oxide-semiconductor field effect transistors. To fabricate a top-gated graphene transistor, a growth of high-k thin film is essential on graphene surface. Unfortunately, the growth of high-k thin film on the graphene surface is not favorable even using atomic layer deposition (ALD) due to an absence of surface functional groups on the graphene surface, which is necessary for oxide ALD.



Here, we propose a novel method for the generating of nuclei which enhances a growth of high-k thin film such as HfO_2 and Al_2O_3 via a graphene surface treatment using trimethylaluminum (TMA) and H_2O prior to the deposition of HfO_2 and Al_2O_3 film on the graphene. The graphene surface treatment provides Al_2O_3 nuclei as the adsorption sites on the graphene surface, and they enhanced the nucleation and growth characteristics of high-k thin films grown by ALD on the graphene surface. As a result, a leakage current (with a capacitor fabrication) was decreased by a factor of 10^5 (than that without using the surface treatment). This graphene surface treatment provides the enhanced nucleation and electrical properties of HfO_2 films without degrading the mobility of graphene such that it provides promising opportunities in graphene electronics.

Keywords:
Novel treatment method using physical adsorption.

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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P1-ap.032*

Magnetic filed-assisted self-assembled plasmonic chiral film

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Abstract:
Helix is representative structures which shows optical activity. In nature, helical structures exist everywhere. From the molecular level for example biological molecules such as DNA, amino acid to cosmic phenomenon, planetary movement, gravitational wave, we can easily find the chiral and helical structures and vortex movements, and circularly polarized waves. The origin of chirality is coming from the structural asymmetry. Chiral structures such as helix have no any symmetric point, line, and plane. So it cannot be overlapped with its symmetric images. This figures can give different interactions with right- and left-handed circular polarized light. Here, we fabricated nature-inspired helix-mimetic optical activity modulator with self-assembled magnetoplasmonic nanochains. In the polymer gel and solution, we can assemble magnetic nanochain by external magnetic field. In addition, we can control its structures by physical force and magnetic field arrangement. As a results, circular dichroism signal intensities and sign can be changed.

Keywords:
magnetic field, magnetoplasmonic nanoparticles, chirality

P1-ap.033*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Enhanced electrochemical properties of multi-dimensional nanocarbons used as electrodes of electrochemical capacitors

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Abstract:

Recently, nano-structured carbons or nanocarbons have been extensively studied as electrode materials for supercapacitors. In general, high specific surface area and proper pore size are important factors of electrode materials to achieve high electrochemical characteristic. This work focuses on the improving electrochemical properties of multi-dimensional nanocarbons materials which are formed by combining of different types of nanocarbons. We obtained high performance of electrochemical properties by using the multi-dimensional nanocarbons as electrode material. Carbon nanoplatelets (CNPs, two dimensional structure of nanocarbons) were combined with carbon nanotubes (CNTs, one dimensional nanocarbons) to form multi-dimensional carbons (2D-1D, CNP-CNTs). The CNP-CNTs were synthesized by directly growing CNTs on CNPs. The specific capacitance of CNP-CNTs is two times higher than those of CNP. Also, Wrinkled Graphene Oxide(WGOs, 3D structure of nanaocarbons) were combined with CNTs. The WGO-CNTs were synthesized by directly growing CNTs on WGOs (3D-1D). Electrochemical characteristics of WGO-CNTs as supercapacitor electrodes including cyclic voltammetry and galvanostatic charge-discharge reveal enhanced properties compared to CNP-CNTs.

Acknowledgements
This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2017R1D1A1B03032466). This work was supported by the Technology Innovation Program (10052774, Development of hybrid supercapacitor by nano structure carbon for ISG Applications) funded by the Ministry of Trade, Industry & Energy (MI, Korea).

Keywords:
nanocarbons; carbon nanoplatelets; carbon nanotubes; graphene oxide; wrinkled graphene oxide; supercapacitors

P1-ap.034*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Optical anisotropy of WS_2/ReS_2 heterostructure

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Abstract:

Recently, homo- or hetero-structures of layered materials are an attractive topic because of their unique properties [1]. Tungsten disulfide (WS_2), which is one of the most-studied transition-metal dichalcogenides (TMDs), shows isotropic properties, whereas rhenium disulfide (ReS_2), has anisotropic properties. The optical anisotropy of heterostructures of these materials is not understood yet.
We fabricated heterostructures of WS_2/ReS_2 using a dry-transfer method [2]. We confirmed the stacking quality from low-frequency Raman measurements which are sensitive to the inter-layer interactions. Using polarized Raman measurements, we investigated the anisotropic properties for the artificially stacked region. Also, we measured the excitation energy-dependent Raman spectra with several excitation energies. We compared the Raman spectrum of heterostructure to each monolayer's spectra. We also found that the intensities of specific Raman modes show anomalous enhancement in the heterostructure.

References
[1] A. K. Geim *et al.*, *Nature* **499**, 419-425 (2013).
[2] A. Castellanos-Gomez *et al.*, 2D Mater. **1**, 011002 (2014).

Keywords:
Transition-metal dichalcogenides, heterostructures, Raman spectroscopy, WS2/ReS2

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.035*

The Study on the Topological Insulator Bi_2Se_3/WSe_2 Vertical Heterostructure for High performance Photodetectors

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Abstract:
Tungsten diselenide (WSe_2) belongs to a group of substances called transition metal dichalcogenide compounds (TMDCs). TMDCs have dragged huge research interests with their strong optical properties and tunable band gap unlike graphene. They are regarded as one of the candidates for future devices, and their use as photodetectors have been reported as well. Various materials have been tried for their use as photodetectors for improving performance. Here, we tried on topological insulator-TMDCs heterojunction for photodetector application. Bi_2Se_3-WSe_2 devices were fabricated. For the preparation of the device, we exfoliated tungsten diselenide (WSe_2) on the SiO_2/Si substrate by mechanical method and Bi_2Se_3 30 QL(1Quintuple Layer = 0.954 nm) films layer were sequentially grown by molecular beam epitaxy system. We analyzed the structural and morphological properties using various physical measurement tools such as Raman spectroscopy, SEM, AFM, and KFM. We used a 520 nm pulsed diode laser and compared the optical detection characteristics of the WSe_2(metal contact) and WSe_2-Bi_2Se_3(Topological insulator contact) device. We obtained the reaction rate and the photoresponsivity through changing the laser power. As a result, the WSe_2-Bi_2Se_3 optical device has faster response speed and higher photoreactivity than the WSe_2 devices. Finally, using a WSe_2-Bi_2Se_3 optical device, we can successfully accomplish a high efficiency photo-detecting device and show the high-performance electronic and optoelectronic applications.

Keywords:
TMDC, WSe2, optical device, Topological insulator, Bi2Se3

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.037

Strain-mediated coupling of a diamond spin qubit to a mechanical oscillator

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Abstract:

Using diamond Nitrogen-Vacancy (NV) center combined with a diamond mechanical oscillator, we construct a hybrid mechanical system in which strain field effectively couples the NV's spin states to the mechanical motion of the oscillator. NV center's ground spin states either shift or split depending on the types of strain field. In this poster, we discuss the interaction mechanism and coupling strength of various strain components. Afterward, we discuss our recent efforts on engineering strain environments by using multiple mechanical modes including flexural mode and torsional mode. By using multi-modes, one can fully control six independent strain components and therefore effectively control the NV's spin states via engineered strain.

Keywords:

nanomechanics, NV center

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.038*

Simulation and Design of porous graphene membrane using COMSOL Multiphysics

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Abstract:
We designed the porous graphene sheet to make nanoelectromechanical system(NEMS) resonator with high frequency and high quality factor. Using COMSOL Multiphysics, we found the geometric optimization of porous graphene membrane structure by tuning pore size, pore to pore distance and the number of pores. Comparing eigen frequency of first mode and quality factor of each geometry, it was found that as the number of holes increases, the bonding between carbons is broken and the damping decreases. The quality factor and the frequency were higher as the number of the holes increases. So, we simulated and obtained the optimal structure, which maintains the eigen frequency highly also the quality factor is high. Furthermore, we numerically calculated Young's modulus from the tensile strain and stress obtained by COMSOL Multiphysics. Then we found the structural effect of the hole on the graphene sheet.

Keywords:
Graphene, nanoelectromechanical systems

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

P1-ap.039*

Organic light-emitting molecule-embedded CTMA-DNA nanolayers for white light emission

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Abstract:

Researchers have started to recognize that biomaterial-based devices and sensors can be used in the development of high-performing environmentally-friendly technologies. In this regard, DNA can be utilized as a competent scaffold for hosting functional nanomaterials to develop a designated platform in the field of bionanotechnology. Here, we introduce a novel methodology to construct CTMA-modified DNA nanolayers (CDNA NLs) embedded with single (*e.g.*, red, green, and blue) double (violet, yellow, and orange), and triple (white) iridium-based organic light-emitting materials (OLEMs, including $Ir(piq)_2(acac)$ for red, $Ir(ppy)_2(acac)$ for green, FIrpic for blue) that can serve as active light-emitting layers. The OLEM-embedded CDNA NLs were fabricated using simple solution processes, and their spectral properties were investigated *via* Fourier-transform Infrared (FTIR), X-ray photoelectron (XPS), UV-Vis, and photoluminescence (PL) spectroscopies. FTIR analysis of OLEM-embedded CDNA NLs suggested that the complexes are stable and chemically inert. XPS revealed the various modes of interaction between OLEMs and CDNA. The evidence of interactions between blue OLEM and CDNA was demonstrated by peak shifts. The wide band gap characteristics (~4.76 eV) and relatively high optical quality (no absorption in the visible region) of OLEM-embedded CDNA NLs were observed in UV-Vis absorption measurements. We observed PL emission in OLEM-embedded CDNA NLs, which was caused by the energy transfer from CDNA to OLEMs (ligand-centered and metal to ligand charge transfer). Lastly, a white light-emitting OLEM-embedded CDNA thin film was constructed using a combination of appropriate concentrations of red, green, and blue OLEMs. Its operation was demonstrated through spectral measurements. In addition, color coordinates were plotted in International Commission on Illumination (CIE) color space, which confirmed the color identity for the developed colors (including white). Consequently, the OLEM-embedded CDNA NLs can likely be used as a biomaterial in bio-imaging and bio-photonics.

Keywords:
CTMA-DNA, organic light-emitting molecules, nanolayer, spectroscopy, white light emission

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Fabrication and Characterizations of MoS_2 Layers on Au Nanostructures

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Abstract:

Two-dimensional (2D) transition metal dichalcogenides (TMDCs) are atomically thin semiconductor of a combination of a transition metal atom and a chalcogen atom. TMDC materials can be used in flexible electronics, including transistors, light emitting devices, and photodetectors, since they possess a sizable direct bandgap. There have been numerous research works to characterize MoS_2, one of the most representative TMDC materials. In recent days, plasmonic metal nanostructures have attracted growing research attention. In this work, we prepared MoS_2 layers on Au nanostructure arrays, which were fabricated by nanosphere lithography (NSL). NSL is a cost-effective technique to form hexagonally close packed nanopatterns on relatively large area samples. The NSL-fabricated Au nanostructures exhibited strong light absorption and scattering at the plasmonic resonance wavelength. We carried out optical characterizations of the MoS_2/Au-nanostructures and compared them with finite-difference time-domain simulation results. This work could show how the plasmonic effects in the underlying metal nanostructures influence the physical properties of 2D MoS_2 layers on them.

Keywords:

MoS2 Nanostructure Nanosphere lithography Plasmonic effects

P1-ap.041*

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Physical properties of MWCNT-integrated DNA thin films

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Abstract:

Thin films made of deoxyribonucleic acid (DNA), dissolved in an aqueous solution, and cetyltrimethyl-ammonium (CTMA)-modified DNA (CDNA), dissolved in an organic solvent, utilising multiwall carbon nanotubes (MWCNTs) are not yet well-understood for use in optoelectronic device and sensor applications. In this study, we fabricate MWCNT-integrated DNA and CDNA thin films using the drop-casting method. We also characterise the optical properties (*i.e.*, absorption spectra, Fourier-transform infrared spectra, Raman spectra, photoluminescence, and time of flight-secondary ion mass spectrometry) to study spectral absorption, interaction, functional group, chirality, and compositional moiety and its distribution of MWCNTs in DNA and CDNA thin films. The electrical property for conductance and the mechanical characterisations of hardness, modulus and elasticity for stability are also discussed. Lastly, to show the feasibility of directional alignment of MWCNTs in DNA thin films, we perform an alignment experiment with MWCNTs in DNA via brushing and shearing methods, and we evaluate the results using polarised optical microscopy. Our simple methodology to align ingredients in DNA and CDNA thin films leveraging various optical, electrical and mechanical properties, provides great potential for the development of efficient devices and sensors.

Keywords:

DNA thin film, multiwall carbon nanotube, optoelectronic characteristics, mechanical property, alignment

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Measuring Dielectrophoresis Force Using Quartz Tuning Fork System and Particle Sorting

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Abstract:

Dielectrophoresis(DEP) force is widely studied area since it has high utility on various research areas. In recent, DEP force is used in various research areas such as biology, chemistry, microfluids, MEMS, CMOS and nanotechnology because of its potential in the manipulation of microparticles and cells. In this reason, it is significant to comprehend about DEP force for efficient usage. Here, we used DEP force to separate the 100nm diameter silica particles and 60nm diameter Au particles according to their electric properties, and confirmed the directionality of the DEP force. The 100nm non-metallic silica particles get negative DEP force and move toward the minimum point of the square of the electric field instead the 60nm metallic Au particles get positive DEP force when high frequency AC voltage is applied because of their Clausius-Mossotti (CM) factor. We also measured the amplitude of DEP force using Quartz Tuning Fork - Atomic Force Microscopy (QTF-AFM) system in the confined water system on the electrodes. The AFM system is basically a system that is widely used to measure force at micro scale. QTF based AFM system is suitable to measure force on a micro scale sensitively by unique high stiffness. The DEP force magnitude measured by the experiment is ~1nN, similar to the simulation results, and the tendency of the measured force is also consistent. It shows the possibility to use QTF-AFM system as the fine sensor in confined water system.

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Keywords:
QTF-AFM, force sensor, DEP force, sorting particles, metallic/non-metallic particles

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Color and Thermocolor added DNA films

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Abstract:
DNA has been considered as useful building material for arrangement of nanomaterials possessing specific target functionalities. We constructed multi-layered color-added DNA films on substrates with individual layer having different color by either drop-casting (single layer) or spin-coating (single, triple, and quintuple). Self-supporting DNA films with mixture of various color were also fabricated by oven-drying procedure. We measured transmittance and absorption to verify optical properties of color-added DNA films with different dye concentration. We noticed decrease of transmittance at characteristic color peaks when colors were added, and further decrease was observed as increase of dye concentration. In addition, *L*, *A*, and *B* values in CIE (International Commission on Illumination) color space was obtained by measuring reflectance of self-supporting color-added DNA film. Hue angle and chroma of given sample were calculated from *L*, *A*, and *B*, which represented brightness, x-axis (green-red) and y-axis (yellow-blue), respectively. Here, hue angle of each film indicated characteristic color and chroma of mixed color indicated dark achromatic properties. Finally, reversible color change of self-supporting films by adding thermochromatic dyes were demonstrated to test possibility for practical application. When temperature was increased from room temperature to 40°C, the color of film changed from blue to pink and turned back after cooling. Our technique can be used for numerous applications such as color and temperature sensitive device or sensor.

Keywords:
Hue and chroma, thermocolor, DNA film, self-supporting, transmittance

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팔라듐/그래핀옥사이드 나노복합체 기반의 가스센서

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Abstract:
최근 삶의 질 향상과 관련된 문제가 주목을 받으면서 환경 유해가스 모니터링에 관심이 높아지고 있으며, 청정에너지원인 수소 에너지의 사용이 확대되면서 고감도 수소가스 센서의 개발에 대한 수요도 증가하고 있다. 저가의 고감도 가스 센서의 개발이 시대적으로 요청되고 있으나, 대부분의 고감도 가스 센서는 전계효과트랜지스터를 기반으로 제작되기 때문에 제작공정이 복잡하고 제작단가도 높아진다. 따라서 단순한 공정으로 저가의 고감도 가스센서를 개발하는 것이 필요하다. 본 연구에서는 간단하게 저가로 제작이 가능한 그래핀옥사이드 기반의 화학저항식 가스센서를 제작하고 특성을 평가하였다. 그래핀옥사이드는 변형된 Hummers 방법으로 합성하였고, 합성된 그래핀옥사이드를 포토리소그라피 공정으로 전극이 형성된 기판 위에 스핀 코팅 공정으로 코팅하였다. 금속/그래핀옥사이드 나노복합체의 경우, 그래핀옥사이드보다 가스 센서의 감도가 매우 향상되는 것으로 알려져 있으므로[1,2], RF 마그네트론 스퍼터를 이용하여 그래핀옥사이드 나노시트 위에 얇은 팔라듐 박막을 코팅하였다. 제작된 화학저항식 가스 센서에서 그래핀옥사이드의 합성 및 환원 방법의 차이에 따른 전기적 특성과 가스감지 특성을 조사하였고, 그래핀옥사이드 위에 코팅되는 팔라듐의 두께 및 표면형상과의 상관성에 따른 가스센서의 성능 특성을 조사하였다. 그래핀옥사이드와 팔라듐 박막의 표면형상 및 표면적은 AFM 및 FE-SEM으로 분석하였고, 그래핀옥사이드 나노시트의 품질은 Raman Spectroscopy로 분석하였다. 또한 가스센서 특성은 나노종합기술원의 가스센서 측정시스템 내부에서 I-V 곡선을 측정하여 분석하였다.

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Keywords:
수소가스 센서, 그래핀옥사이드,팔라듐

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Crystal structure of epitaxial ultrathin films analyzed by COBRA

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Abstract:

Coherent Bragg Rod Analysis (COBRA) is a powerful tool to analyze the detailed 3-dimensional crystal structure of epitaxial thin films [1]. Here, we investigated crystal structures and their physical properties of epitaxial ultrathin films using COBRA. For instance, we were able to detect the detailed lattice parameters of SrRuO 3 grown on SrTiO 3 and to address the intriguing physical properties. The x-ray scattering studies can provide new insight for the hidden relation between electrochemical activity and physical properties of energy materials.

Keywords:

coherent bragg-rod analysis, pulsed laser deposition, X-ray scattering

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Stability Boundary Analysis of Magetohydrodynamic Circulator for the Intermediate Heat Transfer System of Prototype Gen IV Sosium Fast Reactor

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Abstract:
The most important part of researching generation IV nuclear reactor is safety. In the research of generation IV sodium cooled fast reactor, magnetohydrodynamic (MHD) circulator is received attention to transport coolant stable. In this study, the stability of an magnetohydrodynamic (MHD) circulator were evaluated by the mathematical approach to obtaining critical value of developed pressure. The critical developed pressure equation is function of flow rate and dimensionless parameters which are derived from the theoretical model of MHD circulator with dimensionless scaled velocity, flow rate, and pressure. The stability conditions which are expressed by critical value of developed pressure and dimensionless parameters are investigated according to the change of the MHD circulator main design variables. Both relationships between dimensionless parameters, stability phenomenon and the main design variables as stability boundary of MHD circulator are analyzed. It is shown that stability of MHD circulator is safe when the stability criterion is lower than 1.

Keywords:
MHD circulator, stability, Dimensionless parameter, design variables, PGSFR.

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Electronic structure of Iridium oxide catalyst during the oxygen evolution reaction determined by resonant inelastic x-ray scattering

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Abstract:
Water splitting reaction consists of two half-cell reaction, oxygen evolution reaction (OER) and hydrogen evolution reaction (HER), i.e., energy conversion. However, the practical cell requires overvoltage than theoretical value (1.23 V) to perform the water splitting reaction due to sluggish of oxygen evolution reaction. Therefore, a catalyst is used to lower the overpotential of the reaction. The most known metals with the highest catalyst activity for OER are based on Ru and Ir. Among them, Iridium oxide (IrO_2) is the only one having long term stability for acid-based electrolysis and used for OER anodes in acid-based industrial processes. Iridium oxide has the 5d electronic system which is known as a good catalyst. In other words, to understand the OER mechanism using IrO_2, we must know the electronic structure of IrO_2. Band calculation, e.g. Density function theory, can theoretically be used to predict electronic structures, but it is not perfectly matched to actual band structure because it is a strongly correlated electronic system. Therefore, it is essential to investigate band structure using spectroscopy. Here, we conduct resonant inelastic x-ray scattering (RIXS) at L_3-edge to reveal the electronic structure of Iridium. RIXS spectra elucidate elementary transition, e.g. magnon, d-d transition, and charge transfer. We used three amorphous iridium oxide films (IrBL, IrPi, IrOx) with ionic changes in the same iridium cation. Their oxidation and reduction states were used as samples. Our RIXS result gives information that the electronic structure of the 5d system (Iridium oxide) at oxidation state and reduction state and contribute to the understanding mechanism of oxygen evolution reaction.

Keywords:
Iridium oxide, oxygen evolution reaction, catalyst, RIXS

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3차원 임피던스 센서의 특성: 3차원 세포구조체와 약물 반응 분석

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Abstract:

임피던스 분석은 전기화학 측정법 중의 하나로 산화환원 반응, 세포-약물 반응 등을 연구하는데 활용된다. 이를 통해 전자의 전달을 방해하는 원인을 해석하여 용액의 반응 과정을 전기적인 신호로서 정확히 결정할 수 있다. 본 연구에서는 용액 내부의 임피던스를 3차원적으로 측정할 수 있는 센서를 반도체 및 MEMs 공정을 사용하여 제작하였다. 임피던스 측정에는 ECIS(Electric Cell-substrate Impedance Sensing)기법을 사용하였으며, 임피던스 패턴에 따른 층별로의 이소프로필 알코올 증발 과정을 측정하여 3차원 임피던스 센서의 신뢰성을 확보하였다. 또한 젤라틴 메타크릴로일을 사용한 3차원 세포구조체에서의 세포-약물 반응(HeLa Cell-Cisplatin) 임피던스 변화를 관찰하여, 실제 체내에 존재하고있는 세포덩어리와 특성이 비슷한 3차원적인 세포구조체의 특성에 대해 확인하였다.

Keywords:

HeLa Cell,cell-drug reaction, Impedance, 3D sensor, ECIS

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펄스방전에 의한 리튬이온배터리의 등가회로 모형 분석

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Abstract:

본 연구는 RC회로를 이용한 리튬 이온 배터리 등가회로 시뮬레이션에 관한 연구이다. RC회로를 기본으로 모델설정 한후 리튬 이온 전지 등가회로를 구성하였고 이를 바탕으로 컴퓨터 프로그램 환경에서 시뮬레이션을 수행하였다. 실제 배터리를 사용하여 2A의 등전류 방전 상태에서의 배터리의 단자전압을 MBL을 이용하여 측정하였으며 이를 시뮬레이션의 지표로 삼았다. 그리고 전지의 방전 방법을 방전/휴지 상태를 반복하는 펄스방전에 의한 실험을 수행하였다. 연속방전과 펄스방전에 의한 전류, 전압 데이타를 바탕으로 각각의 전산 시뮬레이션을 수행하였다. 시뮬레이션 결과 후 정확도 차이를 비교하여 논의하고자 한다.

Keywords:

Lithium-ion battery, Equivalent circuit model, Discharge, State of charge, Equivalent circuit models

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Carrier transport mechanisms of organic memristive devices fabricated utilizing $CsPbBr_3$ perovskite quantum dot-based nanocomposites

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Abstract:
Organic bistable memristive devices based on $CsPbBr_3$ perovskite quantum dots (PQDs) embedded in a poly(methyl methacarylate)(PMMA) were fabricated. The active layer were coated by spin-coating technique. Current-voltage (I-V) measurements on Al/PQDs-PMMA/indium tin oxide devices at 300K showed nonvolatile rewritable memristive performance. The value of ON/OFF ratio is as large as $2x10^4$. The electrical behavior of the devices related to the interaction between the PQDs and PMMA polymer matrix were explained by adjusting thickness of the active layer and the mass fraction of the PQDs in the active layers. The carrier transport mechanisms were described on the basis of I-V results and the aid of energy band diagrams.

Keywords:
Organic memristive device, CsPbBr3 perovskite quantum dot, PMMA, carrier transport mechanism.

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Facile Preparation of high quality WSe_2 Quantum Dots for Organic Bistable Memory Devices

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Abstract:

A facile approach for synthesis of tungsten diselenide (WSe_2) quantum dots (QDs) in the presence of distilled water and ethanol mixture is proposed. The obtained WSe_2 QDs uniformly dispersed in the transparent liquid mixture were prepared by ultrasonication and hydrothermal process. As an application, the obtained WSe2 QDs were dopped in the polyvinyl carbazole (PVK) matrix, which exhibited a typical bistable electrical switching and nonvolatile behaviors were fabraiceted. The maximum current-voltage (I-V) ON/OFF ratio value of the devices is $1X10^4$, indicative of an excellent bistable property. Also the high stability of the devices were obereved. The carrier transport mechanisms were explained by I-V curves with the ait of the fitting lines, and the possible operating mechanisms were explained via the band diagrams.

Keywords:
WSe2 quantum dots, nanocomposites, memristive device, highly stable,

P1-ap.052*

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수중 드라이아이스 표면 얼음층의 형성과 해석

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Abstract:
일정한 온도의 수중에 있는 드라이아이스 표면에 얼음층이 형성됨을 관찰하고 해석하였다. 일정한 온도의 수중에 직사각형 모양의 드라이아이스를 넣으면 드라이아이스가 승화되면서 그 부피는 점점 감소되고 표면에 얼음층이 형성된다. 형성된 얼음층은 시간에 따라 증가하는데 최종 일정한 두께로 유지되는 정상상태에 도달한다. 그리고 정상상태에서 얼음층의 두께를 측정하고, 이를 이용해 얼음층을 통과하는 열에너지 흐름률을 계산하였다. 또한 물, 얼음층, 드라이아이스의 각 계면에 대한 과도상태와 정상상태 하에서의 형성 모델을 수립하고 해석하였다. 이 결과는 영구동토층 해빙 역학과 그로 인해 방출되는 온실 가스량의 추정에 활용될 수 있다.

Keywords:
드라이아이스, 얼음층, 열에너지 흐름률, 영구동토층

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A Simple Transfer Method for Two-Dimensional Materials Using Polyvinyl Acetate

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Abstract:

In this work, we demonstrate a simple transfer method that allows any large area two-dimensional (2D) materials to be effectively transferred onto target substrates by using polyvinyl acetate (PVAc) as a rigid support layer during the transfer procedure. Particularly, compared to the PMMA assisted transfer approach, the PVAc assisted transfer technique renders graphene to achieve an impressive carrier mobility of up to ~9000 $cm^2V^{-1}s^{-1}$ at room temperature. Our results demonstrate that the PVAc assisted transfer technique may be a very promising approach towards the application of 2D materials to high-performance electronic devices.

Keywords:

2D materials, transfer technique, polyvinyl acetate, electronic devices

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층 제어된 그래핀 나노시트의 합성과 그래핀 위에 직접 성장된 바나듐 옥사이드 나노구조물

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Abstract:

이산화바나듐(VO_2)은 대표적인 금속-절연체 상전이 물질로서 상전이 특성에 관하여 많은 연구가 이루어졌다. 특히 나노구조를 갖는 VO_2는 2차전지 음극소재, 가스센서, 응력센서 등에 활용될 수 있는 것으로 보고되고 있다. 기상수송법(Vapor Transport Method)은 형상제어 나노소재의 합성에 사용되는 합성법으로서, Thermal CVD를 이용한 기상수송법으로 실리콘(Si)기판, 사파이어(Al_2O_3)기판, 쿼츠(SiO_2)기판 등의 다양한 기판 위에서 1차원의 이산화바나듐(VO_2) Nanobeam 또는 Nanowire가 성장되는 것이 보고되었다[1]. 특히 최근에는 HOPG에서 박리된 그래핀 나노시트 위에서는 성장조건에 따라 다양한 형상의 VO2 나노구조물이 성장되는 것이 보고되었는데, 저압의 성장조건과 대기압의 성장조건에서 전혀 다른 바나듐 옥사이드 나노구조물의 성장이 보고되었다[2]. 따라서 본 연구에서는 Thermal CVD 공정으로 합성된 그래핀 나노시트 위에 기상수송법으로 바나듐 옥사이드 나노구조물의 성장양상을 조사하였다. 그래핀 나노시트는 Cu Foil을 이용한 Single Layer Graphene(SLG)과 Ni/Cu 박막을 이용한 Bi-Layer Graphene(BLG) 및 Multi-Layer Graphene(MLG)을 합성하였고, 기상수송법으로 그래핀 나노시트 위에 바나듐 옥사이드 나노구조물을 직접 성장시켰다. 합성된 SLG, BLG, MLG의 품질과 바나듐 옥사이드 나노구조물의 결정학적 특성은 Raman Spectroscopy로 분석하였고, 형상학적 특성은 FE-SEM으로 조사하였다. 그 결과 기판으로 사용된 SLG, BLG, MLG의 표면상태 및 저압과 대기압의 성장조건 등에 따라 전혀 다른 형상을 갖는 바나듐 옥사이드 나노구조물이 성장되었다.

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Keywords:
바나듐 옥사이드, 그래핀, 기상수송법

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고품질 Cu(111) 박막으로 만들어진 Cu_2O (111) 박막의 구조적, 광학적 특성

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Abstract:
제일산화구리 Cu_2O는 4.2 k에서 직접 금지 (direct forbidden) 에너지 갭 2.17eV와 직접 허용 (direct allowed) 에너지 갭 2.62eV를 갖는 p형 반도체이다. 또한 구리가 지구상에 풍부하게 존재하여 생산원가도 낮으며 독성이 없고 10^5/cm 정도의 높은 흡수계수를 가지고 있어 광전지, 광촉매, 박막트랜지스터, 가스 센서 등의 많은 소자 이용에 널리 사용되고 있다. 소자의 기능은 전하 운반체의 밀도와 이동성과 같은 전기적 특성, 광투과도, 광흡수도와 같은 광학적 특성에 영향을 받고 이런 특성들은 소자에 사용된 물질의 품질에 의해 의존하게 된다. 그러므로 Cu_2O를 이용한 소자가 올바른 기능을 발휘하기 위해서는 Cu_2O의 품질 제어가 필요하며 많은 연구자들은 고품질 Cu_2O 박막을 만들기 위해 구리 포일의 열산화, 전기침전, 스퍼터링, 화학증기증착, 펄스 레이저 증착, 등 여러 가기 방법을 시도해 왔다. 그러나 대부분 제이산화구리인 CuO 상을 함께 가지고 있는 Cu_2O 박막이나 다결정 Cu_2O 박막을 얻었다.
본 연구에서는 RF 스퍼터링 방법으로 증착한 고품질 Cu(111) 박막을 고온 (650~1,000°C) 급속 열처리 공정 (RTP: rapid thermal process) 과정을 통하여 에피택셜한 Cu_2O(111) 박막을 얻고자 하였다. 열처리 공정의 온도와 시간 등을 변화시키며 만든 Cu_2O 박막을 X선 회절 (XRD)과 전자 등 산란 회절 (EBSD) 분석을 통하여 구조적 특성을 연구하고 주사전자현미경 (SEM)과 원자간력 현미경 (AFM)을 통하여 표면을 연구하였다. 또한 Cu_2O 박막에 존재하는 불순물의 종류와 양을 알아 보기 위하여 광 발광 (photoluminescence) 실험에서 진행하였으며 고품질 Cu_2O 박막을 수소 생성을 위한 광전기화학 소자로의 응용 가능성을 연구하였다.

Keywords:
cuprous oxide, Cu2O, Cu thin film, RTP

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MoO_x induced by O_2-plasma on $MoTe_2$ surface improving transparent pFET performances

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Abstract:
We have fabricated a transparent p-$MoTe_2$ field effect transistor (FET). It is known that MoO_x improves hole injection. We treated O_2 plasma on source/drain area of $MoTe_2$ flake to form MoO_x layer and deposited an ultra-thin Pt layer between the p-$MoTe_2$ surface and indium-tin-oxide (ITO) electrodes. By fabricating two devices on one flake, it is confirmed that MoO_x caused by O_2-plasma greatly improves the performance of p-$MoTe_2$ FET. The pFET with MoO_x layer has an ON current and mobility three times higher than that of the pFET without a MoO_x layer. Consequently, almost transparent 2D FETs are obtained with a decent mobility of ~5 cm^2/V s, a high ON/OFF current ratio ~10^5, and 70% transmittance.

Keywords:
contact resistance, hole injection layers, MoTe2, plasma-induced MoOx, transparent electronics

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Synthesis and Analysis of Tungsten-Doped V_2O_5 Thin Film

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Abstract:

바나듐 산화물은 VO_2, V_2O_3, V_2O_5, V_6O_{11} 등과 같은 다양한 화학량론적 조성을 가지고 있다. 이러한 다양한 바나듐 산화물 중에서 가장 안정적인 오산화바나듐(V_2O_5)은 사방정계 결정구조(orthorhombic structure)에 의해 비등방적인 전기적, 광학적 특성을 나타낸다. V_2O_5 박막은 독특한 광학적, 전기적, 화학적 특성 때문에 여러 분야에서 관심을 받고 있다. 본 연구에서는 V_2O_5 powder와 ammonium tungstate powder를 이용하여 sol-gel법으로 텅스텐이 도핑된 V_2O_5:W 용액을 만든 후 기판에 스핀코팅을 이용하여 박막을 제작 하였다. 제작된 박막은 전기로를 이용하여 공기 분위기에서 150 ℃로 1시간 동안 열처리를 하였다. 열처리된 박막에 SEM과 XRD를 사용하여 구조적 특성을 분석하였다. SEM 측정을 통해 sol-gel법으로 V_2O_5와 V_2O_5:W이 박막형태로 고르게 제작되었음을 확인하였다. XRD 결과에서는 V_2O_5:W의 (110) 피크가 V_2O_5의 (110)피크보다 왼쪽으로 0.2° 정도 이동함으로써 도핑의 영향을 확인할 수 있었다. 또한 온도 변화에 따른 투과율을 측정하고 타원분광법을 이용하여 분석하였다.

Keywords:

V2O5, sol-gel법, Thin film

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Semimetallic Graphene for IR Sensing

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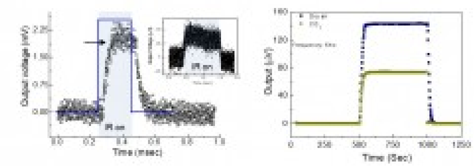
Abstract:



In this study, using the semimetallic multilayer graphene (MLG), IR detection at room temperature is achieved. The relative high Seebeck coefficient, ranging 40~ 60 uV/K, comparing to that of the metal and large optical absorption in mid-IR, benefit the graphene for the detection of IR without an absorber, which is essential for most IR detectors because the band gap of the sensing materials is much larger than the energy of IR and the incident IR can be absorbed directly by sensing material. IR LED with wavelength of 9.6um was utilized and fixed on positioner. The IR controller modulated the amplitude and frequency to the IR LED, the response from the sample was measured with lock in amplifer. The developed detector with SiN_x membrane shows the high responsivity and detectivity, which are 140 V/W and 5 x 10^8 (cm·$Hz^{1/2}$/W), respectively. In addition, the IR sensor shows a response time of 600 usec. Our sensors can detect IR emitted from a human body and track the movement, additionally by employing 4.5um IR LED we are able to use our device for CO_2 detection which illustrates flexibility in application. The availability of large-area graphene in current technology opens new applications for metallic 2D materials and a possibility for scale up.

Keywords:
IR detection, Room-temperature operation, Semimetal, Thermoelectric, Layered materials

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Impact of H-doping on Low Temperature Carrier Transport Mechanism of TMD Channels

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Abstract:

In this research, band-like transport behavior of H-doped transition metal dichalcogenide (TMD) materials has been studied by conducting low temperature electrical measurement on field effect transistors (FET) with channels of H-doped $MoTe_2$, WSe_2, and MoS_2. Doped with H-atoms through atomic layer deposition, those channels show strong n-type characteristics and their mobility increases without decrement in on-state current as the temperature decreases. In the case of naturally doped TMD FETs, contrastively, the mobility always decreases at low temperatures regardless of its majority carrier type. Density functional theory (DFT) calculation indicates that the Fermi levels of H-doped $MoTe_2$, WSe_2, and MoS_2 are above the conduction band edge. Therefore, we conclude that the charge transport mechanism in H-doped TMD channels is band-like transport rather than thermal hopping. These results show that H-doped TMD FETs are practically useful and advantageous especially at low temperature.

Keywords:

TMD, H-doping, N-type, Variable Range Hopping transport (VRH), Band-like transport, Low temperature

P1-ap.060*

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Domain switching dynamics on the wake-up effect in Si-doped hafnium oxide ferroelectric thin films

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Abstract:

We investigated polarization reversal mechanism by measuring the polarization switching behaviors of Si:HfO_2 thin films. The wake-up effect, which is remnant polarization growth by switching cycling, was observed and continued gradually until 10^7 cycles. The polarization switching and leakage current was measured at different wake-up stages. The switching behaviors are well explained by the Lorentzian distribution of logarithmic characteristic times. According to the fitting results, domain switching speed decreased with wake-up effect. The switching speed distribution is narrower with wake-up. From the narrower distribution, we assume that the defect pinning the polarization is diminished.

Keywords:

HfO2, wake-up, switching dynamics

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양자 주파수 변환 신호 계측을 위한 시스템 개발 연구

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Abstract:
양자 주파수를 변환하는 방법으로 키텔모드와 마이크로파 공진기 모드간의 상호작용을 이용하는 방법이 있다. 키텔모드를 사용하는 방법은 상온에서도 적용이 가능하나, 공진기의 quality factor와 변환효율의 정확한 계측을 위해서는 극저온 실험환경이 필요하다. 본 연구에서는 정확한 양자 주파수 변환 신호 계측을 위한 서로 수직 편광한 2주파수 레이저 결합 및 극저온 실험환경에서 실험장치의 진동을 최소화 할 수 있는 방안에 대하여 연구하였다.

Keywords:
양자주파수변환, 극저온 장치, 2주파수 레이저

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P1-ap.062*

The electrical and optical properties of 2D-$MoSe_2$/ 1D-Bi_2Te_3 heterojunction device

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Abstract:
Recently, Transition metal dichalcogenides (TMDs) and topological insulator (TI) have been considered as promising candidates for next generation electronic and optical device. TMDs exhibit many distinctive characteristics such as transparency, visible band gap, and high mobility in subnanometer thickness. TI have very interesting optoelectronic properties such as strong light absorption and broadband photodetection from the infrared to the terahertz. With the exotic physical properties of these materials, the characteristics of optical device can be enhanced by consisting the heterojunction. Herein, we prepared the 2D-$MoSe_2$ and 1D-Bi_2Te_3 grown by molecular beam epitaxy and vapor-liquid-solid method, respectively. In order to fabricate the 2D-1D heterojunction, the $MoSe_2$ was coated by polystyrene/toluene, then transferred to the nanowire. We conducted the spectroscopic measurements, such as Raman spectroscopy and Photoluminescence, to confirm the degradation of the $MoSe_2$ during the transfer process. According to the band alignment between $MoSe_2$ and Bi_2Te_3, the relative p-n junction was estimated. The band-bending was estimated by electrical measurements. In addition, the photocurrents of the junction were enhanced by the electron-hole separations at the interface between $MoSe_2$ and Bi_2Te_3.

Keywords:
MoSe2, Bi2Te3, 2D-1D heterojunction, Photocurrent

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P1-ap.063*

Switching kinetics and simulation of the voltage-time graph for imprinted Si doped HfO_2 capacitors

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Abstract:

Hafnia-based ferroelectrics have received much attention both academically and technologically for their attractive properties such as fast switching speed and low power consumption. There has been proposed an intriguing solution with negative capacitance (NC) phenomena for enhanced electronic device systems. The voltage drop during charging the ferroelectric capacitor has been recently claimed as an evidence of the NC phenomena and interpreted from the switching mechanism and circuit system.

The polarization-voltage graph of our ferroelectric capacitor showed a shifted hysteresis curve, which is called the imprint effect. Possible origin of the imprint can be built-in electric field at the interface with electrode. The ultra-thin TiN electrode affected the random orientation of the grains of the polycrystalline ferroelectrics[1].

In this paper, we simulated the voltage across the ferroelectric capacitor as a function of time measured in the series circuit with an external resistor, considering non-uniform ferroelectrics for NC phenomena. The HfO2-based ferroelectrics was analyzed by employing nucleation-limited-switching (NLS) model, with imprint effect. The effect of imprint on the NC phenomena is discussed.

[1] Seung Dam Hyun et al. (2018), ACS Appl. Mater. Interfaces. 10, 35374-35384

Keywords:

Si:HfO2, NLS model, imprint

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Quantum capacitance in dual-gated graphene FETs with cross-linked PMMA

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Abstract:

The simplest form of capacitance measurement consists of a set of two electrodes separated by dielectrics. When one electrode is replaced by 2-dimensional low density of states material, measured capacitance of the given system becomes a series connection of the quantum capacitance and geometrical capacitance. In this situation, as the geometrical capacitance increase, the quantum capacitance becomes a dominant source of measured capacitance. By measuring quantum capacitance, intrinsic properties of a material can be understood. In this work, dual-gated graphene FETs were fabricated using oxidized Al and cross-linked PMMA as top-gate insulating layers. A capacitance of an insulating layer is controlled to be in the range of ~μF/cm^2 via thickness control, which is comparable to quantum capacitance of graphene of tested size. Quantum capacitance was extracted from measured capacitance, and in turn, the residual carrier density near Dirac point from the quantum capacitance.

In this work, we present the results of quantum capacitance measurement form graphene-based dual-gate FET devices with various controlled insulating layers. The mobility was decreased by 50% after the top-gate electrode was fabricated. The measured minimum quantum capacitance is 1.256 μF/cm. That is lower than calculated data, 0.843 μF/cm^2. This means that there is an additional induced residual carrier density by fluctuating local potential. The results suggest the cross-linked PMMA increase the Coulomb scattering and residual carrier density.

Keywords:

Quantum capacitance, graphene, FET

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Highly Flexible, Water-Proof, Wearable, and Single-electrode Mode Triboelectric Nanogenerator Based on Polydimethylsiloxane/MXenes Films

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Abstract:

MXenes (*e.g.*, titanium carbide $Ti_3C_2T_X$, where T_X stands for -O, -OH, and -F) has been considered as new effective energy harvesting and storage materials owing to the highly conductivity, electronegativity and excellent mechanical stability. We have successfully synthesized and characterized the flexible and wearable single-electrode mode triboelectric nanogenerator (SMTNG) based on polydimethylsiloxane/MXenes films. We studied the effect of both working force and frequency on the output performance of the as-prepared SMTNG. The peak-to-peak open circuit voltage of 170 V and short circuit current density of 18 μA cm^{-2} can be obtained by hammering the SMTNG periodically using human hand.

Keywords:
Water-Proof , Wearable,Single-electrode ModeTriboelectric Nanogenerator, Polydimethylsiloxane/MXenes,

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P1-ap.066*

강제 진동시킨 다공성실리콘의 다양한 기체에 의한 진동수 응답 특성 분석

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Abstract:

본 연구에서 강제 진동시킨 다공성실리콘에 습도, 에탄올 기체 등을 주입시켰을 때 진동수 응답의 변화가 분석되었다. 이를 위해 평행하게 배치된 전면판, 중간판 그리고 후면판으로 구성된 실험장치를 제작하였다. 전면판으로는 다공성실리콘, 중간판과 후면판으로는 알루미늄 판이 활용되었다. 그리고 전면판과 후면판에 역위상의 AC전압을 인가하고 중간판에는 DC전압을 인가하였다. 전면판인 강제 진동하는 다공성실리콘이 습도, 에탄올 기체와 접촉하였을 때 진동수 응답 특성의 변화가 관찰되었다. 이 특성을 구체적으로 분석하기 위해 습도와 에탄올 농도에 따른 진동수 응답의 변화 정도를 조사함으로서 평판 진동형 정전식 기체센서로서의 활용 가능성이 있음을 알았다.

Keywords:
다공성실리콘, 진동수 응답 특성, 습도, 평판 진동형 정전식 기체센서, 센서

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팔라듐 장식된 산화아연 나노로드 나노복합체 기반의 가스센서

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Abstract:

도시화 및 산업화가 진행되면서 각종 유해가스가 우리 일상생활에 다수 발생하고 있고, 이러한 유해가스를 고감도로 감지할 수 있는 가스센서의 개발 필요성이 증가하고 있다. 특히 산화아연 나노로드는 졸-겔 공정으로 비교적 쉽게 합성이 가능한 저가소재이며, 광학적으로 투명하면서 화학적 안정성 및 무독성의 특성을 가지고 있어서 가스센서, 광전소자 및 광 촉매제 등으로 다양하게 응용되고 있다. 산화아연 나노로드는 합성방법에 따라 형상을 제어할 수 있으며, 체적대비 표면적의 비율이 높아 고감도 투명 가스센서에 적용할 수 있다. 하지만 낮은 전도성과 3.37 eV 의 넓은 에너지 밴드 갭 특성 때문에 전하 이동의 한계를 가지고 있다. 이를 극복하기 위한 방안으로 전자구조, 전하이동, 광학 및 표면적 특성과 관련 있는 산소 공공 (Oxygen Vacancy) 결함을 만들어, 밴드 갭 에너지를 2.48 eV로 낮추는 연구결과가 보고되었다[1-2]. 따라서 본 연구에서는 용액 환원 실험을 이용하여 산소 공공이 제어된 ZnO Nanorod를 졸-겔 법을 이용하여 합성하였다[3]. 가스 센서의 감도를 높이기 위하여 수소가스 감지 소재로 활용되는 팔라듐(Pd) 박막을 ZnO Nanorod 위에 RF 마그네트론 스퍼터링법으로 코팅하였다[4]. 산소 공공 결함의 농도 및 팔라듐 박막의 두께, 표면 형상에 따른 가스 센서의 특성을 조사하였다. 합성된 ZnO Nanorod의 형상과 팔라듐 박막 증착후의 표면특성은 전계방출형 주사전자 현미경으로 분석하였고, 산화아연 나노로드의 광학적 특성은 UV-visible Spectrometer를 이용하여 조사하였다. 제작된 가스센서의 특성은 나노종합기술원의 가스특성 평가 시스템을 이용하여 평가하였다.

[1] Chao Zhang et al, Sensors and Actuators B, Vol.248, p.886 (2017).
[2] Xiao-Feng Su et al, Materials Science in Semiconductor Processing, Vol.67, p.55 (2017).
[3] Kai Loong Foo et al, Nanoscale Research Letters, Vol. 9, p.429 (2014).
[4] O. Ozturk et al, Procedia Engineering, Vol.47, p.434 (2012).

Keywords:
가스센서, 산화아연, 팔라듐, 산소공공

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Development of Transparent Memory Device using a Vertically Stacked Two-Dimensional ZnAl-Layered Double Hydroxide

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Abstract:

Diverse forms of two-dimensional (2D) materials have been attracting a lot of attention as emerging materials for low-power and high-performance electronic or optoelectronic devices [1]. Here, we synthesized a 2D material of ZnAl-layered double hydroxide (LDH) via hydrothermal reaction on a sputtered Al_2O_3 layer and confirmed its vertical stacked morphology on the targeted substrate that can show 80 % transparency. The LDH is mainly composed of $[M^{2+}_{1-x}M^{3+}_{x}(OH)_2]^{x+}(A^{n-})_{x/n}\cdot mH_2O$ with a positively charged metal hydroxide layer and intercalated anions [2]. Using this LDH material, we fabricated a form of two-terminal resistive memory device composing of Pt/ZnAl-LDH/FTO vertical junction structure and investigated its switching characteristics. Interestingly, the fabricated device showed a unipolar switching behavior with 10^3 of ON/OFF ratio and acceptable switching endurance (~100 cycles), and the device sustained its switching states over 10^3 sec. A potential switching mechanism will be presented. Taken all these things, we believe that the ZnAl-LDH can be applied as another potential 2D material for the transparent and reliable memory device application.

[1] Cho, J. H. *et al.* Probing Out-of-Plane Charge Transport in Black Phosphorus with Graphene-Contacted Vertical Field-Effect Transistors. *Nano Lett.*, **2016**, *16* (4), pp 2580-2585
[2] Baig, N. *et al.* Applications of layered double hydroxides based electrochemical sensors for determination of environmental pollutants: A review. *Trends Anal. Chem.*, **2017**, *16*, pp 1-15

Keywords:
2D, stacked structure, transparant

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Effect of mixing-vessel oriented impurities on the leakage current for graphene supercapacitors

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Abstract:

The level of self-discharge induced leakage current for supercapacitors is an important performance factor for supercapacitors. And severe self-discharge is a main bottleneck for their usage as a next generation energy storage device. Consequently, various supercapacitors have been tested to determine the self-discharge characteristics. However, the research on this topic is still at an early stage and more research is needed to increase our understanding on this important subject. In this study, we fabricated three types of graphene electrodes using one of the mixing utilities among mortar and pestle, steel balls and steel vessel in ball mill, or zirconium balls and zirconium vessel in ball mill for mixing the source materials (thermally reduced graphene oxide (rGO, 90 wt.%) and PVDF (10 wt.%, DMSO solvent), and then measured the leakage currents of the electrodes at a voltage of 0.8 V in 1 M H_2SO_4 electrolyte using a three electrode system. Our results indicated that the leakage current strongly depended on the fabrication conditions for the electrodes: the lowest leakage current was measured on the electrodes made by mortar and pestle, followed by the ones by steel utilities, and the ones by zirconium utilities. In detail analysis of the results indicated that the impurities originated from the mixing tools were responsible for the varying leakage current behavior of the graphene supercapacitor electrodes. Our results may contribute for increasing the utility of graphene supercapacitors as a next generation energy storage device.

Keywords:

reduced graphene oxide, supercapacitor, leakage current, self-discharge

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자기장 홀센서 맥진기를 이용한 저주파 전기자극에 따른 수축기 혈압 및 시간, 맥파전달 및 말초혈류속도 특성 비교에 관한 연구

안예진[1], 지소연[1], 강병욱[1], 최종구[1], 이상석*[1]
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Abstract:
저주파는 경피신경 자극기인 저주파치료기는 250 Hz 미만의 펄스전류를 직접 피부 접촉부위에 통하게 하여 그 자극으로 근육의 수축과 이완을 반복시킴으로서 효과는 얻는다. 손의 경혈점 합곡과 팔의 경혈점 협백에 전극패드를 붙이고 침전기자극기로 저주파 전기적 자극을 인가하여 영구자석과 홀소자가 구비된 집게형맥진기와 광전용적맥파 측정기(PPG)로 동시에 측정한 맥파를 분석하여 수축기 혈압과 수축기 시간, 맥파전달속도, 말초혈류속도의 특성 변화를 조사하였다. 20대 청년 여자 2명과 남자 1명을 실험 대상자들의 치료 전과 후에 측정된 데이터의 평균, 표준편차를 구하여 비교 분석하였다.

감사의 글: 이 연구는 2018년도 상지대학교 한방의료공학과의 종합졸업설계 및 캡스톤디자인 지원사업에 의해 이루어진 것입니다.

Keywords:
저주파자극기, 광전용적맥파측정기, 수축기혈압, 수축기시간, 맥파전달속도, 말초혈류속도, 집게형맥진기

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Characterization of $La_{2/3}Sr_{1/3}VO_3$ thin films - p-type transparent conducting oxides - grown using RF sputtering deposition

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Abstract:

The development of efficient p-type transparent conducting oxides (TCOs) remains a global material challenge. Converting oxides from n-type to p-type via acceptor doping is extremely difficult and these materials exhibit low conductivity due to the localized nature of the O 2 *p* -derived VB, which leads to difficulty in introducing shallow acceptors and large hole effective masses. High-quality perovskite oxide (ABO_3) thin film p-n junctions have significant potential for electronic devices with multifunctional properties. The p-type perovskites currently in use are not sufficiently transparent in the visible region. Alloying Sr and La at the A-sites of perovskite $SrVO_3$, i.e. $La_{2/3}Sr_{1/3}VO_3$ (LSVO), can introduce holes at the top of the valence band (VB), resulting in p-type conductivity while maintaining reasonable transparency.

In this work, $LaSrVO_3$ thin films were grown on various substrates using RF magnetron co-sputtering deposition with $SrVO_3$ and La_2O_3 targets at 500°C with a mixed gas of H_2 and Ar. Film thicknesses varied between 120 and 150 nm. The growth temperature and sputtering gas ambient were optimized and precisely controlled. The chamber pressure was set at 6mtorr . We used LSAT, $LaAlO_3$, TiO_2/Si, Si, SiO_2/Si as substrates. The structural and morphological properties of LSVO films were studied using grazing angle incidence X-ray diffraction (GIXRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray photoemission spectroscopy (XPS). The electrical properties of all samples were measured using Keithley 4200.

Keywords:

transparent conducting oxides (TCOs), p-type , RF sputtering, LSAT, perovskite oxide

P1-co.103

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Metal-insulator transition driven by Lifshitz transition in moderately spin-orbit coupled 4d transition metal oxide system

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Abstract:
5d strongly spin-orbit coupled Sr_2IrO_4 provided a wide research field of spin-orbit coupling (SOC) induced physics including novel insulating property. By taking it as a motivation, we investigated metal-insulator transition (MIT) mechanism of $Sr_{2-x}La_xRhO_4$, whose mother compound is isostructural and isovalent with Sr_2IrO_4, but has smaller moderate SOC. By electronic structure measured by angle resolved photoemission spectroscopy we observed exotic insulating property with gradually varying insulator gap at wide range of La doping. At the very same point, the multi-band structure generated by moderate SOC experiences Lifshitz transition to become single-band transition due to electron doping from La atoms. These results suggest the exotic MIT is likely induced by the moderate SOC and electron doping. These finding of novel insulating mechanism provides new intrepretation of MIT in $Sr_{2-x}La_xRhO_4$, as well as are able to open new field of novel MIT research in moderate SOC regime.

Keywords:
Lifshitz transition, Spin-orbit coupling, metal-insulator transition, 4d transition metal oxide, Rhodate

P1-co.104

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프러시안 블루 유사계 나노 입자들의 방사광 노출에 따른 전자구조의 변화 연구

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Abstract:

프러시안 블루 유사계 물질 (Prussian Blue analogues)은 분자기반 나노 자성체로 입자들로 작은 크기로 인한 새로운 물성 기술적인 응용 가능성으로 인하여 많은 연구가 되고 있다. 프러시안 블루계 유사 물질은 공통적으로 시아나이드 리간드 (cyanide ligand)를 가지고 있어서 자기 중심들 사이의 효과적인 자기 교환 (magnetic exchange)이 가능해서 금속이온과 리간드 사이의 전자 이동이 용이한 물질이다. 프러시안 블루 유사계 물질의 가장 대표적인 특징으로는 빛에 유발된 스핀 전이 (photo-induced spin transition) 현상을 보인다는 것이다[1]. 그 중 RbxBayMnz[Fe(CN)6]·zH2O은 외부 자기장과 약 ~5 K 의 온도 이하에서 구조 변화를 동반한 자기 상전이 (magnetic transition) 가 일어 난다고 알려져 있다[2]. 이러한 자성 상태의 변화는 이 물질의 전자 구조와 스핀 상태의 변화에 의한 것일 것으로 추측되는데, 그 원인을 알기 위해서는 이 물질을 구성하고 있는 Mn 과 Fe 이온들의 전자 구조 및 스핀 구조에 대한 연구가 중요하겠다.

이 연구에서는 RbxBayMnz[Fe(CN)6]·zH2O (x: 0.19-0.84; y: 0-0.3) 나노 입자들에 대하여 연 X-선 흡수 분광법 (soft X-ray absorption spectroscopy: XAS)을 이용하여 빛에 노출된 시간에 따른 Fe, Mn 이온들의 스핀 상태 및 전자구조의 변화에 관하여 연구하였다. 이를 위하여 시료들이 방사광에 노출된 시간을 변화시키면서 Fe 2p, Mn 2p, O 1s, N 1s 등의 XAS 스펙트럼들을 측정하였다. 이 연구로부터 Fe 이온은 빛에 노출 되기 전 대체로 Fe^{3+} 상태에서 Fe^{2+} 상태가 약간 섞여 있다가 방사광 노출 시간이 길어지면 점점 Fe^{2+} 상태로 변하며, Mn 2p, O 1s, N 1s XAS에서도 약하게 변화가 일어나는 것을 관찰할 수 있었다. 이 발표에서는 방사광 노출에 따른 프러시안 블루 유사계 물질의 전자구조와 스핀 상태의 의 변화에 관하여 논의할 예정이다.

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Keywords:

Prussian blue, molecular nano-particle, XAS

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P1-co.105

EPR Parameters Observaion of Sodium Borate Glasses wtih CuO Content

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Abstract:

$xNa_2O-B_2O_3-yCuO$($x=Na_2O$mol%/B_2O_3mol% and $y=CuO$mol%/B_2O_3mol%) with x=0.1, 0.3 and y=0.01~0.07 were prepared by the melt - quenching method.
EPR measurements have been carried out to understand the role of modifier oxide and dopant CuO in the glasses. The observed values of EPR parameters are characteristic of Cu^{2+} ions of octahedral coordinatin with a strong tetragonal distortion. We observed the change around Cu^{2+} ions arising from the increase in CuO content in the glass samples.

Keywords:

EPR, copper glass

P1-co.106

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Investigation of magnetic and dielectric properties in antiferromagnetic $Fe_4Nb_2O_9$

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Abstract:
We have synthesized the corundum antiferromagnet of $Fe_4Nb_2O_9$ ceramic by using conventional solid-state reaction, and investigated magnetic and dielectric properties. The temperature dependence of magnetic susceptibility reveals the long-range magnetic order of Fe^{2+} moments at $T_{N1} \approx 95$ K. In contrast, two consecutive transitions at T_{N1} and $T_{N2} \approx 80$ K were observed in the temperature dependence of dielectric constant. To unveil the nature of two transitions, precise measurements of isothermal magnetization and dielectric constant at various temperatures were performed.

Keywords:
ferroelectric, magnetoelectric coupling

P1-co.107*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Controlling anomalous Hall effect in $SrRuO_3$ thin film by ionic liquid gating

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Abstract:

We performed ionic liquid gating experiments at 4 u.c. and 5 u.c. $SrRuO_3$ thin film. In all data, anomalous Hall coefficient decreases as the gate voltage increases in the + direction. For the 4 u.c. $SrRuO_3$ thin film, the sign change of the anomalous Hall coefficient can be seen as the gate voltage changes. The 5 u.c. $SrRuO_3$ thin film shows the appearance of the topological Hall effect at the + gate voltage. By analyzing the slope of the ordinary Hall effect contribution, we found that there is a correlation between the anomalous Hall coefficient and the carrier density. When a + (-) gate voltage is applied, electrons (holes) are doped into the sample. And from all transport experiment data, the anomalous Hall effect has been shown to change more than the topological Hall effect with modulating the gate voltage. We suggest that the change in the anomalous Hall coefficient is originated from modulating the Fermi level in the band structure. We expect to have an experimental understanding of the intrinsic origin of the anomalous Hall effect through further research.

Keywords:

ionic liquid gating, anomalous hall effect, SrRuO3, carrier density,

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P1-co.108*

Gate-field effects on the electrical properties of VO_2 and Ru-doped VO_2 heterostructure films

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Abstract:

We report the metal-insulator transition (MIT) properties of VO_2 and Ru-doped VO_2 (VO_2:Ru) films, which are grown by aerosol-assisted chemical deposition. Emphasis is placed on the electrical properties of the heterostructure of VO_2:Ru/VO_2 films under the gate-field applied acorss the heterostructure film to explore a potential candidate of neuromorphic memory devices. Due to a slowdown of miniaturization rates in microelectronics there is an ongoing quest for alternative approaches which will allow to achieve higher performance and bypass fundamental quantum limitations at the same time. One of actively studied options is neuromorphic computing in general and neuromorphic memory devices in particular. Pure VO_2 film has shown almost three orders of magnitude change in resistance during MIT. Addition of 2% of Ru decreases the transition temperature and thus, change in the resistance is much lower than pure VO_2 film with a smeared MIT. The gate-field applied to the heterostructure of VO_2:Ru/VO_2 films is found to change the surface potential of the heterostructure films. In-plane resistance modulation characteristics of the heterostructure with ac gate-voltage are measured. We discuss the experimental results in terms of charge injection from VO_2:Ru layer to pure VO_2 layer possibly allowing modulation of electric property of VO_2 layer. Our results show a route to induce a field-induced MIT in VO_2 and a new concept for implementing neuromorphic memory device using MIT.

Keywords:

Metal-insulator transition, VO2, Heterostructure oxide film. Field-induced phase transition

P1-co.109*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Microscopic investigation of metastable charge-density waves in thin flakes of strongly correlated 1*T*-TaS_2

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Abstract:
In strongly correlated electronic systems, an interplay among electron's degrees of freedom can induce phase transition among various ordered phases. To reveal the effect of the correlated electron's degrees of freedom on the phase transition, research on intermediate phase is crucial. In spite of its importance, most experiments have been limited in macroscopic scale due to instability of such intermediate phases. 1*T*-TaS_2, one of well-known transition metal dichalcogenides, is an appropriate model system by its metastable intermediate phases between coexisting charge-density-wave (CDW) phase and Mott insulating phase to compete with superconductivity [1]. Earlier scanning tunneling microscopy studies on metastable phases of bulk 1*T*-TaS_2 revealed the correlation between smaller CDW domains and Mott gap closing [2, 3]. However, it was very difficult to control such metastable phases in bulk 1*T*-TaS_2, which has been limiting further studies on the correlated phases. In this work, we have prepared thin and clean 1*T*-TaS_2 in order to manipulate metastable CDW phases by electric pulses between an STM tip and thin 1*T*-TaS_2 flakes. Among various metastable CDW phases, we found gradual Mott gap closing due to wide domain boundaries and unusual distribution of CDW domains. These findings will provide fresh insight into the interplay among strongly correlated intermediate CDW phases.

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Keywords:
charge density wave, strongly correlated electrons, transition metal dichalcogenides

P1-co.110*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Study of La-doped $CeIn_3$ via Transport and Calorimetry Measurements

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Abstract:

Antiferromagnetism and superconductivity in cubic $CeIn_3$ provide an ideal environment for studying the relationship between magnetism and superconductivity near their quantum critical point. Electrical resistivity revelaed the coherence temperature of 52 K and T_N of 10 K. Upon applied pressure, on the other hand, T_N is gradually suppressed and projected to zero Kelvin at the critical pressure of 2.6 GPa. On the other hand, the coherence temperature is enhanced under pressure, indicating competition between Kondo and magnetic exchange interactions. La-doping as well as physical pressure effects are expected to change both magnetic and Kondo energy scales, thereby providing an opportunity to explore the complex correlation effects in this system. Here we report transport and calorimetric measurements of 20% La-doped $CeIn_3$ under hydrostatic pressure up to 2.5 GPa. In 20% La doped $CeIn_3$, both T_N and coherence temperature are reduced compared to the non-doped compound. When the pressure is applied, T_N is suppressed completely at around 2.47 GPa and the coherence temperature increases, showing the similar trend to the pure case. Interestingly, the shape of the kink at T_N varies above around 1.4 GPa, suggesting a possible change in the nature of the magnetism before the system reaches to its quantum critical point.

Keywords:

Antiferromagnetism, Kondo coherence temperature, Quatnum ciritical point

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P1-co.111*

Spin-orbit coupling and insulator-to-metal transition in $GaTa_4Se_8$: DFT+DMFT study

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Abstract:

The lacunar spinel compound $GaTa_4Se_8$ is known as the molecular Mott insulator, exhibiting insulator-to-metal transition (IMT) and superconductivity at near 5GPa and 10GPa [1-3]. With first-principles density functional theory (DFT) study shows that spin-orbit coupling (SOC) induce the $J_{\mathrm{eff}} = 3/2$ ground state in 4*d*/5*d* series of lacunar spinel compounds [4]. Recent resonant inelastic X-ray scattering (RIXS) experiments established the spin-orbit entangled $J_{\mathrm{eff}} = 3/2$ electronic structure [5].
To understand pressure induced properties, the stability of $J_{\mathrm{eff}} = 3/2$ electronic structure under the pressure needs to be figured out. Dynamic mean field theory combined with DFT (DFT + DMFT) is one of the most powerful methods to study strongly correlated systems and IMT. In this study, we performed DFT + DMFT calculations with exact diagonalization (ED) solver [6] to understand IMT under the pressure and role of the SOC.

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Keywords:
Spin-orbit coupling, Insulator-to-metal transition, DFT + DMFT, Lacunar spinel

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P1-co.112

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Tuning the electronic and magnetic properties of orthorhombic perovsikte SrIrO3 thin films on SrTiO3 (001)

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Abstract:

We grow orthorhombic perovskite SrIrO3(SIO) thin films using Pulsed Laser Deposition method with various growth condition on SrTiO3 (001) substrate. When the laser energy density or the growth temperature is increased, the temperature dependent electric transport behavior is changed from metallic to insulator-like. Using X-ray Diffraction, Reciprocal Space Mapping, and Resonant X-ray Scattering, we measured the lattice parameter and the structure of metallic and insulator-like SIO thin films. The lattice parameter is almost equal, but the insulator-like SIO film show antiferromagnetic ordering and two fold sine-like azimuthal angle dependent scattering intensity for forbidden peak position at Ir L3 edge. By analyzing Resonant X-ray Scattering and infrared reflectivity, insulator-like behavior in electric transport and antiferromagnetism of SIO thin films are induced by structure change with space group Cmcm.

Keywords:

SrIrO3, thin film,

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Fabrication of novel transistors gated by phase transition of VO_2 thin film via external strain stimuli

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Abstract:

Vanadium Dioxide (VO_2) is a material that undergoes phase transition through various order parameters (orbital, lattice, charge, spin, and strain). Of them, strain dependent metal-insulator transition was extensively investigated recently. In this work, a novel transistor was fabricated by exploiting phase transition of VO_2 thin film through external strain, and its characteristics were confirmed. The gating of the transistor was operated by an external strain instead of conventional applied electric field, which is based on the current amplification at a specific voltage value in the I-V characteristics. Moreover, the transistor uses the current amplification via external strain by controlling the threshold voltage value which changes according to the strain value. The change of electrical characteristics was observed by applying strain constantly through implemented piezoelectric measurement set-up. In this device, the larger change of electrical properties is observed where larger temperature coefficient of resistance was measured. Therefore, better control of these three variables makes it possible to fabricate novel FET devices with greater resistance variations due to strain. Our results may present a new paradigm for developing strain-gated electronics devices

Keywords:

VO2, phase transition, transistor, strain

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P1-co.114*

DMFT study of interaction driven flatband gaps in twisted bilayer graphene

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Abstract:

Recent experiments have reported a sequence of carrier density dependent insulating behavior of magic angle twisted bilayer graphene for integer filling fractions of the eightfold degenerate flatbands near the charge neutrality point. We carry out a DMFT analysis on these gapped phases based on the effective low energy honeycomb lattice model of twisted bilayer graphene using an effective onsite Coulomb repulsion to elucidate the nature of the insulating phases. A variety of candidate phases for the ground-states are discussed for our model, in particular analyzing the spin texture of the antiferromagnetic versus paramagnetic Mott insulator phases that appear as metastable solutions at integer filling. We further obtain the wave function localization properties and the spectral functions that can be explored in STM and ARPES experiments to distinguish the ground states.

This work was supported by the Korean National Science Foundation through grant number NRF-2016R1A2B4010105.

Keywords:

Twisted bilayer graphene, DMFT, correlated phases

P1-co.115*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Thickness and temperature dependent optical properties of few-layer 1T' phase molybdenum ditelluride

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Abstract:

We investigated few-layer 1T' phase molybdenum ditelluride using an optical spectroscopy technique. Generally, bulk 1T`-$MoTe_2$ is a semi-metal. We measured transmittance spectra of 2, 4 and 10 nm thick 1T'-$MoTe_2$ samples in far - infrared, mid - infrared and near - infrared range (40 ~ 10000cm^{-1}) at various temperatures from 8 to 350 K. We obtained the optical conductivity spectra from the measured transmittance using the Tinkham formula. We extracted temperature and thickness-dependent electronic structure evolutions of 1T'-$MoTe_2$ from the measured optical spectra conductivity using the Drude-Lorentz model. We observed a thickness-induced electronic ground state transition from insulating to semiconducting.

Keywords:

Transition metal dichalcogenides, chemical vapor deposition, 1T'-MoTe2, bandgap opening, Fourier transform infrared spectroscopy

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P1-co.116*

Possible evidence of Weyl semi-metallic phase of $Nd_2Ir_2O_7$ thin film

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Abstract:

5d pyrochlore iridate system got a lot of recent attention for the realization of Weyl fermion in solids. Weyl semi-metallic (WSM) phase is characterized by its linear-dispersive band crossing points which have their high mobility and quantum Hall effects. It is theoretically suggested that pyrochlore iridate is predicted to host the WSM phase with strong spin-orbit coupling and electron correlation. Indeed, the previous optical measurement on $Nd_2Ir_2O_7$ with 2% Rh doping at 5 K showed evidence for WSM phase, namely linear dispersion of optical conductivity.
In this study, we suggest that strain effect may also induce the WSM phase in $Nd_2Ir_2O_7$ thin film. We succeeded to stabilize $Nd_2Ir_2O_7$ on YSZ substrate, which gives compressed strain along in-plane direction. Using optical conductivity measurement, we got the optical spectra of the epitaxial $Nd_2Ir_2O_7$ thin film. Detail discussion on the possibility of WSM phase in the strained film using Tight-Binding model will be discussed.

Keywords:
Weyl semi-metallic phase, spin-orbit coupling, 5d transition metal oxides, Nd2Ir2O7

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P1-co.117

The electronic and magnetic properties of multiband Co-doped NiS_2 compounds

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Abstract:

Roles of Hund's coupling attract attention in strongly correlated physics. Especially, in multiband systems, the Hund's coupling can enhance the electron correlation in the vicinity of Mott insulating state. To address such interesting issue, we investigated the electronic and magnetic properties of multiband $Ni_{1-x}Co_xS_2$ ($0 \leq x \leq 1$) compounds. In this study, we measured the electrical resistivity with 4 probe method and magnetic susceptibility with physical properties measurement system. Our study revealed that, upon doping Co, $Ni_{1-x}Co_xS_2$ undergoes the phase transition from an antiferromagnetic Mott insulator NiS_2 to a ferromagnetic metal CoS_2.

Keywords:

multiband Ni1-xCoxS2, metal-insulator transition

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P1-co.118*

Stoichiometric optimization on pyrochlore iridate epitaxial film

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Abstract:

The pyrochlore iridate ($R_2Ir_2O_7$, R=rare earth) has been proposed to exhibit many exotic topological phases, such as Weyl semimetal and Axion insulator [1]. Despite its promising proposal, the pyrochlore iridate has not been intensively studied because of the extreme difficulties on the epitaxial growth, such as the iridium dissociation during the deposition and the structure complexity [2,3]. Nonetheless, we succeed in the *in-situ* epitaxial growth of $Nd_2Ir_2O_7$ thin film, using the dual target method in the pulsed laser deposition system. The stoichiometry of the film was controllable by differing the ratio between the $Nd_2Ir_2O_7$ and IrO_2 target. The x-ray diffraction patterns and the resistivity curves reveal the transition from Nd_3IrO_7 to $Nd_2Ir_2O_7$ phase when the ratio between two targets was varied. Our growth technique of epitaxial $Nd_2Ir_2O_7$ thin film will enable the further studies on the emergent topological phenomena in the other pyrochlore iridate system.

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Keywords:
pyrochlore iridate, stoichiometric optimization

P1-co.119

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Effects of the Spin-orbit Coupling on the Hund's Coupling Driven Correlated System Sr_2RuO_4

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Abstract:

We investigate multiorbital systems, especially, that have strong correlations from the Hund's coupling. They show marked and interesting changes in renormalization factor, orbital dependence, and self-energy

associated to (non-)Fermi liquid behavior. One example is Sr_2RuO_4 known as an unconventional superconductor. Our study based on the density-functional theory plus dynamical mean-field theory with the exact diagonalization reveals its complicated behavior of normal state from the interplay with the spin-orbit coupling and crystal field. We find that qualitatively different behavior of self-energy at zero temperature appears after a transition to the frozen moment phase. The spin-orbit coupling slightly weakens the orbital-dependent correlations from the Hund's coupling and splits its anisotropic excitation energies further. We also observe the anisotropy of magnetic response caused by the spin-orbit coupling, which is in a good agreement with experiment. Effects of doping on this system will be also discussed within the Hund's metal regime for other integer filling.

Keywords:

strongly correlated system, ruthenate, multiorbital, Hund's metal, Hund's coupling, Spin-orbit coupling,

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BNT-ST 무연 압전 소재의 전계유기변형 특성에 대한 하소온도의 영향

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Abstract:
납을 함유하지 않은 $(Bi_{0.5}Na_{0.5})TiO_3$ 는 거대한 전계유기변형 특성을 나타내어 납이 함유된 PZT를 대체할 가능성이 높은 소재로 많은 관심을 끌고 있다. 그 중에서도 $(Bi_{0.5}Na_{0.5})TiO_3$-$SrTiO_3$ (BNT-ST) 고용체는 저전계에서 비교적 높은 전계유기변형 특성을 나타내는 장점을 가지고 있다. 본 연구에서는 납이 함유되지 않은 0.74BNT-0.26ST 압전 세라믹스의 제조 과정에서 하소 온도가 소결체의 결정 구조, 유전 특성 및 전계 변형에 미치는 영향을 살펴보았다. 그 결과 전계유기 변형 특성 면에서 하소온도가 850°C일 때 최적의 물성을 나타내었다. 하소온도가 낮은 경우에는 제 2상이 잔류하는 문제가 발견되었으며, 하소온도가 높은 경우에는 합성분말의 강도가 높아서 분쇄하기 어려운 문제가 발생하였다. 적정 하소조건에서 시료의 밀도는 5.518 g/cm^3, 상대유전율은 1871, 유전손실 계수는 0.047, d_{33}^*는 874 pm/V를 나타내었다.

Keywords:
lead-free piezoelectric

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P1-co.121

Room-temperature ferromagnetism and hydrogen shallow donors in Eu-doped ZnO

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Abstract:

We have studied the rare-earth element Eu-doping effects on the magnetism and hydrogen shallow donors in sol-gel-derived ZnO by means of magnetization and electron paramagnetic resonance (EPR) measurements. As a result, prominent room-temperature ferromagnetism was observed in the Eu-doped ZnO systems for which the spin states were elucidated by analyzing the M-H curves. Furthermore, the activation energies in H-doped samples with and without Eu-doping obtained from the temperature-dependent EPR intensities were compared.

Keywords:

ferromagnetism, Europium, Zinc Oxide, Electron Paramagnetic Resonance, rare-earth element

P1-co.122*

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Domain switching dynamics in $(Hf,Zr)O_2$ capacitors investigated by modified-piezoresponse force microscopy

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Abstract:

Since the first report of ferroelectricity in the doped hafnium oxide (HfO_2) thin films in 2011 [1], HfO_2 has attracted a great of attention in the field of ferroelectricity and non-volatile memories. The reason is that the HfO_2-based films can overcome many problems associated with application of conventional perovskite ferroelectrics (e.g., PZT) for memories, such as poor Si-compatibility, small bandgap, and large physical thickness. Robust polarization and extremely thin thickness make them promising candidates for novel ferroelectric memory and logic devices. However, up to now, most studies have focused on their macroscopic physical properties, including polarization-electric field hysteresis loops, crystal structures, and dielectric constants. Note that understanding how domains nucleate and grow under an external field on the nanometer level is imperative to realize of HfO_2-based ferroelectric devices. In this presentation, we report piezoresponse force microscopy (PFM) results of domain nucleation and growth in $(Hf_{0.3},Zr_{0.7})O_2$ (HZO) capacitors at the nanoscale. Using modified-PFM (m-PFM), we were able to reliably visualize the creation and subsequent growth of domains on top electrodes. We will report the change of switched regions and domain switching dynamics depending on the electrical cycling and discuss wake-up and fatigue effect.

[1] T.S. Böscke *et al.*, *Appl. Phys. Lett.* **99**, 102903 (2011).
[2] D. J. Kim *et al.*, *Appl. Phys. Lett.***91**, 132903 (2007).
[3] S. M. Yang *et al.*, *Appl. Phys. Lett.* **92**, 252901 (2008).

Keywords:
Ferroelectricity, modified-PFM, (Hf,Zr)O2

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P1-co.123*

Direct observation of anisotropic filamentary conduction in Ca-doped bismuth ferrite thin films

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Abstract:

Ionic migration of oxygen vacancies in solids has a significant role in the operation of next-generation devices such as resistive switching memory. Binary states in resistive switching phenomena, which are called low resistance state and high resistance state, are believed to be generated by the creation and rupture of the filamentary conducting paths. Therefore understanding the structure and connectivity of conducting filaments are important for device design. Ca-doped bismuth ferrite is a model material for this research on ionic migration. Due to the electrochromic property of this material, conducting filaments in the material can be seen with the optical microscope in real time. Here, we present our observation of the anisotropic structure of conducting filaments, which tend to grow along crystal axis. Our findings offer useful insight into the understanding of the resistive switching phenomena and the dynamics of oxygen vacancies.

[1] J. S. Lee et al., Applied Physics Reviews **2**, 031303 (2015)
[2] J. S. Lim et al., NPG Asia Materials **10**, 943-955 (2018)

Keywords:

Oxygen vacancy, Resistive switching, Conducting filaments

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A comparative study of metal oxides/rGO composite electrodes on supercapacitor performance.

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Abstract:

We have synthesized binary rGO/metal oxides nanocomposite by using a facile hydrothermal process. The morphology and structure of the composite are confirmed by XRD, SEM, HRTEM and Raman spectroscopy. The specific capacities that have been achieved for the nanocomposites at the current density of 1 A/g are 110, 162, 184 and 201 Fg^{-1} for Fe_3O_4, $Ni(OH)_2$, NiO and MnO_2, respectively. Compared to single metal oxide, the rGO/metal oxide nanocomposite shows superior electric conductivity, excellent electrostatic capacity, and better charge/discharge efficiency indicating that rGO/metal oxide composite is a promising electrode for a supercapacitor application.

Keywords:

graphene oxide, metal oxide, electrode, supercapacitor

P1-co.125*

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Doping site dependence of upconversion efficiency in $AHfO_3$:Ho^{3+}/Yb^{3+}(A = Ba, Sr, Ca) phosphors

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Abstract:

We report on the upconversion (UC) emission property of Ho^{3+} and Yb^{3+} co-doped $AHfO_3$ (A=Ca, Sr, and Ba) polycrystals. We observed the green (545 nm) and red (660 nm and 760 nm) UC emissions of Ho^{3+} in a host material $AHfO_3$ with 980 nm near-infrared excitation. Interestingly, the UC emissions in Ho^{3+} were dependent on doping sites. The green and red emission intensities in the $BaHfO_3$ samples with the substitution of Ho^{3+}/Yb^{3+} for Hf ions were much bigger than those for Ba ions. On the other hand, the emission in the $SrHfO_3$ and $CaHfO_3$ samples with substitution of Ho^{3+}/Yb^{3+} for A ions were much bigger than those for Hf ions. We also found that the upconversion efficiency was biggest for A = Ca, in close relation to the lower crystal symmetry.

Keywords:

Ho3+/Yb3+, upconversion, doping site dependence, host dependence

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P1-co.126*

Local-environment dependence of the Eu^{3+} ion emission in $BaZrO_3$

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Abstract:

We investigated the emission properties of the Eu^{3+} ion doped $BaZrO_3$ with the atomic site dependence (Ba-site vs. Zr-site) as well as the ambient dependence (H_2 and O_2 atmospheres) in the post-annealing process. The XRD experiments revealed that while the doping of Eu^{3+} ions did not disturb the overall cubic perovskite structure of the host material $BaZrO_3$, the secondary phase was identified in $BaZrO_3$ with the Eu ions doped at Ba-sites. From photoluminescence (PL) and photoluminescence excitation (PLE) measurements, we found that the emission properties of the samples with the Eu^{3+} ions substituted at Zr sites showed much better emission properties than those at the Ba sites, which could be related to the crystallinity of the samples. The samples of large crystallite size showed large PL emissions. In addition, the emission intensity of the Eu ions increased significantly with the post-annealing with the H_2 atmosphere. These findings might be closely related to the charge imbalance in the samples depending on the substitution site.

Keywords:
BaZrO3, Eu3+, site dependence, ambient dependence

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Dielectric analysis on single-crystalline (In+Nb) co-doped TiO_2

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Abstract:
Colossal permittivity (CP) materials have shown their great potential for the high-density energy-storage application as well as physical importance. After (In+Nb) co-doped TiO_2 (INTO) was proposed to be a promising CP material, there have been several reports claiming that CP in the material is mainly due to the extrinsic contribution such as grain boundary effects. To investigate the intrinsic dielectric property of INTO, we have grown high-quality single crystals which showed the colossal dielectric permittivity and low dielectric losses as previously observed in polycrystalline samples. We will present our recent dielectric analysis on both the single and polycrystalline INTO and discuss the origin of the CP in the material.

Keywords:
colossal permittivity, TiO2, Single-crystalline, defect dipole, Dielectric analysis, Cole-Cole plot

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Physical Characterizations of Gallium Modified Zinc Oxide Ceramics

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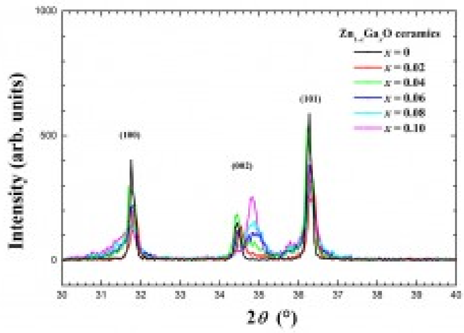
Abstract:

Gallium modified zinc oxides $Zn_{1-x}Ga_xO$ (ZGO, x = 0 ~ 0.10) ceramics were prepared by using the conventional solid state reaction method. The structural, optical and morphological properties of the ZGO ceramics were examined by using the X-ray diffraction (XRD), diffused reflectance spectroscopy (DRS) and scanning electron microscope (SEM). The alternating current (AC) conductivities were investigated by using the impedance analyzer in the low frequency range from 0.1 Hz to 1 MHz. As shown in the figure, the ZGO ceramic of x = 0.06 showed two (002) peaks at the 2θ angle at around 34.5°and 35.0°, respectively. It seems that the ZGO ceramics showed a Wurtzite phase in the XRD patterns in the composition range up to 10 at. % and the secondary phase of Ga_2O_3 was not observed. The optical absorptions of ZGO ceramics is being characterized by using the DRS in the UV-Vis wavelength range. It is considered that the hexagonal lattice has changed i.e., the a-axis lattice constant a was increased but the c-axis lattice constant c was decreased, as the Ga contents was increased in the ZGO ceramics.



Keywords:
Ga2O3-ZnO system, Wurtzite structure

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P1-co.130*

Fe_3O_4 on $NiCo_2O_4$ Nanosheets Catalyst using Electrodeposition for Highly-Efficient Oxygen Evolution Reaction

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Abstract:
최근 화석연료의 고갈 문제와 환경오염 문제로 인해 기존에 사용하던 화석 연료 에너지를 대체할 수 있는 친환경 에너지의 수요가 증가하는 가운데 그 중 수소에너지가 효율적인 친환경 에너지로 각광받고 있다. Water-splitting process는 이러한 수소에너지를 얻어내기 위한 방법 중 하나로, 수소가 발생하는 반응인 Hydrogen Evolution Reaction (HER)과 산소가 발생하는 반응인 Oxygen Evolution Reaction (OER)로 나뉜다.
본 연구에서는 Water-splitting Catalyst로써 사용되는 전극을 만들어 Water-splitting process 중 특히, OER 특성을 확인하였다. Electrodeposition 방법을 이용하여 Nickel foam 위에 $NiCo_2O_4$를 성장하고 그 위에 다시 Fe-Oxide를 coating 하였다. 그 후, Nanostructure의 안정화를 위해 Thermal Furnace 를 이용하여 200 ℃ 에서 2시간 동안 annealing을 진행하였다. 마지막으로, 0.1M의 $NaBH_4$를 이용하여 상온에서 30분 간 Reduction Reaction 과정을 거쳐 $Fe_3O_4/NiCo_2O_4$ 촉매 전극을 제작하여 향상된 OER 특성을 갖는 것을 확인했다. OER 특성을 확인하기 위하여 1 M KOH의 전해질에서 LSV (Linear Sweep Voltammetry), CP (Chronopotentiometry) 를 측정하였다. 또한, 표면 구조 분석을 위해 SEM (Scanning Electron Microscopy) 와 TEM (Transmission Electron Microscopy) 을 통해 구조를 확인하였으며 화학 결합 분석을 위해 XPS (X-ray Photoelectron Spectroscopy) 을 통해 Fe coating에 따른 화학결합 변화를 확인하였다.

Keywords:
Water-splitting, Catalyst, OER, nanosheet, Electrodeposition

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P1-co.131*

Investigation of metal-insulator transition behavior in VO_2 films by using conductive-atomic force microscopy

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Abstract:
Metal-insulator transition (MIT) in complex oxides is one of the major research topics in condensed matter physics. In terms of MIT, vanadium dioxide (VO_2) is an extensively studied material. VO_2 undergoes the MIT near room temperature (about 340 K in bulk) accompanied by a structural phase transition from the monoclinic insulating phase to the rutile metallic phase with an increase in temperature. Due to the relatively low MIT temperature and the significant resistance change (by four orders of magnitude), VO_2 can be used for various electronic applications, including thermal sensors, thermal switches, and memristive devices. However, the primary mechanism of MIT is still under debate. Spatially-resolved images of conductance change during MIT can provide crucial information to understand the MIT mechanism. Here, we present direct visualization results of temperature-dependent conductance change in VO_2 thin films grown on c-sapphire (Al_2O_3) substrate. Conductive-atomic force microscopy combined with a heater was used to obtain local conductance maps. The VO_2 grain boundary is observed to be more conductive than the center of the grain, i.e., donut-like conductance pattern, which is consistent with the previous report [1]. We discuss the conduction mechanism at the grain boundaries based on the current-voltage (I-V) spectroscopy data measured on the grid and investigate structural information of VO_2 using Raman spectroscopy.
[1] Hoon Kim, Tetiana V. Slusar, Dirk Wulferding, Ilkyu Yang, Jin-Cheol Cho, Minkyung Lee, Hee Cheul Choi, Yoon Hee Jeong, Hyun-Tak Kim, and Jeehoon Kim, Appl. Phys. Lett. 109 (23), 233104 (2016).

Keywords:
VO2, Metal-insulator transition, Conductive-AFM

P1-co.201

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Foldy-Wouthuysen spin and Geometrical phase II

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Abstract:
A geometrical phase change of a neutral particle passing through a mesoscopic ring is revisited.
When Foldy-Wouthuysen spin operator is used in place of Pauli spin operator in the Dirac equation, non-relativistic Hamiltonian differs from the origianl one.
We use exact Foldy-Wouthuysen transformation in the presence of constant electromagnetic field
to obtain non-relativistic quantities.
We discuss differences from what we derived before by approximated Foldy-Wouthuysen transformation.

Keywords:
Foldy-Wouthuysen, mesoscopic ring

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P1-co.202*

Optimized microwave transmission line for fast resonant manipulation of nitrogen-vacancy centers in (111)-oriented diamond

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Abstract:

We report design and fabrication of dedicated microwave transmission line toward strong coupling of spin states in (111)-oriented diamond to magnetic resonance control field. In (111)-oriented diamonds, nitrogen vacancy (NV) centers perpendicular to the crystal surface are expected to benefit from high photon collection efficiency compared to other orientations. Also, they are suitable for inducing large magnetic field gradient using surface micromagnets which can lead to, for example, atomic resolution magnetic resonance. However, conventional coplanar waveguide that induces oscillating magnetic field parallel to NV symmetry axis is not suitable to manipulate these spin states. In this work, we designed an optimized microwave transmission line which generates oscillating magnetic field parallel to the crystal face of (111)-oriented diamond. In this presentation, we will describe the details of the newly designed transmission line, the simulation results using Ansys HFSS(high frequency electromagnetic simulation software), experimental demonstration of fast Rabi oscillation(Rabi frequency >50MHz) in (111)-oriented diamond using designed structure, and discuss future applications.

Keywords:

(111)-oriented diamond, nitrogen-vacancy centers, microwave transmission line, spin manipulation

P1-co.203*

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Numerical Simulation of Shapiro Steps in Topological Josephson Junction

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Abstract:
Topological Josephson junctions are expected to exhibit 4π-periodic current-phase relation due to the existence of Majorana zero mode. The 4π-periodic current-phase relation, which is the so-called fractional Josephson effect, would result in anomalous Shapiro steps under the irradiation of microwave. We performed numerical simulations of microwave response of topological Josephson junction, based on the resistively and capacitively shunted junction (RCSJ) model. We modified the RCSJ model with 4π-periodic supercurrent term in addition to a conventional 2π-periodic one. In this simulation, we investigated progressive evolution of Shapiro steps with varying 4π-periodic supercurrent ratio, microwave frequency, microwave power and hysteresis parameter of the junction. Our simulation study can be used to quantify the ratio between topological supercurrent and conventional supercurrent, in comparison with the experimental results obtained from the Josephson junctions made of topological insulator nanoribbons.

Keywords:
Topological Josephson junction, Fractional Josephson effect, Majorana zero mode, RCSJ model

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P1-co.204*

Electrical characterization of graphene nanoribbon on h-BN

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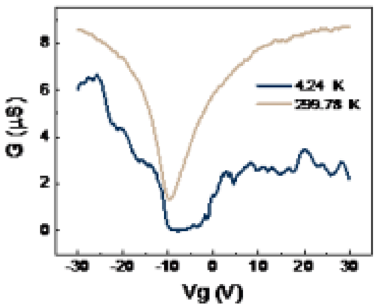
Abstract:

Beneath huge interests on graphene in the last decade, forming an electronic band gap is still a challenge against its electronic logic-gate applications [1]. In this work we took advantage of quantum confinement to create an electronic band gap on graphene nanoribbons (GNRs) [2]. For the first time in our knowledge, a GNR field-effect transistor (FET) on a hexagonal boron nitride/SiO_2/Si substrate was fabricated by a stencil mask technique where indium arsenide nanowire was used as a stencil mask. We performed the electrical measurement on the GNR FET for varying temperature between 300 K and 4.2 K. Diamond-like patterns exhibited on conductance obtained by sweeping source-drain and back-gate voltages at T = 4.2 K, which indicates the existence of quantum dots on the channel [3], so called coulomb diamonds. However, difference in electron and hole quantum dot's capacitances may reflect the presence of some extra charges in the GNR channel. The same conclusion was drawn by measuring and analyzing the competition behavior between the thermally-activated (TA) hopping and variable range hopping (VRH) electrical conductance phenomena with the conductance as a function of temperature at a given back-gate voltage (see right figure for two representative cases). For instance, the characteristic temperature dividing the two regimes showed different puddle's height for electron and hole carriers. In addition, the gate-voltage dependent behavior of the activation energy in the thermal hopping regime was also explained by the existence of localized negative charge on the channel.



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3.Han, M.Y., et al., *Energy Band-Gap Engineering of Graphene Nanoribbons.* Physical Review Letters, 2007. **98**(20): p. 206805.

Keywords:
graphene nanoribbon, hexagonal Boron Nitride, electron transport, Energy bandgap, coulomb diamond, Variable range hopping

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2019-04-24 - 2019-04-26

Bipolar operation of quantized current pumped from a quantum dot

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Abstract:

For a high precision measurement, a bipolar-measurement technique is generally employed needed to eliminate the offset to obtain genuine values of the physical quantity. In a case of non-adiabatic electron pump to generate quantized current, however, it has been hard to develop such bipolar current because there is only one rf-feeding gate. In this study, we suggest a method to make the bipolar function with top-metal gates controlling on electron-flowing directions in an electron pump circuit. Here, an output load, which can be a current amplifier or quantum Hall resistor, will pick up positive or negative voltage value depending on gate manipulation, while the pump continuously generates a quantized current, 12 pA. We also confirmed that the read positive and negative voltage values were consistent in a measurement uncertainty of ~10^{-4}, which is the same level to that of the current amplifier noise, itself, in our experimental environment. In future, it is needed to measure the uncertainty through an ultra-low-noise current amplifier to reach a level of ~10^{-7}, a state of the art for a 100-pA level.

Keywords:

bipolar, single electron pump

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P1-co.206*

Photo-induced Change of the Chern Number and Optical Hall Conductivity of Black Phosphorene

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Abstract:

Recent experiments have shown that the band structure of black phosphorene can be significantly changed by doping alkali ions with varying dopant concentrations. It can lead to a transition from the insulating to half-Dirac semi-metal phase with linear/quadratic dispersion in two perpendicular directions[1]. Topological phase transition (TPT) can also be realized in a quantum system periodically driven by AC electric field. In our work, we have theoretically studied the TPT induced by varying the frequency Ω of the AC field in a single layer black phosphorene both using the Floquet and the perturbation method. We have derived the effective Floquet Hamiltonian in terms of pseudo-spin S=1/2 and calculated the Chern number with varying frequency. We have also studied optical Hall conductivity (OHC) of the system. One may expect that the OHC will start to increase dramatically for Ω>Δ with Δ being the band gap just like the optical longitudinal conductivity. However, we have confirmed that the onset of the OHC occurs only when Δ is comparable to the even integer multiples of Ω. This special feature can deepen our understanding of the optically driven 2D topological material.

[1] Jimin Kim *et. al.*, Phys. Rev. Lett. **119**, 226801 (2017).

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Keywords:
Optical Hall Conductivity, Topological Insulator, Black Phosphorene

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P1-co.207*

Sub-diffraction quantum magnetometry using nitrogen-vacancy centers in diamond

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Abstract:
Quantum metrology using nitrogen-vacancy (NV) spins in diamond have demonstrated promising early results. While showing certain merits of using quantum probe for metrology, demonstration of unprecedented combination of sensitivity and spatial resolution has not been achieved due to, for example, diffraction limit in conventional wide-field microscopy. Here, we demonstrate large-area super-resolution quantum imaging using NV centers in diamond enabled by variation of well-known structured illumination microscopy for magnetometry - structured illumination magnetometry. We show wide-field magnetic imaging over 30 × 30μm^2 with spatial resolution of ~250nm in a wide-field microscopy setup can be achieved. Taking benefits of both wide-field imaging and super-resolution below diffraction limit, the present method demonstrates promising route for showing a firm advantage of quantum imaging and sensing.

Keywords:
Nitrogen-vacancy center, structured illumination microscopy, super-resolution imaging, quantum magnetometry

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P1-co.208*

Anomaly-related magnetoresistance from Weyl spin-orbit coupling

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Abstract:

Weyl semimetals have pairs of topological band crossings called Weyl points and exhibit the chiral anomaly. The chiral anomaly in Weyl semimetals gives rise to negative longitudinal magnetoresistance (LMR) [1], which diverges near the weyl points. Recently, it has been reported that a similar LMR may also arise without topological band crossing [2, 3]. In this work, we consider a three-dimensional metal with Weyl-type spin-orbit coupling, and find that this system also exhibits a diverging LMR near band crossing points generated by the Weyl-type spin-orbit coupling. Furthermore, we discuss the violation of conservation law for the number of particles in the presence of the external magnetic field in our model.

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[2] Yang Gao, Shengyuan A. Yang, and Qian Niu, Phys. Rev. B 95, 165135 (2017).
[3] Hiroaki Ishizuka and Naoto Nagaosa, arXiv:1808.09093v1.

Keywords:

Negative magnetoresistance, Chiral anomaly, Noncentrosymmetric system

P1-co.209

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Flatbands in twisted double bilayer graphene

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Abstract:
We investigate the electronic structure of a twisted bi-bilayer graphene to find the parameter space where flatbands can emerge as a function of twist angle, vertical pressure, and interlayer potential differences. We find that in twisted bi-bilayer graphene the bandwidth is generally flatter than in twisted bilayer graphene by roughly up to a factor of two in the same parameter space of twist angle and interlayer coupling, making it in principle simpler to tailor narrow bandwidth flatbands. A moderate vertical electric fields contribute in lifting the degeneracy of the low energy flatbands by enhancing the gap near the primary Dirac point and the gap with the higher energy bands. We study the effect of the remote hopping terms in modifying the electronic structure of the flatbands and obtain the phase diagram of the valley resolved Chern numbers as a function of external electric fields.

Acknowledgment: This work was supported by Samsung Science and Technology Foundation under project no. SSTF-BA1802-06, and by the Korean National Science Foundation through grant number NRF- 2017R1D1A1B03035932.

Keywords:
Flatbands, twisted bilayer graphene, topological bands

P1-co.211*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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First-principles study of the effect of inserted gas molecules at Ni-MoS_2 interfaces

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Abstract:

Transition metal dichalcogenides (TMDs) are considered as next generation materials because of their unique and superior properties compared with existing bulk materials. Especially, molybdenum disulfide (MoS_2), one of TMDs, shows various possibilities for electronic devices applications due to its semiconducting properties. For example, there have been many efforts to use MoS_2 in field-effect transistors (FETs) for investigating the contact properties between diverse metals and MoS_2. Significantly, it is important to understand the changes in the metal-MoS_2 interfaces at the source/drain contacts of the device.

In this study, we investigate the ferromagnetic contact behaviors between Ni and MoS_2 with density functional theory (DFT) calculations. It is known that n-type contact behaviors appear at Ni-MoS_2 interfaces with Fermi level pinning (FLP) [1]. Especially, we analyze the change in contact behaviors at Ni-MoS_2 interfaces by considering the effect of inserted gas molecules such as H_2, O_2, N_2, and S_2. The partial density of states (PDOS) and charge density difference are investigated for analysis.

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Keywords:

First-principles, Ni-MoS2 interfaces, Transition metal dichalcogenides, Density functional theory, Fermi level pinning

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P1-co.212*

Polarization and orbital angular momentum in Rashba spin-orbit coupling

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Abstract:

The Rashba spin-orbit coupling is a crystal momentum(**k**)-dependent spin splitting in non-centrosymmetric systems. This coupling is an essential ingredient for various interfacial spin phenomena [1-2] and modern spintronics applications [3-5]. The coupling is commonly interpreted as the relativistic effect by which makes an electric field is felt as an momentum-dependent effective magnetic field. But this common interpretation is hard to explain various properties of the Rashba coupling. Recent studies reported that the coupling may be large even in situations with very small electric field [6-8]. It is also reported [9] that the Rashba coupling may be order of magnitude enhanced by an *in-plane* potential gradient instead of out-of-plane direction gradient. Although all these properties can be explained within first-principles calculations, the conceptual understanding is rather limited. There are suggestions that wavefunction distortion near nucleus core is important [10], but there are strong criticisms against such suggestions [11]. There are suggestions that orbital angular momentum near nuclues cores is important [6,7,12].

Our theoretical analysis starts from the three essential ingredients of the Rashba coupling; atomic spin-orbit coupling, inversion symmetry breaking, and deviations of **k** from time-reversal invariant points. We demonstrate that these ingredients naturally lead to orbital angular momentum, spin-dependent wavefunction polarization, and spin-dependent kinetic energy. Furthermore, we find that our analysis quantitatively agrees with Rashba constants and Rashba splitting gaps reported in experiments [6-9]. Our investigation is expected to give new insight to the Rashba coupling. Some guidelines are proposed for giant Rashba materials.

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Keywords:
Rashba spin-orbit coupling, polarization, orbital angular momentum

P1-co.213*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Electronic properties of 2D-GaX (X = S, Se, Te) / 3D-Si(111) heterostructure

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Abstract:

In recent years, mixed-dimensional materials have attracted various attention from the scientific community with their unique atomic and electronic properties. Upon this opportunity, many scientists have studied mixed-dimensional heterostructures based on various 2D materials such as graphene, transition metal dichalcogenides (TMDs), and so on. In this study, we investigate the atomic and electronic structures of MMCs such as GaX (X = S, Se and Te) using density functional theory (DFT) calculations. Our calculations show that MMCs have semiconducting properties with indirect band gap between p orbital of chalcogenide atoms and s orbital of Ga atoms. Furthermore, we investigate two dimensional (2D) /three-dimensional (3D) heterojunction between MMCs and Si(111) with two types of surface termination. We analyze the contact behaviors between MMCs and Si(111) by obtaining the partial density of states (PDOS), band structure and band alignment of MMCs/Si(111) heterostructure. In the case of MMCs/clean Si(111), MMCs show some change in their valence bands due to interaction with the dangling bonds of clean Si(111). For MMCs/H-covered Si(111), GaS and GaSe show n-type contact behaviors, while GaTe shows p-type behavior. Such investigations will provide possibilities of MMCs/Si(111) for their device electronic applications.

Keywords:

metal monochalcogenides, first-principles calculations, heterostructures, silicon, 2D materials, band alignment

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P1-co.214*

Long-lived photoexcited state of topological insulator Bi_2Te_3

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Abstract:

Topological insulators (TIs) are novel quantum state of matter, hosting helical Dirac Fermion on its unique topologically protected surface state. In bulk state of 3D TIs, due to the strong spin-orbit interaction (SOI), an inverted band gap is formed at symmetric point. On the surface of 3D TIs, the inverted states overpass the bulk conduction and valence band, closing the band gap. Also, because of SOI, the inverted states on the surface are naturally spin(*s*)-polarized and, subsequently due to TRS, those ***s***-polarized surface states become degenerate at a specific point named Dirac point. Bands with linear energy(*E*)-momentum(***k***) dispersion like graphene are formed on the surface accordingly, whose degenerate point is protected by TRS according to the Kramer's theorem. As a result, 3D TIs exhibits unique and robust topological surface state with ***s***-polarization and linear dispersion protected by TRS, which is called topological surface state (TSS).Especially, the TRS and strong SOI incude the spin-polarization to have definite direction perpendicular to the momentum, resulting in a helical spin texture around symmetric point.

With terahertz time-domain spectroscopy (THz-TDS), we already identified the stationary state responses of TSS and observed high mobility of TSS channel. In this work, we measured femtosecond timescale dynamics of the photoexcited topological insulator Bi_2Te_3 single crystal. We utilized THz-TDS and angle-resolved photoemission spectroscopy (ARPES) to acquire the separate responses from the TSS and bulk state. We observed various relaxation dynamics ranging from femtosecond timescale to over microsecond timescale, in bulk state, TSS, and phonon. Especially, the long-lived response of TSS over 4 microseconds is of interest to us, as it provides a potential of TIs for optoelectric applications. Combining two experiments, we would like to study the mechanism of relaxation dynamics of TSS, in addition to the previously studied mechanisms such as surface photovoltage[1].

[1] M. Hajlaoui *et al.*, Nat. Commun **5**, 3003 (2014)

Keywords:
topological insulator, optical pump-terahertz probe, time- and angle-resolved photoemission spectroscopy

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Measuring Dynamics of the Nanoscale Water Meniscus on Mica and HPOG surface *via* Quartz Tuning Fork based Atomic Force Microscopy

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Abstract:

The quartz tuning fork (QTF)-based mechanical sensor offers quantitative understanding and practical applications such as surface analysis and mass detection with high sensitivity [1]. Especially, the QTF-based atomic force microscopy (AFM) has pros on controlling the tip-sample precise distance and avoid instable 'jump to contact' situation since its high stiffness [2]. Henceforth, it provides high stability to study on nanoscale water meniscus. The dynamics of nanoscale water meniscus on hydrophilic surfaces has been studied widely. Since nanoscale water exists not only hydrophilic environment, but also hydrophobic surroundings [3]. Despite its importance, however, the nanoscale water meniscus on hydrophobic surfaces has not been studied yet in the case of meniscus problem. Here, we present the dynamics of the nanoscale water meniscus on both hydrophilic mica and hydrophobic HOPG surfaces. With high vertical resolution less than (Δz ~0.1 nm) and high sensitivity of (Q ~ 3,000), we obtained the dynamic mechanical properties of nanoscale water meniscus such as elasticity, viscosity and dissipation energy on both surfaces [4].

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Keywords:

Quartz tuning fork; water nanomeniscus; atomic force microscopy; hydrophoicity

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P1-co.216

Investigation of the interaction of a nano-confined water and a visible laser using tuning fork based AFM-TERS

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Abstract:
We build a Raman-AFM system based on a homemade QTF-AFM, and further TERS(Tip-Enhanced Raman Spectroscopy) system is set up from this Raman-AFM. We employ a QTF as a force sensor, and the QTF is electrically driven to make it as a Self-oscillating sensor. Because two laser lines(532nm, 633nm) are available in this instrument, also we had to make different kinds of TERS tip for each laser line using two kinds of metal. Silver and gold for 532nm laser and 633nm laser respectively. A constant voltage electrochemical etching is used to fabricate a TERS tip. As a result, the high-quality metal tips are produced when the end timing is precisely determined for each metal. Our TERS system combined with QTF-AFM offers a quantitative measurement of viscoelastic materials. And at the same time, the instrument also measures its chemical information with highly enhanced Raman signals.

Keywords:
TERS, SERS, quartz tuning fork, AFM

P1-co.217

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General behavior of surface tension of spherical interface from molecular and mean field liquid model study

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Abstract:
We report molecular dynamics simulations of spherical liquid nanodroplets and density function theory studies to investigate the general properties of surface tension of liquid spherical interfaces. By using the molecular dynamics simulation with TIP4P/2005 molecular water model , we obtain the surface tension from the integration of the pressure tensor distribution of nanodroplet which is obtained via the calculation of free energy change from volume perturbation. To explain this behavior with a general framework of Tolman's work, we use density function theory with a mean-field liquid model. Density functional theory results show that Tolman's initial work, which assumes that the Tolman length is constant value is no more true in small nanodroplets with a radius of about 5 molecule size. Considering the Tolman length as a linear function of inverse of droplet radius, we obtain the second order equation from 1 the Gibbs-Tolman-Koenig-Buff equation which relates between tension and curvature. This second order equation well describes the surface tension of spherical interface and get a physical meaning by comparing with Helfrich's equation about free energy of the elastic membrane.

Keywords:
Surface tension, Nanodroplet, Tolman length, Molecular dynamics, Density functional theory

P1-co.218*

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Nanoscale Detection of Photon-induced Hot Carriers on Metal-Semiconductor Nanodiodes with Atomic Force Microscopy

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Abstract:

Direct measurement of hot electron flux from a plasmonic Schottky nanodiode is important for obtaining fundamental insights explaining the mechanism for electronic excitation on a surface. Here, we report the measurement of photo-induced hot electrons on a triangular Au nanoprism on TiO_2 under incident light with photoconductive atomic force microscopy (pc-AFM), which is direct proof of the intrinsic relation between hot electrons and localized surface plasmon resonance. We find that the local photocurrent measured on the boundary of the Au nanoprism is higher than that inside the Au nanoprism, indicating that field confinement at the boundary of the Au nanoprism acts as a hot spot, leading to the enhancement of hot electron flow at the boundary. Under incident illumination with a wavelength near the absorption peak (645 nm) of a single Au nanoprism, localized surface plasmon resonance resulted in the generation of a higher photo-induced hot electron flow for the Au nanoprism/TiO_2, compared with that at a wavelength of 532 nm. We show that the application of a reverse bias results in a higher photocurrent for the Au nanoprism/TiO_2, which is associated with a lowering of the Schottky barrier height caused by the image force.
Furthermore, to characterize electrical properties of hot holes in Au nanostructure, we fabricated patterned Au islands on p-type GaN substrate and measured the local photocurrent with the pc-AFM under back illumination of the light. We also found that the photocurrent depends on the wavelength of laser, and the bias between Au and GaN. These nanoscale measurements of hot carriers with pc-AFM indicate efficient photon energy transfer mediated by surface plasmons in hot electron-based energy conversion.

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H. Lee, Y. K. Lee, T. N. Van, and J. Y. Park, Appl. Phys. Lett. 103, 173103 (2013)
H. Lee, H. Lee, and J. Y. Park, Nano Lett. 19 (2), pp 891-896 (2019)

Keywords:
Au nanoprism, field confinement, hot carriers, hot electrons, hot holes, localized surface plasmon resonance, Photoconductive atomic force microscopy, Schottky diode

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P1-co.219*

Effect of Oxygen Concentration in Insertion Layer on the Schottky Barrier Height

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Abstract:

At metal-semiconductor junction, the fermi level pinning (FLP) is a key issue for the device application. It is well known that the FLP prevents the interface between metal and semiconductor from determining obviously the Schottky barrier height (SBH) by Schottky-Mott model. As an attempt to overcome the FLP problem, there has been a method using a dielectric thin layer as an insertion layer between metal and semiconductor. Since the insertion layer impede an interaction between metal and semiconductor, we could expect it to reduce the pinning strength and to control the SBH.

In this study, we investigate the effect of the oxygen concentration in the insertion layer on the SBH. We fabricated Schottky diodes of the metal-silicon interface having the insertion layer of metal or metal oxide. We chose aluminum oxide as an insertion layer between metal and p-type silicon. Oxygen content in the insertion layer was controlled by oxidation time or various reactive sputtering condition. We discuss widely the effect of oxygen content in the insertion layer on the SBH. We expect this work sheds light on a way to control readily the electronic transport property at the interface of metal and semiconductor for high performance devices.

[Acknowledgement: NRF-2018R1A6A1A06024977, NRF-2015R1D1A1A01060381]

Keywords:
Schottky barrier, Schottky diode, Fermi-level pinning, insertion layer

P1-co.220*

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Monolayer MoS_2-based triboelectric nanogenrators (TENGs) using depletion layer

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Abstract:

In recent years, the TENGs have received considerable attention because of broad potential applications for energy harvesting. However, most of the friction layers used for TENGs are limited to polymeric dielectrics. Here, we report monolayer MoS_2-based triboelectric nanogenerators (TENGs) consisting of MoS_2/PDVF/PDMS/ITO/PET (bottom layer) and Au/PET or PPy/PET (top layer). Compared to TENGs without MoS_2, TENGs with MoS_2 exhibit higher power efficiency and self-rectified behaviors. Because Schottky junction and pn junction form for Au/MoS_2 and PPy/MoS_2, respectively, a built-in potential across the junction is considered to generate higher output voltage and induce the self-rectified behaviors.

Keywords:

Triboelctric nanogenerators, MoS2, Depletion layer, Schottky junction, pn junction

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P1-co.221

Structure and formation of hydride of Co-Fe alloy under high pressure

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Abstract:
Cobalt and iron are known to form monohydrides under high pressure of hydrogen above 4 and 10 GPa, respectively, at room temperature. Our preliminary calculations of density functional theory and convex hull suggest that CoFe alloy will be able to contain high hydrogen concentration at high pressure and temperature, and will exhibit relatively high Tc superconducting temperature. An alloy of $Co_{91}Fe_9$ was pressurized in a diamond anvil cell under hydrogen pressure and the changes of the structure were compared with the ones of measured at Ne medium up to 62 GPa at room temperature. Synchrotron-based X-ray diffraction (XRD) data revealed that the structure of the $Co_{91}Fe_9$ alloy is an FCC with a lattice constant of 3.55 Å but transformed to an HCP phase starting at 11.3 GPa. After decompression, structure of the sample did not recover to an original phase. Instead, it became a mixture of HCP and FCC phases. $Co_{91}Fe_9$-H has hydrogen contents of 1.69 wt. % with a high volumetric hydrogen density of 155.22 g/L at 50 GPa. $Co_{91}Fe_9$-H phase (FCC with a lattice constant of 3.70 Å) started to form at 4.31 GPa of hydrogen pressure. The samples recovered an original phase after decompression to an atmosphere. Mechanical properties of the alloy were estimated: bulk modulus of CoFe-H (237 GPa) has slightly less than the one of non-hydrogenated one (243 GPA).

Keywords:
High pressure, Metal hydrides

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Experimental band structure of two-dimensional crystals studied by nanoARPES

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Abstract:

The dimensionality of crystals has become more important since it directly affects to their properties. Even for van der Waals materials, for example, the band structures of bulk and few-layer are clearly distinguished because of the difference of interlayer interactions. After the successful exfoliation of graphene from graphite, a variety of two-dimensional (2D) layered crystals, such as transition-metal dichalcogenides and black phosphorus, have attracted interest as a mother of exfoliated 2D crystals with intriguing physical properties different from their 3D counterpart. Yet, a direct observation of the band structure of few-layer crystals are still extremely rare. This is because the clean and large grain of 2D crystals is required to directly measure their band structure with angle-resolved photoemission spectroscopy (ARPES). Normally the size of exfoliated materials is comparable with or even smaller than the beam size of ARPES, and it is difficult to be spotted. ARPES with the beam size smaller than 1 micrometer or less (nanoARPES) can solve such problems. In this presentation, we will introduce our recent nano-ARPES study on the band structure of 2D crystals in comparison to those measured by conventional micro-ARPES. Possible problems such as slow focusing and spotting the position of sample may be overcome with automated procedures.

Keywords:
two-dimensional crystals, black phosphorus, nanoARPES

P1-co.223

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First-principles study of work functions of transition-metal dichalcogenides

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Abstract:

We studied the work function, ionization energy, and electron affinity of bulk transition-metal dichalcogenides (TMDs) in 2H phase using the density functional theory (DFT) and the GW approximation. To obtain the work function of a system, we need to find the chemical potential of the system with respect to the vacuum level. In case of bulk DFT calculations, however, the vacuum level is not well-defined. We obtained the vacuum level of bulk TMDs by considering a sufficiently thick slab system which has a similar band gap with bulk. We also introduced the GW approximation to obtain the quasiparticle energy shift of valence band maximum and conduction band minimum and obtain more accurate ionization energy and electron affinity. This work is supported by the NRF of Korea (Grant No.2011-0018306). Computational resources have been provided by KISTI Supercomputing Center (Project No. KSC-2018-CRE-0097).

Keywords:

TMD, GW, DFT, Work function

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Magnetoresistance in Two-dimensional Electron Gas at $CaZrO_3/SrTiO_3$ Interface

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Abstract:

The discovery of two-dimensional electron gases (2DEGs) in $SrTiO_3$-based heterostructures provides new opportunities for nanoelectronics. Herein, we create a new type of oxide 2DEG by the epitaxial-strain-induced polarization at an otherwise nonpolar perovskite-type interface of $CaZrO_3/SrTiO_3$(CZO/STO).

We growth the CZO/STO system under different thicknesses of the film and measure Magnetoresistance at interface with PPMS.(Physical Property Measurement System)

Keywords:

2DEGs, CaZrO3/SrTiO3

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P1-co.225*

Holstein polaron in a valley-degenerate two-dimensional semiconductor

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Abstract:

Two-dimensional crystals have emerged as a class of materials with tunable carrier density. Carrier doping to two-dimensional semiconductors can be used to modulate many-body interactions and to explore novel composite particles. The Holstein polaron is a small composite particle of an electron that carries a cloud of self-induced lattice deformation, which has been proposed to play a key role in high-temperature superconductivity and carrier mobility in devices.
We report the discovery of Holstein polarons in a surface-doped layered semiconductor, MoS_2, in which a puzzling 2D superconducting dome with the critical temperature of 12 K was found recently. We found strong band renormalizations collectively identified as a hitherto unobserved spectral function of Holstein polarons. The short-range nature of electron-phonon coupling in MoS_2 can be explained by its valley degeneracy, which enables strong intervalley coupling mediated by acoustic phonons. The coupling strength is found to increase gradually along the superconducting dome up to the intermediate regime, which suggests a bipolaronic pairing in the 2D superconductivity.

Keywords:
ARPES, Two-dimensional semiconductor, Transition metal dichalcogenides, Polaron

P1-co.226

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Study on electrical properites of strain effect in epitaxial $SrIrO_3/SrTiO_3$ heterostructure membranes using $Sr_3Al_2O_6$ sacrificial Layers.

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Abstract:

The perovskite oxide thin films and heterostructures are affected by the strains caused by the difference in lattice constant between film and substrate. As a result, the lattice structure of epitaxial thin film is changed, which represents many physical properties such as magnetism, two-dimensional electron gas (2DEG), and metal-insulator transition (MIT). Therefore, the strain tuning applied to the film can be used as a powerful tool to investigate the various physical properties of the oxide film. On the other hand, the process of creating and manipulating materials such as membranes with graphene shows a variety of physical phenomena in the condensed matter physics. However, unlike the case of graphene, the separation of the oxide film from the substrate is difficult, and the production of these heterostructures is also limited. As a solution, we have grown an epitaxial $Sr_3Al_2O_6$ sacrificial water-soluble buffer layers on a perovskite substrate and grown a $SrIrO_3/SrTiO_3$ heterostructure on it. These heterostructure films offer the opportunity to transfer the $Sr_3Al_2O_6$ sacrificial layers into water and transfer it to another substrate and incorporate it as a layered compound such as graphene. Through this membrane, we will investigate the effect of a wide range of strain effects on the physical properties such as conductivity in thin films.

Keywords:

SrIrO3, SrTiO3, oxide heterostructure, strain effect, membrane

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Angle-resolved photoemission study on the band structure of PbI_2

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Abstract:

Organic-inorganic methylammonium lead triiodide perovskite ($CH_3NH_3PbI_3$) has become one of the most promising material in the rapidly growing field of perovskite solar cell. This material can be synthesized by the combination of methylammonium iodide (CH_3NH_3I) and lead iodide (PbI_2). The latter itself is a two-dimensional van der Waals semiconductor that has attracted interest owing to its potential for application in optoelectronic devices. The bulk form of PbI_2 has the direct band gap of 2.5 eV that corresponds to the visible light region [2]. This direct band gap changes to an indirect band gap when thinned down to the monolayer, which is opposite to the indirect-to-direct gap transition in transition-metal dichalcogenides. We measured the electronic band structure of $PbI_2$by angle-resolved photoemission spectroscopy (ARPES). The experimental band structure of $PbI_2$was analyzed based on theoretical band calculations [3].

References:
[1] W.S. Yang et al., Science. 348, 1234-1237 (2015)
[2] M. Schluter et al., Phys. Rev. B 9, 1652 (1974)
[3] Alexis S. Toulouse et al., Phys. Rev. B 91, 165308 (2015)

Keywords:
ARPES, Band structure, PbI2

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Fabrication of Nanoporous Silicon on Flexible Substrate

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Abstract:
Freestanding np-Si(nanoporous silicon)를 기계적으로 유연하고 광학적으로 투명한 PDMS(polydimethylsiloxane) 기판 위에 전사시켜 PDMS/np-Si/PDMS 구조의 박막을 제작하였다. 제작된 박막의 액 · 기체 투과성 및 이에 대한 감응성은 아주 우수한 것으로 나타났다.

Keywords:
freestanding porous silicon, PDMS, PDMS/np-Si/PDMS

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P1-co.229

Behavior of Ge atom in $GeTe/Sb_2Te_3$ Superlattice with Laser Power

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Abstract:

Phase-change materials are under aggressive research for next generation nonvolatile memory devices. Recently, superlattice structures, which consist of Sb_2Te_3 and GeTe, have been demonstrated to dramatically improve the optical and electrical performances of chalcogenide based phase-change materials. Until now, an unified model has not been clearly confirmed: instead, several models such as zipper model, Ge/Sb intermixing model, and umbrella flip-flop model have been suggested. However, there would be dominant mechanism according to switching conditions, such as laser power, $GeTe/Sb_2Te_3$ layer thickness and so on. Since it is difficult to monitor the atomic behavior in the atomic scale, only a few experimental results have been recently reported. In this work, the experimental evidences of switching mechanism was investigated in GST-SL by X-ray Photoelectron Spectroscopy. For the preparation of the superlattice structures, Sb_2Te_3 5 QL(1 Quintuple Layer =1nm) / GeTe 4nm/ Sb_2Te_3 10 QL thin films were grown on the Si(111) substrate by molecular beam epitaxy system. Varying irradiating laser power, evolutions of atomic configuration of GT/ST SL are traced. In high energy regime, above 18mJ/cm^2, tetrahedral portion of local environments of Ge was increased, which indicates that phase-change mechanism of superlattice is dominant by umbrella flip-flop model. In low energy regime, under 10mJ/cm^2, octahedral and tetrahedral portion of local environments of Ge was little changed, which indicates that local environments of Ge atom do not change during the phase-change process. That is, the zipper model is governed by Sb, Te bilayer inversion and local environments of Ge are not changed. Therefore, phase-change mechanism of superlattice in low energy regime is dominantly goverened by zipper model.

Keywords:

MBE, Superlattice, XPS

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2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Retrospective dosimetry of heated materials

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Abstract:

For a rapid assessment method of retrospective dosimetry using heated materials, for example red brick, roof tile, ceramic tile and toilet porcelain, SAAD-POSL method with core-disc sampling was newly introduced. In the SAAD-POSL method, the reliability was proven in the range of lethal doses up to 7 Gy and the calculation time for an equivalent dose was as short as 2 h. In this study, we carried out the fading test to evaluate the stability of the resulting equivalent dose obtained from various heated materials. We also determined the effectiveness of the SAAD-POSL method for a rapid assessment method of retrospective dosimetry.

Keywords:

Retrospective dosimetry, Heated materials, Fading, SAAD-POSL method

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P1-nu.002*

Crystal Growth and Luminescence Properties of Dy^{3+} Doped $Li_6Y(BO_3)_3$ Crystal

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Abstract:

For the purpose of neutron imaging, scintillation crystals composed of Li, B or Gd, which have very high thermal neutron absorption coefficients are becoming popular. These crystals can provide distinct luminescence properties with different rare earths dopants (Ce^{3+}, Dy^{3+}, Eu^{3+} etc.). In the present work, $Li_6Y(BO_3)_3$ (LYBO) pure and doped with 4 mol% Dy^{3+} single crystal have been grown using the Czochralski method. X-ray induced luminescence properties have been studied for both pure and doped crystal at room temperature. Photoluminescence and decay times have been measured in low temperature from 290 K to 10 K for 4 mol% Dy^{3+} doped LYBO crystal. Characteristic emission of Dy^{3+} ion has been observed for LYBO crystal doped with 4 mol% Dy^{3+} under X-ray irradiation. The maximum intensity of excitation and emission peaks are found at 350 nm and 578 nm, respectively. Decay time decreases from 690 μm at 290 K to 655 μm at 10 K. In future, the crystal will be applied as a scintillator for thermal neutron imaging.

Keywords:
Li6Y(BO3)3 Crystal, Luminescnece, Decay time

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P1-nu.003

Structure shape evolution in deformed even-even nuclei

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Abstract:

We studied the characteristics of the evolution of the collectivity in even-even nuclei. The structures of deformed even-even nuclei are calculated within the framework of the IBM and critical point symmetry. Firstly, the structure in some of them is described by using the matrix elements of the Hamiltonian and the electric quadrupole operator between basis states of SU(3) limit in IBM. Secondly, low-lying energy level and E2 transition ratio corresponding to the observable physical values are calculated by adding perturbed term with first-order Casimir operator of U(5) limit to SU(3) Hamiltonian in IBM. We compared the results with experimental data of deformed nuclei. Lastly, the potential of Bohr Hamiltonian is represented by harmonic oscillator, and then the structure of deformed nuclei can be expressed by closed form from an approximate separation of variables.
The results of theoretical prediction will be able to understand the tendency of nuclear structure changes in deformed even-even nuclei of relevant to the region of mass numbers.

Keywords:

IBM, critical point symmetry, deformed nuclei, energy level, E2 transition

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P1-nu.004*

Simulation Study of Thin and Long Scintillator Detectors with Multiple MPPC Readout for the J-PARC Hyperon Spectrometer

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Abstract:
We study optical properties of a thin and long plastic scintillator using Geant4 simulation toolkit. The scintillator detector is 800 mm long with a cross section of 10 x 70 mm^2. Scintillation light is read out by using eight MPPCs at each end. The MPPC signals are amplified using differential op-amps and a unity-gain sum amplifier. Thirty-two scintillator detectors will constitute the Trigger Hodoscope surrounding the Hyperon time projection chamber (HypTPC) in the Hyperon Spectrometer at J-PARC. The Hyperon Spectrometer consists of a 1.3 T superconducting magnet, the HypTPC, and the Trigger Hodoscope. We simulate scintillation process, light propagation, and MPPC response in this study. We will report Geant4 simulation results on the optical properties for the Hodoscope prototypes in comparison with bench test results.

Keywords:
HypTPC,Scintillation Counter,Geant4,MPPC,Optical Simulation

P1-nu.005

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Lifetime measurement of ^133Cs excited states using NaI(Tl) detectors and 500 MHz Flash ADCs

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Abstract:

We report a systematic study on the limit to nuclear lifetime measurements in the subnanosecond range. The precision measurement for short lifetimes in the subnanosecond range needs a gamma-ray fast timing coincidence measurement. We have measured a half-life of the first 5/2^+ excited state in 133Cs using four NaI(Tl) detectors. A prompt 356 keV gamma-ray from the 1/2^+ -> 5/2^+ transition triggers a two-fold coincidence with a 81 keV gamma-ray from the 5/2^+ -> 7/2^+ transition in 133Cs. The NaI(Tl) detector signals are fed to a 500 MHz flash ADC so that we can digitize the pulse shapes in every 2 ns. We have studied systematic uncertainties in measuring time differences between the prompt and slow gamma-ray signals, which incude timing variations with crossing times for different fractional pulse heights, time-walk corrections, and time jitters. We also simulated scintillation processes, light propagation, photoelectron statistics, and data processing using a Geant4 toolkit. We will present preliminary results on the detection limit to nuclear lifetime measurement in the subnanosecond range and also discuss a new measurement plan with LaBr3 detectors in this talk.

Keywords:

NaI(Tl),gamma-ray,133Cs,Flash ADCs,Geant4

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P1-nu.006*

Crystal growth and luminescence properties of $Zn_2Te_3O_8$ crystal for neutrinoless double beta decay search

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Abstract:

The applications of scintillation crystal as cryogenic phonon-scintillation detector element for searching the neutrinoless double beta (0νββ) decay are very promising due to its excellent energy resolution and good particle discrimination capability. Among the 0νββ decay isotope candidates, ^{130}Te is the best choice due to its highest natural isotopic abundance (34%). The well-known TeO_2 crystal has no luminescence at room and low temperatures and has been being used only as a bolometer for the 0νββ decay search in ^{130}Te by the Cryogenic Underground Observatory for Rare Events (CUORE) experiment. Therefore, a Te-based luminescent crystal will be advantageous to be used as cryogenic phonon scintillation detector for the 0νββ decay search. For this purpose, we investigated the crystal growth and luminescence properties of a $Zn_2Te_3O_8$ crystal. The single crystal is grown by the Czochralski method. The single crystalline phase of the grown crystal is confirmed by a powder X-ray diffraction method. The luminescence properties of the grown crystal are measured in a temperature range of 300-10 K under 266 nm laser excitation. The present investigation reveals that $Zn_2Te_3O_8$ can be a good candidate for the future 0νββ decay search experiments. The growth and characterizations of the $Zn_2Te_3O_8$ crystal will be presented.

Keywords:

0νββ decay, 130Te, Czochralski method, Scintillation crystal

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양성자 가속기에서 생성한 ^{8}Li+ 빔을 이용한 β-NMR 재이온화 장치에서의 He 가스에 대한 재이온화 과정의 전산모사 연구

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Abstract:

β-NMR은 방사성 동위원소의 핵스핀의 방향에 따라 베타 붕괴하여 방출되는 전자의 asymmetry를 측정하여 물성 연구를 하는 기법이다. β-NMR 시설은 크게 빔 생성 장치, 편극화 장치, 분광 장치로 구분되고, 편극화 장치는 다시 중성화 장치, optical pumping을 통한 편극화 장치, 재이온화 장치로 구분된다. 본 연구에서는 양성자 가속기를 이용한 ^{8}Li+ 빔을 사용하여 재이온화 과정을 위한 전산모사 연구를 수행하였다. 재이온화 과정은 빔의 편극도를 유지하고 빔을 제어하기 위해 필요하다. 재이온화 장치는 He 가스를 이용한 창없는 구조로 구성하였다. 전산모사 연구를 위해 Geant4를 활용하여 코딩하였으며, He 가스의 밀도를 계산하기 위해 Molflow+ 프로그램을 사용하였다. ^{8}Li의 He 가스에 대한 재이온화 단면적을 계산하기 위해 캐나다 TRIUMP 연구소의 실험 데이터를 이용하였으며, He tube의 길이, He 가스의 유량에 따라 재이온화율과 emittance의 변화를 계산하였고 최적화 값에 대하여 70%에 가까운 재이온화율을 얻을 수 있었다. 또한 빔라인의 진공도 유지를 위해 He 가스의 배출이 중요하며, 진공펌프의 배출속도에 따른 재이온화 장치 chamber 내에서의 He 가스 밀도의 변화를 Molflow+ 프로그램을 통해 계산하여 진공 적합도를 판단하였다.

Keywords:

β-NMR, 8Li 재이온화, He gas

P1-nu.008

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Experimental Study on Production Cross Sections for ^{8}Li based on a 100-MeV Proton Beam at KOMAC

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Abstract:

Development study of a radioactive lithium-8 beam with a high-power proton driver beam by adopting isotope separation on-line (ISOL) technique is an ongoing research project at Korea Multi-purpose Accelerator Complex (KOMAC), Korea Atomic Energy Research Institute (KAERI). In this study, a production cross section is a fundamental and essential physical quantity for estimating the yield of radioactive isotopes of interest at a production target. In this endeavor, we have performed experiments for measuring production cross sections for a ^{8}Li isotope through proton-induced reactions on Beryllium and Boron production targets based on a 100-MeV proton beam. An experimental setup was constructed for on-line beta-decay measurement at the low-flux target room of KOMAC, consequently, the production cross sections for ^{8}Li via proton-induced reactions on light-element targets have been measured for the first time. In this presentation, we describe the details of experimental setups and discuss the results.

Acknowledgements: This work has been supported through KOMAC (Korea Multi-purpose Accelerator Complex) operation fund and the NRF grant (No. NRF-2017M2A2A6A02071070 and NRF-2018M2A2B3A02072238) funded by MSIT (Ministry of Science and ICT).

Keywords:
Proton Accelerator, Li-8 Production Cross Section, Proton-induced reactions

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P1-nu.009

Theoretical study on the production of neutron-rich No isotopes

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Abstract:

The possibilities of production for yet unknown neutron-rich isotopes of No are explored in the variety of multinucleon transfer reactions. The production of a given isotope of neutron-rich No is optimized by a suitable choice of projectile-target combinations and bombarding energies. The production cross sections of neutron-rich No isotopes in the 0n and 1n evaporation channels of multinucleon transfer reactions are compared. The prospects for the use of radioactive beams in the production of new No isotopes are discussed.

Keywords:

neutron-rich No isotopes, multi-nucleon transfer reactions

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P1-nu.010

β-NMR 시설을 위한 $^{8}Li^{+}$빔의 중성화과정 전산모사와 장치의 상세설계

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Abstract:

첨단 표면 분석용 베타-검출 핵자기 공명(β-NMR)은 편극된 방사성 이온빔이 베타 붕괴하여 방출하는 베타입자의 Asymmetry를 측정하여 물성과학 연구에 활용하는 기법이다. 양성자 가속기 센터에서는 $^{8}Li^{+}$빔을 생성하고 이를 활용하기 위해 편극도 70% 이상의 편극된 빔을 요구한다. 빔 라인을 편극하기 위해서는 이온빔을 중성화하는 중성화과정과 광학펌핑과정, 재이온화과정이 필요하다. 본 연구에서는 Na 가스 셀을 이용한 $^{8}Li^{+}$빔 중성화과정의 전산모사 연구를 수행하였다. 전산모사 연구를 위하여 전하교환 반응단면적과 가스의 온도에 따른 밀도의 변화는 C 코드를 개발하여 계산하였고, 이를 소프트웨어 툴킷(Geant4)에 적용하여 수행하였다. 또한, 전산모사 결과에 대한 검증을 위해 TRIUMF 연구소의 실험 데이터와 비교연구를 수행하였으며, 최적화된 Geometry를 결정하여 상세설계를 하였다.

Keywords:

β-NMR, 8Li+빔, 중성화장치, Geant4

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Study of pulse shape discrimination with selected Li-contained scintillation crystals

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Abstract:

We report the pulse shape discrimination capability of our Li-contained inorganic halide scintillator crystals for the neutron detection. All crystals were grown inside fused quartz ampoules having a conical tip, sealed under high vacuum, by using vertical Bridgman technique. The scintillation pulses of the crystals were measured under α-particles and ɣ-rays from ^{241}Am and ^{137}Cs sources, respectively using a 400-MHz FADC. Charge integration method was employed for the pulse analysis, and the figure-of-merits (FOM) were estimated for the comparison of pulse shape discrimination capability of each crystal. The best FOM was obtained to be 1.6 among all the measured crystals. The scintillation decay times under α-particles and ɣ-rays excitation were also measured for their correlation with PSD power.

Keywords:
Scintillation crystal, Pulse shape discrimination, Decay time, Figure-of-merit, Charge intergration method

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Beta-NMR 시설 구축을 위한 8Li+ 빔 편극화 장치내에서의 빔 궤적 전산 모사 연구

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Abstract:

8Li+ 빔 편극화 장치는 크게 중성화 장치 Optical-pumping 장치 재이온화 장치로 구성되어 있다. 중성화 장치에서 중성화되지 않은 이온들을 걸러주는 Deflector와 각각의 장치들을 통과하면 초기 입사된 빔보다 빔이 퍼지게 되어 이를 모아주는 Einzel-lens, 빔의 궤적을 휘게 만들어 target까지 이르게 하는 Electric-bender 등을 G4beamline 전산모사 프로그램을 이용하여 각각의 조건을 변화시켜 그에 따른 결과를 도출하였다.

Keywords:

빔 Beta-NMR 빔라인 Deflector Einzel-lens Electric-bender G4beamline

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Luminescence properties of Ce3+ doped boron-gadolinium-tungstate glass scintillator

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Abstract:

Glass scintillators can be fabricated in large sizes and various shapes at low cost than the single crystal scintillators.They can be doped with different elements to improve their luminescence properties. Ce^{3+} doped boron-gadolinium-tungstate glasses, with (30-x)B2O3:27.5Gd2O3:42.5WO3:xCeF3 (where x=0.1, 0.5, 1.0 and 2.0) composition, were fabricated by the melt-quenching technique. In most scintillators, Ce3+ ion showed broad band emission between 300-600 nm and fast decay constants due to spin and parity allowed 5d-4f transition. Due to such properties Ce3+ is ideal activator for the radiation detection in different applications such as medical imaging, high energy physics and astroparticle physics. In this study, The prepared glasses were studied various properties such as physical, optical, luminescence and scintillation under various radiation source such as X-ray, photo, proton and laser.

Keywords:

Glass scintillator, luminescence, Ce^{3+}

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P1-nu.014*

Study of Pulse Shape Discrimination with Li-Tl Co doped CsI crystal scintillator

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Abstract:

Neutron detecting scintillators are studied due to increasing demands from security application heavily. Cs2LiYCl6 (CLYC) and Cs2LiLaBr6 : Ce (CLLB) whichare Li-containing elpasolite single crystals have a significant results. Their capability of well-defined neutron-gamma pulse shape discrimination (PSD) makes it possible to perform neutron-gamma detection with a single detection material. However, due to material cost, difficulty in handling crystal and complexity in crystal growth, available size of these crystals have a limit. In particular, CsI:Tl can detect neutron-gamma by co-doping Li in the crystal matrix. Thermal neutron detection is realized by the 6Li(n,t)α neutron capture reaction. The reaction products, an alpha particle and a triton, deposit a total of 4.8 MeV energy in the crystal. In this poster, Li co-doped CsI:Tl single crystals have been studied with optical scintillation properties and neutron-gamma PSD capabilities.

Keywords:
PSD, CsI(Tl)(Li), scintillator

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Enriched $Li_2{}^{100}MoO_4$ Crystal Growing at Center for Underground Physics

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Abstract:

The Center for Underground Physics (CUP) of IBS is searching for the neutrinoless double beta decay of ^{100}Mo isotopes in the AMoRE (Advanced Molybdenum-based Rare-process Experiment). The experiment requires ultra-pure crystals to minimize internal backgrounds to achieve the “zero-background” in the energy region where the two beta particles from the decay deposit in the crystals. At first, we studied the Li_2MoO_4 crystal growth with natural molybdenum after some purifications in the CUP. After confirming the purities of grown $Li_2{}^{Nat}MoO_4$ crystals by an ICP-MS and two HPGe detectors, we carried out a $Li_2{}^{100}MoO_4$ crystal growth using the enriched molybdenum (^{100}Mo > 95%) and the purity of the grown crystal were measured. We will also increase the ingot length (~5 cm (Φ) x ~11 cm (L)) to obtain two crystal elements (~5 cm (Φ) x ~5 cm (L) each) per one ingot in the next growth. The third CZ grower was installed at the CUP recently so that there will be three growers operating at the same time for a mass production in order to produce ~400 crystal elements for the AMoRE-II. We will present the growths and characterizations of the $Li_2{}^{100}MoO_4$ crystals at the CUP.

Keywords:
Li2100MoO4, AMoRE, Scintillation properties, Czochralski

P1-nu.016

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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An Evaluation of the Antiproton Therapy by using Simulation Method

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Abstract:
In order to evaluate the therapy effects of antiproton therapy, by using simulation method, the human phantom including a target volume and three interested volumes are constructed. Then, the interaction for proton (antiproton) beams with materials is simulated, and the dose depositions in target and three related normal volumes are calculated. The calculation results show that the dose deposition of upstream volume is lower for antiproton beam than that for proton and carbon ion. However, in the downstream volume behind the target volume (SOBP area), the less dose is deposited by proton. Through this study, it can be concluded that the Antiproton Therapy has advantages as a radiation therapy method for the case that lower dose is required for upstream of target.

Keywords:
Radiation Therapy, Antiproton Therapy, Monte Carlo Method

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P1-nu.017

A Study on the Shielding Ability of Aerospace Materials against Space Radiation

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Abstract:
Space radiation is one concerns for space missions, and with the development of spaceflight enterprise, the research of shielding materials against space radiation has become more important. In this study, the phantom, shielding materials and geometry of shielding is defined. Then the radiation shielding properties of various materials together with the consideration of mass problems of shielding materials are evaluated. The protection ability of materials against space radiation was appraised by the perspectives of radiation dose. In conclusion, under the same level of mass of shielding materials, it is more advantageous to use the composites and non-metal materials than using metals or alloys. In addition, the multi-layers shielding is better than the single layer shielding.

Keywords:
Space Radiation, Radiation Shielding, Aerospace Materials

P1-nu.018

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Relativistic analyses for the proton scatterings from heavy nuclei

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Abstract:
Relativistic Dirac analyses are performed phenomenologically for the proton inelastic scatterings from heavy nuclei. The optical potential model is used and the Lorentz covariant scalar and vector optical potentials are considered employing the S-V model. 2-parameter Fermi shape is used for the geometry of the optical potentials. The first order collective model is used to obtain the transition potentials for the low-lying excited states. Calculated optical potential parameters and the deformation parameters are analyzed and compared with those obtained from the non-relativistic calculations.

Keywords:
Dirac analyses, optical potential model, collective model, proton scattering

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P1-nu.019

Radon chamber detectors for rare-process search experiments

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Abstract:
It is very important to monitor the amount of radon (Rn-222) in the underground experiments such as rare process search experiments with ultra low background requirements. The radioactivity from the radon can be a significant background source to the experiments and need to be measured precisely. Over the last three years, the 70 L radon chamber detector used in the KIMS experiment was upgraded and tested. The energy resolutions of alpha particles emitted from the decays of the daughter particles were measured to be better than 0.6%. We have constructed two new radon chamber detectors of a round shape design with a thin (~3 mm) stainless steel plate for a light weight and a more uniform electric field. The inner surfaces of the two chambers were also electropolished to get rid of the radon daughters on the surfaces. The concentration calibration with the radium source was performed and the reduction power of the Radon Reduction System (RRS) installed in Yangyang underground Laboratory (Y2L) was measured using this result. We will present performances of the two new radon chamber detectors and their calibrations.

Keywords:
radon, chamber, silicon PIN photodiode, radioactive

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P1-nu.020

Growth and Characterization of the NaI pure crystal grown by the vertical Bridgman Techniques

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Abstract:

This work reports the growth of Pure NaI crystal using carbon coated quartz ampoule. The ampoule is coated with carbon by homemade carbon coating setup. The optimized condition is found out for coating the ampoule. The nitrogen gas is continuously purged during pre-heating and annealing. For coating, hexane is passed inside the ampoule with the help of nitrogen gas for 2 hours at 750 ºC. The grown crystal was cut into three pieces and its X-ray luminescence, photoluminescence was measured. The X-ray induced emission peaks of the crystals are at 300 nm, 375 nm and 650 nm. The temperature dependence of the scintillation and luminescence of the crystal was studied from room temperature to 10K using different excitation source. For scintillation measurement, radioactive source such as ^{137}Cs and ^{241}Am was used as the excitation source. The presence of defect or impurities on the crystal is confirmed by studying its thermoluminescence study from 10 K to 300 K, with the excitation of the crystal by X-ray source at 10K

Keywords:

NaI Crystal, Carbon Coated quartz ampoule, X-ray luminescence, scintillation, thermoluminescence

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P1-nu.021

Nuclear reactions induced by alpha irradiation of ceramic materials and their application to wettability control

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Abstract:

When high-energy alpha particles are irradiated onto materials, nuclear reactions can be induced. Those nuclear reactions usually happen near the surface of materials because of high linear energy transfer (LET) so that surface properties of materials can be changed. Wettability is one of the most important surface properties because it is closely related to various phenomena such as adhesion, painting, printing, lubrication, and so on. Wettability is usually described by water contact angle (CA) on a material's surface. When the surface shows CA less than 90°, it is considered as hydrophilic. On the other hand, if the surface exhibits CA higher than 90°, it is called as hydrophobic. If we produce amine ($-NH_2$) or carboxyl (-COOH) functional groups on a surface, the surface can become hydrophilic. In addition, hydrocarbon ($-CH_n$) or fluorocarbon ($-CF_n$) functional groups can make a surface hydrophobic.

In this research, we irradiated high-energy alpha particles onto ceramic materials, which are usually metal oxides and therefore have many oxygen atoms, and then measured their wettability. ^{19}F atoms were produced on the surface by $^{16}O(\alpha, n)^{19}Ne$ reaction and following β+ decay. These fluorine atoms resulted in the increase of ceramic material's CA. In addition, color of surfaces could also be changed by the high-energy alpha irradiation.

Keywords:

alpha irradiation, nuclear reaction, ceramic, wettability

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P1-nu.022*

The nuclear structure and deformed Woods-Saxon potential

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Abstract:

최근 희귀동위원소 실험 시설이 발전함에 따라 불안정 동위원소에 대한 연구의 관심이 증대되고 있다. 그러나 핵력을 기술하는 기존의 구형 퍼텐셜 모형만으로는 불안정 핵종을 포함한 모든 핵종의 구조를 기술하기 어려운 상황이다. 이에 본 연구에서는 불안정 동위원소의 핵구조를 기술할 수 있는 퍼텐셜(potential) 모형의 연구를 진행했다. 불안정 동위원소의 구조를 기술하기 위해서는 구형 퍼텐셜 모형으로부터 변형된 형태의 퍼텐셜 모형이 필요하다. 이를 위해 본 연구에서는 파동함수의 기저(basis)로 Nilsson basis를, 퍼텐셜 모형으로는 변형된(deformed) Woods-Saxon potential 모형을 이용하여 불안정 핵종의 구조를 기술하려 한다. 이번 발표에서는 이러한 모형을 탄소(Carbon) 및 산소(Oxygen) 핵의 동위원소들에 적용하고, 그것으로부터 기술되는 단일 입자 상태(single particle state)의 계산 결과를 보일 예정이다. 또한 실험 데이터와의 비교를 통해 변형된 Woods-Saxon 퍼텐셜을 분석하고, 이러한 퍼텐셜 모형이 적용될 수 있는 범위와 그 한계성에 대해 논의할 것이다.

Keywords:

deformed Woods-Saxon potential, single particle states, rare isotope, unstable nuclei

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P1-nu.023

HPGe measurements of detector material samples and background screening study at YangYang Laboratory

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Abstract:

The AMoRE experiment searching for neutrinoless double beta decay and the COSINE experiment which searches for WIMP(Weakly Interacting Massive Particle) dark matter are two main experiments of the Center for Underground Physics. Both are running at the Yangyang Underground Laboratory.

To control the experiment sensitivities, the respective detector materials were measured using two 100% high-purity germanium (HPGe) detectors with confirmed efficiency calibrations. For standard analysis of small samples, peak rates observed during background runs with no sample are subtracted from peak rates observed during sample runs. However, large and dense samples such as Pb and Cu can potentially screen the detector from background-producing gammas originating from beyond the sample space. Therefore the background may be over-subtracted resulting in inferred activities that are less than the actual values. For accurate analyses, the background screening effect was simulated for each relevant sample using the Geant4 simulation toolkit.

We will present measurements of the samples together with background screening studies.

Keywords:
HPGe detector, AMoRE, COSINE, Efficiency Calibaration, Geant4, Background study

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P1-nu.024

Gluon distributions in the constituent quark and in the nucleon

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Abstract:
We calculate the unpolarized and polarized gluon distributions in the constituent quark by using the perturbative quark-gluon interaction and the non-perturbative quark-gluon interactions. We extend the gluon distributions in the constituent quark to the gluon distributions in the nucleon and discuss the results.

Keywords:
gluon distributions, quark, quark-gluon interactions

P1-nu.025

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Measurement of Delayed Gamma-ray Energy Spectrum from Residual Nuclide for $^{nat}Pb(p,xn)Bi$ Reaction by 100-MeV Proton Accelerator

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Abstract:
The gamma-ray energy spectrum was measured from natPb(p,xn) nuclear reaction. Irradiation experiment was performed at the high-intensity 100-MeV proton linac facility (Korea Multi-purpose Accelerator Complex, KOMAC). The targets, irradiated by 100-MeV protons, were arranged ina stack consisting of natrual Pb, Al and Pb foils. The HPGe detector was used to measure the gamma-rays of the samples, In the current studyy, we observed that the proton reaction spallation neutron was generated between the Lead target and the high energy proton beam. The excitation functions of natPb(p,xn)Bi reaction within the proton energy of 75.4 - 93.4 MeV. The preent results have been compared with the literature data and theoretical values. This process is important to obtain proton nuclear reaction cross-section.

Keywords:
Proton induced reaction, HPGe detector, natPb(p,xn), delayed gamm-ray, 100-MeV proton beam, KOMAC

P1-nu.026

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Past and future of the performance in heavy ion run period with the CMS detector

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Abstract:
In the last two months of 2018, CMS has successfully completed the 2nd run period, collecting the PbPb collision data with the integrated luminosity of 1.6 nb^{-1}. And CMS has estimated the results during the future HL-LHC run period, based on present physics results and Monte Carlo studies. In this presentation, we will wrap up the performance during the run2 period and show the future expectation of the performance in HL-LHC run period, focused on the analysis using the dilepton channel.

Keywords:
CMS, heavy ion run, HL-LHC, PbPb run

P1-nu.027

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Measurement of Thermal neutron capture cross sections and resonance integrals of ^{174}Yb and ^{176}Yb at the Pohang Neutron Facility

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Abstract:

In this work, we have determined the thermal neutron capture cross sections (s_0) and resonance integrals (I_0) of the ^{174}Yb(n,g)^{175}Yb and ^{176}Yb(n,g)^{177}Yb reactions by using the method of neutron activation analysis based on the 100-MeV electron linac of the Pohang Accelerator Laboratory (PAL). The measurements were done with respect to the ^{197}Au(n,g)^{198}Au reference reaction. The induced g-ray activities in the irradiated foils were measured with high purity germanium (HPGe) g-ray detector. The thermal neutron capture cross sections for the ^{174}Yb(n,g)^{175}Yb and ^{176}Yb(n,g)^{177}Yb reactions have been determined to be 74.17 ± 1.85 barn and 2.92 ± 0.11 barn relative to the reference value of 98.65±0.09 barn for the ^{197}Au(n,g)^{198}Au reaction. The resonance integrals for the ^{174}Yb(n,g)^{175}Yb and ^{176}Yb(n,g)^{177}Yb reactions have been determined to be 28.89 ± 1.76 barn and 6.56 ± 0.35 barn with respect to the reference value of 1550± 28 barn for the ^{197}Au(n,g)^{198}Au reaction. The comparison between the present measurements and various literature values are discussed.

Keywords:

Thermal neutron capture cross section; Resonance integral; Activation method and off-line ɣ-ray spectrometric technique; 174Yb(n,g)175Yb and 176Yb(n,g)177Yb reactions

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P1-nu.028

JFET 구조 기반의 실리콘 배열형 센서 연구

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Abstract:
의료용 검출기 개발을 위해 X-ray의 직접 검출 방식을 이용하는 실리콘 배열형 센서를 연구한다. 센서는 PIN 다이오드 구조를 가지며 선명한 영상을 획득하기 위하여 픽셀로 설계하였다. 신호 처리 채널 수를 줄이기 위해 각 픽셀에 Junction Field Effect Transistor (JFET) 구조를 설계하였다. 디자인 변수에 따른 JFET 구조의 스위치 효과를 확인 하기 위해 JFET 구조에 중점을 둔 프로토 타입의 센서를 제작하였다. 이번 연구에서는 센서의 변수에 따른 스위치 경향과 그 결과를 바탕으로 새로운 센서 디자인에 대해서 발표할 계획이다.

Keywords:
의료용 검출기, Junction Field Effect Transistor (JFET), 실리콘 배열형 센서

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P1-nu.029*

Charmonium measurements in PbPb and pPb collisions at 5.02 TeV with the CMS experiment

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Abstract:
The charmonium production in PbPb collisions is affected by the competition between melting and statistical recombination in hot and dense QCD medium. And the production in pPb collisions is also important to investigate the cold nuclear matter effect. CMS has measured the nuclear modification factors for prompt J/psi and Psi(2S) in pPb and PbPb collisions at 5.02 TeV. We will present the final results of charmonium production until 2015 and 2016 run periods.

Keywords:
J/psi, charmonium

P1-nu.030*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Measurements of bottomonia states in pPb and PbPb collisions at 5.02 TeV with the CMS experiment

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Abstract:
In the LHC era, bottomonia are important probes of the quark-gluon plasma since they are produced at the early stages of the collisions and keep the information of the QCD medium. The nuclear modification factors of the ground and excited Upsilon states were measured via dimuon channels in PbPb collisions at 5.02 TeV with the CMS detector. The recent CMS results on the bottomonium production in pPb and PbPb collisions at 5.02 TeV will be presented.

Keywords:
CMS, bottomonia, LHC, quark gluon plasma

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P1-pa.001*

Neutrino Oscillations under the Non-Standard Interaction at Korea Neutrino Observatory

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Abstract:
We consider the effect of a Non-Standard Interaction for a proposed T2HKK (Tokai to Hyper Kamiokande to Korea) experiment using the Korea Neutrino Observatory. The CP-violating asymmetry, as well as the neutrino mass and mixing parameters, can be affected by the new physics. We simulate the expected effects and discuss some methods to distinguish the new physics effects.

Keywords:
Neutrino oscillations, Long baseline neutrino experiment

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P1-pa.002

Right-handed neutrino magnetic moments

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Abstract:
I will discuss the phenomenology of the most general effective Lagrangian including up to dimension five operators built with standard model fields and right-handed neutrinos. In particular, the new interactions by a dimension five electro-weak moment operator of right-handed neutrinos will be shown mainly.

Keywords:
right-handed neutrino, phenomenology, effective Lagrangian, dimension five operator

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P1-pa.003

Study of 10-inch PMT saturation

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Abstract:
The JSNS2 experiment plans a search for sterile neutrino oscillation at a short baseline using a high intensity neutrino beam produced by muon decays at rest in the J-PARC MLF. The JSNS2 considers use of 10-inch Hamamatsu's PMT R7081. It is important to understand in which photoelectron region the PMT responds linearly to the light signal. To find the PMT saturation region in response to a large signal, a study was made using a laser light with various filters. In this presentation, we report the linear response region of the PMT R7081.

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P1-pa.004

A performance study of the muon detector in the NEOS-II experiment

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Abstract:
Background events from spallation muons seriously mimic the inverse beta decay signals in the reactor neutrino experiment. In order to veto muon backgrounds, a muon detector was constructed in the NEOS-II experiment. It consists of counter modules of a plastic scintillator, two light guides and two 2 inch PMTs or three 5-inch PMTs. We studied the characteristics of muon signals at a shallow depth of overburden and present the results on muon veto efficiency and background related to muons.

Keywords:
neutrino, NEOS

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P1-pa.005

Vertex reconstruction at RENO

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Abstract:
The RENO experiment has been taking the data since 2011. The detector degradation because of decreased number of active PMTs and decreased attenuation length of liquid scintillator, the reconstructed vertex become worse. We have developed modified the vertex reconstruction to recover the reconstructed vertex to early 500 days vertex. This presentation will show how to recover the vertex to early 500 days of n-Gd and n-H analysis.

Keywords:
RENO, vertex, neutrino

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P1-pa.006

Charge correction at RENO

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Abstract:

The RENO experiment has been taking data since Aug. 2011 and has seen decrease of observed scintillation charges by time. The reduced charges come from decreased attenuation length of gadolinium loaded liquid scintillator and decreased number of active photo-sensors. This resulted in a non-uniform charge response in the detector and worsened the energy resolution. We have developed a charge correction method using the peak energy of neutron captures on gadolinium. In this presentation, we present the charge correction method to make the observed charge response constant in time and uniform in the detector volume.

Keywords:
RENO, charge correction

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P1-pa.007*

Improvement of Measuring Devices on Attenuation Length in the Aqueous Detector

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Abstract:
고에너지 실험에서 입사한 입자는 체렌코프효과 혹은 섬광반응을 통해 빛을 방출한다. 이같이 액체 사용 검출기에서 생성된 빛은 광증폭관에 도달하는데, 인ㄴ 액체섬광검출용액의 감쇠거리에 의존한다. 본 포스터는 감쇠거리 측정하기 위해 새로 제작한 장치 및 방법에 대해 간단히 발표한다.

Keywords:
중성미자 감쇠거리 액체섬광검출용액

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Feasibility Study on the Water-Based Liquid Scintillator

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Abstract:
차세대 중성미자 검출기는 대규모이고, 초순수를 사용한다. 물을 사용할 경우 감쇠거리가 길어지고, 비용이 줄어들며 체렌코프 빛을 이용할 수 있다는 장점이 있다. 이에 대한 파생결과로 동시에 물 기반 액체섬광검출용액 연구도 할 수 있다. 여러 가지 계면활성제를 사용한 물 기반 액체섬광검출용액을 개발 및 특성조사를 하였다.

Keywords:
중성미자, 중성미자검출, 액체섬광검출용액, 감쇠거리, 계면활성제, 초순수

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P1-pa.009*

Study on the Reactor Neutrino Directionality in the Liquid Scintillator Detection

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Abstract:
액체섬광검출용액은 중성미자 검출을 위해 유용하게 사용되고 있다. 액체섬광검출기는 체렌코프 검출기와 달리 중성미자의 방향정보를 재구성하는 것이 매우 어렵다. 하지만 원자로에서 방출된 반전자 중성미자의 경우 역베타붕괴 반응 이후 생성되는 신호들을 이용한 방향정보 재구성에 대한 연구 결과가 있으며, 이를 이용하여 액체섬광검출기에서 원자로 중성미자의 방향정보 재구성에 대한 가능성을 조사하였다.

Keywords:
reactor neutrino, directionality, liquid scintillator

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P1-pa.010

Background simulation for AMoRE-pilot

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Abstract:

AMoRE is an experiment searching for neutrinoless double-beta decay of ^{100}Mo. AMoRE experiment requires extremely low radioactive background contributions from detector materials. In AMoRE-pilot Run-5 detector setup, the dominant background contibutions are pin connector, Stycast, and PCB. Pin connector was removed in AMoRE-pilot Run-6 detector configuration. Stycast and PCB parts were replaced with low activity materials such as Pb-Sn solder and Kapton PCB. Another detector parts were also updated such as bolts, sensor holder, PEEK, reflector, heater and clamps. To investigate background sources and their contributions, a Monte Carlo simulation was performed. Effects of ^{238}U and ^{232}Th contaminations in detector material were simulated. ^{210}Pb contamination in the Pb-Sn solder was also considered. The background contribution from different components were well identified and reduced significantly by replacing them. The details of the study will be presented in this poster.

Keywords:
AMoRE, Background, GEANT4, Neutrino, Simulation

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P1-pa.011*

Decorrelating optimum filter in AMoRE-Pilot experiment.

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Abstract:

Advanced Molybdenum-based Rare-process Experiment (AMoRE) will search for neutrinoless double beta decay($0\nu\beta\beta$) of Mo-100 isotope using scintillating crystals through simultaneous detection of temperature change and scintillation at milli-kelvin temperatures. The detector consists of six crystals in a row and features excellent energy resolution of several keV over a range of energy from hundreds of keV to a few MeV. If there is a noise correlation due to physical vibrations of the equipment, it is expected to be eliminated using a multi-channel correlation cancellation algorithm. If there is noise correlation due to physical vibrations of the equipment, it is expected to be eliminated using a multi-channel correlation elimination algorithm and the resolution will be improved. This presentation discusses the results of applying decorrelating optimum filter(DOF) to run 5 and run 6.

Keywords:

AMoRE Decorrelating optimum filter

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P1-pa.012*

Shielding design for AMoRE-I

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Abstract:

AMoRE is an experiment to searching for neutrinoless double-beta decay of 100Mo. AMoRE experiment requires extremely low radioactive background contributions from detector materials.

In the future AMoRE-I experiment, background events from external source neutron are one of the dominant sources in backgrounds. We conducted a neutron simulation for the research with Geant4 framework. Notably, among these neutrons, fast neutrons (above 1MeV below 10MeV) mainly tested with various thickness of polyethylene and additional materials containing hydrogen and boron. Then the background rate from neutrons has been calculated. Detailed configuration and result will be discussed in this poster.

Keywords:

AMoRE, neutrinoless double beta decay, Geant4, simulation

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P1-pa.013

Rock gamma simulation study for AMoRE-I

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Abstract:

The AMoRE(Advanced Mo-based Rare process Experiment) is an experiment for neutrinoless double beta decay search in Korea.
Neutrinoless double beta decay is a very rare process and requires zero background level in the region of interest where the two beta particles' energy combined. The AMoRE has been operating in the underground to reduce the cosmic ray background. For this reason, the AMoRE-I will be installed at Y2L (Yangyang underground Laboratory). In this configuration, the rock layer is one of the dominant gamma background sources. Rock gammas for the AMoRE-I configuration have been simulated and studied to understand the impact of rock layers accurately and the results will be presented.

Keywords:

AMoRE, Background, simulation, neutrino-less double beta decay, Geant4

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P1-pa.014

Light detector optimization for AMoRE

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Abstract:

AMoRE (Advanced Mo-based Rare process Experiment) is a large-scale low temperature detector to search for neutrinoless double beta decay (0νββ) of ^{100}Mo. The project employs MMC readouts for simultaneous phonon-scintillation detection from scintillating crystals containing ^{100}Mo elements. For the AMoRE-Pilot, Au:Er sensor material MMCs are used. However, the response amplitude of the light signal measured by the current light detector is smaller than that of the phonon signal. To improve this, the device was fabricated using Ag:Er sensor material, which has a higher signal than Au:Er at low temperature, and then tested. Also, the response amplitude of signals measured by the device depends on the size of the Ag:Er material. To optimize the response amplitude of signals, we fabricated that the MMCs is different sizes with Ag:Er material. We will report on the Ag:Er MMCs fabrication and test results.

Keywords:

AMoRE(Advanced Mo-based Rare-process Experience), MMC(Metallic Magnetic Calorimeter), AgEr

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P1-pa.015*

A study of cosmogenic activation in the COSINE-100 NaI(Tl) detector array

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Abstract:

COSINE-100 is a direct dark-matter (WIMP) search experiment that uses an underground array of low background NaI(Tl) scintillating crystals as a target/detector in the Yangyang deep underground laboratory. In spite of the underground experimental environment, the detector array and surrounding materials still contain some radioactive nuclides that were primarily produced by previous exposures to cosmic rays. Studies of the time-dependent contamination levels of these cosmogenic radioactive isotopes are required in order to understand these backgrounds to rare event search experiments. In this presentation, results of studies of cosmogenic nuclide contaminations in the COSINE-100 detector materials and comparisons to MC simulations will be presented.

Keywords:
Dark matters,WIMPs,Cosmogenics

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P1-pa.016*

Neutron Monitoring System for the COSINE-100 Experiment.

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Abstract:

The COSINE-100 experiment, a dark matter WIMPs(Weakly Interacting Massive Particles) search experiment, is running at the Yangyang underground laboratory which is about 700m below the earth surface with a low cosmic-ray muon background environment. In this experiment, it is important to distinguish neutron event rate, because nuclear recoils by neutron events can mimic the WIMP-nucleon interactions. In order to monitor the neutron event rates, we have installed liquid scintillator(LS) detectors and a ^{3}He gas detector for detection of fast and thermal neutron respectively. For the fast neutron monitoring, selection of neutron events was made based on pulse shape discrimination method and time coincidence to identify gamma and alpha events respectively. For the thermal neutron, measurements at a ground lab and the underground lab by the 3He gas detector will be compared. Performances of the muon monitoring detectors both at ground and underground will be presented.

Keywords:

neutron, fast neutron, thermal neutron

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P1-pa.017*

An alpha event analysis in the COSINE-100 NaI(Tl) detector

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Abstract:
COSINE-100 is a direct dark matter detection experiment using NaI(Tl) scintillation crystals. Understanding backgrounds in the NaI(Tl) crystals is important for the dark matter search experiment. Major internal background sources in the NaI(Tl) crystals are U-238 and Th-232. Many alpha particles are produced in the alpha decays of daughter nuclei of the U-238 and Th-232 decay chains. The goals of alpha events analysis are to figure out quenching factors of alpha particles and to estimate contamination of U-238 and Th-232 in NaI crystals. An alpha event analysis using the two years of COSINE-100 data will be presented.

Keywords:
COSINE, alpha decay, dark matter, WIMP

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P1-pa.018

NaI(Tl) crystal characteristics with temperature dependence

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Abstract:
For a direct dark matter detection experiment with NaI(Tl) crystals, two major characteristics of the crystals are a high light output and a good pulse shape discrimination(PSD) power among different particles. We installed a 1.2kg test NaI(Tl) crystal in a freezer whose temperature can go down to -35 degree Celsius. Energy resolution of the crystal is measured to be 16% at 59.54keV gamma emission from Am-241 with light yield of 10.04±0.24 photoelectron/keV. PSD-separator alpha activity is 0.73±0.16 mBq/kg. Measurements of light yields and PSD powers of the NaI(Tl) crystal in different temperatures will be presented.

Keywords:
low temperature, Dark Matter, NaI(Tl) crystal, PSD

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Simulation of Ra226 Contamination on NaI Crystal, Focused on Depth Profiling

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Abstract:

It has been known that decays of daughter elements of ^{222}Rn on the surface of a detector cause significant background at energies below 10 keV. In particular, ^{210}Pb and ^{210}Po decays on the crystal surface result in significant background for dark matter search experiments with NaI(Tl) crystals. However, we have no clear idea about how energy spectrum of contaminated crystal would be affected according to the depth distribution of its contaminating source. To get a clear understanding of depth distribution, we contaminated a NaI crystal in purpose with ^{226}Ra, and derived energy deposition plot as reference data. To analyze this data, Monte-Carlo simulation data with various depths have been obtained using Geant4 simulation tool. An analysis of the contaminated crystal focused on depth profiling using MC simulation will be presented.

Keywords:
surface alpha, contaminated crystal, NaI Crystal, Geant4, simulation

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P1-pa.020*

Microwave Cavity Axion Dark Matter Search from 3.3 to 12.4 μeV at IBS/CAPP

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Abstract:

The CAPP-12TB experiment is a resonant microwave cavity axion search planned at IBS/CAPP in KAIST for the axion mass range of 3.3 - 12.4 μeV. The system consists of a 12 T superconducting magnet with a bore size of 320 mm, a cryogenic system with physical temperatures around 50 mK, a high-Q, large volume (30 L) cavity with a copper tuning rod, and nearly quantum-limited noise amplifiers. The first phase of the experiment is under development with the cavity design being optimized through simulation studies. A new design is introduced in order to resolve the issue of so-called mode mixings - mixture of the desired resonant mode with unwanted modes during the frequency tuning process, which are present in the conventional cylindrical cavity. Preliminary results of the improved cavity design are presented and plans of the upcoming stages of the experiment are discussed.

Keywords:

axion, haloscope, dark matter, resonant cavity

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P1-pa.021

Axion dark matter search through radio telescope observation of neutron stars

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Abstract:
Axions are a possible solution to both the Strong-CP problem and dark matter. They are expected to convert into photons in the presence of an external magnetic field. Observations of high B-field neutron stars with radio telescopes may provide a method of searching for axions in the frequency range of 10 [MHz] ~ 38 [GHz], complementing current microwave cavity-based experiments. With 24 hours of integration time, we would be able to test for 10g_{KSVZ} and g_{KSVZ} for frequencies between 8.4 [GHz] ~ 20 [GHz] with the Green Bank Telescope and the SKA2 respectively. We may be able to reach g_{DFSZ} at certain frequencies with the SKA2 as well.

Keywords:
axion, dark matter, neutron stars

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P1-pa.022

Progress on ARIADNE collaboration at IBS/CAPP: probing non-DM axion

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Abstract:
The Axion Resonant InterAction DetectioN Experiment (ARIADNE) is designed to search for a hypothetical particle, axion, mediated by long-range interaction. This interaction can be detected by the NMR technique. Since the interaction is macroscopic, it is possible to detect the pseudo-magnetic fields as a function of the distance of two objects. ^{3}He is used in this experiment because it has a long relaxation time and can be treated as an elementary particle. To polarize ^{3}He, the IBC/CAPP ARIADNE group utilizes Metastable Exchange Optical Pumping (MEOP). For 1m long double ^{3}He polarization system, we designed a Helmholtz coil using 4 sets of square coils to achieve the uniformity over 99%. In order to reduce the environmental magnetic field by 8 orders of magnitude, we deposit sub-nm Nb film on the quartz tube. We update the status of the experiment and discuss future plans.

Keywords:
Axion, 3He Polarization, Magnetic shield

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CAPP-8TB axion haloscope sensitive to the mass range of 6.62 - 7.04 μeV

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Abstract:
CAPP-8TB is an axion search experiment in IBS/CAPP sensitive to the cold dark matter axion within the mass range of 6.62 - 7.04 μeV (1.6 - 1.7 GHz). A High cavity Q factor of around 105 at an extremely low temperature around 50 mK, static magnetic field of 8 T, and the total system noise temperature expected to be less than 1.5 K characterize the experiment and target sensitivity. The first phase run of the CAPP-8TB experiment with a series of HEMT amplifiers is planned to take data for three month to reach the sensitivity of 4 times the KSVZ line. After the run a SQUID amplifier having quantumlimited noise temperature will play an important role for the first amplification. Thus it will substantially drop down the total system noise temperature and allow the second phase of the experiment to reach sensitivity of the QCD axion within the same setup and running time. In this poster, the overall status of the first phase run and plan for the second phase run of CAPP-8TB will be presented.

Keywords:
Axion, cold dark matter, CAPP-8TB

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P1-pa.024

18T high temperature superconducting magnet and 4K test of CAPP18T experiment

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Abstract:

Axion haloscope is currently one of the most sensitive detector technology for Dark Matter axion search experiment. The detector consists of a strong B-field solenoid magnet, microwave cavity, cryogenic system and low noise receiver chain. To enhance the detector sensitivity, CAPP18T experiment adopted a strong solenoid magnet using high temperature superconducting (HTS) technology. In this poster, we introduce an 18 T HTS magnet and report a full scope of test results. We also report 4K (Lhe temperature) test results which is sensitive to near KSVZ dark matter axion parameter space.

Keywords:

Dark matter axion, axion haloscope, high temperature superconducting magnet, cryogenic cavity experiment

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P1-pa.025

Event Parameters Estimation Method for GNOME Data Analysis

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Abstract:

The Global Network of Optical Magnetometers to search for Exotic physics (GNOME) is an experiment looking for transient events by axion domain walls through the coupling of axion field gradient with atomic spins. GNOME is based on synchronized collaborative efforts from multiple GPS-equipped magnetometer stations located in geographically separated places around the Earth. One of those stations, located at IBS/CAPP in Daejeon, South Korea, employs a highly sensitive cesium atomic magnetometer. A magnetometer can detect spin signals from terrestrial axion domain wall events, but it would not be possible to distinguish real physics events from false positives due to environmental noise sources. IBS/CAPP is developing a new scheme of data analysis method to enhance the experimental sensitivity by considering coherence among multiple magnetometers data.

Keywords:

axion, axion-like particle, axion domain wall, data analysis

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P1-pa.026*

CAPP18T: DAQ system of Axion dark matter search experiment

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Abstract:
We introduce the data acquisition system (DAQ) for the CAPP18T Axion dark matter search experiment. Devices such as cavity, step motor, network analyzer (NA), Analog to Digital Converter (ADC), DAQ computer, spectrum analyzer (SA) are compiled to form the DAQ system. The devices are controlled by LabVIEW software. The acquired data are reformatted and analyzed using ROOT package. The system previously used SA to analyze the detected signal but the ADC combined with the DAQ computer, or realtime DAQ system, replaces the role in order to substantially reduce DAQ deadtime. After the input data are digitized, the Readout Unit and Preprocessor divide and allocate the data samples to the multi-thread FFT process, then each pieces combined by the Organizer. The realtime DAQ system was tested out to be capable of infinite sampling mode with deadtime defect less than 0.00001%.

Keywords:
dark matter, axion, CAPP, 18T

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P1-pa.027*

RF receiver chain and cryogenics system for axion dark matter search experiment at IBS/CAPP in KAIST

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Abstract:
About 23% of the energy density of the universe is considered to be in a form of dark matter. One of the strong candidates of dark matter is a hypothetical particle called the axion. In an axion haloscope experiment, axions coherently scatter off the magnetic-field potential in a frequency-tunable resonant cavity. CAPP18T experiment is equipped with a 18T magnet, high quality factor microwave cavity with frequency tuning-rod, high gain low noise amplifier (JPC), and a dilution refrigerator. Our detector is designed to be sensitive to frequency range of 4.757 - 5.01 GHz which is correspond to the axion mass range of 19.67-20.72 μeV. We report details of the receiver chain and cryogneics system of CAPP18T.

Keywords:
Axion, Axion haloscope, Dark matter, JPC

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P1-pa.028*

Development of a small size tracking system for education purpose.

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Abstract:
The Silicon Tracker with International Education Objective (SiTrInEO) project intends to design and build a tabletop tracker to be used with conventional sealed sources. The driving idea consists in providing an easy-to-handle and open instrumental platform, which students can use for experiment. The instrument platform implemented in the GEANT4 includes CMOS pixel sensor chips, magnetic field and electron generator (electron gun or radioactive source). In other to better understand the tracker design parameters, we developed a full simulation tool of the instrument based on the GEANT4. The studies of interaction between beta-ray and the materials e.g. bending of the beam, multiple scattering and lever-arm effect will be shown. The SiTrInEO can be helpful students to understand the basic knowledge of the tracking system.

Keywords:
Tracking system, GEANT4 Simulation.

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P1-pa.029

Pick-off quenching of ortho-positronium

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Abstract:

Positronium research is one of the best probes to discover new physical phenomena. Because of the unique system of electron (particle) and positron (antiparticle), we can study unacceptable reactions in a standard model (SM). Positronium possesses either singlet spin state (para-positronium: p-Ps) or triplet spin state (ortho-positronium: o-Ps). Especially, the decay time of o-Ps (142 ns) is 10^3 times slower than p-Ps (125 ps). It means o-Ps provides an enhancement factor of 10^3 in the sensitivity for new interaction. Therefore, o-PS is mainly focused on research in the new physics phenomenon. The ortho-positronium theoretically has a lifetime of 142 ns in a vacuum and has generally shorter than 142 ns due to the pick-off quenching. In this study, we measured ortho-positronium lifetime in N_2 gas condition. The results show that ortho-positronium has a longer lifetime in N_2 gas than air. Based on these results, we will include the N_2 gas flow part in the trigger parts for the ortho-positronium system.

Keywords:

ortho-positronium, lifetime, annihilation, pick-off

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P1-pa.030

Positronium Annihilation Test in Aerogel

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Abstract:

This experiment is planned to study for the positronium annihilation. Positronium(Ps) has two isomers depending on the spin state, singlet and triplet known as para, and ortho positronium respectively. In the air, almost ortho-positronium vibrate with para-positronium therefore we can observe only para-positronium annihilation in the air. The ortho-positronium annihilation can take place only in vacuum; therefore in the proposed experiment Aerogel will be used to induce the ortho-positronium annihilation, which can be detected by BGO scintillation crystals coupled to SiPM. Aerogel is a porous material with a very low density, so in the Aerogel, ortho-positronium can be annihilated without any interaction. We will compare ortho-Ps annihilation in aerogel without and covered by lead, aluminum or steel.

Keywords:

positronium, aerogel

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P1-pa.031*

GEM cosmic ray stand muon detection

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Abstract:
Cosmic ray stand was designed to test the performance of GEM (Gas Electron Multiplier) detectors. Two PMTs are used as reference detectors to trigger on the muons and the trigger signal and GEM detectors are read out to measure the efficiency of the test detectors.

Keywords:
GEM,muon,cosmic ray,telescope,detector,particle physics

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Measurements of two enriched ^{100}Mo powder samples using an array of fourteen HPGe detectors

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Abstract:

The AMoRE-II experiment needs detector crystals with low levels of radioactive contamination in order to achieve the "zero-background" level in the region of interest at the energy of the neutrinoless double beta decay of ^{100}Mo. In order to achieve this low radioactivity level in the crystals, the raw material of the crystals (isotopically-enriched ^{100}Mo powder, $^{100}MoO_3$) should be low in levels of radioactive contaminants. An array of fourteen high-purity germanium detectors (each with relative efficiency of 70 %) was constructed at the Yangyang underground laboratory for high-sensitivity measurements of radioactive isotope activities. Two sets of powder samples (~ 10 kg of 95 % enriched $^{100}MoO_3$ powder each) delivered in 2016 and 2018 were measured in the array and compared with two background data sets taken without the two samples. Analyses of specific activities of various radioactive isotopes will be presented.

Keywords:

AMoRE, detector crystals, radioactive contamination, neutrinoless double beta decay, high-purity germanium detectors,

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P1-pa.033*

Time synchronization of DAQ for JSNS2

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Abstract:

The JSNS2 is an experiment for sterile neutrino search at J-PARC. Photon signals from inverse beta decay of neutrinos will be detected by omnidirectional PMTs. Time synchronization in DAQ is essential to event vertex reconstruction using time likelihood method. We adjust phase of clock through internal clock propagation with daisy chain, and take sampling data. We present the result of time synchronization studies in JSNS2 DAQ system.

Keywords:

Time Synchronization, FADC, DAQ, JSNS2, JSNS2

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Study on Geant4 simulation using low-energy physics profiling system

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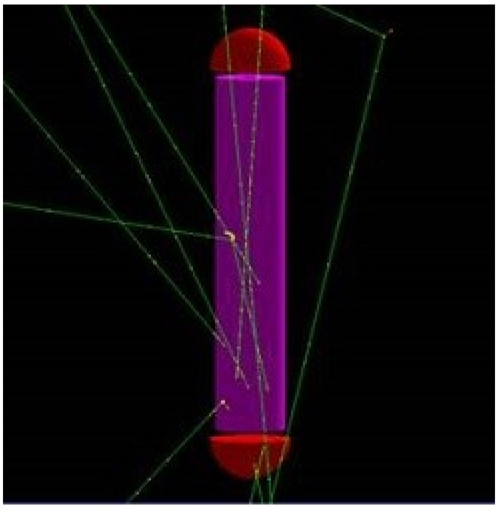
Abstract:

The Standard Model in particle physics is refined. However, new physics beyond the standard model, such as dark matter, requires thousand to million times of simulation events compared to those of the Standard Model. Thus, the development of software is required, especially for the development of simulation tool kits. In addition, computing is evolving. It requires the development of the simulation tool kit to accommodate the evolving computing architecture. Therefore, an efficient simulation tool kit is needed. Then, a profiling system is required to confirm it. In Geant4, a typical simulation tool kit, a profiling system in higher-energy physics areas such as the LHC experiment is well developed, contributing to the development of the software. However, profiling systems in the low-energy physics domain are in the beginning stage. Therefore, we develop it and show performances using it. In addition, profiling is performed depending on the development of software. These profiling systems could be used to confirm the development of software for evolving computing architecture.



Keywords:
low energy physics, Geant4, profiling system

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P1-pl.001

최적화된 전자 빔 인출을 위한 Klystron 전자총 열팽창 설계 연구

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Abstract:
Klystron은 고출력 고주파 발생 장치로서 전자 빔을 인출하는 가속기를 구성하는 핵심 장치이다. Klystron의 전자 빔 인출 성능은 내부에 위치한 전자총의 성능에 의해 좌우된다. 전자총은 cathode의 초고진공 환경 및 가열 온도 ~1,000℃에서 cathode 표면에서 전자가 인출되며, 전자총은 Tungsten, Molybdenum, Stainless Steel 등의 금속으로 구성된다. 서로 다른 열팽창계수를 가진 소재를 사용하므로, Klystron 전자총 설계 단계부터 열팽창을 고려한 설계가 필수적이다. 본 연구에서는 Klystron 전자총의 열팽창의 계산, 비가열조건 및 가열조건에서의 설계 비교, 실제 제작 공정에서 적용 가능성을 고려하여 최적화된 Klystron 전자 빔 인출을 위한 전자총 설계의 과정 및 방법을 연구하였다.

Keywords:
klystron, 전자총, scalloping,전자빔

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P1-pl.002*

Gas-cell Development for Laser Wakefield Acceleration

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Abstract:
Particle acceleration using a high power laser and plasma has been pursued for development of advanced particle accelerators since Tajima and Dawson first introduced the concept in 1979, followed by the breakthrough in high-power laser technology by Strickland and Mourou's chirped-pulse amplification (CPA) technique in 1985.
Important issues, such as the trapping/injection mechanism, dephasing, depletion and diffraction problems, should be taken into account in the development of the plasma source for LWFA (laser wakefield acceleration). In this work, we will introduce our new design for a compact capillary gas cell to provide a tailored gas/plasma density. In this experiment, different gas species and pressures are fed into capillary gas-cell feedlines separately to produce tailored gas and plasma density. The density transition effect or ionisation injection mechanism can be realised via this newly designed gas-cell to further improve electron trapping and acceleration in LWFA experiments. Preliminary results of the electron acceleration experiment will be shown in this presentation.

Keywords:
gas-cell, laser wakefield acceleration, CPA laser

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P1-pl.003

미세회절 실험용 해석 소프트웨어의 보정 루틴

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Abstract:
포항방사광가속기-II의 4B 빔라인에서는 X-선 미세회절 실험에서 도출되는 수만 개의 라우에 영상을 자동 해석하는 ASME(Analysis Software for Microdiffraction Experiments)라는 소프트웨어를 자체적으로 개발하고 있다. ASME는 크게 보정 루틴과 자동해석 루틴으로 구성되는데, 보정 루틴은 자동해석 루틴의 주요 알고리즘을 모두 포함한다. 따라서 보정 루틴이 제대로 구성되면 자동해석 루틴의 구성은 직접적이라고 할 수 있다.
보정 루틴은 회절점 탐색 및 근사 알고리즘, 대략적인 기하 매개변수 계산을 위한 예비 보정 알고리즘, 이론 사잇각 구성 및 축약 알고리즘, 결정의 전역 범위 회전과 이를 이은 국부 범위 회전 후의 패턴 정합을 통한 기하적 구속 알고리즘, (이론 및 실험 회절점의 위치 정합에 의한) 회절점 색인 알고리즘, CCD 검출기의 위치 보정을 위한 최적화 알고리즘, 격자표축 계산을 위한 최적화 알고리즘, 정규직교화 과정 및 변율 계산 알고리즘, 변환행렬 도출 알고리즘 등으로 구성되어 있다.
본 발표에서는 최근에 완성된 보정 루틴의 알고리즘 각각의 원리 및 기능과 알고리즘의 상호 연결에 의한 수행 결과에 대하여 상세히 기술한다.

Keywords:
X-선 미세회절 실험, 라우에 영상, 자동 해석, 보정 루틴, 최적화 알고리즘, 정규직교화 과정

한국물리학회 The Korean Physical Society

P1-pl.004*

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Generation of low energy electron beams for ultrafast electron diffraction by laser-plasma accelerator

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Abstract:

The ultrafast electron diffraction (UED) is a powerful method to observe ultrafast phenomena along with X-ray. The advantage of UED compared with X-ray is that it is more cost-effective and of larger cross-section. In order to utilize UED properly, however, the electron beam for UED should have an ultrashort pulse duration less than 100 fs, which is challenging for RF-based conventional accelerators. Compared with conventional accelerators, laser-plasma-based accelerators can generate that kind of ultrafast electron beam pulses easily for UED and we have an ongoing experimental program for UED. In this presentation, we are going to report the recent results for generation of a few MeV electron beams by a laser-plasma accelerator, where the Ti:sapphire laser pulse with 40 mJ in energy and 40 fs in pulse duration is irradiated to a gas-jet target with a dimeter of 1 mm.

Keywords:

Ultrafast electron diffraction, UED, Laser wakefield acceleration, laser-plasma-based accelerator, electron beam generation, LWFA

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P1-pl.005

Two-section 위글러를 갖는 자유전자레이저에서 3차원 효과

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Abstract:
Two-section 위글러를 갖는 자유전자레이저에서 시간 의존성 시뮬레이션 코드를 개발하였다.
이 코드를 사용하여 시간 변화에 대한 전자의 에너지 손실이 방사광의 에너지로 변환될 때 방출된
방사광의 증폭과의 관계를 연구하기 위하여 전자의 위상 공간에서의 에너지 분포에 관하여 연구하였다.
또한 여러가지 디튜닝 파라미터에서 시간의 변화에 따른 방사광의 증폭, 에너지 퍼짐성, 위상공간에서
전자 빔과 방사광의 특성을 연구하였다.

Keywords:
자유전자레이저, 위상공간, 방사광의 특성

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P1-pl.006*

Simulation studies for enhancement of electron beam energy by using a modulating laser pulse in laser wakefield acceleration

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Abstract:

The laser wakefield acceleration (LWFA) has been studied extensively due to its advantage of having a large accelerating electric field up to ~100 GV/m. However, there are several mechanisms which limit the electron beam energy. One of them is the dephasing problem, which is caused by the difference in propagation speed between the accelerated electron beam pulse and the laser wake wave. In this research, we propose a new solution by using an additional laser pulse in LWFA, where a rather weak modulation laser pulse is imposed on the accelerated electron beam. In this case, the electron beam speed can be slowed down in the longitudinal direction and this will enhance the electron beam energy. To investigate this phenomenon, we performed two-dimensional (2D) particle-in-cell (PIC) simulations and show that the weak modulating laser pulse could amplify the energy of the electron beam. Detailed simulation results are shown in this presentation.

Keywords:

enhanced electron energy, laser wakefield acceleration, modulating laser pulse, particle-in-cell simulation

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Generation of relativistic pair plasmas for laboratory astrophysics

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Abstract:
Relativistic electron-positron pair plasmas (REPP) are ubiquitous in high-energy astrophysical phenomena, but its laboratory realization has been hardly investigated. With the recent development of ultrahigh-power lasers and accelerators, highly luminous high-energy particles have become available for generating REPP, and much attention is being paid to the experimental study of REPP for laboratory astrophysics. In this study, we investigate the characteristics of electron-positron pairs generated with currently available particle sources such as laser wakefield accelerator, direct laser accelerator, and conventional linear accelerator. By using relativistic particle-in-cell simulations, EPOCH, and Monte Carlo particle interaction simulations, Geant4, we obtained the basic parameters such as size, density, neutrality, and temperature of the electron-positron pairs. We discuss the requirements on the total charge, divergence, and energy of a driver for generating REPP.

Keywords:
electron-positron plasma, laser accelerator, laboratory astrophysics

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Beam dynamics simulation of 6/3 MeV linear accelerator for security inspection equipment

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Abstract:

The Korea Atomic Energy Research Institute (KAERI) has been developing a security inspection equipment to distinguish materials with a high density and a low atomic number. It has multi-radiation generators that produce a neutron and a dual-energy X-ray beam. The X-ray is produced when electron beams collide with the tungsten target. In order to obtain the high resolution X-ray images of the material, parameters of an electron beam at the target are crucial. In this paper, we present the beam dynamics simulation of the 6/3 MeV dual energy linear accelerator and optimization of the beam parameters in terms of current, power and shape at the target by using the ASTRA code.

ACKNOWLEDGEMENT

This works has been carried out under the nuclear R&D program of the Ministry of Science and ICT (MIST) of Korea (NRF No. 2019M2A2A4A05031483).

Keywords:

cargo inspection, X-ray, neutron, Multi-radiation image, linear accelerator

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Development and current status of 7 T EBIS at KOMAC

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Abstract:

At Korea Multipurpose Accelerator Complex (KOMAC), we have been designing and manufacturing a 7 Tesla superconducting electron beam ion sources (EBIS) for the production of multiply charged ion beams which will be used as an injector of a 200 MHz Radio-Frequency Quadrupole of 1 MeV/n beam energy. In the EBIS, an electron beam is used for the ionization. The 7 T EBIS consists of an electron gun, a 7 T superconducting magnet, drift tubes, electron collector and ion optics etc. We have completed the design of the entire layout and parts are being manufactured. Here, we present the development of the 7 T EBIS, modification of the electron collector based on TRAK simulation and thermal analysis on the electron collector. We also show the current status and plans of construction of the 7 T EBIS.

Acknowledgment
This work has been supported through KOMAC (Korea Multi-purpose Accelerator Complex) operation fund of Korea Atomic Energy Research Institute by MSIT (Ministry of Science and ICT).

Keywords:
Electron Beam Ion Source

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P1-pl.010

중성자, X-선 동시발생 연구를 위한 전자선형가속기 시스템 구축

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Abstract:

검사대상을 손상, 변형시키지 않고 내부를 확인하거나 대상자체의 결함을 찾기 위한 비파괴검사 방법의 하나로 X-선이나 중성자 라디오그래피(radiography)가 널리 사용된다. X-선이나 중성자선 같은 방사선을 검사대상에 투과시키면 물질의 종류나 투과 깊이에 따라 투과 방사선의 에너지 감쇠도에 차이가 생기는데 이를 이용하여 물체 형태를 파악하고 물질의 종류를 구별할 수 있게 된다. 일반적으로 방사선 비파괴검사에는 구조가 단순하면서 소형인 발생장치의 제작이 가능한 X-선이 많이 이용되고 있으나, 최근 중성자를 이용한 검사법이 활발하게 연구되고 있다. X-선은 검사대상을 구성하는 원소의 질량이 클수록 투과하기가 어려워지기 때문에 금속 등에 의해 쉽게 차폐가 된다. 반면 중성자는 Gd, Cd, B 등 특정 원소에 대해 투과가 어렵기 때문에 X-선과 중성자를 함께 비파괴검사에 사용할 경우 비파괴검사 과정에서 물질분별력을 대폭 향상시킬 수 있게 된다. 한국원자력연구원에서는 고성능 비파괴검사장비의 개발을 위해 기존에 연구원에서 보유하고 있는 15 MeV급 전자선형가속기를 활용하여 X-선과 중성자를 동시에 발생시키기 위한 연구를 진행하고 있다. X-선은 가속기로부터 발생된 고에너지 전자빔이 금속 타겟에 입사될 때 일어나는 제동복사로 발생시키는데, 이 때 동시에 중성자가 발생되며 전자빔의 에너지가 클수록 발생하는 중성자의 선속도 커진다. 여기에서는 비파괴검사용 X-선과 중성자 동시발생 연구를 위한 전자선형가속기 시스템과 타겟부의 구축상황에 대해 논의하였다.

Acknowledgment:

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Keywords:
Radiography, X-선, 중성자, 선형가속기, 비파괴검사

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DIAC을 고속 중성자원으로 활용하기 위한 리튬 이온원 기초 개념 연구

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Abstract:
중수소-삼중수소 핵융합에서 발생하는 14 MeV 중성자를 모사하기 위해 DT 중성자 발생 장치를 사용할 수 있으나, 삼중수소를 취급하여야 하는 어려움이 있다. 이를 대신하여 중수소를 가속하여 리튬에 조사하여 13 MeV 중성자를 얻는 방법이 있다. 2 MeV로 가속된 중수소를 이용하는 경우 1 μA 당 1 초 당 약 10억 개의 중성자를 얻을 수 있을 것으로 예상된다. 하지만 중수소를 가속하는 경우도 중수소-중수소 핵반응에 의한 중성자 발생으로 인해 가속기 자체의 방사화가 우려되므로, 이를 피하기 위해 리튬을 가속하여 중수소에 조사하는 inverse-kinematics 반응을 이용하고자 한다. 한국원자력연구원 본원에 위치한 DIAC (Daejeon Ion Accelerator Complex)의 경우 핵자당 1 MeV로 가속이 가능하므로, 리튬-7의 경우 7 MeV로 가속하여 정지된 중수소에 충돌 시킬 수 있다. 여러 형태의 리튬 이온원이 가능하나, 열이온 방출형 이온원이 장치의 간편성 등 여러 측면에서 유리하므로 이를 선택하여 DIAC을 고속 중성자원로 활용하는 방안을 검토하였다. 이 학회에서는 이러한 기초 개념 연구 내용을 발표하고자 한다.

Keywords:
DIAC, 고속중성자, 중수소, 리튬, inverse-kinematics 반응, 이온원

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Parameter optimization for new undulator line at PAL-XFEL

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Abstract:
PAL-XFEL has been successfully operated and the most-stable XFEL facility in the world. For hard X-ray beamline, there is only one undulator line of which the maximum undulator parameter K is 1.87 and the minimum photon energy with 10 GeV electron beam is 13.3 keV. When the lower photon energy is required from the beamline users, the electron beam energy has to be decreased from 10 GeV and it results in the decreased accessible FEL pulse energy. To make full use of PAL-XFEL performance in the lower photon energies, therefore, new hard X-ray undulator line with higher undulator parameter K has to be installed in the vacant space beside the existing undulator line. In this presentation, FEL-related fundamental parameters are determined for new hard X-ray undulator line and compared with existing undulator line. FEL simulation results using GENESIS are also presented.

Keywords:
PAL-XFEL, undulator, free electron laser

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반사파 위상에 따른 클라이스트론 출력 특성

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Abstract:
양성자가속기연구센터에서는 총 9기의 클라이스트론이 사용된다. 이 가운데 20~100MeV 가속기에 사용되는 7기 클라이스트론의 출력 도파관 레이아웃은 동일하며, 3~20 MeV 가속기에 사용되는 클라이스트론의 출력 도파관 레이아웃은 나머지 것과 다르다. 20~100 MeV 가속기에 사용하던 클라이스트론을 3 ~ 20 MeV 가속기에 사용한 결과 그 출력 특성이 이전과 다름을 알 수 있었다. 측정 및 계산으로부터 반사파 크기뿐 아니라 위상에 따라서도 클라이스트론 출력 특성이 변화함을 알 수 있었다. 본 발표에서는 반사파 위상에 따른 클라이스트론 출력 특성에 대해서 보고한다.

본 논문은 과학기술정통부 연구비 지원을 받았음

Keywords:
클라이스트론, 반사파 위상, 출력 특성, KOMAC

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KOMAC 100-MeV 선형 양성자 가속기용 350 MHz, 1.6 MW 펄스 클라이스트론 초기 운전

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Abstract:
KOMAC에서 운영 중인 100 MeV 선형 양성자 가속기의 구동을 위한 고출력 고주파원으로 총 9대의 클라이스트론이 사용된다. 개별 클라이스트론의 누적 운전시간은 3만 시간을 초과하였으며 이 중 두 대의 클라이스트론을 교체하였다. 교체된 클라이스트론은 첨두 출력 1.6 MW, 동작 주파수 350 MHz, 듀티 9%의 제원을 가지고 있다. 공장 시험시 전자빔 전압 106 kV, 전자빔 전류 26 A, 드라이브 고주파 50 W에서 1.62 MW의 고주파 출력을 얻을 수 있었다. 기존 클라이스트론에 비해 교체한 클라이스트론의 경우 전자총의 perveance가 절반이하로 줄었으며 이에 따라 anode 전압 인가를 위한 분배 저항의 저항값을 변경하여 초기 운전 시험을 수행하였다. 3 MeV RFQ 및 20 MeV DTL을 부하로 하였을 때, 운전 전압 105 kV에서 동작시켜 포화 출력까지 instability 없이 동작함을 확인하였다.

본 연구는 과학기술정보통신부의 연구비 지원을 받았음.

Keywords:
KOMAC, 클라이스트론, 고주파

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Variation of Spectral Bandwidth of 14.5 keV FEL by Bending Angles of Bunch Compressors in PAL-XFEL

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Abstract:

A Hard X-ray (HX) line in PAL-XFEL with three bunch compressors (BC) generates 2.5 - 15-keV FEL with over than 1-mJ pulse energy. We make an energy chirp in an electron bunch for bunch compressing in magnetic BCs. This energy chirp is reduced after last BC because the energy of tail slices is reduced by wakefields from head slices. Since an energy spread of the bunch should be minimized at the end of undulators for lower spectrum bandwidth of the generated FEL, the energy chirp of the bunch should be remained and optimized at the entrance of undulators. Therefore, if the longitudinal electron distribution of the bunch is almost the same, energy chirps of the optimized conditions are the same although the peak currents are different. We optimize the 14.5 keV FEL during vary the bunching angle of BC2 for varying the peak current along with the fixed energy chirp. The phase space of optimized conditions for various angles are measured by the beam analyzing system with a deflector and a dipole magnet. In this paper, we investigate the correlation between the energy chirp and FEL generation. Also, we present the detail of e-beam and machine parameters for the optimized FEL.

Keywords:
XFEL, energy chirp, bunch compressor, FEL pulse energy, spectral bandwidth

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FEL features from the phase scan using the phase shifter

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Abstract:

The phase shifter is used to maintain the maximum FEL intensity during undulators. The maximum FEL intensity can be obtained by selecting the optimal phase of the electron beam against the FEL phase. In actual, the phase scan using the phase shifter is performed and the optimal phase so called 'in-phase' is selected at the maximum FEL intensity. The phase scan gives the maximum and minimum FEL intensities, which correspond to 'in-phase' and 'out-of-phase' of the electron beam slice, respectively. In this presentation, we suggest some features of the bunching factor and the gain curve by analyzing 'in-' and 'out-of-' phases. The gain curve solutions of the 1D linear FEL pendulum equations are introduced as well as the bunching factor formula. From the analysis we show that the phase shifter simply shifts the FEL gain curve and the bunching factor is proportional to the square-root of the difference of the maximum and minimum intensity of the phase scan.

Keywords:

FEL, phase shifter, bunching factor

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항공화물 컨테이너 검색용 6/3 MeV 이중에너지 X-선 발생장치 개발

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Abstract:

본 연구는 항공화물 컨테이너 보안검색을 위한 6/3 MeV 이중에너지 X-선 발생장치의 개발에 관한 것이다. 이중에너지 X-선 발생장치는 6/3 MeV 이중에너지 X-선을 이용함으로써 검색 대상물의 투과영상과 유/무기물 분별영상의 동시 획득이 가능하다. 이중에너지 X-선 발생장치에 사용된 고주파 전자가속관은 side-coupled standing-wave 방식이며, π/2 모드로 구동되고, 공진주파수는 2856 MHz인 S-band 가속관이다. 3차원 전자기장 해석코드 및 전자빔 궤적 코드를 이용하여 이중에너지 고주파 전자가속관의 최적화 설계를 수행하였다. 최종 설계 사양을 바탕으로 실제 전자가속관을 제작하고 빔 커미셔닝을 진행하였다. 가속된 전자빔을 텅스텐 타겟에 입사시켜 발생된 X-선의 최대 선량은 전자빔 에너지가 6 MeV 일 때, 약 5 Gy/min@1 m 이상으로 측정되었다.

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Keywords:
항공화물 컨테이너, 전자가속관, X-선, 보안검색

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50 W급 저전력 홀추력기 플라즈마 모드 변화에 따른 성능 및 이온빔 특성 진단 연구

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Abstract:

홀추력기는 자기장 및 전기장을 활용하여 이온을 가속함으로써 추력을 얻는 전기추력기의 일종으로, 비추력과 전력 대비 추력 비율이 높아 여러 우주임무에 활발히 활용되고 있다. 최근 100kg 이하 소형위성 기반의 우주임무가 급증함에 따라 소형위성 운용을 위한 100 W 이하 저전력 홀추력기의 수요 역시 가파르게 증가하고 있다. 그러나 100 W 이하 저전력 홀추력기의 경우, 추력기 크기의 감소로 인해 플라즈마 부피 대비 표면적 비율이 증가하여 플라즈마와 내벽간 상호작용이 증가한다. 이에 따라, 방전이 일어나는 내벽으로의 입자 및 전력 손실이 증가하여 추력 성능 및 수명 감소, 열 발생으로 인한 자기장 세기 감소 등 연구개발에 여러 난제가 존재한다. 본 연구에서는 자기장 제어 기반의 50 W급 저전력 홀추력기 랩모델을 설계 및 제작하고, 추력기 운전 변수에 따른 성능 및 이온빔 특성 분석을 진행하였다. 제작된 홀추력기는 전자석과 영구자석의 조합으로 방전채널 내에 자기장을 형성하였으며, 채널 벽으로의 입자 및 전력손실을 감소시키기 위해 자기력선이 채널 벽에 닿지 않고 양극방향으로 오목하도록 설계하였다. 추력기 음극은 자체 개발하여 사용하였으며, 양극 제논유량 2.8 - 4.3 sccm 조건에서 소모전력 30 - 70 W 범위에서 안정적인 방전을 확인하였다. 본 추력기는 54 W 소모전력에서 추력은 약 2.9 mN, 양극효율은 약 22%을 보여 해외 우수그룹과 유사하거나 더 우수한 성능을 확인하였다. 특히, 제작된 홀추력기는 제논유량 3.8 sccm 이상에서 방전전류가 급격히 감소하는 플라즈마 모드 변화를 관찰하였다. 양극유량 4.3 sccm 및 양극전압 180 V에서 모드 변화가 관찰되었으며, 변화 직후 방전전류는 0.37 A에서 0.29 A로 약 21% 감소하고, 추력은 3.1 mN 에서 3.5 mN으로 약 12% 증가하였다. 패러데이 탐침 분석 결과, 모드변화 직후 분사각이 약 18도 감소하고 전자전류 감소로 인한 전류효율 증가로 인해 추력 성능이 크게 증가한 것으로 확인되었다.

Keywords:

전기추력기, 자기장 제어, 저전력 홀추력기

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홀추력기 플라즈마 내 Xe 이온의 에너지분포 측정 및 특성 분석

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Abstract:

홀추력기는 추력밀도와 전력효율이 높은 장점으로 인해 전세계적으로 여러 인공위성에 활발히 이용되고 있다. 홀추력기는 자기장에 구속된 전자가 연료를 방전 및 유지시키고, 발생한 이온이 축방향의 전기장에 의해 가속 및 분출되면서 추력을 발생시키는데, 추력의 근원이 되는 이온의 가속을 최대화하기 위해서는 플라즈마 내에서 이온이 가속되는 과정을 이해해야 한다. 본 연구에서는 레이저유도형광 분광 진단법을 이용하여 방전채널 직경이 50 mm인 고리형 홀추력기와 원통형 홀추력기에서 Xe 이온의 에너지분포를 측정하였다. 양극유량과 음극유량은 각각 7 sccm과 1 sccm으로 고정하였으며, 양극전압을 200 - 400 V에서 조절해 홀추력기를 구동하였다. 고리형 홀추력기에서는 방전채널 출구면으로부터 10 mm 떨어진 지점에서 양극전압의 70%에 해당하는 에너지를 얻은것에 반해, 원통형 홀추력기에서는 10 mm 지점에서 30%의 에너지만을 얻었으며 출구면으로부터 60 mm 지점에 달해서야 70%의 에너지를 얻게됐으며, 이를 통해 고리형과 원통형 홀추력기에서 서로 다른 영역에 가속구간이 형성되는 것을 밝혀내었다. 고리형과 원통형 홀추력기는 에너지분포에서도 큰 차이를 보였는데, 고리형 홀추력기가 Maxwellian에 가까운 에너지분포를 가진데 반해 원통형 홀추력기는 최빈값 이상의 에너지를 갖는 이온들에 의해 에너지분포의 비대칭성이 뚜렷한 에너지분포를 가지는 것이 확인되었다. 본 발표에서는, 레이저유도형광 분광 진단시스템의 구성과 에너지분포 분석에 대한 상세한 연구결과가 소개될 예정이다.

Keywords:

홀추력기, 레이저유도형광, 에너지분포

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P1-pl.020

High Stable Precision Magnet Power Supply

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Abstract:

A high stable precision magnet power supply (MPS) was developed, which was a bipolar type with 200A of the output current at the 36V of output voltage. The MPS has been implemented by the digital signal processing technology using the DSP, FPGA, ADCs and so on. The output current stability of the MPS showed about 6 ppm peak-to-peak in a short term experiment at its full 200A output current. The long term stability was shown in 15 ppm peak-to-peak for 10 hours at 200A. And the others experimental results about the MPS were shown in this paper.

Keywords:

MPS

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P1-pl.021

PIXE와 RBS 분석법을 이용한 고분자 필름 내 탄소 성분 분석

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Abstract:
일반적으로 물질 내 탄소나 산소와 같은 경원소의 성분 분석은 용이하지 않은 것으로 알려져 있다. 하지만 물질 내, 특히 얇은 박막 내 산소나 탄소의 성분 분석의 필요성은 증가하고 있으며, 그 이유는 이들 성분의 함량에 따라 박막의 특성이 달라지기 때문이다. 따라서, 본 연구에서는 한국원자력연구원 양성자가속기연구센터에 설치된 1.7 MV 탄뎀가속기의 PIXE와 RBS 빔라인을 활용하여 박막 내 다른 성분들과 함께 탄소나 산소 성분의 분석을 실시하였다. 경원소의 분석이 가능하도록 PIXE 장치를 개선하였으며 탄소 성분의 정량적 분석을 위해 RBS 장치를 이용해 시료 내 탄소 성분을 정량화한 후 이를 PIXE 분석 시 반영하였다.

Keywords:
PIXE, RBS, 탄소, 산소, 성분 분석

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P1-pl.022

Development of Radiation Dose Monitoring System

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Abstract:

The PAL-XFEL has been operating successfully since 2016. The beam energy of the PAL-XFEL is 10GeV. The PAL-XFEL has been installed two undulator beam lines. The one is for the hard X-Ray and the other is for soft X-Ray. The twenty out-vacuum undulators were installed at the hard X-Ray and seven at soft X-Ray. The permanent magnets of the undulators were degraded gradationally by the radiation doses. The monitoring system of the integrated irradiation doses for the undulator magnets was developed. Furthermore, this system can be applied to the other devices throughout the accelerator. The sensor of RFT300 from REM Oxford was adapted. The DSP TMS320F28335 from TI controlled the over the whole system. This monitoring system configured to have up to four channels in a standard shelf. This paper describes the implemented hardware and software functions of the radiation monitoring system.

Keywords:

Undulator, Radiation Dose

P1-pl.023

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The transition from the LS-RPA regime to the HB-RPA in the laser-target interaction with several critical density ranged targets

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Abstract:
The radiation pressure acceleration (RPA) scheme with a circularly polarized laser is known to be an efficient ion acceleration than the conventional target normal sheath acceleration (TNSA) scheme. Depending on the thickness of the target, the light-sail RPA (LS-RPA) occurs in the ultra-thin target, on the other hand, the hole-boring RPA (HB-RPA) does in the relatively thick target. The target thickness for the LS-RPA in the solid density ranged target is usually in the nm-scale, but by using the foam density ranged target, we can expect the LS-RPA regime in the um-scale. In this work, by using a particle-in-cell (PIC) simulations (EPOCH), we investigated the ion acceleration via the LS-RPA and the HB-RPA. The transition between the LS-RPA regime and the HB-RPA regime is clearly observed and can be explained with a suitable theoretical 1D model. To check the multi-dimensional effects such as a target expansion and hydrodynamic instabilities, 2D simulations are also carried out. From the results of 2D simulations, the transition between LS and HB-RPA turns out to be different from that of the theoretical 1D model. The possible explanation of this difference will be made by considering the multi-dimensional effects and relativistic self-induced transparency (RSIT).

Keywords:
ion acceleration, radiation pressure acceleration

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P1-pl.024

Beam Optics and Orbit Correction of RAON Beam Lines for KOBRA and Bio-Medical Facility

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Abstract:
Experimental facilities of RAON (Rare-isotope Accelerator complex for ON-line experiment) includs KOBRA (Korea Broad acceptance Recoil spectrometer and Apparatus) and Bio-Medical facility. Beams for these facilities are provided by the low energy section of superconducting linac (SCL3) for KOBRA and the full linac chain (SCL3-SCL2) for Bio-Medical facility. This work is related to the beam dynamics results, error analysis and orbit correction in the linac and beam lines.

Keywords:
RAON, Superconducting linac, Beam Line, Beam Dynamics, Orbit Correction

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P1-pl.025*

Experiment Design of Time-resovled X-ray ABsorption Spectroscopy for Warm Dense Carbon

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Abstract:

Warm dense carbon is of particular interest as its basic properties have been debated, while our understanding has been hampered in part due to the complicate interplay of physical processes in warm dense state. An early X-ray Absorption Near Edge Structure (XANES) study of liquid carbon indicated that the bonding of liquid carbon is primarily of sp type at low densities, with increasing components of sp^2 and sp^3 bonding at higher densities. The experimental setup suggested here is designed to measure time-resolved XANES for warm dense carbon. A femtosecond Ti:sapphire laser pulse which has 800 nm as a central wavelength and 30 fs pulse duration, isochorically heats a 70 nm thick amorphous carbon or diamond sample to warm dense state. A broadband X-ray probe beam is generated by irradiating 150 TW Ti:sapphire laser pulse (5 J, 30 fs) to the mid/high Z metal. This broadband X-ray pulse transmits through the warm dense carbon to probe electronic structure of it. The transmitted X-ray will be resolved by a flat-field soft X-ray spectrometer, which is constructed with tioroidal mirror and aberration corrected concave grating which has 2400 grooves/mm to achieve high resolution around carbon K-edge.

This work was supported by Institute of Basic Science (IBS-R012-D1) and National Research Foundation of Korea (NRF-2016R1A2B4009631) of Korea.

Keywords:
warm dense matter, x-ray absorption spectroscopy, laser-plasma x-ray source

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P1-pl.026*

THz Radiation from plasma dipole generated by obliquely propogated laser pulses in plasma.

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Abstract:

Emission of radiation from electrons undergoing plasma oscillations (POs) with a frequency ω_p in plasma has been investigated. The existence of intriguing and non-trivial coupling mechanism between the electrostatic PO and the emittence of electromagnetic wave can be utilized widely to extinct ranges of applications with THz spectral range. In this work, we show that a spatially-localized plasma dipole oscillation (PDO) can be generated when electrons are trapped in a moving train of potential wells produced by the ponderomotive force of two slightly detuned counter-propagating laser pulses that collide in plasma. Further, we demonstrate the improved way of generating the PDO which can be a better source for THz radiation by obliquely launching the laser pulses.

Keywords:
Laser plasma, THz radiation, ponderomotive potential, PIC simulations, plasma dipole oscillation, force balance model.

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Simulation on Femtosecond Dynamics of Excited Electron Distribution in Dense Aluminum Plasmas

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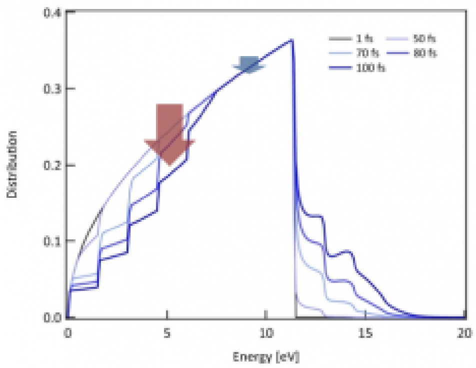
Abstract:

With the development of ultrafast probing techniques using x-ray free electron laser (XFEL) and femto-second laser system, a detailed microscopic understanding of thermalization and transition process from cold states to dense plasma states could be acquired. Especially, on sub-picosecond time scale (< 1 ps), there is the particular interest in the field of research on thermalization process of energetic electrons induced by ultra-intense laser. In this poster, we would like to present a numerical model for non-equilibrium dynamics of free electrons on dense plasmas in the sub-picosecond regime. Initial Fermi-Dirac distribution of free-electrons in metal Aluminum would be evolved to a temporal electron distribution with nascent excitation process, described in the model as both two separated distributions: thermal and non-thermal electron distribution. The numerical model also considers the evolved electron distribution including electron-phonon scattering as well as electron-electron scattering. Conclusively, we calculate not only the probabilistic free electron distribution of each time steps, but also an electron-electron thermalization time of ~ a few hundred in Aluminum laser-induced dense plasmas which is well matched up with the experimental data.



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Keywords:
Warm Dense Plasmas, Laser-plasma interaction, Non-equilibrium dynamics of free electrons

P1-pl.029*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Simulation Studies for THz Coherent Transition Radiation

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Abstract:
Terahertz (THz) radiations have a wide range of applications in science and technology. However, it is not easy to generate high energy THz pulses. One of the solutions would be to use coherent transition radiation (CTR). For this purpose, we propose to use electron beam pulses from the laser plasma acceleration (LPA), which can be achieved by a high power laser in table-top size. By using the LPA, electron beam pulses with a pulse duration of a few hundred fs can be generated easily and the CTR employing the electron beam pulses and a thin foil may produce high-energy THz pulses. We have a planned experiment in our laboratory, but extensive simulation studies should be done before the experiment. In this poster, some simulation results with a particle-in-cell (PIC) code will be presented.

Keywords:
coherent transition radiation,terahertz radiation,PIC simulation

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P1-pl.030*

Energy conservation model for the radiation reaction of a constantly accelerating particle

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Abstract:
가속 운동하는 점전하가 느끼는 radiation reaction (RR)은 주로 Abraham-Lorentz-Dirac (ALD) 방정식이나, Landau-Lifshitz (LL) 방정식으로 기술된다. 이 방정식들은 몇가지 문제들을 내포하고 있는데, 특히 등가속도로 운동하는 입자에 대한 RR을 설명하지 못하는 치명적인 문제를 가지고 있다. 등가속 운동에서도 당연히 광자들이 방출되므로 입자는 RR을 느껴야 하며, 이 때문에 ALD와 LL을 개선 혹은 대체하고자 하는 노력이 지금까지도 이어지고 있다. 이 발표에서 우리는 점전하와 구분이 불가능한 매우 특수한 부피전하를 고려한 후, 이 부피전하가 등가속도로 운동할 때 느끼는 RR을 해석적인 방법으로 제시한다. 최종적으로 상대론적 유효질량이 속도 뿐만 아니라 가속도에도 영향이 받는다는 것을 증명한다.

Keywords:
radiation reaction, acceleration, self force, point charge

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P1-pl.031*

Theoretical & numerical study of Plasma dipole oscillation

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Abstract:
THz radiation has been widely researched in the various field for the application: Basic science, Ultrafast communication and Global environmental monitoring. Many studies discovered the THz radiation from the plasmas by using counter propagation of two color lasers. We suggest plasma dipole oscillation model to understand how to generate THz radiation from the laser-plasma interactions and investigate the radiation spectral characteristics by the cplPIC code.

Keywords:
Plasma dipole oscillation, THz radiation, cplPIC

P1-pl.032

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Digital Radiography 시스템을 사용한 전 척추 검사 시 차폐체 두께에 따른 유방피부선량 측정

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Abstract:

자동노출제어(Auto Exposure Control, AEC)mode를 이용하여 유방을 차폐했을 때와, 차폐하지 않았을 때의 선량을 측정하였다. 차폐체를 사용하지 않았을 때의 선량은 1.540mGy 이었으며 collimator를 사용하였을 경우는 0.506mGy로 측정되었다. 또한 차폐체 1개(0.3mm)를 사용하였을 경우는 0.733mGy, 5개(1.5mm)를 사용하였을 때는 0.523mGy로 측정되었다. 차폐체 5개를 사용하였을 때의 선량과, collimator를 사용 하였을 때의 선량이 유사함을 알 수 있었다. 그리고 차폐체 8개(2.4mm)를 사용 하였을 경우는 0.233mGy로 측정되었다. 본 연구의 결과에서 방사선에 민감한 장기인 여성의 유방을 차폐하여 검사하였을 경우 차폐하지 않았을 때보다 두드러진 차이를 나타내고 있다. 차폐체를 사용할 경우 collimator를 사용할 때보다 더 일정하게 차폐를 할 수 있으며, 방사선의 노출로 인한 유방암의 위험 요소를 줄 일 수 있음을 알 수 있었다.

Keywords:

디지털 라디오그라피, 전 척추검사, 자동노출제어, 조리개, 선원피부간 거리

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P1-pl.033

Inductively coupled plasma 동작 모드에 따른 23S 준안정 준위 원자의 온도와 밀도 진단

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Abstract:

Inductively coupled plasma(ICP)는 저온 플라즈마 소스의 한 종류로 낮은 기체 압력에서 높은 플라즈마 밀도를 얻을 수 있으며, 다양한 분야에서 활용되고 있다. 본 연구에서는 ICP 챔버에서 생성된 헬륨 플라즈마의 23S→23P 전이선(1083nm)에 대한 흡수스펙트럼을 측정하였으며, 흡수 스펙트럼의 선폭과 넓이를 이용하여 23S준위의 온도와 밀도를 진단하였다. 플라즈마 동작 조건에 따라 E 모드와 H 모드 두 개의 모드로 플라즈마가 동작함을 확인하였다. 위치와 헬륨가스 압력, RF 파워에 따른 23S 준위의 밀도와 온도를 진단하였다. 다양한 동작조건과 위치에 따른 진단결과를 토대로 E모드와 H모드에서의 23S 준위의 밀도와 온도의 공간 분포를 결정하고 분석하였다.

Keywords:

plasma diagnostics, absorption spectroscopy, metastabel state atom, Inductively coupled plasma,

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Analyzing Spectra of Helium Plasma Generated by Atmospheric Pressure Non-Equilibrium Plasma Jet

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Abstract:
Atmospheric pressure non-equilibrium plasma jets (APNPJs) were generated by applying ac power at room condition. Recently, APNPJs take a strong attraction in research field owing to their plenty of applications, such as surface modification, biological decontamination, combustion and environmental protection. In our study, atmospheric pressure helium (He) plasma was created from our constructed dielectric barrier discharge (DBD) jet at the ac bias of 5kHz of frequency and 10kVp.p of amplitude. The plasma radiations were collected by an optical system and the plasma spectra were measured. Spectra of helium (He), molecular helium (He_2) and other species in air such as hydroxyl radical (OH), molecular nitrogen (N_2) and molecular nitrogen ion (N_2^+) were measured along the axial position of APNPJ by adjusting the electric field. By changing the distance between the quartz tube of DBD jet and the counter electrode, spectra of helium and other species were varied at different position from the head of quartz tube to the counter electrode.

Keywords:
Atmospheric pressure non-equilibrium plasma jets, dielectric barrier discharge (DBD) jets, plasma, helium

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P1-pl.035

Formation of steady-state field-reversed configurations (FRCs) by producing Hall current with RF antennas and microwave heating

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Abstract:

Field-reversed configuration (FRC) plasmas have closed-field lines, surrounded by an open vacuum field. A noticeable characteristic of FRCs is that it is consistent of only poloidal fields having very little or no toroidal field. This unique feature allows to have high β_p of 90%, which by pressure-balance can reach D-T nuclear fusion condition by 1 Tesla. In addition, the device is a cylindrical shape that is able to reduce engineering complications and is most likely suitable for becoming a compact source that produces hot plasmas. Conventionally known FRCs are by theta-pinch formation, which quickly reverses the applied external magnetic field causing reconnection at the ends. Formation happens in such a short period that if not carefully controlled leads to asymmetry, where plasma lasts only for serveral ~ μs. For this reason, there has been attempts on steady-state formation that depend on non-inductive current-drive methods. In this research, the RF antenna forms axial electric field (E_z) and radial magnetic field (B_r). When both fields are combined gives the E×B drift that pushes the electrons and ions in the azimuthal direction. By applying extra heating to the plasma, the diamagnetic drift increases by steepening the pressure gradient such that the ion azimuthal velocity is suppressed. There are two important outcomes. The first is lowering resistivity allowing the RF drive to function more efficiently. The second is suppression of rotational instability that enables the FRC to become more stable.

Keywords:

Field-reversed configuration, plasma, confinement

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P1-pl.036

MHD Stability Analysis of Low-n Mode Using the GATO Code in KSTAR

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Abstract:

It is important to analyze the magnetohydrodynamic (MHD) mode stability for stable operation of KSTAR tokamak plasma. The GATO code is used for the MHD stability analysis of the fusion plasma. The code uses the variational principle to minimize the Lagrangian and to compute the equilibriums of plasmas in a self-consistent method by maintaining the distribution of physical parameters. In order to determine the growth rate, the code solves eigenvalue problems. The GATO code is calculated using the equilibrium data obtained from the KSTAR experiment. Plasma equilibrium with various plasma pressure and current density profiles is applied to the GATO code to analyze the MHD plasma stability in low toroidal mode. As a result, the growth rate, the plasma displacement, the mode structure, and the MHD modes were obtained.

Keywords:
MHD, Stability, GATO, KSTAR

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P1-pl.037

Modified Korteweg-de Vries Theory of Ion-acoustic non-monotonic Double Layer in an Ion-beam Plasma System

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Abstract:

The propagation of ion-acoustic non-monotonic double layer is studied in an ion-beam plasma system with cold ions, beam ions and trapped, as well as free electrons. The modified Korteweg-de Vries equation is derived by the usual reductive perturbation technique from a set of basic hydrodynamic equations. A time stationary propagating non-monotonic double layer solution is obtained in an ion-beam plasma system. It is shown that the ion-acoustic non-monotonic double layer is a nonlinear extension of the ion-acoustic solitary hole and monotonic double layer having negative trapping parameter. The effects of physical parameters for non-monotonic double layer are discussed in an ion-beam plasma system.

Keywords:

Ion-acoustic non-monotonic double layer, Modified Korteweg-de Vries equation, Reductive perturbation technique, Ion-beam plasma system

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Theory of Weak Nonlinear Double Layers in Multi-components Plasma with Negative Ions.

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Abstract:

A theoretical investigation has been made of non-monotonic type double layers in multi-components plasma which consists of positive ions, negative ions and two electrons- one free the other reflected. By using Sagdeev's pseudopotential method, we find the self-consistent analytic solution for nonlinear double layers associated with a set of nonlinear eigenvalue conditions. This solution is the analytic extension of the solitary hole and the monotonic double layer with a potential depression at the low potential side. Properties of physical parameters in multi-component plasma are discussed.

Keywords:

Non-monotonic type double layer, Sagdeev's pseudopotential method, Solitary hole, Monotonic double layer

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P1-pl.041

Statistical Analysis of pedestal structure in KSTAR H-modes using Neural Network

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Abstract:

The high energy confinement mode (H-mode) is being widely studied in tokamaks and selected as the reference scenario of ITER. In this H-mode, the plasma pressure forms a very steep edge (pedestal) profile, leading to periodic bursts of energy from the edge of the plasma, so-called ELM (Edge Localized Mode). Because ELM bursts severely damage tokamak walls, several approaches, such as RMP(Resonance Magnetic Perturbation), are used to suppress ELM [1]. Since the energy loss by ELM is strongly dependent on the edge pedestal structure, its understanding is very important. Many theory-based models are developed on this purpose, for example EPED [2]. But, their applications are limited due to non-linearity and complexity of the pedestal and the ELM modelling requires heavy computational resources and long calculation times. Recently, with development of machine learning and deep learning, neural network is being applied in many tokamak problems, including the real-time control system [3], prediction of the onset of plasma disruptions [4], modelling of transport phenomena [5], and transport simulations [6]. In this work, neural network is applied for predicting the H-mode pedestal structure using the KSTAR H-mode database, and investigating the RMP effects by comparing shots with RMP and without RMP.

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Keywords:
Edge Localized Mode, H-mode, Pedestal, Neural Network, KSTAR, RMP

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P1-pl.042*

Fast ion driven drift instability in reversed shear plasmas

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Abstract:
It is shown that trapped fast ions produced by fusion reaction can destabilize the electron drift wave because a significant fraction of trapped fast ions reverses their precession direction in reversed shear (RS) plasma to the electron diamagnetic direction and can resonate with the electron drift wave. We perform a local stability analysis with fusion reaction condition and calculate consequent quasilinear transport caused by this new instability using bounce-averaged gyrokinetic equations in toroidal geometry. We consider the equilibrium distribution function of fast ions as slowing down distribution and compare to the equivalent Maxwellian case for illustration. The new instability occurs when the temperature profile of fast ions peaks sufficiently compared to the density profile and magnetic shear is strongly negative. The resulting particle flux of fast ions is outward while the particle flux of main hydrogenic ions can be inward. This new instability might be beneficial for burning plasma operation because it can expel lower energy He ions preferentially while keeping the ion working gas inside.

Keywords:
Fusion reactor plasmas, alpha-particle-driven instability, drift wave, precession reversal of trapped particles, wave-particle resonant interaction, reversed shear plasmas, Helium ash removal, gyrokinetic equation

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P1-pl.043*

Analysis of intense bursts of whistler-frequency waves during the edge transport barrier collapse in KSTAR H-mode plasmas

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Abstract:
In high-confinement mode (H-mode) tokamak plasmas, edge transport barrier (called pedestal) is formed inside the last closed flux surface. In typical H-mode plasmas, magnetohydrodynamic (MHD) instabilities called edge-localized modes (ELMs) occur at the pedestal. The ELM evolves in several distinct stages [1-2] and eventually leads relaxation events of pressure called pedestal collapse. The electron cyclotron emission (ECE) imaging diagnostic has revealed that the collapse occurs within tens of μs [1]. To explain such a fast energy dissipation, collisionless magnetic reconnection (MRX) models with radiative dissipation are suggested [3-4]. In KSTAR, a high-speed broad-band (0.1-5 GHz) radio frequency (RF) spectroscopy system has been developed to study the wave phenomena associated with the pedestal collapse. In the early measurements using dipole-type antennas outside the vacuum vessel through a large-aperture viewport [5-6], the collapse always coincided with intense and short (~100 μs) broadband (<800 MHz) RF bursts [5-6], which was conjectured as a result of fast localized MRX. To better understand the origin of the RF emissions, higher frequency (up to 5 GHz) has been measured in 2018 KSTAR campaign by resolving the modulation in the ECE, which provides local measurement unlike the dipole antennas. During the pedestal collapse, narrow-band intense emissions with rapid frequency up/down chirps in the whistler frequency range (~ 3 GHz) appeared for tens of microseconds, suggesting collisionless fast magnetic reconnection [4]. Bicoherence analysis shows that the GHz emissions have substantial nonlinear interaction with the sub-GHz ion cyclotron harmonic waves, implying that both waves are generated at the same spatial location. The local nature of the wave emissions is consistent with the existence of solitary filament and its localized burst at the pedestal collapse [1-2]. This work is supported by R&D program of “KSTAR Experimental Collaboration and Fusion plasma research” (NFRI-EN1801-9), the National Research Foundation of Korea (NRF) under contract No. NRF-2017M1A7A1A03064231 and BK21+ program.

Keywords:
KSTAR, tokamak, ELMs, magnetic reconnection, plasma waves, whistler waves

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Group delay compensation for the plasma density profile conversion of the reflectometer measurements

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Abstract:
Reflectometer obtains the plasma density profile by measuring the group delay of microwave propagating in the plasmas. To obtain the group delay of plasmas, all the contributions from the instrument except the plasma should be extracted from the measurements. The major contribution comes from the group delay of filters. In this paper, we measured the group delay of various components of reflectometer by using vector network analyzer (VNA) or calculated the group delay numerically for the components that cannot be measured with VNA. An algorithm is developed to compensate the group delay of components from the reflectometer measurements. By utilizing this algorithm, the detailed time evolutions of density profile structure of KSTAR tokamak plasmas during L-H transition, internal transport barrier (ITB) formation, and edge localized mode (ELM) are measured. The compensation algorithm is explained in detail and the measured density profiles are shown.

Keywords:
reflectometer, group delay, plasma density profile

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Fast-ion D_α spectroscopy diagnostics in KSTAR

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Abstract:
Fast-ion D_α (FIDA) spectroscopy technique has been widely employed in many fusion devices. FIDA diagnostic system has been developed and installed on KSTAR and the commissioning has been performed in 2018 KSTAR experimental campaign. KSTAR FIDA spectrometer consists of the grism, two tele-lens sets, blocking strip and EMCCD. A narrow neutral density filter (transmittance < 0.1%) strip was used for blocking the main D_α emission peak in order to increase signal-to-noise ratio of the peripheral emission intensity. The temporal, spectral and spatial resolutions of the spectrometer are 20 msec, 0.0215 nm and 4-10 cm respectively. There has been active view which is blue-shifted from the main D_α line (656.1 nm) in 2018 campaign. The weight functions of FIDA view have been calculated with geometric information of KSTAR neutral beam and FIDA line of sights for evaluating the diagnostic coverage and sensitivity of the fast-ion phase-space. Since background subtraction and extraction of FIDA signal are necessary, FIDASIM calculations are in progress. FIDA array system and upgrade plan are presented.

Keywords:
fast ion, spectroscopy, FIDA, KSTAR, diagnostics

P1-pl.046

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KSTAR L-mode 플라즈마에서 자기장 구조에 따른 디버터 분리 연구

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Abstract:
토카막 내에서 디버터 분리를 통한 디버터 열속 제어는 노심 플라즈마로부터 많은 열속이 방출되는 ITER를 포함한 장래 토카막 운전에 있어서 매우 중요한 주제 중 하나이다. 디버터 분리 현상은 토카막 장치 내 디버터 기하 구조와 자기장 구조 등에 따라 다른 특성을 나타내는 것으로 알려져 있다. 본 연구에서는 KSTAR 토카막의 두 가지 자기장 구조에 따라 디버터 분리 양상이 어떻게 달라지는지 실험 및 전산모사를 통해 분석하였다. 2018년 KSTAR에서 수행한 플라즈마 밀도 스캔 실험에서 자기장 구조의 외측 타점이 중앙 디버터에 존재하는 경우, 디버터 분리 현상이 양 디버터 타겟에서 비대칭적으로 일어나고 외측 타점이 외측 디버터에 존재하는 경우, 대칭적으로 일어나는 것을 확인하였다. 이는 SOLPS-ITER 전산코드를 이용한 모델링에서도 예측되었다. 모델링 결과로부터 두 가지 자기장 구조에서 디버터 분리의 중요한 원인인 중성입자 밀도 분포의 대칭성이 다름을 확인하였다. 이로써 자기장 구조에 따라 중성입자의 분포가 달라지고, 이 때문에 디버터 분리의 대칭성이 달라짐을 밝혀내었다. 후속 연구로는 자기장 구조가 플라즈마와 중성입자 간 상호작용 등 디버터 분리의 요인들에 어떤 영향을 미치는지 분석하고 더 많은 자기장 구조 스캔을 진행할 예정이다.

Keywords:
디버터 분리, 자기장 구조, SOLPS, KSTAR

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P1-pl.047

Design improvement of Passive Active Multijunction antenna: H-PAM

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Abstract:

A prototype PAM for KSTAR LHCD system was developed. PAM is a combination of passive waveguide and multijunction structure. The former can improve the RF power coupling to plasma at low plasma density (~ cutoff density). The latter can reduce the reflected power by redirecting the reflected power owing to the bijunction effect. However, multijunction structure has inherent distortion of N// spectrum due to bijunction effect. Phase shifts of the second forward field between toroidal adjacent waveguide are different from those of incident field. This fact excites side peak and distort the N// spectrum, resulting degradation of the launcher directivity. In addition, multiple round trip of the reflected field forms standing wave and increase the electric field intensity in the waveguide. In this paper, electric field increase and N// spectrum distortion will be investigated depending on the waveguide length and phase shifter configuration and solutions are suggested. Optimization of the waveguide length can relieve the maximum electric field intensity to some extent. Adding hybrid structure at the end of launcher mouth can reduce the side peak by keeping the phase shift of second forward field unchanged comparing to the first forward field.

Keywords:
KSTAR, LHCD, launcher, PAM, hybrid

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Measurement of Deuterium Permeation in Hastelloy and Tungsten

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Abstract:

Hastelloy and tungsten have been developed for nuclear fusion applications due to their excellent properties of corrosion and mechanical strength. However, information on the hydrogen-isotope permeation in hastelloy and tungsten is very limited. In this study, we have performed deuterium permeation experiments by using hastelloy C-276 and tungsten of ITER-grade. The samples were fabricated into disk-shaped membranes (diameter: 20 mm, thickness: 1.0 mm, 0.2 mm). The transport parameters (permeability, diffusivity, and solubility) of deuterium in the samples were determined in high-temperature range. The results are presented and compared with previously reported results for other authors.

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Keywords:

hastelloy, tungsten, hydrogen-isotope permeation

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P1-pl.049

Current Status of KSTAR Thomson Scattering Diagnostic System in 2018

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Abstract:

KSTAR Thomson scattering diagnostic had been installed in 2010 [1]. And a proto-type ITER edge Thomson laser system had been tested in the KSTAR Thomson system from 2012 to 2014. In 2018, the KSTAR TS diagnostic system was measured 27 spatial points with 27 polychromators (core 14, edge 13), and major upgrade has been performed. To measure the Thomson scattering signal, signal noise and vibration of collection lens must be suppressed sufficiently because Thomson signal is very weak and sensitive to alignment. To solve this problem we upgraded the KSTAR Thomson system in 2018. An anti-vibration lens support system was installed, and lighten the weight of collection optics (Core , Edge) with upgrade the collection lens performance through new lens design. Simulation of this new lens design has confirmed that vignetting and the modulation transfer function (MTF) are improved compared with previous lenses. For the new design, the core lens, the F-number (F-#) more than doubled from 2.26 (old lens) to 5.9 (new lens), the weight of the core lens was reduced from 26 kg to 18 kg. In case of the edge lens, the F-# increased 1.75 times compared with old lens, and the weight of the lens decreased from 23 kg to 12 kg. KSTAR campaign in 2018, improved light collection optic systems were used and measured Thomson signals without vibration effect. In this research, I will explain status of Thomson scattering diagnostic and next upgrade plan.

References:
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Keywords:
KSTAR, Thomson scattering, Fusion Plasma, Tokamak

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P1-pl.050*

The study on the compression, ignition and burning processes of the inertial confinement fusion by 1D radiation hydrodynamic simulations

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Abstract:
The inertial confinement fusion (ICF) is a type of fusion energy researches that attempts to initiate nuclear fusion reactions by heating and compressing a fuel target. We studied a compression process of the ICF event and a thermonuclear burning of deuterium-tritium (DT) by using an 1D radiation hydrodynamic code (MULTI-IFE) which contains essential physics models such as a thermal diffusion, a radiation energy transport and an alpha particle diffusion to investigate the hydrodynamic behaviors of a hot-dense matter. In this work, by using relevant input parameters from the usual experiments and detailed data for material properties (the equation of state, the opacity and the emissivity and so on), we thoroughly investigated the whole process in the ICF.

Keywords:
Inertial Confinement Fusion

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Research of Polychromator Noise Reduction for KSTAR Thomson Scattering Diagnostic

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Abstract:

Thomson scattering (TS) is a standard diagnostic device for measuring the electron temperature and density in Tokamaks. The KSTAR TS system has 27 polychromators, 14 polychromators were installed to measure the core area and the other 13 polychromators were installed to measure the edge area [1]. Inside the polychromator the spectrum is dispersed into separate spectral channels [2]. Every spectral channel consist of five interference filters, five APDs (avalanched photo diode) and five relay lens sets.

TS diagnostic is very sensitive to measure a scattered signal because the signal is less than 50mV in a normal plasma. For this reason, noise reduction in a polychromator APD is important. The APDs in polychromators have two kinds of input voltage. One is +12 V for activating APD, and the other is +200V ~ +360V for sensitivity of light. In this research, we measured the signal to noise ratio (S/N) during increase the sensitivity control voltage and found the value of the break APD down voltage and high S/N voltage. As a result, we were able to clearly control the optimized APDs voltage. Thus, in the 2018 KSTAR campaign, the spectral response of polychromators have improved compared to 2017.

Reference
[1] J.H.Lee et al., "Development of prototype polychromator system for KSTAR Thomson scattering diagnostic", Journal of Instrumentation 10 C12012(2015).
[2] S.Schmuck et al., "Design and Calibration of a Polychromator for the Thomson Scattering at Wendelstein 7-X", AIP Conference Proceedings 993, 195(2008)

Keywords:
KSTAR, Tokamak, polychromator, APD

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플렉시블 대기압 유전장벽방전 플라즈마 발생기의 특성 연구

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Abstract:

대기압 약전리 플라즈마는 기존의 저압 저온 플라즈마 대비 운용의 편의성과 여러 독특한 장점을 보이고 있으며, 환경, 재료분야 뿐만 아니라 식품, 농업, 생의학 등 산업의 전반적인 분야로 응용이 시도되고 있다. 플라즈마 처리 대상이 인체와 식품 등과 같이 복잡한 형태를 가짐에 따라, 높은 변형 자유도를 갖는 플라즈마 소스에 대한 수요가 급격히 증가하고 있다. 본 연구에서는 플렉시블 유전격벽방전(Flexible Dielectric Barrier Discharge, FXDBD)을 개발하여 그 특성과 활용 가능성을 실험적으로 고찰하였다. 유연한 기판 위에 방전을 위한 전극을 구성하여 높은 변형 자유도를 가진 FXDBD를 개발하였고, 제작된 플라즈마 발생기의 안정적인 플라즈마 생성 여부를 확인했다. 기초적인 특성 관찰을 위해 전극 및 기판의 변형 한계와 소모 전력, 광진단 및 기체 화학종 측정기를 이용한 오존 및 질소 화합물의 농도 측정이 이루어졌다. 제작된 FXDBD는 플라즈마와 전극의 물리적 및 화학적 상호작용에 의해 플라즈마 발생 특성이 변하는 모습을 보이며, 다양한 전극 형태에 대한 측정 결과, 전극의 기하 구조에 따른 화학종 발생 비율이 변화한다는 점을 확인할 수 있었다. 더 나아가 제작된 FXDBD의 실제적인 응용으로써 목표 물체를 내부에 넣어, 제한된 공간에 효과적으로 플라즈마를 발생시키기 위한 '파우치 플라즈마'를 실현, 블루베리를 대상으로 품질 유지 기간 증대 효과를 실험적으로 확인했다. 기존 연구에 비해 방전기의 형태와 크기의 제약이 적으며 제작 단가 및 제작 시간이 현격히 개선된 본 연구를 통해 플라즈마 기술의 실생활 응용으로의 도약을 기대한다.

Keywords:

Flexible, Dielectric Barrier Discharge, 파우치 플라즈마

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플라즈마 처리수 내 화학종 발생 및 광분해 효과 전산 모델링

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Abstract:

플라즈마 처리수(방전수) 내에는 플라즈마에서 발생한 여러 화학종들이 처리 후에도 상대적으로 오랜 시간 존재하는 등 산업적으로 활용도가 높아 이에 대한 관심이 갈수록 커지고 있다. 특히 하이드록실 라디칼(·OH)은 플라즈마 처리수 내 과산화수소(H_2O_2), 오존(O_3) 및 질산염(NO_3^-) 등에 비해 100-10,000배 낮은 농도임에도 뛰어난 살균 능력을 보인 바 있으며[1], 일산화질소(NO)는 생산된 농산물이 저장, 유통되는 과정에서 호흡을 억제할 수 있을 뿐만 아니라 세포의 생장 활동에 큰 영향을 끼친다고 알려져 있다[2]. 본 연구에서는 ·OH와 NO를 포함한 플라즈마에서부터 생성되는 여러 화학종들의 시공간적 조성을 전산모사 및 실험을 통하여 확인하였고, 외부 광원에 의한 특정 화학종들의 광분해 반응이 ·OH와 NO 의 생성에 미치는 영향을 분석하였다. 플라즈마 처리 시간 및 플라즈마로부터 거리에 따른 화학종들의 농도 분포를 모사하기 위해 플라즈마 방전 영역을 0차원으로, 기체와 액체 영역을 1차원으로 계산하는 전산 모델을 개발하였으며, 자외선 광분해에 의한 전체 화학종들의 거동을 분석하고자, 광원의 스펙트럼 및 방출광 세기, 조사 위치에 대한 플라즈마 화학종 농도를 분석하였다. 계산 결과 기상에서는 O_3의 농도가 가장 높았고, 액상에서는 O_3과 함께 기상에서의 농도와 용해도가 모두 비교적 높은 H_2O_2 및 NO_3^-의 농도가 높았다. 고전력 상에서는 온도 상승으로 인해 시간이 지나면서 O_3가 사라지고 NO의 농도가 증가했으며, 외부 광원(자외선)을 조사한 결과 O_3의 최대 농도가 감소하고 ·OH와 NO가 증가하는 것을 확인하였다.

[1] J. Y. Park, S. Park et al., ACS Appl. Mater. Interfaces **9**, 43470 (2017).
[2] M. Rosselli et al., Hum. Reprod. Update **4**, 3 (1998).

Keywords:

플라즈마 처리수, 하이드록실 라디칼, 일산화질소, 광분해, 전산모사

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저온 대기압 플라즈마 시스템의 일산화질소 제어 기술

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Abstract:

최근 농식품의 저장단계에서 일산화질소(Nitric oxide, NO) 처리를 통해 에틸렌 발생을 저감하여 식품 품질 유지 및 저장기간을 연장하는 연구 결과들이 발표되고 있다. 본 연구에서는 간단한 플라즈마 발생장치를 이용하여 최대 600 ppm 이상의 NO 가스 생성할 수 있음을 확인하였다. 특히 기체 온도 조절 및 자외선 조사를 통해 플라즈마 방전시 생성하는 오존(O_3)을 억제하고, NO를 포함한 질소 산화물(NOx)의 생성을 촉진하는 기작을 전산모사와 실험을 통해 확인하였다. 온도 제어는 히팅 플레이트를 사용하여 챔버를 가열하여 기체 온도를 제어하는 것으로 하였고, 자외선은 254 nm 및 365 nm의 파장 영역대를 가진 12 W급 램프를 사용하여 조사하는 것으로 하였다. 또한 O_3와 NOx와 관련된 화학종들과 다양한 물리적, 화학적 변수를 확인하기 위해 통합 측정 진단 시스템을 구성하여 NO, 이산화질소(NO_2), 아질산(HONO), 습도, 기체온도, 방전 전력 등을 실시간으로 측정하여 NO 발생 기작을 분석하였다. 본 연구 결과 기체온도 및 자외선 조사로 NO의 생성 시간을 약 300초 이상 단축할 수 있으며, 에너지 효율도 약 100배 정도 개선이 되는 것으로 확인되었다. 또한 높은 NO의 선택비(NO>>NO_2)를 갖는 플라즈마 운전 조건에 도달하는 시간이 약 300초 이상 개선되었다.

Keywords:

대기압 플라즈마, 일산화질소, 오존, 광분해

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Plasma Characteristics of a Compact Permanent Electron Cyclotron Resonance Ion Source for Neutron Generators

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Abstract:
Korea Atomic Energy Research Institute (KAERI) is currently developing a mobile deuterium - deuterium neutron generator with a neutron yield rate of over 10^{10} neutrons per second for various applications. The electron cyclotron resonance (ECR) device has been selected for an ion source of the neutron generator due to its high-intensity ion beams at low operating pressures ranging from sub-mTorr to a few mTorr. The ion source has to be capable of delivering of D^+ beams of over 50 mA for the successful development. A compact permanent magnet ECR ion source system has been designed and fabricated in order to fulfill the requirement. In this study, plasma characteristics of the ion source dependent on input powers of up to 1 kW and pressures ranging from 0.8 to 2.2 mTorr are explored utilizing a Langmuir probe system. Through the experimental investigation, it is validated to ensure that the ion source meets the performance goal by supplying a deuterium ion beam current of 62 mA at a pressure of 1 mTorr. The experimental results will be shown and discussed in more detail in the presentation.

Keywords:
electron cyclotron resonance, ECR, ion source, neutron generator, deuterium

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Ion beam irradiation effects on polycarbonate

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Abstract:

The property changes by ion beam irradiation have been investigated for polycarbonate (PC). FT-IR spectra show that the lighter ion mass causes the increase of C=O (1680-1750 cm^{-1}), C=C (1500-1700 cm^{-1}) stretching vibration and the relative ratio of C-O-C peak near the wave number of 1200 cm^{-1} decreases with increasing dose and energy of H^+ ion. In addition, thermogravimetric analysis has been performed for two different samples: pristine PC and ion irradiated PC. We discuss the surface hardness mechanism based on these results.

Keywords:
ion beam, polycarbonate

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RF magnetron sputtering에 의한 TiO2 박막의 성장 및 표면특성

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Abstract:

이산화티타늄(TiO2) 박막은 고굴절율, 고유전율, 가시광 및 근적외선 영역에서 높은 광투과율을 가지므로, 염료감응형 태양전지, 광촉매, 광학박막, ULSI의 커패시터 재료로 활용이 검토되고 있다. 또한 광촉매와 자기세정 특성을 이용하여 태양전지, 자동차 외장 부품, 건물의 외벽 등의 항균 코팅으로 사용되고 있다. 그러나, TiO2 박막의 다양한 결정구조 및 표면형상에 따른 물성의 체계적인 연구는 미흡한 실정이다. 본 연구에서는 TiO2 박막을 성장시켜 결정구조 및 표면형상에 따른 TiO2 박막의 친·소수성 및 광촉매 특성에 대하여 연구하고자 한다.

RF magnetron sputtering을 이용하여 Si 및 Glass 기판 위에 TiO2 박막을 증착하여, sputter 조건에 따른 결정의 배향성과 표면형상의 변화를 조사하였다. Sputter 조건은 chamber 내 분위기 가스 압력을 6 mTorr로 하였고, 가스의 전체 유량을 고정시키고 Ar과 O2 가스의 유량 비율은 상대적으로 변화시켜 가면서 성막하였다. 기판 온도는 상온, RF power는 150 W에서 실험하였다. 제작된 TiO2 박막은 XRD에 의해 결정구조 및 배향, SEM 및 AFM에 의하여 표면형상을 측정하였다.

가스의 전체 유량을 10 sccm으로 고정시키고 Ar과 O2 가스의 분압 비율을 상대적으로 변화시켰을 때 TiO2 박막의 증착 속도를 조사하였다. Ar 가스만 일 때 TiO2 박막의 증착속도가 가장 크며, O2 분압이 커질 수록 TiO2 박막의 증착속도는 점차 감소하는 경향을 나타내었다. SEM에 의해 TiO2 박막의 표면형상을 관찰한 결과, Ar 가스만 일 때 TiO2 박막의 결정립이 가장 크며, O2 분압이 작아질 수록 TiO2 박막의 결정립은 점차 작아지는 경향을 나타내었다. 분위기 가스 중 Ar과 O2 가스의 상대적 비율의 변화에 따른 TiO2 박막의 물방울과의 접촉각(contact angle)을 측정한 결과, O2 가스 분압이 커질 수록, 즉 TiO2 박막 표면의 결정립이 작아질 수록 접촉각이 커지는 경향을 나타내었다. 즉 TiO2 박막의 친수성 여부는 결정구조나 표면의 화학결합 상태보다는 박막의 표면 형상에 더 좌우되는 것으로 나타났다.

Keywords:
TiO2 박막, RF magnetron sputtering, 표면형상, 친수성

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고압분위기에서 고전압 펄스수중방전 특성 연구

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Abstract:

저전력으로 고출력의 효과를 낼 수 있는 고전압 펄스방전은 다양한 산업 분야로 활발하게 적용되고 있다. 고전압 펄스방전의 활용분야중 하나로 이를 이용한 지하수 관정 세정이 주목을 받고 있다. 수중 관정에 펄스 플라즈마 발생기를 넣고 방전을 시키면 충격파에 의해 관정 내의 스케일 등 찌꺼기가 제거되는 공정이다. 그러나 지하 관정 특성상 깊은 수심으로 갈수록 수중방전의 효과가 적어지며 기존 수중방전과는 다른 효과를 보이는 문제점을 야기하였다. 이에 본 연구에서는 고압챔버를 이용하여 깊을 수심을 모사하고 이를 이용하여 고압의 수중방전에서 일어나는 충격파의 발생특성에 대하여 연구하였다. 챔버는 5,000 kPa 시험으로 건전성을 확보하였으며 전력은 캐패시터 방전을 사용하여 직류 고전력 펄스를 얻었다. 물의 압력과 전선의 길이를 변화시키며 펄스전기방전의 특성을 분석하였다.

* 본 연구는 중소벤처기업부에서 지원하는 2018년도 산학연협력 기술개발사업(No. C0663278)의 연구수행으로 인한 결과물임을 밝힙니다.

Keywords:
펄스전기방전, 충격파, 수중방전, 관정세정

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P1-pl.059

Development Strategy of Portable, Compact, and Simultaneous Analysis Technology for Radioactive Multi-Isotopes with OES Method in Decommissioning Nuclear Power Plant

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Abstract:

There has been a development plan of portable compact radioactive multi-isotope analysis technology using two optical emission spectroscopy (OES) devices for decommissioning nuclear power plants at the Korea Atomic Energy Research Institute (KAERI). One is an inductively coupled plasma (ICP) OES device, and another is a liquid electrode plasma (LEP) OES device. ICP-OES is now widely used, and is one of the most versatile methods of inorganic analysis. The ICP is an eddy (or ring-like) plasma, in which the volume filled by the ionized gas is comparable with a short circuited secondary turn of a transformer. In the plasma generating system an induction coil surrounds a quartz tube through which flows working (Ar) gas. This plasma has high electron density (~10^{14} cm^{-3}) and temperature (~10,000 K), and the energy is used for the excitation-emission of the sample. In general, ICP-OES cannot measure Cesium (Cs) at the sub-parts per million (ppm) level due to the low sensitivity of Cs atoms. The most sensitive emission line of neutral Cs at 852.12 nm is overlapped by an emission line of the working gas (Ar) at 852.14 nm. The most Cs atoms are ionized at the high electron temperatures (8,000~10,000 K) of ICP while the energy provided by ICP is insufficient for exciting the ionized Cs. Those are the main reason for low sensitivity of ICP-OES to Cs. To overcome the detecting limit of ICP-OES for Cs isotopes, the LEP-OES can be used as an attractive prospect for the radiochemical analysis. In especial, there are not required a plasma gas, a high-power source, and a nebulizer in the LEP-OES system. In the LEP-OES, the discharge plasma is generated between two liquid electrodes in a microchannel (or microchip), containing a sample solution. A high-resolution spectrometer and signal processing units and computers are needed to read the measuring results.

Keywords:

ICP-OES, LEP-OES, decommissioning nuclear power plant, radioactive isotope, inorganic analysis, radiochemical analysis

P1-pl.061

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ECR Plasma profile measurements in SNU linear plasma device

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Abstract:

ECR (Electron Cyclotron Resonance) Plasma source was studied as apart of heating mechanism in the studies of beam plasma target interaction in plasma linear devices. Microwave of 2.45 GHz was launched radially with power ranging from 200 watts to 1400 watts. Plasma simulation was performed to study the effect of magnetic field intensity on the position of ECR layer. Hydrogen gas was fed to the chamber through flow meter with pressure ranging from 2*10^-4 Torr to 8 *10^-3 Torr.Two identical magnetic coils were used with current ranging from 90 A to 160 A. Radial and axial Langmuir probes were installed for plasma profile measurements. Electron temperature was measured and ranging from 7 to 16 eV with electron plasma density range of 8*10^15 m^-3. Electron temperature groups were studied by means of EEDF. It was found that the shape of EEDF was affected by the applied magnetic field and gas pressure.

Keywords:

ECR, linear plasma device

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Pseudo-$Al_{0.043}In_{0.052}Ga_{0.950}N$ 장벽 구조 적용을 통한 양자우물 내부 전기장 감소와 표면파 적용에 따른 광전류 변화 연구

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Abstract:

질화물 기반 반도체는 태양 스펙트럼 내 파장을 자유롭게 조절 할 수 있는 밴드갭(InN:0.7 eV ~GaN:3.4 eV)을 갖고 있어 광전지 응용소자에 매우 유요한 물질이다. 또한 높은 열적 안정성, 높은 흡수 계수, 방사선에 매우 강한 물성을 가지고 있어 우주 밖 태양전지 등 거친 환경에서 동작하는 광전지 소자로 매우 유망한 물질이다. 이론적으로 예상되는 변환 효율은 약 40 % 이지만 현재까지 실험적인 변환 효율은 5 % 미만에 그치고 있다. 이러한 현상의 주된 원인은 InGaN/GaN 양자우물 계면에 격자 상수 차이로 발생되는 압전 전기장이 있다. 압전 전기장은 빛 흡수로 인해 발생한 전자와 홀을 양자우물에 다시 속박하게 하여 추출을 방해한다. 또한, 기판 및 양자우물에서 발생된 높은 결함 밀도는 비-발광 재결합 과정을 통해 양자 우물로부터 나온 전자를 제거하며 낮은 변환 효율의 원인을 제공한다.
본 연구에서는 p-i-n 구조 내 $Al_{0.065}Ga_{0.935}N/In_{0.16}Ga_{0.84}N$ 초격자 장벽구조(pseudo-$Al_{0.043}In_{0.052}Ga_{0.950}N$ 장벽) 적용을 통한 양자우물 내부 전기장 감소와 표면파 적용에 따른 광전기 효율 증대에 관하여 연구를 진행하였다. 내부 전기장은 역 방향 전압에 따른 photocurrent 측정 시 Franz-Keldysh 효과를 통하여 얻었으며, GaN 장벽과 Pseudo-$Al_{0.043}In_{0.052}Ga_{0.950}$ 장벽의 내부 전위는 각각 1.25 MV/cm 와 1.10 MV/cm 로 평가되었다. Xenon 램프 (500 W)를 활용하여 광전지 특성을 분석하였으며 Pseudo-$Al_{0.043}In_{0.052}Ga_{0.950}$ 장벽이 적용된 p-i-n 구조의 변화효율은 GaN 장벽에 비하여 약 2 배 이상 증가하였다. 표면파를 p-GaN 위에서 발생시키며 photoluminescence를 측정 하였을 때 양자 우물의 거동을 확인 하였으며, 표면파 적용을 통하여 양자우물 내 전자를 쉽게 추출할 수 있음을 확인하였다. 이러한 결과들은 질화물 기반 광전지 소자 연구에서 변환효율을 높일 수 있는 방안으로 매우 유용한 정보를 제공할 것으로 판단된다.

Keywords:
III-V semiconductor, Quantum Well, Photocurrent, Surface acoustic Wave (SAW)

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P1-se.002

고분해능 x-선 회절법을 이용한 단계적 AlGaN 조성 변화층의 변형력 및 조성 분석 연구

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Abstract:

지난 수십여 년 동안 AlInGaN 화합물은 ultra-violet light emitting diodes, laser didoe, 그리고 광 검출기의 활성 층 및 클래딩 층으로 널리 사용되어져 왔다. 특히 AlGaN/GaN 기반 고속전자 이동도 소자(high electron mobility transistor, HEMT)는 높은 전자 이동도와 거친 환경에서 신뢰성을 확보 할 수 있는 소자로 고전력, 초극단파 시스템에 대하여 큰 응용 가치가 있다. 이러한 소자는 화합물의 조성 비율이 소자 성능에 중대한 영향을 끼치기 때문에 정확한 제어가 수반되어야만 한다. 하지만 성장 조건에 따른 압축력 변화에 의하여 정확한 화합물의 조성 비율을 제어하고 측정, 평가하는 것은 아직까지 해결해야할 과제로 남아있다. 최근 격자 부정합으로 인한 compositional pulling effect에 의하여 완충층 종류에 따라 AlGaN/GaN 구조에서의 AlGaN 조성 비율과 성장률이 달라진다는 보고가 이루어졌다.
본 연구에서는 분자선 결정성장법으로 단계적으로 조성이 변화된 다층 AlGaN완충층 위 AlGaN/GaN HEMT 구조를 성장하였으며 x-선 회절법을 이용하여 Al 조성 비율 및 변형력을 분석하였다. 다층 AlGaN 완충층의 조성을 확인하기 위하여 변형력에 면간간격 변화가 민감하지 않은 (205)면의 단일 2θ 훑음 분석을 진행 하였으며, (004)면과 (105)면에 대한 단일 2θ 훑음 분석을 통하여 변형력과 조성 비율 차이를 확인하였다. 이후 변형력 변화에 따른 2차원 전자가스 거동 변화를 Hall 효과 측정과 capacitance-voltage 측정의 depth-profile 을 통하여 논의하였다.

Keywords:
HRXRD, GaN, HEMT, Hall effect, depth profile

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P1-se.003*

defect states of Indium-Gallium-Zinc oxide using photo-induced current transient spectroscopy(PICTS).

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Abstract:

Transparent amorphous oxide semiconductors (AOSs) have been paid wide attention as an attractive active channel layer with high switching speed, for various electronic display applications, including liquid crystal displays (LCDs) and active-matrix organic light emitting diodes (AMOLEDs). Compared with conventional amorphous/poly-silicon thin film transistors (TFTs), oxide TFTs have significant advantages, such as high electron mobility, transparency, low temperature, and low-cost process, with the preservation of the amorphous structure. Various semiconductors based on indium and zinc oxide compounds have been intensively studied, since the 2004 report on amorphous indium-gallium-zinc oxide TFTs with high device performance. However, for practical mass production, higher device performance and better device instability still remain as some of the most important and critical issues. Recently, many efforts have been made to seek alternative oxide semiconductors with good stability under bias and illumination stress, using combinatorial material design.
In this presentation, physical analysis of Indium-Gallium-Zinc oxide will be discussed in terms of electronic structure related to defect states below the conduction band by photo-induced current transient spectroscopy(PICTS). These interpretation could be helpful to figure out the electrical properties of films and to predict the performance and reliability of oxide TFTs.

Keywords:

photo-induced current transient spectroscopy, defect, Indium-Gallium-Zinc oxide, cation, display

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P1-se.004

Fabrication of Impermeable Etalon Filter Using Copper and Graphene

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Abstract:
We fabricate a copper-based etalon filter which is coated by the graphene layer. This anti-oxidation of copper is studied by optical microscopy, X-ray photoelectron spectroscopy, and transmission measurement in UV-visible spectral ranges. The copper surface is well protected from oxidation. The graphene coated structure allows overcoming inherent oxidation of copper-based etalon filter, which realizes inexpensive production compared to conventional silver-based etalon filter.

Keywords:
Filter, Etalon, Anti-oxidant, Graphene

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P1-se.005

광반사 분광법(photoreflectance)을 이용한 InAsSb/GaSb 에피구조의 응력(strain)에 관한 연구

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Abstract:
본 연구에서는 InAsSb p-i-n 구조의 응력분포를 조사하기 위해 MBE(molecular beam epitaxy; MBE)법을 통해 를 GaSb 기판위에 성장하였다. As과 Sb의 조성에 따라 InAsSb의 띠 간격 에너지가 조절됨을 확인하였다. 성장된 시료를 HR-XRD(high resolution x-ray diffraction)측정을 하여 InAsSb 층과 GaSb 층 사이의 응력(strain)을 확인하였다. 그 결과 InAsSb의 격자상수 변화를 확인하였다. 이러한 InAsSb층과 GaSb층 사이의 격자상수 차이는 시료에 응력(strain)을 형성한다. 소자 내부에 형성된 응력은 소자의 결함 생성과, 띠 간격 에너지에도 영향을 미친다. 광반사(photoreflectance; PR) 분광법을 이용하여 응력에 의한 띠 간격 에너지 변화를 조사하였다. 여기광 세기 및 온도 의존성 PR을 측정하여 그 결과를 논의하였다.

Keywords:
photoreflectance, InAsSb/GaSb, strain, lattice mismatched

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P1-se.006*

UV-Oxidation and Raman analysis of CVD graphene.

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Abstract:

During the last decade, extensive efforts have been attributed to the study and applications of graphene due to its extraordinary mechanical and optoelectrical properties. For applicability of graphene in different types of devices, controlling the chemical and electrical properties of this 2D material is significant which requires detailed studies of various graphene derivatives. Like graphene, graphene oxide (GO) not only offers a wide range of applications but also the epoxide groups in GO is more reactive than the sp^2 bond in graphitic structure. Therefore, GO can be used as a transitional phase to modify graphene with other functional groups. However, applicability and reproducibility require highly uniform and large area GO to be used in an array formation. Commonly, oxidation is a time consuming and destructive process for graphene layer due to the use of strong acids. However, in this work, we present a new technique with optimized oxidation condition which results in highly uniform GO sheet comparing to other works and leaves the hexagonal structure of graphene intact. In this method, UV irradiation is used for oxidation of graphene with time variation between 5s to 70s. Also, we performed a detailed study of Raman characteristics of GO which shows the relative changes of peaks to oxidation rate can be used as a powerful tool to indicate different defect concentrations and regimes in graphene. Raman mapping is used to confirm the optimized oxidation time for obtaining uniform GO layer. X-ray photoelectron spectroscopy (XPS) is utilized to determine the ratio of oxygen and carbon content of GO. Also, through XPS we could confirm that there is no functional group on the GO sheet other than epoxide while using a UV system for oxidation. We measured the height profile of GO by AFM and its band gap by ARPES.

Keywords:

CVD, graphene, graphene oxide, Raman.

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P1-se.007*

Synaptic devices based on Bi

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Abstract:

Neuromorphic devices are studied around the world as an alternative to the existing von Neumann structure for better image, sound, and large data processing. One of candidates for such a neuromorphic device is the ReRAM that changes the resistance of the device by controlling the ions, such as Ag, Cu, and oxygen ions, inside the insulator by applying the voltage. In this study, we have investigated resistance switching behaviors in Bi_xTe_y thin film with Au and Sb electrodes. The Bi_xTe_y thin film was fabricated by electroplating and oxidized into an insulator. Our devices exhibit abrupt SET/ Reset switching behaviors at high voltage (> 4V), while intermediate switching behaviors are observed at low voltages. EDX analysis reveals that intermediate state may originate from migration of oxygen ions.

Keywords:

Neuromorphic device, ReRAM, Electroplating

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P1-se.008*

Optical phonons in quantum-dot-based semiconductor solar cells

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Abstract:

InAs 양자점을 기반으로 하여 성장된 태양전지에 대한 라만 산란 연구 결과를 보고한다. 태양전지는 GaAs 기판 위에 InAs 양자점 및 GaAs, AlGaAs 층이 순차적으로 성장된 구조를 지닌다. InAs 양자점의 크기 변화에 따른 GaAs 층에 생기는 변형의 차이를 확인하기 위하여 광학 포논에 대한 연구를 수행하였다. 다양한 파장의 레이저를 각각 사용하여 취득한 라만 스펙트럼으로부터 광학 포논에 대한 포괄적인 정보를 얻을 수 있었다. InAs 양자점 크기 변화에 따라 GaAs LO 포논 에너지가 변화함을 관측하였는데, 이로부터 GaAs 층에 변형이 생김을 확인할 수 있었다. 또한, GaAs LO 포논 에너지 보다 높은 에너지 영역에서 넓은 선폭의 LO 포논-플라즈몬 결합 모드가 형성되었는데, 이를 분석한 결과 GaAs 층에 도핑 된 홀의 농도 값을 얻을 수 있었다. [이 논문은 2016년도 정부(교육부)의 재원으로 한국연구재단의 지원을 받아 수행된 기초연구사업임 (과제번호: 2016R1D1A1B03935270)]

Keywords:

태양전지, 양자점, 라만 산란

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Micro-photoluminescence excitation measurement on a single InGaN quantum dot for investigating excited states

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Abstract:

Semiconductor quantum dots have attracted much attentions as the promising platforms to realize single photon sources for quantum information technologies, due to their scalability and rapid recombination rate. In particular, III-nitride quantum dots have large exciton binding energy, which makes them possible for single photon sources operating at room temperature. Conventional experimental studies of III-nitride quantum dots exploited non-resonant excitation scheme, which suffers from several issues such as non-radiative recombination from the barrier and time-jittering in the relaxation from the barrier to the ground state. Quasi-resonant excitation scheme is an alternative to circumvent these hurdles and requires our ability to finely probe the excited levels of a single quantum dot. In this work, we perform the micro-photoluminescence excitation (PLE) measurement to meet the above requirement of quasi-resonant excitation scheme. We identify the excited level of a single InGaN quantum dot by tuning and locating the excitation wavelength at which its PL emission has peak intensity. To demonstrate that quasi-resonant excitation resolves the shortcomings of the non-resonant scheme, we show that the linewidth is decreased owing to reduced non-radiative recombination rate in the barrier and time-jittering in our micro-PLE experiment.

Keywords:

Quantum dot, Micro-photoluminescence excitation, Quasi-resonant excitation

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Fabrication and optical analysis of self-rolled up microtube structures

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Abstract:

Currently, microtubes are becoming promising platform for optoelectronics and integrated optics. One simple method to fabricate the microtubes is to make strained multilayers freestanding, resulting self-rolling to relax their strain. Even though they have advantages of simple fabrication process and low cost, there have been studies only with limited materials such as SiO_2/Si. In this study, we aimed to fabricate the microtube structures with group III-nitride semiconductors having mechanical and chemical stability. Especially, photoelectrochemical (PEC) etching method is employed, which can etch specific material selectively by its high band-gap selectivity. In the PEC etching process, materials with their band-gap energy lower than the laser excitation energy can generate electron-hole pairs, and the photo-generated holes oxidize the material and then it is dissolved in the etchant. In this study, InGaN/GaN/AlGaN multi-layer structures were grown by metal-organic chemical vapor deposition, followed by photolithography patterning and inductively coupled plasma reactive ion etching. Subsequently by PEC etching, only InGaN layer which has the lowest band-gap energy is etched selectively. Eliminating the InGaN layer, the AlGaN/GaN bilayer can be rolled up by strain relaxation. Voltage and molar concentration of the etchant is optimized for the fabrication. Structural and optical properties of the microtubes are investigated by scanning electron microscopy and photoluminescence.

Keywords:

PEC etching, strain relaxation, self-rolled up, microtube

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InAs 층의 두께 변화에 따른 InAs/GaSb 제2형 양자우물 구조의 광발광 및 광반사 특성

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Abstract:

본 연구에 사용된 InAs/GaSb 제2형 양자우물(type-II quantum well; T2-QW) 구조는 InAs QW층의 두께를 3~5 ML로 다르게 하여 분자선박막성장장치로(molecular beam epitaxy; MBE) 제작하였다. 두께에 따른 광학적 특성을 광발광(photoluminescence; PL) 및 광반사(photoreflectance; PR) 분광 실험을 통하여 연구하였다. Fig .1 은 13 K 에서 측정한 두 시료의 PL 신호이다. InAs QW 두께가 3 ML 및 5 ML 시료의 PL 피크 위치는 각각 0.489 eV 와 0.486 eV 에서 관측되었으며, PL신호의 반치폭(FWHM)은 각각 59 meV와 25 meV 이었다. PL 피크 위치의 적색 편이는 QW두께 변화에 따른 양자 구속 효과(quantum confinement effect)에 기인하며 FWHM은 QW의 두께가 감소함에 따라 PL 신호의 FWHM이 국소적인 InAs QW의 계면의 균일도에 민감한 것으로 사료된다. 아울러 InAs/GaSb MQW 구조에서 PR 특성을 여기광 세기 및 온도 의존성 실험을 진행하여 결과를 비교 분석하였다.

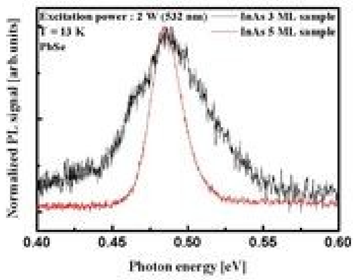

Fig. 1. Low temperature (13 K) PL spectra of InAs/GaSb MQW with InAs thickness of 3 and 5 ML.

Keywords:
MBE, PL, PR, T2-QW, QW, MQW

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Highly Efficient Carrier Transfer in Quantum Dots-Perovskite Hybrid Structure

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Abstract:

Organic-inorganic halide perovskites (CH_3 NH_3PbX_3, where X = Cl^-, Br^-, I^-, or a mixture) have been attracted attention as prospective materials for photovoltaic and optoelectronic devices due to simple synthesis process, low-cost, tunable band gaps, and high-power conversion efficiency. However, solution processed perovskite (PS) contains intrinsic defects such as grain boundaries and surface/point defects,

and PS has a poor stability in air. We synthesized a mixed halide PS ($CH_3NH_3PbI_2Br$), which is well known for its resistance to humidity in air, and coated the top of the PS film with CdSe/ZnS quantum dots (QDs) in order to improve the PS stability and luminescence properties. In this study, we investigated the carrier transfer (CT) from QDs to PS as a function of diameter of QDs using photoluminescence (PL) and time-resolved PL spectroscopy. The diameter of QDs were varied from 2.7 to 6.5 nm. The PS in the QD/PS hybrid structure yielded much stronger PL intensity and longer PL decay time than those of the bare PS. In addition, the QDs in the QD/PS hybrid structure exhibited the quenching of PL intensity and the shortening of PL decay compared with that of the bare QDs. These PL and decay behavior could be attributed to CT from the QDs to PS. This study provides the fundamental luminescence properties of the QD/PS hybrid structure, and new opportunities for applications in PS-based optoelectronic devices.

Keywords:
perovskite, carrier transfer, photoluminescence, time-resolved photoluminescence

Acoustic Dephasing Dynamics in Nonlinear Phononics

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Abstract:

The ultrafast detection of acoustic (AC) wavepackets is extended to trace phase by the previously ignored nonlinear photoelastic (PE) coefficients, which provoke continuously varying phase in degenerate pump-probe schemes as a function of time and compositional strain profiles. The compositional strain of AC wavepackets was manipulated by external bias, V_{ext}, representatively in piezoelectric diodes with InGaN/GaN multiple quantum wells, and propagating strain profiles are illustrated in Fig. 1(a). To estimate the PE response of AC waves, the linear (p_{13}) and nonlinear (p_{133}) PE coefficients were calculated as a function of probe energy, E_{probe}, and based on that, the nonlinear PE regime could be recognized with E_{probe} in Fig.1(b). Under the nonlinear PE regime, as the entire AC spectrum should be additionally involved in amplitude of dynamic Fabry-Perot interference in differential reflectivity spectra (DRS), and thus high-frequency AC dephasing behavior could be effectively monitored in contrast to conventional linear regime [1] where the only Brillouin frequency component of AC spectra was measured at around sub-terahertz range. The DRS is contrasted in Fig. 1(c) and (d) for the linear regime at E_{probe}=3.163 eV and for the nonlinear regime at E_{probe}=3.289 eV, respectively. From the time-dependent phase analysis in Fig. 1(d), the abrupt phase shift during the AC surface reflection (t_{Rf}>t>t_{Ri}) and gradual phase changes during photon propagation in defect-abundant electron reservoir (t>100 ps) are both explicated in terms of the frequency-dependent AC decay [2] only measurable in the nonlinear regime which is clearly distinguished from phase-invariant oscillations in the linear regime.

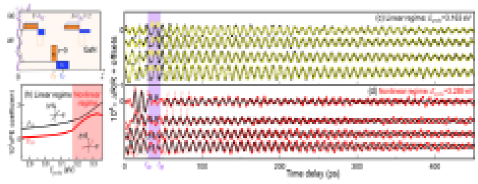

Figure 1. (a) Illustration for the AC phonon generation and the subsequent propagations in nanoscale piezoelectric diode. (b) Calculation of the linear and nonlinear PE coefficients. DRS measurement results in the (c) linear and (d) nonlinear regimes.

Keywords:
acoustic phonon, phononics, nonlinear phononics, dephasing

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Magneto-optical transitions of organic-inorganic perovskite crystals

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Abstract:

Organic-inorganic hybrid perovskite (Methyl-ammonium-lead-trihalides : $MAPbX_3$, X=Cl, Br and I) materials are vastly investigated last one decade due to the application of highly efficient solar cell and other optoelectronic devices. We have measured photoluminescence of $MAPbCl_{3-x}Br_x$ (x=0, 0.5, 1, 1.5, 2) in high magnetic fields. We found several optical transitions from each samples believed to be trap mediated monomolecular and band to band bimolecular transitions. In the presence of magnetic fields, these transitions show red- and blue-shifts depend on samples. We believe that these anomalous transitions are related with the spin states of Rashba splitting in the conduction and the valence bands. Normally, it is said that the Rashba effect in the valence band is small and can be ignored in comparison to the conduction band splitting. However, we found a clue that the valence band effect cannot be ignored. The valence band of the sample structures consists of Pb 6s and Cl 3p (or Br 4p) levels. Our preliminary experimental data showed that the Rashba effect was enhanced as the ionic radius changes from Cl to Br. In this proposal, in order to verify the enhanced Rashba effect in the valence band, we will present detailed experimental results of the polarized optical transmission and photoluminescence measurements of $MAPbCl_{3-x}Br_x$ crystal samples in high magnetic fields.

Keywords:
Magneto-optical transitions, Rashba effect, organic-inorganic perovskite

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Enhanced Performance of the Steam Generator by Hydrophilic Carbon Foam@TiO_2

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Abstract:

Harvesting solar energy for steam generation is an efficient way for brine and sewage water treatment. However, conventional steam generators rely on expensive light-concentrators, for heating bulk water that results in massive heat losses. The performance of an ideal solar steam generation mainly depends on four factors, (*i*) broad band solar absorption, (*ii*) thermal managements (heat losses), (*iii*) water managements and (iv) water evaporation. Here in, we report the controlled water managements, capillary action through the solar steam generation device. The solar steam generation device is comprised of TiO_2 nanorods (TNRs) grown on carbon foam by hydrothermal method. Using titanium butoxide (TBO) solutions for the growth of TNRs is effective, because it imparts hydrophilicity to the carbon foam as well, yielding in a much-enhanced capillary action. Moreover, the induced hydrophilicity is sustainable for a longer period compare to other chemical methods adopted for hydrophilicity. The hydrophilic nature of TiO_2 nanorods along with controlled capillary action through carbon foam yields to an enhanced evaporation rate of 3.15 Kg/m^2h under one sun illumination. The facile preparation method and the excellent stability of TiO_2@CF device make it a good candidate to be applicable on a large scale.

Keywords:

Steam Generation, Hydrophilic, TiO2, Water Transport

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Structural and Spectroscopic Properties of ZnSe Thin Films

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Abstract:

ZnSe는 II-VI족 화합물 반도체로서 2.70 eV의 넓은 밴드갭을 가지고 있어서 청녹색 영역의 광전소자로의 응용 가능성이 높은 물질로서 다양한 연구가 이루어지고 있다. ZnSe 박막은 열벽적층성장법 (Hot-Wall Epitaxy;HWE)으로 GaAs(100) 기판위에 성장시켰다. 성장된 박막들의 결정구조와 결정성을 알아보기 위하여 XRD 패턴을 이용하였고, 박막의 정확하고 광범위한 광학적 특성을 평가하기 위하여 투과측정을 이용하여 분광학적 특성을 연구하였다. 박막의 표면상태를 확인하기 위하여 AFM을 사용하여 측정하였다. 또한 광학적 특성을 알아보기 위하여 분광학적 엘립소미트리을 이용하여 측정하였고 측정된 박막의 데이터들은 복소유사유전함수인 $\langle\varepsilon(E)\rangle = \langle\varepsilon_1(E)\rangle + i\langle\varepsilon_2(E)\rangle$를 실온에서 2.0-8.5 eV의 포톤에너지 범위에서 얻을 수 있었다. 광학적 유사유전함수의 결과로부터 반사율(R), 굴절지수(n), 소광계수(k), 흡수계수(α) 등을 얻을 수 있었다. 타원편광분석법을 이용하여 획득된 데이터의 이계도함수를 이용하여 각각의 임계점 피크들을 구하였다.

Keywords:

ZnSe, 열벽적층성장법, 타원편광분석법, 유사유전함수, 원자간력 현미경, 투과측정

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P1-se.018*

Circularly Polarized Raman Spectroscopy on Interlayer Interaction in Few-Layer $SnSe_2$

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Abstract:

Tin diselenide ($SnSe_2$) is an indirect band gap semiconductor material that attracts much interest because of its potential application in the field of data storage and solar cells. In this work, the interlayer interaction of mechanically exfoliated $SnSe_2$ samples was investigated using both circularly and linearly polarized Raman spectroscopy. The measurement was carried out at room temperature using a 514.5 nm (2.41 eV) excitation laser with a spot size of approximately ~ 1 μm in a backscattering configuration. The laser power of ~ 100 μW was maintained to avoid local heating. To prevent degradation of the sample, all the measurements were performed by keeping the sample in an optical vacuum chamber. The low-frequency interlayer shear and layer-breathing modes below 50 cm^{-1} showed multiple peaks depending on the layer number, which were difficult to identify by linearly polarized Raman measurements. However, those interlayer peaks were clearly resolved and distinguished by using circularly polarized Raman measurements. Those modes can give information on the number of layers.

Keywords:

Tin diselenide, Raman spectroscopy, Circularly polarized Raman spectroscopy, Linearly polarized Raman spectroscopy, Interlayer interaction

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P1-se.019*

Optical Phonons in $SnSe_{(1-x)}S_x$ Semiconductor Alloys

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Abstract:

The Raman spectra of $SnSe_{(1-x)}S_x$ semiconductor alloys (x=0.2, 0.4, 0.5, 0.6, 0.8) are studied. Both single- and double-mode behaviors of optical phonons are observed. The SnSe-like A_g and B_{3g} modes in the low-frequency region (<100 cm^{-1}) of the observed Raman spectra exhibit a single-mode behavior. On the other hand, a double-mode behavior is observed in the high frequency region for SnSe-like A_g and B_{3g} modes. In the case of SnS-like A_g and B_{3g} modes, which are observed in the higher frequency region, a double-mode behavior is observed. The Raman active modes are assigned by using a Raman tensor analysis, and then are confirmed by using low-frequency polarized Raman spectroscopy. Polarization dependence of each mode is further checked for parallel polarization configuration in the backscattering geometry Raman setup to exhibit two-fold symmetry and four-fold symmetry for A_g and B_{3g} modes, respectively. Finally, five excitation energies (1.96, 2.33, 2.41, 2.54 and 2.81 eV) were used in the Raman measurements, which showed that 1.96-eV laser is most appropriate to observe all modes in these semiconductor alloys. However, majority of the observed modes in these alloys are most intense when 2.41-eV excitation laser was used.

Keywords:

Optical phonons, Raman spectroscopy, polarized-Raman, low-frequency Raman, one-mode, two-mode, SnSe(1-x)Sx alloys,

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P1-se.021*

Formation mechanism of defect domains in CVD-grown WS_2 based on liquid metal precursor

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Abstract:

전이금속 칼코겐화합물 중 WS_2 단일층은 원자단위의 두께와 가시광영역의 밴드갭을 가지고 있어서 전기소자 및 광전소자 응용 측면에서 많은 연구가 진행되고 있다. 이러한 WS_2 단일층의 합성 방법 중 화학기상증착법이 널리 사용되고 있는데, 가스 유량과 수소의 함량이 증가함에 따라 삼각형 모양에서부터 육각형 모양으로 WS_2의 결정형태가 바뀌게 된다. 특히, 육각형 모양에서는 단결정 내에서도 결합이 서로 다른 도메인 (domain)을 형성하는 것으로 알려져 있으나 그 정확한 성장 메커니즘이 실험적으로 연구되지 않은 실정이다. 본 논문에서는 화학기상증착법으로 성장한 육각형 WS_2 단일층의 이종결함 도메인 형성 메커니즘을 실험적으로 규명하고자 한다. 우선 용액형 텅스텐 (W)-전구체 (precursor)를 이용하여 성장된 다양한 육각형 WS_2의 표면형태를 원자힘 현미경 (AFM)을 이용하여 관찰한 결과, W-vacancy (WV) 도메인의 결정입면과 S-vacancy (SV) 도메인의 결정입면에 쌓인 W 전구체의 잔유물 차이를 확인할 수 있었다. 각 도메인 특성은 confocal photoluminescence and Raman spectroscopy 방법을 이용하여 비교 분석하였다. 이를 통해 잉여 전구체의 축적 차에 따른 조성 차가 WV와 SV 형성 메커니즘에 기여한다는 것을 제안하였다.

Keywords:

transition metal dichalcogenides, liquid metal precursor, WS2, growth mode, chemical vapor deposition

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P1-se.022*

CVD-grown MoS_2 using Na-free promoter

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Abstract:
전이금속 칼코겐화합물 반도체 중 대표적인 물질인 MoS_2 단일층은 원자단위 두께에서 높은 전기전도 및 전자이동도, 직접천이 밴드갭을 가지고 있다. 이러한 이유로 전계효과 트랜지스터 및 광전소자 응용에 많은 연구가 진행되고 있다. 화학기상증착법을 이용하여 MoS_2를 성장 시 Na 또는 K가 포함된 알칼리 금속 (alkali metals) 프로모터 (promoter)가 주로 사용된다. 하지만, CMOS 반도체 공정에서는 이러한 프로모터가 오염원으로 작용하기 때문에 반도체 공정에 적용하기 위해서는 Na-free 프로모터를 사용한 공정개발이 필요한 상황이다. 본 논문에서는 화학기상증착법을 이용하여 MoS_2 단일층 성장 시 다양한 Na-free 프로모터를 사용하여 성장거동을 분석하였다. 캐리어 가스 유량, 온도, 프리커서 분포 조건 등을 통해 공정을 최적화하고, 최적화된 MoS_2 단일층은 Confocal photoluminescence and Raman spectroscopy와 전계효과 트랜지스터를 통해 분석되었다.

Keywords:
Transition metal dichalcogenides, monolayer MoS2, Na-free, Chemical vapor deposition

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P1-se.023

상온 트라이온 발광을 위한 2차원 물질 기반 헤테로구조 발광 소자 (Novel carrier accumulation strategy: Carrier injection light emitting quantum well devices for generation of trion at room temperature)

류희제[1], 권준영[1], 이관형*[2]
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Abstract:

Tungsten diselenide (WSe_2) is a typical representative of layered transition metal dichalcogenides (TMDs) with unique electrical and optical properties. Monolayer WSe_2 has inverted sign of spin-orbit splitting of conduction band states at different momentum space, which makes WSe_2 one of the most promising candidates for advanced optoelectronic applications. Here we demonstrate a light-emitting tunneling device based on monolayer WSe_2, which is encapsulated by ultrathin hexagonal boron nitride (hBN) and contacted with graphene electrodes. The light-emitting tunnel devices of Gr/hBN/WSe_2/hBN/Gr clearly show a tunneling Ids-Vds curve, which is an evidence for direct tunneling transport through hBN to WSe_2. Electrons and holes are injected into monolayer WSe_2 by tunneling through hBN from top and bottom graphene electrodes. Due to a quantum well structure of WSe_2 sandwiched by wide-bandgap hBN, the generated excitons are confined in a well, emitting a visible light through recombination of electrons and holes. For additional modulation of electroluminescence (EL), we contacted another graphene electrode directly on WSe_2 light-emitting layer. When more carriers are directly injected to WSe_2, concentrations of excitons and trions in WSe_2 can be modulated by changing a gate bias (Vgs) and carrier injection contact bias (Vis), allowing for tuning of EL spectrum. Our work shows a great potential of van der Waals tunneling devices for multifunctional light emitting applications.

Keywords:

van der Waals heterostructure, trion, light emission, room temperature

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Monolayer WSe_2 Field-effect light emitting transistors with multi-mode operation

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Abstract:

Two dimensional (2D) materials and their heterostructures hold great promises in various applications due to their unique properties and newly discovered physics. Especially, direct band gap, high exciton binding energy and emergence of charged excitons, *i.e.* trions, have shown that optoelectronic applications based on 2D semiconductors, such as transition metal dichalcogenides (TMDs), are promising. Although lots of optoelectronic devices based on the van der Waals heterostructures of 2D materials, such as photodetectors, solar cells, and light emitting devices, have been demonstrated, development of novel optoelectronic devices is still required to fully utilize unique properties of 2D materials and enable multi-functions and versatile applications. Here we demonstrate 2D filed-effect light emitting transistors (2D-FELET) consisting of monolayer WSe_2 (light-emitting channel layer) and graphene contacts (tunable carrier injection electrodes). We encapsulated monolayer WSe_2 with two pieces of hexagonal boron nitride and fabricated graphene contacts to two ends of WSe_2. To selectively inject different types of charge (electrons and holes) at two graphene contacts, two separate top gates on top of WSe_2-graphene overlap regions were fabricated. By independent modulation of two top gates, Schottky barrier heights for electrons and holes can be tuned, which enables the selective charge injections. When two top gates are oppositely biased, electrons can be injected from one end of WSe_2 channel and holes can be injected from the other end. These opposite charges are recombined at the middle of WSe_2 channel, leading to strong light emission. The performance of the 2D-FELETs is tunable by additional electrical field from back gate. Furthermore, the devices produced in this work can be used as polarity-tunable FETs and photodetectors, simultaneously, which are beneficial for further CMOS integration. Our study shows great potential of 2D-FELETs toward future optoelectronic applications, which request ultra-thinness, transparency, flexibility, high efficiency, multi-functions, and high integration.

Keywords:

Light emitting transistor, WSe2, van der Waals heterostructure, two-dimensional material

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2019-04-24 - 2019-04-26

Carrier type conversion of TMDCs by polyvinylpyrrolidone for CMOS application

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Abstract:

Conversion of the carrier type in 2D semiconductors is fundamental importance for realizing complementary logic inverter. We confirmed that the n-type semiconductor characteristics of MoS_2 was changed to semi-metallic properties by polyvinylpyrrolidone (PVP). Additionally, the p-type and ambipolar property of WSe_2 were clearly converted to the n-type property by PVP. To investigate this phenomenon, we systematically performed optical and electrical analysis. Finally, we have solved one of the major issues that require greatly stable dopant in ambient condition for industry-compatible complementary metal oxide semiconductor (CMOS) application. This study provides a new approach to fabricate next-generation CMOS based on TMDCs.

Keywords:

Carrier type conversion, MoS2, WSe2, CMOS

Ferromagnetic Transition on Zinc blende AlAs via Cr Doping

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Abstract:

Choromium (Cr) has the highest AFM transition temperature (T_N), 311 K, among AFM materials, and it differently configurates a magentic nature as regard to how Cr atoms are surrounded by oxygens and pnintide [1-3], and how away Cr atoms are along with.

Here we report that the ferromagnetic transition (T_c) on Zinc blende AlAs is observed through Cr doping, which is believed owing to the localization of Cr, not to the itinerant character donated by the hole carrier of Cr. The Cr doped AlAs polycrstal has been synthesized by means of solid state reaction, and the electrical resistance and magnetization have been examined as a function of temperature. The resistance is classified by three criteria with intrinsic 62 ~ 300 K, extrinsic 23 ~ 62 K and freeze-out 10 ~ 23 K as doped Silicon, except for being not perfectly saturated in the saturation region. Below the T_c of 75 K, It shows weak ferromagnetic hysteresis curve on M - H with ~ tens of Oe for coercive field. Interestingly, it is found that it has the AFM fluctution above T_c.

In this poster, we will be giving the physical proerties of the Cr doped AlAs, and why it is not typical regarding to other compounds containing Cr.

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[2] Sandhyarani Punugupati et al. Appl. Phys. Lett. 105, 132401 (2014).
[3] Wu *et al.*, Nat. Commun. 5, 5508 (2014).

Keywords:

Dilute semiconductor, AlAs, Ferromagnetic transition, Cr doping, Cr-AlAs

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Hole Transfer Process Strongly Correlated with Polymer Blend Morphology in Ternary Blend Polymer Solar Cells

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Abstract:

In the field of organic solar cells, it has been generally accepted until recently that a difference in band energies of at least 0.3 eV between the highest occupied molecular orbital (HOMO) level of the donor and the HOMO of the acceptor is required to provide adequate driving force for efficient photoinduced hole transfer due to the large binding energy of excitons in organic materials. In this work, we investigate polymeric donor:non-fullerene acceptor junctions in binary and ternary blend polymer solar cells, which exhibit efficient photoinduced hole transfer despite negligible HOMO offset and demonstrate that hole transfer in this system is dependent on morphology. The morphology of the organic blend was gradually tuned by controlling the amount of ITIC and $PC_{70}BM$. High external quantum efficiency was achieved at long wavelengths, despite ITIC-to-$PC_{70}BM$ ratio of 1:9, which indicates efficient photoinduced hole transfer from ITIC to the donor despite an undesirable HOMO energy offset. Transient absorption spectra further confirm that hole transfer from ITIC to the donor becomes more efficient upon optimizing the morphology of the ternary blend compared to that of donor:ITIC binary blend.

Keywords:
hole transfer, polymer solar cells, ternary

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Resistive Switching Effects of Zinc Silicate Thin Films for Nonvolatile Memory Applications

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Abstract:

ZnO thin films have been widely investigated for ReRAM(Resistive Random Access Memory) applications, and the nonvolatile memory properties, such as fast switching speed, large on/off-resistance ratio, moderate endurance, and long retention, were revealed. Here, we considered using Zinc Silicate ($ZnSiO_3$ or Zn_2SiO_4) as a new material for ReRAM application to improve the nonvolatile memory characteristics, such as high program/erase speeds and low power consumption for the memory operations. In previous experiments, we studied the thermal annealing effect on the nonvolatile memory characteristics, and observed that the Zinc Silicate thin film showed the resistive switching properties.

In this experiment, we have demonstrated the fabrication and application of a nonvolatile ReRAM with the Zinc Silicate thin film. Zinc Silicate thin films were deposited on a highly doped Si substrate by RF-magnetron sputtering method with ZnO-SiO_2 mixed target. In particular, the optimum partial pressure-condition of oxygen gas during the reactive sputter-deposition was investigated. We observed that the Zinc Silicate thin films occasionally exhibited bipolar or unipolar resistive switching properties. In the bipolar operation, the set- and reset- voltages were around 3.5 V and -2.8 V, respectively. Current ratio of Low Resistance State (LRS)/High Resistance State (HRS) was 10^2. In the case of unipolar operation, the set- and reset- voltages were around 3.8 V and 1.2 V, and current ratio of LRS/HRS was ~10^4. It should be noted that the unipolar operation showed better endurance behavior than those of bipolar operation. However, the HRS of unipolar operation was unstable in endurance measurements. We speculate that the large current-fluctuations in HRS of the unipolar operation could be attributed to non-repeatable formation of the nonstoichiometric phase of Zinc Silicate. In this talk, we will also discuss the change of endurance property depending upon the partial pressure of oxygen gas during the reactive sputter-deposition.

Keywords:
ReRAM, Zinc Silicate, oxide semiconductor, reactive sputter-deposition

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Thermal annealing effect on nonvolatile memory characteristics of ZnO/SiO_x multilayer ReRAM device and its endurance improvement depending on O_2-gas flow rate during deposition of intermediate ZnO layer

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Abstract:

Since ZnO thin film exhibited good nonvolatile memory characteristics in terms of switching speed, on-off resistance ratio, and data retention, ZnO-based ReRAM(Resistive Random Access Memory) devices have been extensively studied to realize next generation of a high performance nonvolatile memory. However, the thin film is stressed with increasing number of on-off resistive switching cycles, so that it is unlikely for the memory device to exhibit stable and reproducible resistive switching behavior. In order to improve the resistive switching properties of ZnO-based ReRAM, a ZnO/SiO_x multilayer structure has been proposed. It is worthwhile to note that a resistive switching was also observed in defective SiO_x thin films, although Si is not a transition metal.

In this experiment, we investigated thermal annealing effect on the nonvolatile memory characteristics of the ZnO/SiO_x multilayers and the endurance-change with the O_2-gas flow rate during sputter-deposition of intermediate ZnO layer. Both ZnO and SiO_x thin films were deposited using RF magnetron sputtering at room temperature, and the intermediate ZnO layer was deposited with various O_2-gas partial pressures. The ZnO/SiO_x multilayers were then annealed at various temperature and time conditions under N_2 gas atmosphere using RTA. As a result, reproducible on-off operations with the on-off resistance ratio of $>10^2$ were obtained during ~500 cycles. Based on the experimental results, we will discuss the effect of thermal treatment on the nonvolatile memory characteristics and relation between the O_2-gas flow rate and the endurance improvement.

Keywords:

RRAM, ZnO, SiO2 , Sputtering, RTA

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TaO_x를 이용한 RRAM 소자 연구

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Abstract:
뉴로모픽(neuromorphic)은 신경계에 존재하는 신경생물학적 구조를 모방하기 위해 전자 아날로그 회로를 포함하는 초고밀도 집적회로(VLSI) 시스템이다. 뉴로모픽 컴퓨팅(neuromorphic computing)은 아날로그, 디지털, 이 둘을 혼합한 VLSI, 그리고 신경계 모델을 구현하는 소프트웨어 시스템을 기술할 수 있다. 따라서 금속-절연체-금속의 구조를 가지는 차세대 비 휘발성 메모리 중 하나인 RRAM 소자를 이용하여 실현할 수 있다. RRAM은 전압을 인가하였을 때 이에 따른 저항 변화를 이용하여 뉴런과 같은 메커니즘을 보일 수 있다. 본 연구에서는 TaO_x를 이용하여 만든 Pt/TaO_x-Ta_2O_5/Pt 구조에 전압을 인가하여 전도성 필라멘트 형성에 따른 스위칭 전압을 확인하였다. 따라서, 다른 물질에 비해서 전류 밀도의 우수한 특성을 가지는 Ta를 절연체인 TaO_x로써 이용하여 RRAM 소자의 Pt/TaO_x-Ta_2O_5/Pt 구조를 만들었으며 내구성이 높고 저전력 구동이 가능하다는 장점을 확인하였다.

Keywords:
TaOx, RRAM, Pt/TaOx-Ta2O5/Pt

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TiO_x 기반의 RRAM 소자

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Abstract:

뉴로모픽칩은 뉴런의 형태를 모방한 회로를 만드는 새로운 반도체이다. 뇌의 작동방식을 최대한 실리콘에 구현하는 기술로 방대한 양의 데이터를 효율적으로 처리하여 두뇌처럼 동작하는 메모리소자들이다. 그 중에서도 특히 RRAM은 저항에 따른 스위칭 시스템을 사용하여 스위칭속도가 빠르고 3차원 적층구조를 사용할 시에 높은 저장용량을 가져 주목 받고 있는 뉴로몰픽칩 중 하나이다. RRAM의 저항변화 시스템에는 전이금속 산화물등의 절연체를 사용하여 개발되고 있다. 본 연구에서는 고온에서도 안정적인 성질과 높은 내식성, 저항성과 같은 인상적인 특성를 이용하여 전이금속 산화물 중 하나인 TiO_x를 절연체로 사용하였다. Pt/TiO_x/Pt 기반의 RRAM에서 발생하는 산화물 활성층 내의 결함의 형성 및 이동은 저항성 스위칭을 수행하는 전도성 필라멘트의 형태로 생성되는 상의 형성을 유도하는 것을 확인하였다. 따라서 본 연구에서는 TiO_x기반 RRAM 의 거동 전압에 따른 저항성 스위칭을 확인하였다.

Keywords:

TiOx, RRAM, Pt/TiOx/Pt

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열 레이저 용접에 의한 CFRP / AZ31Mg 합금의 계면 효과

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Abstract:

최근 자동차 산업에 있어, 세계 각국의 연비규제 강화 때문에 차량 경량화가 요구되고 있다. 이에 따라, 초기에는 차체 경량화를 위해 대체 소재로 알루미늄이나 마그네슘 등 비철금속을 주로 적용하였으며, 최근에는 고급 차종 및 전기자동차를 중심으로 차량 경량화를 위해 고강도, 내식성 및 피로 강도가 우수한 탄소섬유강화플라스틱(Carbon Fiber Reinforced Polymer, CFRP) 소재를 차체 조립에 사용하는 사례가 증가하고 있다. 하지만, CFRP의 비금속적인 특성 때문에 CFRP와 금속간의 이종접합이 쉽지가 않다. 이를 해결하기 위해 주로 기계적 접착 하이브리드 접합 공법을 이용하여 CFRP와 금속간 이종접합을 시행하였지만, 물질들 간의 열팽창계수 차이와 접착제의 경화시점으로 인해 변형이 발생되어 접합부 파단이 발생하는 문제점을 가지고 있다.
본 연구에서는 금속으로 마그네슘 합금(AZ31Mg)을 사용하여 접합제를 사용하지 않고 열 레이져 용접 (Thermal Laser Joining) 방법을 통해 CFRP와 AZ31Mg 합금간 이종접합에 따른 계면특성을 조사 하였다. 마그네슘은 열전도성이 우수하고, 고품질의 주조물 형성이 용이하며, 무엇보다 쉽게 재활용이 될 수 있는 금속체이다. CFRP와 AZ31Mg 합금간 기계적 결합 유도를 위해 표면 연마에 의한 패턴닝 효과와 화학적 결합을 유도하기 위한 표면 전처리에 따른 접합 메커니즘을 규명하고자, 시료에 대한 인장강도 (Tensile shear strength)를 측정하고 XPS를 이용하여 계면에서의 결합상태 및 화학적 성분 변화 등을 비교 분석하였다.

Keywords:
CFRP, Mg합금, thermal laser Joining, interface

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Theoretical design and characterization of high efficient $Sr_9Ln(PO_4)_7$: Eu^{2+} phosphors

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Abstract:

Substitution of Ln site in $Sr_9Ln(PO_4)_7$: Eu^{2+} matrix prepared from powder-based precursors were designed for the first time. The Rietveld refinement verified the successful substitution for Ln^{3+} site in $Sr_9Ln(PO_4)_7$: Eu^{2+} matrix such as La, Y, Lu, and Sc. Under 360 nm excitation, the emission spectra exhibited a continuous red-shift from 410 nm to 500 nm with the corresponding luminescence varied hues from blue to yellow light by modulating the host compound. As internal quantum efficiency was found to be 100%, the $Sr_9Ln(PO_4)_7$: Eu^{2+} has potential to overcome the low efficiency of the commercial phosphors. Moreover, they possess a high thermal quenching stability up to 90%, respectively. Therefore, a series of $Sr_9Ln(PO_4)_7$: Eu^{2+} phosphors are expected to be exploration of technologically important material as excellent wavelength-conversion phosphor.

Keywords:
Quantum efficiency, Tunable luminescence, Phosphor

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Enhanced white luminescence of $GdNbO_4$: Dy^{3+} phosphors

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Abstract:

The Dy^{3+}-activated $GdNbO_4$ phosphors were synthesized *via* common high temperature solid-state reaction. The X-ray diffraction (XRD), photoluminescence excitation, emission spectra, fluorescent decay curves and concentration quenching were applied to characterize the samples. Under the excitation of UV light, the $GdNbO_4$:Dy^{3+} phosphors exhibit the characteristic emission of Dy^{3+} ion, including blue ($^4F_{9/2} \rightarrow {}^6H_{15/2}$), yellow ($^4F_{9/2} \rightarrow {}^6H_{13/2}$) and red ($^4F_{9/2} \rightarrow {}^6H_{11/2}$) emissions. It was found that the emission intensity increases up to 3 mol% of Dy^{3+} and then quenched. What's more, Bi^{3+} dopants were found to be beneficial for enhancing Dy^{3+} luminescence, and the related mechanisms were discussed. What's more, Dy^{3+}, Bi^{3+} co-doped $GdNbO_4$ phosphors possess relatively good thermal stability and excellent color purity. The obtained $GdNbO_4$:Dy^{3+} phosphors have potential application in the areas of UV white-light-emitting diodes and field emission display devices, etc.

Keywords:

Rare-earth, Phosphor, Photoluminescence

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2019-04-24 - 2019-04-26

A tantalum-based double perovskite red phosphor having an absorption band in the blue region

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Abstract:

This study describes the synthesis of Pr^{3+} doped $SrLaMgTaO_6$ (SLMTO) double perovskite phosphors using solid state reaction and and investigation of the dependence of their structural and photoluminescence (PL) properties on the concentration of Pr^{3+} ion. Eu3+ doped SLMTO red phosphor has been vigorously studied in recent years because of its high efficiency compared to that of commercial red phosphor. However, the Eu3+ doped SLMTO red phosphor has not the blue absorption bands and it is difficult to apply for the white LED based on the blue chips. Our results indicate that 3 mol% Pr^{3+} doped SLMTO produces the brightest red emission. X-ray photoelectron spectroscopy (XPS) analysis indicated that the oxidation state of the Pr element is identical to that of Pr_2O_3. Our results implies that the Pr^{3+} doped SLMTO red phosphor may serve as a substitute for the red emission band deficient in the white light source based on the blue LED.

Keywords:
double perovskite, x-ray photoelectron spectroscopy, Pr(III) dopant

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Effect of Ni valence state on structural and electrical properties of $LaNiO_3$ and non-stoichiometry $LaNiO_3$

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Abstract:
Among the transition metal oxide, $LaNiO_3$(LNO) is a metallic system and one of the highest active materials having stoichiometry Ni^{3+} valence state. It is well known that the chemical binding state of between transition metal and oxygen affect the physical properties, e.g., structural defects, non-stoichiometric compositions of transition metal oxide. For this reason, it is essential and important to control the valence state of the transition metal. In this thesis, LNO films and non-stoichiometry LNO films were grown on $SrTiO_3$(001) substrate by using pulsed laser deposition(PLD). The oxygen partial pressure was systematically changed to control the Ni valence state. By using X-ray scattering, it found that increasing oxygen partial pressure leads to decrease out-of-plane lattice parameters of LNO films and non-stoichiometry LNO films. The increase of oxygen partial pressure caused the Ni^{3+} oxygen state dominant, which was observed using X-ray photoelectron spectroscopy. To understand the correlation between chemical binding state and electrical properties, low-temperature electrical measurement was performed. Increasing the Ni^{3+} concentration caused a decrease in resistivity, and lowest resistivity was observed in the sample with the highest Ni^{3+} concentration. It was confirmed that the Ni oxygen state has sensitive effect on the conductivity, and the Ni valence state was controlled to lower the resistivity of the LNO thin film.

Keywords:
thin film, PLD, valence state

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P2-ap.106

Effect of sintering conditions on characteristic of $BaFe_2(PO_4)_2$ powder and ceramic target production

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Abstract:
Inorganic compounds composed of low-dimensional ferromagnets exhibit fascinating properties and provide a rich opportunity to investigate the ferromagnetic ground states, magnetic transitions and magnetization phases. Over the last few decades, 2-dimensional honeycomb lattices have attracted attention in relation to physical phenomena such as superconductivity, magnetism, topological phase and 2-dimensional material graphene. Among these physical phenomena, recent discovery of topological insulators in honeycomb lattices has increased research on honeycomb lattices. We have decided to study $BaFe_2(PO_4)_2$ (BFPO), which is the 2-dimensional Ising ferromagnet with the first honeycomb lattice. BFPO's ceramic targets are difficult to produce because of the fact that the material changes during the sintering process. However, since the sintering process is indispensable for making ceramic targets, we have studied the effect of sintering process on BFPO and have created a BFPO ceramic target.

Keywords:
Magnetism, Phase transition, Ceramic target

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Synthesis and characterization of magnetic property of $Cr_{(1-\delta)}Te$

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Abstract:

Chromium based Telluride ($Cr_{(1-\delta)}Te$) has been known as P-type ferromagnetic material with various quire temperature(170K to 350K). Depending on the amount of Cr deficiency composition of Chromium and Tellurium changes, and also the magnetic character of the $Cr_{(1-\delta)}Te$, also changes(ex Tc, Hc). Although their magnetic property has been studied already, the origin of their magnetic property has not been studied yet. In our research, we used X-ray absorption(XAS) and X-ray magnetic circular dichroism(XMCD) to find the origin of magnetic property of Chromium based Telluride ($Cr_{(1-\delta)}Te$) by measuring various composition of epitaxial $Cr_{(1-\delta)}Te$ film. The composition of Chromium based Telluride ($Cr_{(1-\delta)}Te$) has been controlled by the growth condition. By increasing Chromium vacancies, XMCD normalized intensity has been decreased.

Keywords:

Chromium Telluride, XMCD, XAS, Epitaxy

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Molecular Assembly behavior of C_{60} on Black Phosphorus

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Abstract:

Two-dimensional (2D) materials have been used as templates for fabrication of various heterostructures hosting inorganic nanostructures, organic molecules, and other 2D materials. Novel physical properties can emerge from the coherent interaction of components in various heterostructure. Among various 2D materials, black phosphorus (BP) can serve as a unique 2D template due to its anisotropic puckered atomic structure. Here, we prepared and investigated organic molecular assembly on BP. As an example, C_{60} molecules were chosen and deposited on BP surface using thermal evaporation. Transmission electron microscopy revealed that the assembly of C_{60} shows high crystallinity and well-defined relation with respect to the BP crystal structure, showing a strong epitaxial behavior.

This work supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF-2017R1A5A1014862)

Keywords:

2D material, Heterostructure, Phosphorene, C60, Epitaxial growth

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P2-ap.109*

Stochastic domain wall motion and thermal field characterization

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Abstract:

Magnetic domain wall (DW) motion has been attracting much interest for the fundamental study [1] as well as technological application [2]. Despite the importance, however, our understanding of the DW motion is far from complete. In particular, the physical mechanism of thermally activated DW motion is still a debating issue because the stochastic nature due to the finite temperature effect. Therefore, it is of great importance how to understand the thermally-induced magnetic field. In this work, we try to characterize the thermally-induced magnetic field. We first set the mathematical model to analyze stochastic domain wall motion with multiple pinning site. From this model, we obtain depinning probability of DW by varying the driving external field. Finally, we characterize thermally-induced magnetic field based on both Gaussian distribution [3] and Arrhenius law. We find some discrepancy between Gaussian thermal field model and Arrhenius' thermal activation model , which suggests that we need further controlled experiments to understand the mechanism underlying the thermally activated DW motion.

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[2] S.S. P. Parkin, M. Hayashi, and L. Thomas, Science **320**, 5873 (2008)
[3] Vansteenkiste, Arne, et al., AIP advances **4**, 107133 (2014)

Keywords:
Thermal activation, Domain wall, Stochastic motion

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Infrared excited Er^{3+}/Yb^{3+} codoped $NaLaMgWO_6$ phosphors with intense green up-conversion luminescence and high temperature sensing performance

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Abstract:

The Er^{3+}/Yb^{3+}-codoped $NaLaMgWO_6$ phosphors with strong upconversion (UC) emission intensity and ultra-sensitive optical thermometric behaviors were synthesized through the traditional high-temperature solid-state reaction method. The excellent temperature sensing performance of the prepared phosphors were thoroughly investigated by studying the temperature-dependent up-conversion emission intensity ratio in the range of 293-533 K. A remarkable enhancement of green UC emission as well as enhanced temperature sensitivity were observed by increasing the Yb^{3+} concentration. Furthermore, the temperature sensing properties of $NaLaMgWO_6$:0.01Er^{3+},0.06Yb^{3+} shows a good exponential relationship between ratiometric intensity and temperature ($R^2 > 0.999$). The maximum absolute sensor sensitivity of the prepared $NaLaMgWO_6$:0.01Er^{3+},0.06Yb^{3+} materials was approximately 2.29% K^{-1} at 533 K. Furthermore, when the pump power of the 980 nm laser increased from 200 to 1000 mW, a slightly elevated temperature from 293-307 K was achieved in the compounds. These characteristics indicating that the Er^{3+}/Yb^{3+}-codoped $NaLaMgWO_6$ phosphors have a potential application is the optical thermometry.

Keywords:
Optical thermometer, Up conversion emission, NaLaMgWO6

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2019-04-24 - 2019-04-26

P2-ap.111

Crystal growth and characterization of Tetrafluoroaluminates ($TlAlF_4$) crystal

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Abstract:

The single crystals of a new non-hygroscopic scintillating material $TlAlF_4$ has been grown by the Bridgman-Stockbarger technique. The recorded powder X-ray diffraction pattern was compared with standard JCPDS pattern and found to be in good agreement. Thermal behavior of this material was studied by using thermo gravimetric analysis (TGA) and the differential scanning calorimetric (DSC). The UV-VIS spectral analyses were carried out to study the optical absorption bands. The optical band gap was calculated from the absorption spectrum and found to be around 4.57 eV. The X-ray induced luminescence measurements of the grown crystal sample exhibits a very strong intrinsic emission band in the wavelength range from 300 to 450 nm with a peak center at 390 nm. Scintillation properties of the grown crystal such as pulse height spectra and decay time were investigated using ɣ-rays from ^{137}Cs radiation source. The scintillation light yield was estimated to be 11,800 ph/MeV. Decay time curve was fitted with bi-exponential function and found the fast component of 273 ns (15%) followed by a slow component of 1.02 μs (85%). All the foregoing results suggest that $TlAlF_4$ is a promising scintillator crystal and could be used for X-ray and gamma ray detection.

Keywords:

A. Crystal; B. Scintillation; C. Photoluminescence; D. X-ray emission

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생리식염수에 담긴 자성비드 농도에 따른 자기저항 특성

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Abstract:

나노자성입자와 자성비드를 구별하여 적혈구와 생리식염수(PBS)에 혼합한 후 구조의 차이와 외부자기장의 유무에 의존하는 저항 변화를 조사하였다. 나노자성입자는 코어 Fe에 카르복실기(-COOH)가 붙은 직경크기는 460 nm이고, 자성비드는 코어 Fe3O4에 -Si-OH기를 갖는 평균 직경이 약 1 μm이었다. 7~9 개의 자성비드와 결합된 4가지 상이한 유형의 적혈구(RBC)는 정상적인 원형과 비정상적인 타원형 적혈구 막을 갖는 중앙과 가장자리 위치하고 있음이 조사되었다. PBS에 담긴 RBC들과 결합된 다량의 나노자성입자들과 자성비드들에 영구자석을 사용해 클러스터 흐름의 모양이 굽이굽이 나타나는 모습을 관찰하였다. PBS 2.5 cc에 0.5 cc의 나노자성입자와 자성비드 용액을 고르게 섞은 후, 2단자 구리전극봉이 내장된 아크릴 수조에 넣어 영구자석을 움직어 장성비드의 흐름을 유도하였다. 외부자기장의 영향에 따라 2분 간격으로 30분 동안 각각 다르게 증가하는 2단자 자기저항값들로 유지함을 보여주었다. 자성비드가 섞인 경우, 나노자성입자와 비슷하게 외부자기장의 존재에 따라 자기장이 센 쪽으로 이동을 유발시켜 한곳으로 모이게 되어 저항값이 10분 동안 단조롭게 0.6 kΩ/m 비율로 증가하다가 22 kΩ으로 일정한 값을 유지하였다. 나노자성입자와 자성비드의 클러스터 움직임 현상은 농도를 달리했을 경우, 외부 자기장의 변화에 따라 뚜렷한 차이가 있을 것으로 보인다. 또한, 자기비드 및 자성나노입자 군집 운동은 외부 자기장에 따른 자기저항곡선이 민감하게 변화하는 다양한 특성을 가질 것으로 예상되기 때문에 정량적으로 분석하여 그 민감도의 특성을 자성센싱 소자로 활용할 수 있음을 제시하였다.

감사의 글: 이 논문은 교육부의 재원으로 한국연구재단(NRF)의 기초연구 사업 지원을 받아 수행된 연구(No. NRF-2016R1D1A1B03936289)의 결과입니다.

Keywords:

나노자성입자, 자기저항곡선, 영구자석, 아크릴수조, 2단자, 구리전극봉, 민감도

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Effect of Eu^{3+} concentration on the luminescent properties of $Ca_3ZrSi_2O_9:Eu^{3+}$ phosphor synthesized by microwave irradiation

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Abstract:

Commercial white light-emitting diodes (WLEDs), combined with blue LED chips and yellow phosphor, have being researched to replace the traditional lighting because of its long durability, reduced energy consumption, enhanced brightness and small size. However, using a commercial WLEDs are possess a low color rendering owing to the poor red emission, which restrict on lighting application with high color rendering. To solve these problem, developing an efficient red phosphor is the one of solutions for high color rendering WLEDs.

According to the past study, the $Ca_3ZrSi_2O_9:Eu^{3+}$ phosphors emits a sharp red light at 610 nm and good thermal stability, those are useful advantages as red phosphor in white LEDs. However, using a solid-state reaction occur a time consumption, demand of high temperature and irregular morphology.

In this study, the $Ca_3ZrSi_2O_9:Eu^{3+}$ phosphors were synthesized by using a microwave irradiation. Compared with conventional solid-state reaction, using a microwave irradiation provide rapid and direct heating, high efficiency. The structural, morphological and luminescent properties of $Ca_3ZrSi_2O_9:Eu^{3+}$ phosphors were analyzed.

Keywords:

Ca3ZrSi2O9:Eu3+, phosphor, microwave irradiation

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$YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors for latent fingerprint detection in forensic applications

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Abstract:

Fingerprints have been applied for identifying crime scenes. Therefore, the effective way for detection of latent fingerprints has been much researched. The most commonly used powder dusting method has several disadvantages such as, low resolution, sensitivity, contrast and high background noise. To resolve these problems, we synthesized the $YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors through a solvothermal method. The crystal structure of the $YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors is well crystallized. The photoluminescence spectra of the $YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors show the green and red emission. The photoluminescence intensity is increased with increasing Ln^{3+} ion concentration from 0.01 to 0.07 mol. The latent fingerprints developed on several substrates (glass, plastic card, and passport) using the $YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors exhibited the highly clear ridge patterns of fingerprints regardless of background interference. The detailed minutiae of fingerprint with different levels can be clearly observed. Therefore, the $YBO_3:Ln^{3+}$ (Ln=Eu, Tb) phosphors can be applied to luminescent materials for detection of latent fingerprint.

Keywords:

phosphor, optical materials, fingerprint

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Damage studies on diamond due to ion implantation

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Abstract:

Diamond is one of the promising material for quantum information system, nano-scale magnetic sensing and biological applications. These applications are based on ion implantation and high temperature annealing technique. Because the crystal damage of diamond is a crucial role for the device performance, structural analysis of each process were conducted.
The ion implantation and annealing process were conducted at Korea Muli-purpose Accelerator Complex (KOMAC). 200 keV-H and 100 keV-N ions were implanted into CVD diamond (Louyang Yuxin diamond Co., Ltd.). The fluence was varied from 1 × 1014 to 5 × 1016 ions/cm2. After ion irradiation, the samples were annealed at 800℃ in vacuum. The structural analysis was conducted using Raman spectroscopy and X-ray diffraction (XRD).
According to Raman spectroscopy, the crystal damage of diamond was recovered after annealing process when the damage density was under the critical damage density. The strain induced by ion implantation was observed using XRD measurement. Color center in diamond was observed after high temperature annealing process. Detailed results will be presented at the conference.

(This work was supported by the National Research Foundation of Korea (NRF) grant (No. NRF-2018M2A2B3A01072437) funded by the Korea government-MSIT (Ministry of Science and ICT).)

Keywords:
diamond, structural analysis, quantum information system, color center

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Nanoscale Investigation on Triboelectric Properties of Chemically Modified Ultrananocrystalline Diamond Films

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Abstract:

We report the enhanced tribocharging properties of ultrananocrystalline diamond (UNCD) by UV irradiation using atomic force microscopy (AFM). UNCD has distinguished mechanical and thermal properties. The films exhibit the elastic modulus of ~1000, which is similar to that of single crystal diamond [1]. The UNCD films were fabricated on silicon substrate by microwave chemical vapor deposition method using CH4 and Ar mixture gas [2]. The surface of UNCD could be modified by UV irradiation to be graphitic and oxidized due to oxygen radicals. Depite the treatment, surface physical properties did not change as confirmed by morphology, adhesion and friction measurements, but chemical properties varied by oxygen radicals resulting in oxgyen rich surface, evolution of reactive radicals and graphitization. The chemical changes were observed by X-ray photoelectron spectroscopy and contact angle measurements. Kelvin probe force microscopy (KPFM) and Ultraviolet photoelectron spectroscopy measurements exhibited that the work function of UNCD increased with increasing UV exposure time. Tribocharges were generated by scratching the surface of UNCD with diamond-coated AFM tip employing contact-mode AFM applying various load, 0, 50 and 100 nN and were measured by KPFM that can record topography and contact potential difference between tip and sample simultaneously applying CD bias to the tip (or sample) [3]. Also, observed load dependent behavior of tribocharges can be explained by correlation between applied load and friction. On the other hand, the charges generated on bare UNCD decayed in ~1h, because of the reactive radicals, the tribochages on the UV-treated UNCD remained after 5h due to reactive radical groups which can trap the charges and insulating surface. Furthermore, incorporation of other element can enhance the triboelectric properties of UNCD [4]. Additionally, the effect of triboelectrification-induced hydrogenation using Pt and sulfuric acid on the tribocharging properties of UNCD films will be shown, and the effect of hydrogenation on nanoscale tribocharging phenomena will be discussed.

Reference

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Keywords:
AFM, UNCD, Triboelectrification

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Analysis of oil paints in the terahertz region

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Abstract:
We measured the transmission spectra of oil paints by using terahertz time-domain spectroscopy. The optical constants of oil paints calculated from the transmittance data can be used to nondestructively estimate the thickness layer of artworks. In addition, we propose to identify key oil paints by their spectral absorption features which can be useful for the identification of counterfeit artworks.

Keywords:
terahertz spectroscopy, oil paints

P2-ap.119*

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Design of Patterned Surfaces with Controllable Wettability Using Pulsed High-Voltage Electrohydrodynamic Lithography and Their Facile Transfer onto Desirable Substrates

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Abstract:

The fabrication of nanostructured surfaces with a combination of ultrahydrophobic and hydrophilic properties at desirable locations by high-voltage electrohydrodynamic lithography is reported. Much effort on wettability control has been devoted worldwide using micro / nanostructures produced by a lithography. Critical issues such as aspect ratio, geometric shape, and array type have been carefully addressed to control the wettability during pattern replication process by implementing the conventional electrohydrodynamic lithography method using pulsed ultrahigh electric field. This technique enables us to replicate micro/nanostructures with controllable wettability. In addition, we also developed a facile transfer method that allows for the patterned film to be transferred to any convex and concave surfaces. Our transfer technique is extremely versatile in delaminating any organic polymer from other polymers where there is a difference in density between them. Design of patterned surfaces with controllable wettability and its capability of transfer on to any desirable target substrates may present an innovative approach to fabricate viable futuristic optical, biological and electrical devices.

Keywords:

Wettability , Electrohydrodynamic Lithography, Facile Transfer onto Desirable Substrates

P2-ap.120

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Thickness Measurement Using Terahertz Time Domain Spectroscopy

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Abstract:
Terahertz time-domain spectroscopy has been used as one of the non-destructive characterization tool of optical properties of films such as the refractive index and extinction coefficient. We propose a new method of determining the film thickness, which allows fast and accurate analysis of double layers as well as monolayers. Our method should find applications in various materials useful to industry.

Keywords:
terahertz time domain spectroscopy, thickness analysis, pigment

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P2-ap.121

Energy dependence of Epitaxial IrO_2 thin film on TiO_2 substrates using Resonant Inelastic X-ray Scattering

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Abstract:

The Iridates, IrO_2, has been studied extensively due to intriguing physical properties, e.g. a very large spin Hall resistivity [1] and a topological nodal line semimetal [2]. Understanding the electronic structure of IrO_2 based on the spin-orbit coupling (SOC) [3,4] is still yet incomplete. Here, we investigate the electronic structure of epitaxial IrO_2 films grown on TiO_2 substrates using Resonant Inelastic X-ray Scattering (RIXS). RIXS is a powerful tool among several spectroscopies to monitor the d electron states of Iridium in the transition metal oxides [5,6]. We performed the RIXS measurements at 3A beamline in PLS. Interestingly, we found the different features in the energy dependence of both IrO_2 (100) and (002) films. We will discuss possible physical origins.

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Keywords:
RIXS spectra, IrO2

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Verification of parametric spin wave mode selectivity in the Permalloy nanowire by electric current control

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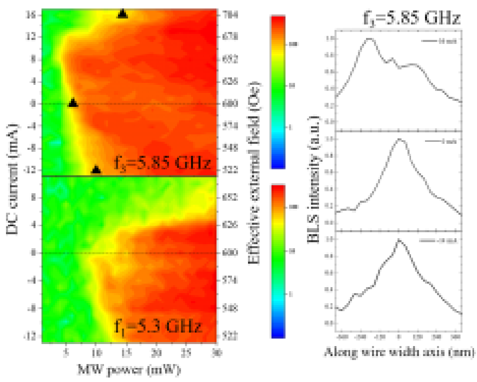
Abstract:

Transition on the parametric spin wave property of the Permalloy nanowire controlled by electric current was intensively studied by micro-Brillouin light scattering (μ-BLS). Parametric pumping is a nonlinear wave phenomena and one of the promising spin wave exciting techniques having threshold characteristic and high excitation efficiency for spin wave with large wave vector. Recent studies have shown that one can selectively generate the parametric spin wave mode depending on the magnitude of the external magnetic field of which results increase the applicability of the parametric process to the magnonic device. In experimental nanowire structure characterized with width of 800 nm and length of 20 μm, we have clearly detected a parametric pumping of several quantized spin wave modes using low microwave power. From the electric current dependency of parametric threshold power of each modes, it have been shown that the parametric threshold characteristics could change by using induced Oersted field by electric current, which means it is possible to attribute the parametric mode selectivity by electric current instead of magnetic field. We also have proven that efficiency of the parametric process decrease under the certain low field range where the hybridization of fundamental mode (n=0) with higher-order mode exists and mode transition from hybrid mode to single discrete mode have a considerable effect to full threshold characteristics of the sub-micro sized magnetic system.



Keywords:
parametric pumping, electric current control, threshold characteristics

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P2-ap.123

Annealing effect on the magnetic properties of Mn_3Ga thin films

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Abstract:

Heusler compounds have gained interest in the field of condensed matter physics because of its extraordinary diverse physical properties [1]. Especially, Mn-based Heusler materials have attracted a lot of attention because of the compensated ferrimagnetic ordering with high spin polarization [2]. Furthermore, the magnetic ordering is easily tuned by the crystal structure or the chemical composition [3]. In this study, we fabricate two different Mn_3Ga thin films with $D0_{22}$ tetragonal ferrimagnetic phase and $L1_2$ cubic antiferromagnetic phase by RF magnetron sputtering method. The films are annealed as varying pressure, temperature, and time. We find that the annealing effect is sensitive to the pressure, compared to the temperature and time. For both films, the magnetic state is changed to a ferromagnetic state with higher saturation magnetization and lower coercive field after annealing. The $D0_{22}$ tetragonal structure is transformed to a $L1_0$ cubic phase while retaining perpendicular anisotropy, whereas the disordered $L1_2$ cubic structure is to an ordered $L1_2$ cubic with isotropic magnetism. These tunable structural and magnetic properties of Mn_3Ga upon annealing can be used for possible applications in spin-based electronic devices.

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Keywords:

magnetic thin film, Heusler material, spintronics

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Electric field induced magnetization switching in antiferromagnetic insulator

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Abstract:

In the development of spin-based electronic devices, one steady issue is the manipulation of the magnetic state with high speed and low power consumption. Although research has focused on the current-induced spin orbit torque based on strong spin orbit coupling, the charge-based and the torque-driven devices have fundamental limitations: Joule heating, phase mismatching and overshooting. In this work, we investigate numerically and theoretically alternative switching scenario of antiferromagnetic insulator (AFI) in a confined structure sandwiched with two electrodes. As the electric field could break inversion symmetry and induce DM interaction and pseudo-dipole anisotropy, the resulting spiral texture takes symmetric or antisymmetric configuration due to additional coupling with the crystalline anisotropy. Therefore, by competing two spiral states, the magnetization reversal of AFs is realized, which is valid in ferromagnetic counterpart. Our finding provides promising opportunities to realize the rapid and energy-efficient electrical manipulation of magnetization for future spin-based electronic devices.

Keywords:

electric field induced switching, antiferromagnetic soliton, chiral magnet

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Determination of the individual atomic site contribution to the electronic structure of 3,4,9,10-perylene-tetracarboxylic-dianhydride (PTCDA)

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Abstract:

We have studied the element and orbital-specific electronic structure of thin films of 3,4,9,10-perylene-tetracarboxylic-dianhydride (PTCDA) using a combination of synchrotron radiation-exited resonant x-ray emission spectroscopy, x-ray absorption spectroscopy, x-ray photoelectron spectroscopy, as well as density functional theory calculations. Resonant and non-resonant x-ray emission spectroscopies were used to measure the C and O 2p partial densities of state in PTCDA. Furthermore, resonant x-ray emission at the C and O K-edges is shown to be able to measure the partial densities of states associated with individual atomic sites. The flat molecular orientation of PTCDA on various substrates is explained in terms of the carbonyl O atom acting as a hydrogen-bond acceptor leading to multiple in-plane intermolecular C=O...H-C hydrogen bonding between carbonyl groups and the perylene core of the neighboring PTCDA molecules. We support this conclusion by comparison of our calculations to measurements of the electronic structure using element-, site- and orbital-selective C and O K-edge resonant x-ray emission spectroscopy, and photoemission spectroscopy.

Keywords:

synchrotron-radiation, organic semiconductors, x-ray emission spectroscopy, x-ray absorption spectroscopy, photoemission, PTCDA

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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CIGS 태양전지에 대한 유한요소법 기반 사입사 광학 모델링에 관한 연구

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Abstract:

$Cu(In,Ga)Se_2$(CIGS) 태양전지는 높은 흡수율과 넓은 흡수 파장영역 등의 장점 때문에 많이 연구가 되고 있다. CIGS 태양전지는 광 간섭성과 비간섭성이 혼합된 모델인데, 이는 결과값에 크게 영향을 미치는 요소이기 때문에 비간섭성이 적용된 광학 모델링이 필요하다. 또한 실제 태양광은 하루 중에 입사각이 변화하므로 입사각 변화에 의한 태양전지의 흡수율 변화에 관한 연구도 필수적이다. 본 연구에서는 유한요소법 기반으로 CIGS 태양전지의 사입사를 포함한 광학특성을 모델링하고, 광흡수율을 분석하고자 한다. 기판의 광 비간섭성을 고려하기 위한 방법으로는 기판에 미세한 두께 변화를 주고 얻은 값을 평균 내서 이용하는 ETM (equidistance thickness method) 방식을 적용하였다. 또한, 광 입사각 변화에 따른 광흡수율 변화를 계산하고 분석함으로써CIGS 태양전지가 실제 하루 동안 생산할 수 있는 에너지 양을 예측해 보았다. 또한, 유한요소법 기반 수치해석 결과의 정합성을 검증하기 위하여 동일 CIGS 태양전지 구조에 대해 수학적 해석 모델인 GTMM (generalized transfer matrix method)을 적용하여 계산한 결과와의 일치 여부를 확인하였다.

본 연구는 한국전력공사의 2016년 선정 기초연구개발과제 연구비에 의해 지원되었음 (과제번호 : R17XA05-14)

Keywords:

CIGS 태양전지; 사입사 광학모델링; 유한요소법;

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P2-ap.203*

Impurity-doped organic-inorganic planar perovskite solar cells with improved efficiency and enhanced environmental stability

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Abstract:

In this work, we intentionally doped several impurities in a precursor to form a pinhole-free perovskite film with improved crystallinity, enlarged grain size, and enhanced environment stability. We found that the impurity doping might suppress the formation of crystallizing nucleus and decrease the crystalline growth velocity, eventually increasing the power conversion efficiency. The details of our experimental data such as UPS, AFM, IPCE, EIS and J-V measurements will be given and discussed.

Keywords:

perovskite solar cells, impurity, crystallinity

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Tailoring energy of highly transparent metal oxide ETL in Perovskite Solar Cells

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Abstract:

We fabricated perovskite solar cells with N-I-P (regular planar) structure by using various metal oxides as electron transport layers (ETLs). The proposed ETLs worked as hole blocking layer and electron injection layer on the interface consequently reduces the recombinations as a result increase the open circuit voltage (Voc). The incorporation of these novel metal oxides let the PCE increased from 8.23% to 16.05% by increasing the V_{OC} and FF remarkably, with small increase in Jsc as well. In addition, The scanning electron microscope (SEM) and atomic force microscope (AFM) images shows the large crystal size of perovskite with less grain boundries which confirm enhanced crystallinity. In this study, we show that the novel metal oxide in perovskite can be used as an electron transfer layer to improve the efficiency.

Keywords:

Perovskite solar cells, Metal oxide, Eletron tranport layers

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P2-ap.205*

Metal ion as an Additive into Pb(Ac)2-based perovskite solar cells: the improvement of the photovoltaic performance.

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Abstract:
$Pb(Ac)_2$ as a lead precursor for fabricating CH_3NH_3PbI3 perovskite solar cells have attracted much attention because it enables antisolvent-free process, which is beneficial for commercialization of perovskite solar cells. However, $Pb(Ac)_2$-based perovskite solar cell is not stable against moistures and its crystallization speed is difficult to be controlled, being easily degraded in ambient air. In this work, we added metal ions into $Pb(Ac)_2$-based perovskite precursor and investigated the role of metal ions in defect passivation.

Keywords:
perovskite solar cell, lead acetate, metal

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Programmable molecular rectifier driven by the interfacial band alignment between 2D semiconductor and the self-assembled monolayers

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Abstract:

Since Aviram and Ratner initially proposed the possibility of a molecular-scale rectifier in 1974, diverse type of molecular diodes driven by a specific molecular itself or the asymmetric interfacial engineering has been extensively suggested and demonstrated [1-4]. In this study, we first implemented a new class of molecular rectifier composed of a self-assembled monolayers (SAMs) of molecules and MoS_2 stacked on the Au/Cr/SiO_2/Si substrate, which is investigated by a conductive atomic force microscopy (CAFM) technique. The tip-loading force was set as 1 nN to fix the molecular coupling strength between molecular SAMs/2D semiconductor interface. In the case of the OPT2/1_L-MoS_2 junction, the diode feature with rectification ratio (*RR*) > ~10^3 was observed. Furthermore, the *RR* can be programmed according to different 2D materials, the number of MoS_2 layers, molecular length, and molecular backbone structure [5]. The observed rectifying features might be mainly originated from different transport pathways according voltage polarities induced by the interfacial band alignment between molecular SAMs and 2D semiconductor of the heterostructure, which will be properly addressed. Our suggested rectifier architecture can provide potential benefit to simply implement the molecular-scale diode function and propose the idea to improve the diode performance.

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Keywords:
Molecular electronics, Heterostructure, Two-dimensional materials, Transition metal dichalcogenide

P2-ap.207*

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Resistive switching properties of unipolar organo-metal halide perovskite resistive memory devices and their operational stability under ambient

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Abstract:

Resistive random-access-memory (RRAM) has many advantages as a memory device due to their low-power consumption, non-volatility and simple device structure. Moreover, a diverse range of solution-processed materials available for the active layer enables low-cost device fabrication. Among these, RRAM based on organo-metal halide perovskite materials have recently demonstrated excellent performance such as high ON/OFF ratio and low operation voltages. However, fabrication of high-yield and high-density perovskite memory devices still remain as a main challenge for practical application. To achieve this goal, deposition of uniform and pinhole-free perovskite thin film is essential. In this presentation, we report unipolar perovskite RRAM in 8-by-8 cross-bar array architecture with the yield up to 94%. Smooth and nearly pinhole-free perovskite thin films were made from a simple single-step spin-coating with a non-halide lead precursor. The high yield and a relatively uniform operation voltage distribution among memory cells in the cross-bar array devices can be attributed to the fine quality of the active perovskite memory layer. A statistical analysis of the crossbar-array memory devices was performed in order to investigate the effect of set and reset voltage distributions towards a reliable memory operation. In addition, we investigated how the memory device properties varied throughout the 30 days of storage under ambient condition in terms of the ON/OFF ratio and operation voltages.

Keywords:
유기소자

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Y_2O_3-SiO_2: Nd^{3+} 합성분말의 볼 밀링 시간과 열처리 온도에 의한 구조적 특성

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Abstract:

본 연구에서는 SiO_2 분말을 Y_2O_3분말에 첨가하여 2 mol% Nd^{3+}를 도핑시킨 Y_2O_3-SiO_2: Nd^{3+} 형광체 분말을 고에너지 볼 밀링(HEBM) 방법을 이용하여 상온에서 합성하여 볼 밀링 시간과 열처리 온도에 따른 형광체 분말의 결정구조와 입자의 결정성 및 표면형상을 비교 분석하였다. FE-SEM을 통하여 표면형상 및 미세구조를 관찰했으며, EDS 분석 결과 Y(Yttrium), O(Oxygen), Si(Silicon), Nd(Neodymium)으로 구성되어 있으며 다른 물질들은 존재 하지 않는 것을 확인하였다. X-선 회절(XRD) 분석 결과, 볼 밀링 시간이 30분부터는 주요 회절피크의 세기가 급격하게 줄어들고 주위에 작은 회절피크들이 나타났으며, 150분까지 multiphase 구조가 보였다. 볼 밀링 시간 300분에서는 주요 회절피크 주위의 작은 피크들이 사라지고, 회절 피크의 위치가 큰 각 쪽으로 미소하게 shift 되었으며, 주요 피크의 폭이 약간 넓어지는 현상이 나타났다. 이러한 결과는 라만 스펙트럼에서도 확인 할 수 있었으며, 볼 밀링 시간에 따라 상전이가 일어남을 확인 할 수 있었다.

Keywords:

고에너지 볼밀링(HEBM), Y2O3-SiO2:Nd3+, 상전이 (phase transition), X-선 회절, 라만스펙트럼

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방사광의 크기조절을 위한 거울의 유연 다물체 동역학 해석

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Abstract:
포항가속기연구소의 저장링에서 방사된 광자빔을 이용하여 다양한 연구를 위해서는 거울 집속에 의한 광자빔의 크기 조절이 필요하다. 집속에 의한 광자빔의 크기를 조절하는 여러 가지 방법이 있지만 다양한 표면 형태의 거울을 직접 굽혀주는 부하를 작용하여 만들어진 표면의 곡률로 방사광을 집속하여 크기를 조절하는 방법이 있다. 이 방법은 설비를 크게 하지 않아도 되며 간단하면서도 빠르고 정확하게 방사광의 크기를 조절할 수 있는 장점이 있다. 하지만 검증되지 않은 부하를 작용하는 것은 거울의 손상을 가져올 뿐만 아니라 이상적인 곡률 형상으로 굽혀지지 않고 또한 거울표면의 곡률을 정밀하게 조절 할 수 없다. 또한 실제 거울측정 중에 발생하는 반복되는 시행착오로 많은 시간과 노력이 소요된다. 본 발표에서는 이러한 문제를 줄이기 위해서 반경 1.0Km~4.0Km에 속하는 거울표면의 곡률을 조절하기 위한 부하조절 시뮬레이터 모델을 개발하였다. 거울에 작용하는 부하는 동역학 모델의 입력하중으로 사용하고 동역학 해석을 수행하여 곡률 조절을 위한 최적의 부하와 거울표면의 변화량을 검증하였다.

Keywords:
Beam size adjustment, Flexible body, Multibody dynamics

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반도체 폴리머의 온도에 따른 결정 구조 변화 및 구조-특성 관계 연구

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Abstract:

반도체 폴리머는 OLED나 유기물 트랜지스터 등 휘어지는 전자소재로 이용될 수 있기 때문에 많이 주목을 받고 있다. 이러한 유기물 전자소재의 경우 결정 구조의 특성이 소자 특성과 연관되어 있는 경우가 많이 때문에 구조-특성 관계 연구가 중요하다. 우리는 가장 전형적인 반도체 폴리머인 poly(3-hexylthiophene) (P3HT)가 저온에서 보이는 결정구조의 변화와 이에 따른 트랜지스터 특성 변화를 연구하기 위하여 in-situ 2D GIXD (grazing-incidence x-ray diffraction) 및 FET (field-effect transistor) 전압(게이트)-전류(드레인) 측정을 수행하였다. 반도체 폴리머의 기본 결정 구조는 반도체 특성을 갖는 공액 분자 backbone chain과 용액 형태로 녹이기 위한 alkyl side chain으로 구성되어 있는데, 각 부분의 결정 구조가 정렬되는 온도가 서로 다르고 이에 따른 폴리머 반도체의 charge transport가 달라짐을 관측할 수 있었다. 폴리머의 특징인 낮은 결정성에도 불구하고 저분자 유기물 반도체 단결정 이상의 높은 전하 이동도를 보이는 반도체 폴리머가 최근 속속 개발되면서 기본적 메카니즘을 이해하려 노력 중인데, 본 연구의 구조-특성 관계에 대한 연구가 도움이 될 것으로 기대한다.

Keywords:

반도체 폴리머, 유기물 트랜지스터, P3HT, 2D GIXD

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Study of the C60 / Ag interface using the Low-Energy Photoelectron Spectroscopy

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Abstract:

Accurate measurements of the valence electronic structures of multilayered interfaces are important for the developing and understanding of organic electronic devices, materials, and interfaces. In particular, ultraviolet photoelectron spectroscopy (UPS) is a powerful technique to probe the occupied electronic structures in the valence region, and in practice has been utilized upon numerous model systems relevant to organic materials to unveil their fundamental electronic phenomena and functionalities. However, there are certain problems that accompany the conventional UPS, such as sample charging with the low electrical conductivity of typical organic semiconductors limiting the film thicknesses that can be measured for many materials to only a few nm. The other problem is sample damage which is often manifested by driving reactions with residual atmospheric gases, mediating photo-chemical reactions, and causing the bond breaking or cross-linking. There is also radiation damage which is commonly observed by changes in the spectral features of the valence band, or by substantial shifts in binding energy, which makes interpretation in the presence of radiation damage difficult.

In order to avoid these problems of sample charging and damage during photoemission measurements using the low-energy photons for observing multilayered materials even the buried interfaces to its expected longer probing depth. Here we present the application of a photon source that emits monochromatic photons at 10.2 eV with no higher energy emission lines and without the use of a monochromator. The source produces H Lyman-α emission at 10.2 eV (121.6 nm) and the intensity of the source can be readily adjusted over a wide range to reduce sample damage and charging. It can produce up to 2 × 1018 photon/s in the continuous wave mode, can be separated from the UHV system by a MgF2 window to eliminate differential pumping requirements, is small in size allowing for easy outfitting to existing systems, has a long lifetime, and is relatively easy to operate (i.e. no precise adjustment of pressure and no need for differential pumping).

Keywords:

Low-energy photoelectron spectroscopy, Electronic structure, HOMO, Fermi level, Energy Level Alignment

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Origin of high contrast in microscopic images of graphene on copper

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Abstract:
We investigated the origin of visible high contrast in confocal microscopic images of graphene grown on copper foil by chemical vapor deposition (CVD). The imaginary part of optical conductivity of single crystal graphene accounts for large contrast above ~ 2.3 eV. However, the image contrast can still be visible below 2.3 eV due to combined Fabry-Perot reflection of graphene/Cu interface. This method may help to envisage the condition of graphene flake during CVD processes.

Keywords:
confocal microscopy, graphene

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Vacuum deposition requisites for color-controlled perovskite light emitting diodes

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Abstract:

Organic-inorganic hybrid halide perovskites have potential as a light emitter due to easy bandgap tunability and high color purity. By the benefit of the low temperature crystallization, many researches have grown the perovskite emitter with solution process. Today, vacuum deposition systems are widely installed in display industries, thus the development of vacuum-deposited perovskite is highly required for rapid commercialization. However, low molecular weight compounds such as MABr (methylammonium bromide), which randomly evaporates, cause severe discordance between evaporation rate on QCM and the actual thickness on substrate. Besides, this omnidirectional vapor causes interference with other QCMs which are not in the targeted position thus it hinders precise deposition of other precursors.

Here, we propose the requisites for perovskite precursor deposition. A new chamber and crucible were built for perovskite use-only. Firstly, each evaporation source has QCM and shutter independently. Secondly, molecular beam-like evaporation of low molecular weight precursor is materialized utilizing internal pressure difference of crucible with on-board nozzle and inner plate. As a result, interference-free evaporation from multiple sources was realized successfully. By combining different metal precursors and controlling the deposition rate of reactants, bandgaps of perovskite were controlled. Then various light emitting diodes were fabricated. Depending on I/Br ratio and Cl/Br ratio, EL peak positions of light emission spectra were controlled precisely from blue to red.

This research was supported by the MOTIE (Ministry of Trade, Industry & Energy (10079558)) and Development of materials and core-technology for future display support program.

Keywords:
Perovskite, Vacuum deposition, bandgap, light emitting diode

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뉴클레오사이드 시티딘을 전자 주입층으로 이용한 역구조 유기태양전지

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Abstract:

미래의 지속 가능한 발전을 위해 반도체 소자 제작 공정에 있어서 환경 친화적인 방법을 도입하는 연구들이 진행되고 있다. 특히 동물과 식물에서 추출할 수 있는 물질들은 친환경적이고 생분해성이 좋은 장점을 가지고 있어 이를 소자에 활용하는 연구가 유망하게 떠오르고 있다. 이러한 물질 중 하나로 DNA 를 구성하는 뉴클레오사이드 물질인 시티딘(cytidine)은 낮은 일함수를 갖고 있는 것으로 알려져 있어 다양한 반도체 소자에서 전자 주입층으로 활용될 수 있을 것으로 생각된다.

본 연구에서는 유기태양전지 내 효율적인 전자 주입층으로 시티딘 박막을 이용하였다. P3HT:PCBM 벌크 이종접합을 광흡수층으로 사용하는 역구조(inverted) 유기태양전지를 제작하고 ITO 음극과 광흡수층 사이에 시티딘 박막의 두께를 변화시키면서 소자 특성의 변화를 관찰하였다. 전기적 특성을 이해하기 위해 광조사 및 암전 상태의 전류 밀도-전압 곡선과 임피던스 곡선을 측정하였다. 또한 시간 경과에 따른 소자효율 저하를 측정하여 시티딘 전자주입층이 소자 수명에 미치는 영향을 분석하였다. 본 연구를 통해 다양한 반도체 소자에서 시티딘을 활용할 수 있는 기초정보를 제시하고자 한다.

Keywords:
cytidine, electron injection layer, organic solar cell

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P2-ap.215*

Colored, semitransparent hybrid solar cells using dielectric mirrors

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Abstract:

Colorful, semitransparent solar cells have drawn intense attention for their potential in integrating smoothly with both interior and exterior surfaces of automobiles and buildings. In this work, we present a design of colored, see-through undoped amorphous silicon/organic hybrid solar cells employing multilayer dielectric mirrors. Semitransparent red, green, and blue colors can be created, which are readily tuned by altering incidence angles and polarizations of incident light. We also investigate how the incident angles and the polarization affect transmission and reflection spectra, chromaticity, and electrical characteristics of the colorful, semitransparent hybrid solar cells. The present approach could open the door to a large number of applications, such as decorative solar panels, electricity-generating windows, energy-efficient displays, power-generating solar greenhouses, and building-integrated photovoltaics.

Keywords:
solar cells, dielectric mirrors, interference

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The impacts of dopant incorporations on energy level alignments in organic-inorganic hybrid perovskites

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Abstract:

Organic-inorganic hybrid perovskites have been attracting tremendous attention due to their potentials for high power conversion efficiency (PCE) in solar cell applications. Many fabrication methods have been developed to achieve high PCE of perovskite solar cells (PSC). One of the popular ways is to incorporate noble metal based ionic compounds into the perovskite precursor. Those compounds include CuI, CuSCN, $CuBr_2$ and AgI and they have successfully improved PCE of PSCs, but there are few researches on the atomic distribution of dopants in perovskite solar cells. Herein, we present the effects of dopant distributions on energy level alignments in perovskite films. We also show how this incorporation modifies crystallization kinetics when forming perovskite films. Energy level alignments are measured both in valence band and conduction band by ultraviolet-photoelectron spectroscopy and Inverse- photoelectron spectroscopy.

Keywords:

perovskite solar cells, photoelectron spectroscopy, inverse photoelectron spectroscopy

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The bright perovskite light emitting diode via vacuum deposition with precise control of methylammonium halide

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Abstract:

Organic-inorganic hybrid halide perovskites are now dragging huge research interest with their great potential as solar energy converter and light emitter. Especially, perovskite has intrinsically narrow emission spectra which are comparable to quantum dot emitters. Devices, including the perovskite emitting layer, are usually fabricated via solution processes, which necessitate complex considerations on solubility, orthogonality, and hydrophilicity. Vacuum deposition, which is not accompanied by dissolving materials, is a powerful method for fabricating perovskite with the strength over reproducibility and film uniformity.

By far, there are rare reports on successful perovskite light emitting devices through vacuum deposition due to problems on methylammonium halide control. By modifying the crucible design, we have successfully controlled the deposition ratio of MABr, thereby found out that just a subtle change in ratio got impact on the characteristics of perovskite. We have fabricated light emitting device with perovskite on various precursor ratio and investigated the effect of the morphology, crystallinity and electronic structure on device performance.

Keywords:

Perovskite, Vacuum deposition, Light emitting diode

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P2-ap.218

Film properties of methylammonium lead iodide perovskite by different solvent etching time

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Abstract:

Recently, organic-inorganic hybrid perovskite solar cells (PSCs) have received great attention due to their high power conversion efficiency over than 22% and simple solution-process fabrication method. To obtain high performance PSCs, the film properties including electronic structure, crystallinity, and morphology must be optimized. As an efficient method to fabricate the high-quality perovskite film, one-step spin-coating method is widely used. For this method, methylammonium iodide and PbI_2 are dissolved in mixed solvent of dimethylformamide and dimethyl sulfoxide, and the perovskite solution is spin-coated onto the substrate. During the spin coating process, an additional solvent is dropped [e.g. diethyl ether (DE)]. This solvent engineering plays an important role in the film quality of perovskite. However, the detailed information of film properties by solvent etching time has not well known yet.

In this study, we investigated the film properties of methylammonium lead iodide ($MAPbI_3$) perovskite by DE solvent etching time. The film crystallinity was analyzed using X-ray diffraction and electronic structure was measured using X-ray and ultraviolet photoelectron spectroscopy. The effect of the residual intermediate phase and optimum condition for high efficiency were discussed

Keywords:

Perovskite solar cells, MAPbI3, photoelectron spectroscopy

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P2-ap.219*

Angle-resolved Photoelectron Studies of $CH_3NH_3PbI_3$ and Comparisons with DFT Calculations

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Abstract:

In the past few years organic-inorganic halide perovskite (OIHP) materials have been intensively studied in various electronic and optoelectronic devices. OIHPs and their other similar compounds have shown their great potentials to be used as next-generation of solar cells, light emitting diodes, x-ray and gamma-ray photodetectors, semiconductor lasers and thin-film field effect transistors. This vigorous research activities originate from their excellent optoelectronic properties such as low exciton binding energy, long charge carrier diffusion length, long lifetime of charge carriers, narrow bandwidth in luminescence and high absorptivity. Moreover, ease of fabrication methods yielding high quality films with low defect concentrations make the materials as a good promise for future applications.

Understanding electronic band structures gives significant information on the systems of interest and, therefore, is crucial to interpret physical properties of the systems. Among various techniques developed so far, angle-resolved photoelectron spectroscopy (ARPES) is the most direct experimental technique in measuring band structures of materials.

In this study we present ARPES spectra with He-I excitation source (21.22 eV) measured on the (001) surface of a single crystal $CH_3NH_3PbI_3$ which is the most thoroughly studied material among any other OIHPs. It should be noted that our measurements have the most pronounced features compared to previously reported ones from others. We also compare the measured spectra with DFT-calculated ARPES spectra and discuss some discrepancies between them.

Keywords:
ARPES, photoelectron spectroscopy, organic-inorganic halide perovksite, CH3NH3PbI3

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P2-ap.220*

Study of carrier mechanism in organic semiconductor device by controlling the crystallinity of TIPS-Pentacene

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Abstract:
We studied the carrier behavior and transport mechanism in organic field effect transistors(OFETs) by changing the organic semiconductor TIPS-Pentacene layer crystallinity, i.e., by controlling TIPS-Pentacene crystal shape and size. The control was achieved by changing the TIPS-Pentacene solvent vapor ratio. Upon application of a step voltage to the TIPS-Pentacene OFET, we observed the electric field change in the TIPS-Pentacene layer with different crystallinity. Significant electric field distribution change was suggested due to the carrier injection, depending on the crystallinity of the TIPS-Pentacene. Using the Maxwell-Wagner model, we analyzed the I-V and C-V characteristics of the OFET, in terms of the TIPS-Pentacene crystallinity. Optical CMS measurement was also employed to study the impact of the TIPS-Pentacene crystallinity on the carrier trapping and transport mechanism.

Keywords:
Organic field-effect transistors (OFETs),Crystallinity of TIPS-Pentacene layer, Maxwell-Wagner model

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P2-ap.221*

Modular neuron network analysis using multi-electrode array

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Abstract:
The brain is known to have a modular structure, so it is necesary to investigate the modular system to understand the brain activity. We have patterned four-module neuron networks on the multi-electrode arrays by using simple sucking system. Four-module neuron networks were recorded every three days *in vitro* to observe spontaneous and evoked electrical activities. The network interactions in four-module neurons were investigated by measuring functional connectivity, firing and burst rates and comparing with the signals in normal neuron networks.

Keywords:
Multi-electrode arrays, Neuron , Modular network , Biosensor

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P2-ap.222*

Study of electrohydrodynamic ink properties under high voltage

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Abstract:

Electrohydrodynamic (EHD) Inkjet printing technique is very promising as a non-contact mask-free deposition technique, with high printing resolution and material compatibility. Currently, it has critical problems to be solved, e.g., short lifetime of nozzle, set jetting condition, stabilization of jetting condition and others. In order to resolve these problems, we need to carry theoretical analysis using COMSOL and experimental analysis of EHD fluid under high voltage, e.g., around 1000V. In this study, we investigated the rheological properties of EHD fluid under high electric field condition and showed our research is effective to improve the actual process condition for high performance of display device.

Keywords:

electrohydrodynamic, inkjet printing, viscosity, electric field

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P2-ap.223*

Fiber-shaped organic artificial synapse for wearable neuromorphic applications

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Abstract:

Organic-based artificial synaptic devices that can learn and store massive non-structured information with extremely low-power on purpose have attracted as a practical candidate for the wearable intelligent electronic device due to its inherent mechanical flexibility and functional diversity [1-3]. Here, we fabricated a fiber-shaped artificial synapse based on a ferroelectric organic transistor that could capable of the integrated flexible NOR-type array. The device exhibited the switching stability even under bending radius (R = 1.2 mm). In addition, the fiber-shaped artificial synapse can exhibit excellent and reliable synaptic functionalities, including excitatory postsynaptic current (EPSC), spike rate dependent plasticity (SRDP), spike timing dependent plasticity (STDP), and a transition from short term plasticity (STP) to long-term plasticity (LTP). We believe that the suggested fiber-shaped organic synapse could be utilized as one of the key electronic components toward future wearable intelligent device applications.

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Keywords:

organic synapse, flexible synapse, ferroelectric organic electronic

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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반도체와 금속사이의 산화물에서 하이브리드 플라즈몬의 전파

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Abstract:
We studied the propagation of hybrid plasmon modes at metal/oxide/semiconductor interface. Optical pumping on indium phosphide substrate at various temperatures show increased plasmon propagation, which is originated from semiconductor gain. In contrast to the photoluminescence efficiency, the plasmonic propagation losses are almost temperature-independent. Scattering caused by the metal film's polycrystalline morphology may be the main reason for plasmon propagation loss and its temperature-insensitiveness.

Keywords:
Gain mediated plasmon, Hybrid plasmon

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P2-as.001*

SPIce Hole Camera System to Measure Antarctic Ice Properties at the IceCube Neutrino Observatory

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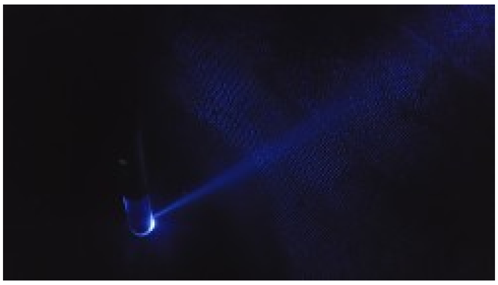
Abstract:

IceCube is a cubic-kilometer scale neutrino telescope located at the geographic South Pole. IceCube utilizes the extremely transparent Antarctic ice as a medium for detecting Cherenkov light produced by neutrino interactions in the detector volume. Last year, the IceCube collaboration reported a high-energy neutrino event which is coincident in direction and time with the flaring gamma-ray blazar TXS 0506+056. Identification of such events critically relies on inaccurate knowledge of the ice. While the ice properties are well understood through intense calibration efforts, there are still many remaining uncertainties associated with the refrozen ice in the IceCube drill holes and through anisotropies in the light propagation. An improved understanding of the ice properties is expected to lead to a reduction in systematic uncertainties of present analyses and allow better pointing of neutrino events, critical for multi-messenger science. In this poster, a self-contained camera system and result will be presented, which surveyed a South Pole Ice Core (SPIce core) hole one km from the IceCube detector, down to a depth of 1.7km. The system has collected image data from the Antarctic ice in January 2019. Preliminary results will be presented that show that the ice properties can be measured using the novel calibration system.



Keywords:
IceCube Neutrino Observatory, Ice Properties, CMOS Camera, South Pole Ice Core, Self-Contained Camera System

P2-as.002*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Expectation of Telescope Array x 4 (TAx4) : Telescope Array expansion for Ultra high energy cosmic-ray research

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Abstract:
Telescope-Array is designed to observe air showers induced by ultra-high-energy cosmic ray using a combination of ground array and air-fluorescence techniques. The Telescope Array observatory is a hybrid detector system consisting of both an array of scintillation surface detectors (SD) which measure the distribution of charged particles at the Earth's surface, and fluorescence stations which observe the night sky above the SD array. One lobe will extend north-northeast from the existing array; the other south-southeast. In this poster I will explain about cosmic-ray, telescope array and expectation of Telescope Array expansion (TAx4).

Keywords:
Astrophysics, TelescopeArray, TA, TAx4, Cosmic-ray, UHECR

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P2-as.003*

Performance of new Surface Detectors for TAx4 project.

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Abstract:
TAx4 project is extension project of Telescope Array (TA) project. Purpose of TAx4 project is observing Ultra high energy cosmic rays (UHECRs) which have energy greater than 5.7x10^19eV with hybrid event using Surface Detectors (SDs) and Fluorescence Detectors (FDs). In TA project, 507 of SDs are spaced with 1.2km square grid for observing air shower produced by UHECRs. At TAx4 project, we built new 260 surface detectors and deployed with 2.08km spacing on Utah, USA. 260 SDs are successfully deployed on each area and expected to get more events of UHECRs. All of SDs are has good quality for our goals, we report the result of 260 SDs performance by muon test.

Keywords:
Astrophysics, Ultra High Energy Cosmic Ray, UHECR, Telescope Array, TA, TAx4, Cosmic Ray

P2-at.001

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Measurements of absorption cross sections in the nonionizing region by double ion chamber method

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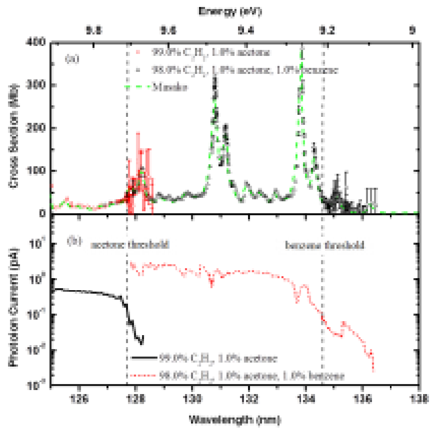
Abstract:

There are two widely used methods for measuring the photoabsorption cross sections of atoms molecules in the vacuum ultraviolet (VUV) region. The one is the absorbency measurement method in which the intensities of the radiation incident upon and transmitted by a gas cell are compared. The other is the double-ion chamber (DIC) method that the photoion currents of two sections in the pass-length are monitored to extract the absorption cross sections. Though the error of the absorbency measurement is generally larger than that of the DIC method, it used to be the only method in the non-ionizing wavelength. In this study, we introduce a method to extend the wavelength region of the DIC measurements beyond the ionization threshold by using the photoion currents from the impurities in the sample gas. This new method enables to extend the measurement as far as substantial amount of photoions is produced from the impurities in the sample gas. To verify this method, the cross sections of C_2H_2 (λ_{th} = 108.8 nm) have been measured from 105 to 137 nm. The natural impurity, acetone (λ_{th} = 127.8 nm), contained 1% in the high purity grade acetylene gas, made possible to measure in the non-ionizing region up to the threshold. Adding 1% of benzene (λ_{th} = 134.6 nm) in the sample gas enabled the extention of the measurement range even further to 134.5 nm. The present measurements are in good agreement with the previous measurements of Suto and Lee.[i]



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Keywords:
double ion chamber, DIC, absorption cross section, photoabsorption, photoionization, vacuum ultraviolet, C2H2, acetone, benzene, impurity, acetylene

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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P2-at.002

자화(磁化) 전자빔을 이용한 원자 및 분자의 총산란단면적 측정

편해욱[1, 2], 김대철[1], 김용현[1], 최영락[1], 박연수[1], 송미영*[1], 김영우[1], 윤정식[1], 조혁[2], SULLIVAN J P[3], BUCKMAN S J[3]

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Abstract:
전자-분자의 상호작용 및 총산란단면적(Total Cross Section, TCS)값은 플라즈마의 이해와 거동을 모델링하는데 중요하다. 본 연구에 사용된 전자충돌실험장치는 Surko 그룹의 양전자 실험장치 개념을 이용하여 양전자 대신 전자를 사용하는 장치로 개발되었다. 전자충돌실험장치는 아르곤(Argon, Ar) 가스의 TCS를 측정하여 성능을 검증하였고, 전자-분자의 TCS 측정을 위해 대기 온난화와 플라즈마공정에 중요한 아산화질소(Nitrous Oxide, N2O)가스를 사용하였다. 기존의 다른 그룹들이 측정한 N2O가스의 TCS값은 5 ~ 50 eV 에너지 영역에서 불일치를 보였고, 이에 따라 본 연구에서 측정한 N2O가스의 TCS값을 제시한다.

Keywords:
총산란단면적, 전자충돌, 전자-분자 총산란단면적, 자화 전자빔, 전자빔, 산란단면적

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Radio-photoluminescence of Silver-doped Phosphate Glass

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Abstract:

Commercial silver-doped phosphate glass is a promising solid-state radio-photoluminescent (RPL) dosimeter. It has several promising characteristics such as RPL intensity linearity with the ionizing irradiation dose, data accumulation, no fading, and measurement repeatability. It can be used as a personal, environmental, and clinical dosimeters as well. The objective of this study was to synthesize silver-doped phosphate glass at laboratory and compare its RPL properties with a commercial glass GD-352M. The absorption, emission and excitation properties of homemade and commercial glasses were measured before and after X-ray irradiations.Intense yellow emission peak at 650 nm and two excitation peaks at 320 and 345 nm were measured for homemade glass after X-ray irradiation. Radiative lifetime of homemade glass had two decay components for yellow RPL. A more comprehensive comparison will be conducted to investigate RPL properties of the homemade silver-doped phosphate glass.

Keywords:

Dosimeter, Radiative lifetime, Radio-photoluminescence, X-ray irradiation

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P2-at.004

Imaging hot spots in nanostructures using a photoemission electron microscope

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Abstract:
We investigate the field enhancement effect near a few 100 nm gold nanostructures exposed to a strong laser field. The formation of a surface plasmon on the structures is analyzed using the finite difference time domain (FDTD) method. A highly localized and enhanced near-field at the edge of the nanostructure is examined. A photoemission electron microscope (PEEM) is used to image photoelectrons liberated from the surface of nanostructures. Although the photon energy of the laser beam does not exceed the work function of the sample, electrons can be emitted from the sample through the multiphoton photoemission (MPPE) process in a hot spot which is an area for highly enhanced and localized field in the nanometer scale. We found that the distribution of hot spots varies depending on the polarization direction of the laser field due to the oscillation of electrons along the polarization direction. The image of the hot spots provides information on the fabrication quality of the nanostructures.

Keywords:
Plasmon, Photoelectron, Ultrafast optics, Finite difference time domain,

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Phase retrieval of above-threshold-ionization spectra near cutoff using an analytic model

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Abstract:

Above-threshold-ionized (ATI) electrons exhibit a characteristic energy spectrum with pronounced ATI peaks and a plateau [1]. The ATI peaks appear due to the interference of electron wavepackets freed at different cycles of the driving laser field. The ATI peaks are separated by the photon energy of a driving laser field. The plateau is formed due to the broad energy range of the electron wavepacket rescattered from the parent ion [2]. The shape of the ATI spectrum may provide information both on the target system and the driving laser field.

When an atom is exposed to a few cycle laser pulse, ionization occurs within a few half-cycles. The energy spectrum of the ATI electron may exhibits a continuum spectrum or ATI peaks depending on the carrier-enveolope phase of the laser field. The continuum spectrum appears if only one electron wavepacket contributes to the spectrum. The ATI peaks appear due to the interference of multiple electron wavepackets. In this work, we show that the phase of the interference near the cutoff energy can be retrieved by using an analytic model [4]. We fit the photoelectron energy spectrum obtained by solving the time-dependent Schrödinger equation (TDSE) in three dimension to retrieve the relative phase between two quantum paths of electron wavepackets back-rescattered at two different cycles. These phase information would provide information on the rescattering dynamics in the strong laser field.

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Keywords:
above-threshold ionization, phase retrieval, analytic model

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Spectral profiles of electromagnetically induced absorption depending on magnetic field in Rb atoms

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Abstract:

We present EIA spectral profiles depending on magnetic field with a strong pump and weak probe beams resonant on F_g=3 ----> F_e=4 hyperfine transitions of ^{85}Rb atoms at room temperature. The pump and probe lasers with orthogonal linear polarizations and 2.8 mW and 15 μW, respectively are prepared with a single laser with two AOMs. The broad EIA spectral profiles with the linewidth of ~ 1 MHz are varied to narrow EIA spectral profiles with respect to the variations of the magnetic fields from 0 to 1.7 mGauss. Comparisons of the experimental and calculated spectral profiles obtained by solving time-dependent density-matrix equations including the optical, Zeeman coherences, and magnetic fields will be discussed.

Keywords:

Rubidium atom, EIA, magnetic field

P2-at.007

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Spin-density wave propagation speed measurement in a spinor Bose-Einstein condensate

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Abstract:

We measure the speed of spin-density waves in a spin-1 antiferromagnetic spinor Bose-Einstein condensate(BEC) of ^{23}Na atoms. We perturb spin-density wave using a spin-dependent obstacle beam whose frequency is tuned between the D_1 and D_2 transitions of Na atom and it is attractive for the $m=1$ spin component and repulsive for the $m=-1$ component. By turning off the laser beam focused on the center of the condensate, we create a magnetization pulse wave that is a composite of a density dip of the $m=-1$ component and a density bump of $m=1$, and we measure its propagation speed in the condensate. We excite a mass-density wave in a similar manner with a spin-independent 532 nm laser and we compare their speeds. We find the propagation speed of a spin-density wave is about 20% of that of mass-density wave, which implies that the spin-dependent interaction coefficient for the Na atom in $F=1$ state is twice larger than the conventional value from [PRL 99, 070403 (2007)].

Keywords:
spinor Bose-Einstein condensate, superfluidity, sound propagation

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P2-at.008

Universal defect formation dynamics in a strongly interacting Fermi gas

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Abstract:

Systems of different microscopic origins exhibit universal properties near a continuous phase transition if they share generic features such as their underlying symmetries and dimensionality. Here, we report the observation of the Kibble-Zurek universality in a strongly interacting Fermi gas. In the Kibble-Zurek mechanism, when a system is linearly quenched across the critical point, the spontaneous creation of topological defects reveals the universal nature of the critical dynamics through a scaling exponent that governs the power-law dependence of the defect density on the quench rate. By linearly quenching the temperature of a strongly interacting gas of ^{6}Li atoms in an oblate harmonic trap across its superfluid phase transition, we create as many as 50 vortices in the sample and demonstrate the power-law scaling of their density with respect to the quench rate. When the microscopic nature of superfluidity is tuned from bosonic to fermionic across the BEC-BCS crossover, the scaling exponent remains constant at a value that is consistent with the prediction of the inhomogeneous KZ mechanism for a harmonically trapped BEC, revealing the underlying $U(1)$ gauge symmetry of the system. However, as the quench rate is increased, we observe a stark departure from this scaling, as destructive collisions among vortices with opposite sign limit the vortex density to a value that is inversely proportional to the square of the interaction-dependent healing length of the superfluid.

Keywords:

Quantum gases, strongly interacting Fermi gases, Kibble-Zurek mechanism

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P2-at.009

Vortex shedding dynamics in a long and oblate ^{87}Rb Bose-Einstein condensate

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Abstract:

Quantum vortex whose circulation is quantized is a characteristic feature of superfluid Bose-Einstein condensate(BEC). When we drag an obstacle in the superfluid, various vortex shedding patterns are observed according to the speed of the moving obstacle [1]. Especially, regular vortex cluster shedding and its transition to turbulent flow resemble the dynamics of classical fluid.

To qualitatively characterize the universal behavior of this vortex shedding dynamics, a long and homogeneous BEC sample is required, which provides enough length for the obstacle to stir the BEC. For this purpose, we use clipped focused-Gaussian beam which makes the focus of optical dipole trap(ODT) long and flat [2]. Here we present long and oblate ^{87}Rb BEC whose length of the major axis is up to about 400um and density profile across the axis is homogeneous. And we show some preliminary images of vortex shedding patterns which are similar with previous experiments [1].

References

[1] Woo Jin Kwon, Joon Hyun Kim, Sang Won Seo and Yong-il Shin, Phys. Rev. Lett. 117, 245301 (2016).
[2] Gillen, Glen D., Christopher M. Seck, and Shekhar Guha, Optics express18.5 (2010): 4023-4040.

Keywords:

ultracold atom, Bose-Einstein condensate, quantum vortex, superfluid, turbulence

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P2-at.010*

Blueprint for a Lithium-7 Quantum Gas Microscope

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Abstract:
The quantum gas microscope, a high-resolution imaging system in optical lattices that resolves a single atom in each lattice site, provides direct access to a many-body quantum state, shedding new understandings in quantum many-body problems. In this poster, we introduce a blueprint for the single-site-resolved imaging system using Lithium-7 atoms. A high Numerical Aperture (NA=0.65) microscope will be installed under a vacuum chamber and collect few thousands of photons emitted during Raman sideband cooling process. We are aiming for observing a unity filling Mott insulating (MI) state containing 10000 atoms.

Keywords:
Quantum gas microscope, Optical lattice, Bose-Hubbard model, Raman sideband cooling

P2-at.011

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Dynamic Vibration Phase Reversal Transition in Cold Atomic Nonlinear Harmonic Oscillator

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Abstract:
We theoretically investigate the vibration phase reversal transition in a parametrically driven nonlinear harmonic oscillator displaying a discrete time-translational symmetry broken cold atomic system with the effectively pulsed bias-field. The time-evolution of the normalized atomic population difference between two vibrational stable states is characterized by the pulse duration, pulse strength, control parameter, and switching time. We observe the dependence of the phase boundary on the control parameter and the switching time. The result also shows the divergence of the relaxation time near the phase boundary. Furthermore, we analyzed the power-law behavior of the order parameter near the critical pulse strength and obtained the exponent.

Keywords:
parametrically driven nonlinear harmonic oscillator, dynamic vibration phase reversal transition

P2-at.012*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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원자 간섭계를 위한 위상 변조 레이저 시스템 개발

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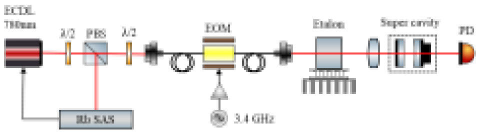
Abstract:



라만 전이를 이용하는 원자 간섭계에서는 진동수가 다른 두 개의 레이저 빛이 필요하고 이들 사이에 위상 결맞음성이 높을 수록 신호의 정밀도가 높다. 원자 간섭계에서는 통상 두 개의 레이저를 서로 광학 위상 잠금(optical phase-lock)을 하여 사용하는데 부피가 크고 진동, 온도 등 외부 환경의 변화에 취약하다. 단일 레이저를 위상 변조하여 얻은 운반자(carrier)와 측대역(sideband)을 사용하는 방법은 안정적이기는 하나 라만 전이에 사용되지 않는 진동수 성분이 광편이를 일으켜 원자 간섭계에 사용하기 적절하지 않다. 이러한 단점을 보완하는 방식으로 본 연구에서는 광학 공동(cavity)를 사용하여 두 일차 측대역 만을 남기고 운반자를 제거하여 광편이를 억제하여 원자 간섭계에 사용할 수 있는 단일 레이저 위상 변조 시스템을 구현하고자 한다.
루비듐 원자를 사용하는 원자 간섭계에 사용하기 위해 파장이 780nm, 선폭이 1 MHz 이하 인 외부공진기 반도체 레이저를 제작하고 이로부터 나온 빛을 전기광변조기를 이용하여 3.4 GHz의 진동수로 위상변조한다. 이 빛을 두께가 15 mm이고 양면에 거울 코팅이 된 FSR(Free Spectral Range)이 6.8 GHz 인 에탈론에 넣고 두 일차 측대역이 에탈론을 투과할 수 있도록 에탈론의 온도를 조정한다. 에탈론의 온도 안정화를 위해 온도 센서, 펠티어 냉각기 등이 장착된 상자를 제작하고 에탈론 코팅면의 반사율을 조정하여 투과 선폭을 넓혀 온도 조절을 통해 두 측대역 사이의 세기를 조정할 수 있도록 하였다. 에탈론을 통과한 빛의 스펙트럼을 초공진기 분광기를 이용하여 측정하여 온도에 따라 투과하는 빛의 세기가 달라짐을 확인하였다. 두 측대역 즉 서로 다른 진동수 성분의 상대적인 세기를 조절하여 라만 전이에서 광편이를 억제하는 최적의 비율이 되도록 하여 보다 정밀한 원자 간섭계를 제작할 수 있다.

Keywords:
phase-modulation, EOM, optical phase-lock, atom interferometry, etalon

P2-at.013*

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블레이드형 이온트랩을 이용한 이터븀 이온의 포획 및 트랩 특성 측정

전홍기[1], 박노준[1], 유지용[1], 제원호*[1], 권영대[2]
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Abstract:

이온트랩은 양자컴퓨터를 구현하기 위한 가장 유망한 플랫폼 중 하나이다. [1] 이온트랩을 이용해 쇼어알고리즘을 실제로 구현하거나 [2] 양자화학적 계산을 해낸바 있다. [3] 블레이드 형 이온트랩은 이온트랩의 고질적 문제인 전극의 노이즈에 의해 이온이 뜨거워지는 문제에서 상대적으로 자유로워 이온을 장기간 안정적으로 트랩 할 수 있다는 장점이 있다. [4]

우리는 이번 연구에서 실제로 블레이드 형 이온트랩을 제작해 이터븀 이온을 포획하는데 성공하였다. 또한 포획 된 이온을 이용해 트랩 진동수와 같은 향후 투 큐빗 게이트의 구현에 필요한 여러 물리량들을 측정하였다.

[1] D. DiVincenzo, *Progress of Physics*, 48 (2000)
[2] T. Monz, R. Blatt, et al., *Science*, 351 (2012)
[3] C. Hempel, C. Roos, et al., Phys. Rev. X, 8 (2018)
[4] D. Cho, T. Kim, et al., Micro and Nano Syst. Lett., 3:2 (2015)

Keywords:
Quantum Computer, Quantum Information, Atomic Physics, Ion Trap

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P2-at.014

원거리 양자 얽힘 생성을 위한 두 챔버의 자기장 보정: Rabi oscillation을 통한 자기장 측정

정준호[1], 김준기[1], 권영대[2], 정창현[1], 조동일[1], 김태현*[3]
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Abstract:

양자 얽힘 상태는 두 입자 간에 강한 상관 관계를 갖는 비고전적인 물리현상으로, 양자 컴퓨팅 및 양자 순간이동, 고밀도 코딩 등에 필수적이다. 1m 이상 떨어진 두 독립적인 챔버에 각각 포획된 이온들의 원거리 양자 얽힘 생성을 위해서는 각각의 이온에서 방출된 단일 광자들의 간섭이 필요하며, 이 때 두 광자는 모든 광학적 특성이 동일해야 한다. 이러한 광학적 정보가 동일한 광자 쌍을 생성하기 위해서는 각 이온에 작용하는 자기장의 세기가 동일해야 하므로 두 이온에 작용하는 자기장 세기를 보정하는 작업이 필요하다. 본 논문에서는 외부 자기장 변화에 따른 Zeeman shift의 변위량을 Rabi oscillation을 통해 측정하여 이온에 작용하는 자기장의 세기를 계산하고 보정함으로써 모든 광학적 특성이 동일한 광자 쌍을 생성할 수 있음을 보였다. 또한 이 과정 중에 사용된 기술은 향후 자기장 측정 센서로 활용될 수 있다.

사사:

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Keywords:
Ion trap, quantum entanglement, Zeeman shift, Rabi oscillation

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P2-at.015*

Observation of Long Coherence Time in a Superconducting Transmon Qubit

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Abstract:
The coherence time of superconducting qubit has been improved by many orders of magnitudes during last decades after its first demonstration in 1999.This improvement in the coherence was one of the key factors that have enabled implementation of a practical quantum information processing device, high fidelity gate operations, and possibility of fault-tolerant quantum computing. Here we report an observation of a coherence time over100 microseconds in our transmon qubit. The long coherence time was achieved by improvements in both device fabrication and measurement system configuration.

Keywords:
Superconducting Transmon Qubit, Coherence Time

한국물리학회
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P2-at.016*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A study on the dephasing sources in superconducting transmon qubit in Ramsey experiments

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[1]Korea Research Institute of Standards and Science, [2]Department of Applied Physics, Korea University, [3]Department of Physics, Ulsan National Institute of Science and Technology, [4]Department of Physics, Chungbuk National University, [5]Science of Measurement, UST, Korea
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Abstract:

We investigated decoherence sources in Ramsay measurement, which represents the depahsing time in superconducting transmon qubit in 3D cavity. The dephasing time is strongly influenced by the measurement environment in addition to the qubit itself. We studied the influence of the drive and readout pulses in time domain measurement. We will also discuss the trajectory measurement where the qubit state is represented on the bloch sphere. We expect the improvement of qubit operation including phase gate fidelity.

Keywords:

Superconducting Transmon Qubit, Ramsey Fringe, Dephasing time

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P2-at.017*

Study on the Efficient Readout Scheme of a Single Superconducting Transmon Qubit in dipersive regime circuit QED

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Abstract:

We present analyses and measurements of the readout scheme in a dispersive circuit QED system by varying detuning between the qubit frequency and the cavity resonant frequency. With larger detuning, the ground state frequency and the bright state frequency get closer and the transition power between them increases in the cavity transmission. This implies that the relatively strong microwave power is allowed for far-detuned qubit readout. Additional number splitting peaks are also observed in qubit spectroscopy. We will discuss the relation between the difference of the ground state and the bright state frequencies and the difference of the qubit and the cavity frequencies.

Keywords:

Superconducting Transmon Qubit, Dispersive Regime, Readout

P2-at.018*

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Bell type measurements for the phase quantification of the 1D spin-1 chain

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Abstract:
The concepts and theories in the quantum information has been recently studied in many-body systems that have been originally described by the statistical physics and the condensed matter theory. The quantum phase transitions in many-body systems are generally described by the (spontaneous) symmetry breaking, the spin-spin correlation function, and the nonanalyticity of the derivative of the ground energy. It is quite recent that the quantum entanglement is exploited to detect the quantum phase transitions and analyze other various properties of many-body physics. Not only the quantum entanglement but also any other concepts such as the fidelity, the mutual information, and the quantum coherence is utilized to study the quantum phase in many-body systems. The correlation of Bell operators has been also studied in many-body system, especially one-dimensional spin-1/2 chain. In this poster, we are going to study the Bell type measurements for the phase quantification of the 1D spin-1 chain with the on-site anisotropy. It is renowned that the 1D spin-1 chain demonstrates completely different physics from 1D spin-1/2 chains(e.g., Haldane phase). Since it is restrictive to find the exact ground state in 1D spin-1 XXZ chain, we are using various numerical approaches as like the MPS method and iDMRG method.

Keywords:
spin-1 chain, quantum phase transitions, Bell operator, CGLMP, MPS, DMRG

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P2-at.019

Semi-device-independent multiparty quantum key distribution in the asymptotic limit

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Abstract:

We present a security analysis of multiparty quantum key distribution (QKD) based on Mermin-Ardehali-Belinskiĭ-Klyshko (MABK) type multipartite nonlocality. Our analysis provides an asymptotic secret key rate of the multiparty QKD under the restriction that successive trials are completely independent. In our analysis, we construct the relation between a secret key rate of the multiparty QKD and an expectation value of MABK operator. We show that side channel attacks, which can threaten the information theoretic (IT) security analysis of multiparty QKD, are prevented in our analysis. We compare secret key rates obtained by using the IT analysis, the existing fully device-independent analysis, and our analysis. It is shown that efficiency of the multiparty QKD can be improved with increasing number of authorized parties in our analysis as well.

Keywords:

Quantum cryptography, Quantum key distribution, Multipartite nonlocality, Device-independent quantum information

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P2-at.020*

Optical Honeycomb Lattice formed in a Circuit QED system with Triple-Leg Stripline Resonators

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Abstract:
Implementing photonic honeycomb lattice structures helps to understand graphene without impurity. We have theoretically implemented an optical honeycomb lattice in a circuit QED using triple-leg stripline resonators (TSR), which possesses two-fold degenerate microwave modes[1]. Recently, linear stripline resonators (LSR) have been used to build several interesting lattice structures including 2D Kagome and Lieb lattice. However, due to its structural limitations, it is hard to fabricate honeycomb lattice structures like graphene using the LSR. In contrast, our TSR can form an optical honeycomb lattice, since each resonator can be symmetrically connected to three adjacent ones. We have shown that the leg length variation inevitable in the fabrication process only leads to the second-order effect. We have theoretically obtained Dirac dispersion produced by photonic orbitals in our optical lattice structure and have compared the result with that of graphene. In addition, the position of the flat band in zigzag ribbon made of the TSRs is shifted differently from graphene in momentum space. It will help to realize the photonic lattice edge states, which have been difficult to observe due to the impurity on the edge in the case of atomic edge structure such as zigzag graphene nanoribbon.

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Keywords:
Circuit QED, Triple-Leg Stripline Resonator, Dirac material

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P2-at.021

Analytical study of electromagnetically induced transparency for a V-type three-level atomic system

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Abstract:

We perform an analytical study of susceptibility in electromagnetically induced transparency for Doppler-broadened three-level atomic system. The susceptibility is obtained in the arbitrary order in coupling Rabi frequency and in the first order in probe Rabi frequency. The susceptibility averaged over Doppler velocity distribution is decomposed into three terms: background, hole-burning, and coherence terms.

Keywords:

EIT, V-type

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P2-bp.001*

C. elegans 체간곡선의 차원축소

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Abstract:
동물은 다양한 환경과 유전형에 따라 표현형에 차이를 보인다. 우리는 모델동물 *C. elegans*를 대상으로 하여, 가장 측정이 쉬운 체간곡선을 분석하는 것만으로도 이러한 정보들을 알아내고자 한다. 이를 위해 우리는 차원축소기법을 활용하였다. 실제 체간곡선을 정확히 표현하기 위해서는 수많은 변수가 필요하지만, 모든 차원을 다 활용하지 않아도 충분히 좋은 결과를 얻을 수 있었다.
*C. elegans*의 경우 4가지의 주요 구성요소를 사용하여 체간곡선 변동의 대부분을 설명할 수 있다. 완전 자동화 방식으로 진행된 선행연구와 달리 인간에 의한 수동분석에서 발생하는 오차가 얼마나 중요한지 알아보았고, 이 방법으로 야생형 동물과 스트레스를 받은 야생형, 그리고 유전형이 다른 동물의 체간곡선에서 정량적인 차이를 확인하였다. 육안으로는 구분하기 힘든 약한 차이도 이 기법을 통해서 객관적으로 비교 분석할 수 있다.

Keywords:
Dimensional Reduction, Spline Curve

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P2-bp.002

Assessment of active vesicle membrane fluctuations

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Abstract:
Non-equilibrium fluctuations of giant unilamellar vesicles (GUV) are detected using laser interferometry. Protein driven active membrane fluctuations are resolved with exceptional resolution in a broad frequency range (0.1 Hz - 1000 Hz) and sub-nm resolution. This yields a deeper assessment into the non-equilibrium mechanics of GUV membranes.
*Korean Institute for Basic Science, project code IBS-R020-D1

Keywords:
Membrane, giant unilamellar vesicle, membrane fluctuation

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P2-bp.003*

Ternary representation of M (M = 1 or 2)-input and 1-output algorithmic assembly demonstrated by DNA

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Abstract:

DNA is good for molecular computation because of high energy efficiency, large information density, and parallel computing capability. Although logic implementation using DNA molecules is well established in a binary system (*i.e.*, corresponding base value of 2) by decoration of hairpin structures on DNA duplexes, systems with base values larger than 2 (such as 3 and 4 which correspond to ternary and quaternary) are rarely discussed due to the complexity of design and experimental difficulties with DNA. Here, we construct DNA lattices which demonstrate 1-input/1-output and 2-input/1-output algorithmic assemblies by the ternary bases using hairpins with different lengths. The total number of possible algorithmic patterns in ternary representation is given by (27^M) where M indicates input number in a M-input/1-output logic gate. For instance, total number of output patterns produced by 1-input/1-output and 2-input/1-output algorithmic assemblies in a ternary representation are 27 ($=3^3$) and 19,638 ($=3^9$), respectively. We demonstrate DNA algorithmic output patterns (*e.g.*, line-like and triangle shaped-embedded) generated by four (two) different rules among 27 (19,638) rules in a 1-input/1-output (2-input/1-output) logic gate. DNA algorithmic assembled patterns are visualized by atomic force microscopy and errors during the growth of patterns are analyzed. Our method can be extended easily to the system having base values lager than 3.

Keywords:

DNA, Algorithmic assembly, Ternary representation, Algorithm

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P2-bp.004*

One-dimensional random walk demonstrated by DNA algorithmic self-assembly

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Abstract:

Recently, researchers start to develop efficient logic implementation methodology into DNA base sequences in order to demonstrate feasibility to construct powerful DNA-based computers. In light of this, algorithmic DNA lattices produced by predefined rules such as COPY, NOT, and XOR are constructed and discussed in previous literatures. When initial input values are given, patterns of them are predictable. In contrast, the trace of random walk (which is implemented rule of the random, *i.e.*, equally probable to go to either left or right in 1D case) is unpredictable and this is not demonstrated experimentally by DNA yet. Here, we design random-rule-implemented DNA tiles and grow DNA lattices containing trace of random walk comprised of DNA rule tiles in order to demonstrate 1D random walk. 1D random walk patterns on DNA lattices are visualized by an AFM. In addition, displacement, mean square displacement, and error rate of random walk patterns are analyzed based upon measured AFM images.

Keywords:

DNA, random, self-assembly, algorithm

P2-bp.005

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Changes of cellular elasticity in human dermal fibroblasts induced by electrical stimulation

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Abstract:

Cellular elasticity has been suggested as an indicator of health and aging in humans, because it strongly correlates with the biological functions of a single cell, including proliferation, differentiation, and migration. The elasticity of a single cell naturally decreases with age whereas abnormal changes in cellular elasticity can cause the breakdown of physiological functions, thus giving rise to disease states such as cancer, vascular disease, myocardial infarction, and Alzheimer's disease. Therefore, various studies are underway to elucidate the mechanisms underlying the changes in cellular elasticity.

In our study, the elasticity of human dermal fibroblasts in response to electrical stimulation was investigated. Cell elasticity was increased by electrical stimulation applied in real time, but elasticity decreased, or returned to the initial level, thereafter. The underlying mechanism could be a Ca2+-sensitive actin filament recycling process, in which gelsolin plays a primary role. Our study also showed that cells exhibit age-dependent responses to an electric field, including changes in Ca2+, F-actin, and elasticity. The results provided insights into the mechanisms underlying the change in cellular elasticity in response to electrical stimulation.

Keywords:
Cellular elasticity, electrical stimulation, AFM

P2-bp.006

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Radiosensitivity enhancement using radiation-guided JNK inhibitor delivery system in mouse brain tumor model

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Abstract:

A primary limitation of radio-sensitizer on intracranial tumors is normal tissue toxicity. Targeted tumor treatment can potentially maximize tumor cure and minimize normal tissue toxicity. c-Jun N-terminal kinases (JNKs) regulates H2AX phosphorylation, which repairs DNA damage by radiation and its blocking can modulate radiosensitivity for tumor cells. HVGGSSV peptide was found to bind specifically to the tax-interacting protein-1 (TIP-1) receptor expressed in irradiated tumor cells. The aim of this study is to establish a drug delivery system using the radiation-targeted peptide in brain tumor mouse model and to assess effect of JNK inhibitor-incorporated nanoparticle (JIIN) on brain tumor growth delay. JIIN copolymer was conjugated to the radiation-targeted peptide to yield JIIN-HVGGSSV polypeptide.

Keywords:

Normal tissue toxicity, Radiation-targeted peptide, Mouse brain tumor model

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P2-bp.007*

Effects of the mutation during carbonic anhydrase catalysis

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Abstract:

Carbonic anhydrases are mostly zinc metalloenzymes that catalyze the reversible hydration/dehydration of CO_2/HCO_3^-. Here, we present structural study of carbonic anhydrase variant V143I (Val143 replaced by Ile) under various CO_2 pressures. Structural study on the V143I variant structures shows that entrapment product (HCO_3^-) and alteration of water molecules on the active site are driven by perturbing of CO_2 binding position.

Keywords:
carbonic anhydrase II, intermediate states, solvent network

P2-bp.008*

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Observation of unexpected bending tendency of short DNA using single molecule FRET

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Abstract:

DNA bending is known as the major factor for nucleosome formation. In order to analyze physical properties of DNA, models like freely jointed chain (FJC) or worm-like chain (WLC) were suggested. Also, these models have been appropriate well with empirical data of long DNA (~kbp) for several decades. However, recent study of extremely short DNA (<100bp) showed that DNA is much more flexible than expected by these models. To explain the inconsistency in detail, we used alternating-laser excitation confocal microscopy (ALEX-FRET) and D-shaped DNA nanostructure. Using ALEX-FRET, we could determine accurate distance in nano-scale at bending level of D-shaped DNA. As a result of the experiments, we found that bending curves about various ssDNA length, salts concentration and sequence completely are not appropriate with previous models. Every result suggested that the curvature of dsDNA is much larger than expected. Therefore, the modification of model should be required to explain these non-canonical bending tendencies of DNA oligo.

Keywords:

smFRET, DNA oligo bending

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P2-bp.009*

Integrative Approaches for Determining Structure and Dynamics of Biological Macromolecular Assemblies

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Abstract:

Biological macromolecular complexes (or biological molecular machines) are the building blocks that drive virtually all cellular and biological processes in a living cell. A mechanistic understanding of the living cell requires the characterization of thousands of its constituent biological assemblies and their mutual interactions. Proper and accurate characterization of the configuration of macromolecular components and their cellular processes provides key insights into development of new diagnostic and therapeutic tools, such as the cure for cancer, HIV, and other diseases of major worldwide concern

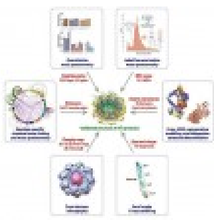

Fig 1. Integrative structure determination of the NPC

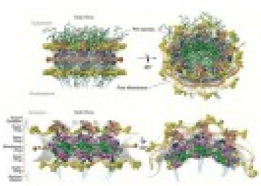

Fig 2. Structural dissection of the NPC

However, the biological macromolecular assemblies are often beyond the reach of traditional and classical structural determination due to their large size and dynamic nature, limiting our understanding of how they function, how they evolve, and how they can be modulated [1]. Thus, integrative approaches that combine a wide variety of dataset obtained using various methods (including X-ray crystallography, chemical cross-linking, mass spectrometry, Cryo-electron microscopy, small angle X-ray scattering, and Bioinformatics) have been applied to elucidate numerous macromolecular complexes [2]. Through the integrative approaches, the individual piece of data from different techniques are translated into spatial and time restraints on the conformation, localization, and relative orientation of the protein components, followed by satisfaction of all the restraints to computationally generate an ensemble of optimized structures consistent with the data. (Fig. 1) [3].

For example, the nuclear pore complex (NPC) is one of the largest biological complexes composed of 552 protein components (~50 MDa) in 8-fold symmetry [4]. The NPC acts as a gatekeeper of RNA and proteins between the cytoplasm and nucleoplasm, regulating the transport of materials across the nuclear membrane. A subnanometer precision structure for the entire 552-protein yeast NPC was determined by satisfying diverse data including stoichiometry, cryo-electron tomography map, chemical cross-links, and small angle X-ray scattering (Fig. 1-2) [4]

The integrative approaches produce ensembles of optimized structures satisfying all the input data used to construct the integrative structures themselves; it consequently adapts new techniques and methods to revise the preciseness, efficiencies, and usefulness of the integrative structural determination. Furthermore, the integrative structure allows us to rationalize the dynamical and functional details of the macromolecular complexes.

References

[1] Andrew B. Ward *et al.*, ***Science*** **339**, 913 (2013)
[2] G. C. Lander, H. R. Saibil, E. Nogales, ***Curr. Opin. Struct. Biol***. **22**, 627 (2012)
[3] F. Alber *et al.*, *Annu. Rev.* ***Biochem***. **77**, 443 (2008)
[4] S.J. Kim *et al.*, ***Nature*** **555**, 475 (2018)

Keywords:

Integrative Approaches, Biological Macromolecular Assemblies, Macromolecular complexes, Biological Molecular Machines, Nuclear Pore Complex, NPC, Ensembles of Optimized Structures

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P2-bp.011*

Comparing *in situ* and *in silico* methods for background suppression in STED nanoscopy

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Abstract:

Provided that the background noise can be theoretically calculated from the parameters in STimulated Emission Depletion (STED) nanoscopy, it is natural to imagine that in silico methods, such as deconvolution, could eliminate the background noise. Here, we would like to compare the state-of-the-art in situ background suppression technique, psSTED, with in silico deconvolution approach. α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor (AMPAR) is important membrane protein in neuron, and its density is 910±36 particles/μm2 in synaptic sites. We set a range of numbers of beads similar to the physiological cellular environment. We observed that peak-signal-to-background ratio(PSBR) of psSTED is higher at density higher than 23,620 particles/μm3 at XY cross section. At XZ cross-sectional images, PSBR of psSTED was higher at density higher than 1181 particles/μm3. At physiological cellular environment, protein density is easily higher than those numbers, hence, psSTED, in situ elimination of background noise, is a more effective tool to image protein distribution than in silico method. We show that the in situ and in silico methods can be combined to achieve superior performance over either the in situ or the in silico method alone.

Keywords:

Super-resolution microscopy, STED, Deconvolution, background suppression

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P2-bp.012*

Modeling Transcription Dynamics of β-Actin mRNA in Neurons

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Abstract:

When trying to understand cell activity, the process of mRNA transcription is very important as the beginning of protein synthesis. Larson et al. [1] determined the initiation and elongation rates of the transcription of mRNA in the yeast gene at the transcription site (TS) of living cells using correlation analysis. After fitting the autocorrelation curve of the fluorescence intensity fluctuation from the TS, the initiation and elongation rates were measured simultaneously. In addition, we simulated the β-actin mRNA transcription model using simple computational methods to determine the contribution of the three stages of transcription, i.e., the initiation, elongation and termination rates. Based on this outcome, we compared the results of a simulation and actual observations through experiments involving mammalian cells.

1. Larson DR, Zenklusen D, Wu B, et al. Real-time observation of transcription initiation and elongation on an endogenous yeast gene. Science. 2011;332(6028):475-478.

Keywords:

Biological Physics, Cell, Transcription

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P2-bp.013*

Single-molecule analysis of Arc mRNA transport in live neurons

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Abstract:
Activity-regulated cytoskeleton-associated protein (Arc) plays a crucial role in long-term memory formation. In neurons, stimulation induces Arc transcription in the nucleus within a few minutes, and mRNAs are exported and locally translated in specific regions of dendrites. To explain the mechanism of mRNA localization, we investigate the transport dynamics of single Arc mRNA molecules in neurons, which are based on two phases: the motor-involved ballistic run and static localization of mRNAs. This work is expected to give insight into the mechanism of the regulation of memory-related gene expression, suggesting theoretical predictions of mRNA transport in neuronal cells.

Keywords:
mRNA localization, mRNA transport, long-term memory formation, Activity-regulated cytoskeleton-associated protein (Arc)

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P2-bp.014*

Formation of Arc mRNA granules in P-bodies

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Abstract:

Structural plasticity is essential for the maintenance of memory. Arc mRNA travels long distances along dendrites of neurons for localized translation at their destinations to modify strength of synapses nearby. However, it is not well known whether these mRNAs are moving in the state of a single Arc mRNA or in the granular state of multiple Arc mRNAs. Here, we investigated the density of Arc mRNA in neuronal mRNP particles and found that multiple Arc mRNAs tend to form a granule and move together as their density increases. Liquid-liquid phase separation involving the interaction between proteins with intrinsically disordered region (IDR) is known to play a key role in the formation of membrane-less organelles. By simultaneous detection of Arc mRNAs and diverse IDR containing proteins, we found that Dcp1a, which is a marker of the Processing body (P-body), co-localizes with Arc mRNA granules. We are currently investigating the mechanism of Arc mRNA granule formation and its role in structural plasticity.

Keywords:

granule, liquid-liquid phase separation, mRNA

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P2-bp.015*

Single mRNA imaging with CRISPR-Cas13

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Abstract:

Single-molecule imaging has been a useful technique to investigate the regulation of mRNA inside a cell. However, most of the current techniques for single mRNA imaging require either fixation of the cell or insertion of the RNA tagging system. In order to visualize endogenous mRNAs without introducing any tagging sequences, we are developing a new RNA imaging method based on clustered regularly interspaced short palindromic repeats (CRISPR)-Cas13 system. CRISPR-Cas13 systems have recently emerged as a platform for RNA knockdown and editing. Using catalytically inactive variants of Cas13 (dCas13) fused to msfGFP, we are pursuing single-molecule imaging of endogenous mRNAs in living mammalian cells. As the first demonstration, we transfected dCas13-msfGFP and the guide RNA targeting the MS2 binding site (MBS) into the mouse embryonic fibroblasts (MEFs) bearing 24 repeats of MBS in β-actin mRNA. Also, we tried to develop multiple gRNA expression methods to image U2OS β-actin mRNA. By using these methods, we expect to visualize the location and dynamics of endogenous mRNA inside a living cell with minimal perturbation.

Keywords:

CRISPR, Cas13, dCasRX, single mRNA imaging

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P2-bp.017*

Mismatch recognition and removal in human cell extracts

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Abstract:

To monitor the dynamic process of DNA mismatch repair (MMR) in real time, we constructed a circular DNA substrate that contains a mismatched nucleotide and fluorescence probes. We introduced strand breaks on particular sites of DNA substrates where an MMR initiates, using a gene editing method, CRISPR/Cas9. Using single-molecule Förster resonance energy transfer (smFRET), we monitored mismatch recognition and mismatch removal by MMR components in human cell extracts. This platform will be applied to screen the MMR function of a single cell.

Keywords:

DNA mismatch repair (MMR), cell extract, single cell

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P2-bp.018*

Single-molecule fluorescence imaging of MLH endonuclease

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Abstract:

Human mismatch repair is activated by MutS homologs (MSH) and MutL homologs (MLH). MSH recognizes mismatched nucleotides and forms stable sliding clamps. MLH authorizes strand-specific endonuclease starting at a distant 3′- or 5′-DNA scission for which PCNA triggers MLH. However, the mechanism of 3′-MMR excision reaction has been poorly understood. To visualize 3′-MMR excision reaction, we developed a real-time single-molecule fluorescence imaging method to confirm the endonuclease activity by MLH. We showed that MLH endonuclease functions the elimination of DNA strand in the 3′-MMR excision reaction.

Keywords:

MMR(mismatch repair), fluorescence imaging, single-molecule

P2-bp.019

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The mechanism of formation of the intercellular nanotubes: Langevin dynamics simulation on the interwound filopodia.

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Abstract:
The intercellular nanotube (INT) which is a tubular structure with diameter ~200 nm between cells for biomolecular transport and signaling evolves from filopodia contact. In previous studies, using an optical fluorescence imaging method, we have found that filopodia grown from two adjacent cells form the helical structure resulting in an actin-based bridge called a nanotube. To understand the mechanism of formation of the intercellular nanotube, we model a filopodium as a bundle of wormlike chains whose net persistence length is consistent with the value measured by our optical tweezers experiment. Using the Langevin dynamics simulation of the model, we quantitatively investigate the conformation, stability, and dynamics of the filopodia in comparison with experiment. In this study, using the simulation model, we simulated the nanotube formation by the filopodia length and the N-cadherin/catenin cluster size. From the simulation results, we propose a region of a magnitude of tension and torque applied to the filopodia to form the nanotube.

Keywords:
Filopodia, Nanotube, Lagevin dynamic simulation

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P2-bp.020*

Lateral diffusion dynamics in lipid monolayers: the molecular dynamics simulation and the stochastic modeling

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Abstract:

Over the several-decade-study of the membrane dynamics, the lateral movement of lipid molecules in the monolayer has not been well understood. Using the molecular dynamics simulation on a model pulmonary surfactant system in an air-water interface, we investigate the lateral diffusion dynamics for a phospholipid and cholesterol in planar quaternary monolayers at various thermodynamic conditions. We systematically identify dynamically distinct two phases of lipid monolayers made of the alveolar surfactants within physiologically compatible environments. Our single-particle analysis on the lipid motion reveals that the lateral diffusion of the single lipid molecules follows the stochastic motion governed by fractional Brownian motion for the monolayers in the wide range of the lipid density, in consistent to the previous finding for the lipid bilayer system [1,2]. However, it turns out that the lateral dynamics becomes transiently non-Gaussian and seemingly non-ergodic at high monolayer densities above a threshold value. At this condition, the lipid motion shows a glassy dynamics akin to that of the supercooled colloidal fluid. We also observe the collective lateral motion of lipids in which the mobile lipids form a cluster and a flow-like diffusion pattern is induced for both phases of monolayers.

[1] Phys. Rev. Lett. 109, 188103 (2012)
[2] Phys. Rev. X 6, 021006 (2016)

Keywords:
anomalous diffusion

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P2-bp.021*

Intracellular displacement of purinosomes shows a subdiffusive but directional transport dynamics

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Abstract:

Purinosome is a dynamic multi-enzyme complex of typically sub-micron size, responsible for *de novo* purine synthesis in a cytoplasm. A single-particle experimental study reported that at *in vivo* conditions, intriguingly, they tend to be colocalized with the mitochondria [1], but the mechanism of the colocalization remains elusive. Here we analyze in detail the trajectories of purinosome particles and get an insight into the mechanisms of purinosome transport and its colocalization with the mitochondria. The experimental data is investigated in terms of physical quantities such as the probability density function, mean-squared displacement, turning angle distribution, speed distribution, and the ergodicity breaking. Our study suggests that while the purinosome dynamics are mostly influenced by the embedding viscoelastic cytoplasmic fluid that brings about a non-Gaussian, anti-correlated subdiffusion, some portion exhibits a sub-ballistic superdiffusion at long times. Based on the analysis, we infer that the observed superdiffusive motion of purinosomes is a viscoelastic, directional transport resulting from the microtubule-based active transport and the interactions with an ER network. We finally suggest a speculation about the transport mechanism of how the purinosomes are arrived at the mitochondria.

[1] French, J. B. *et al., Spatial colocalization and functional link of purinosomes with mitochondria*, Science **351** , 733 (2016).

Keywords:
intracellular trafficking, purinosome, heterogeneity, subdiffusion, directionality

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P2-bp.022

Optimal search strategies: intermittent jumps, resetting, diffusion

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Abstract:

Animals looking for food or proteins in cells that search for binding sites on DNA, these are two out of many examples where the search becomes faster if mixing local diffusive search with occasional long jumps. Another strategy is so-called resetting, where the search starts over from where it begun at a constant rate. These approaches have been considered as independent strategies, but what happens if they are combined? In this paper, we study the combination of searching strategies on a single searcher, represented as particle, that is diffusing on a one dimensional finite line. Starting from a fixed initial position, the particle diffuses until it: (i) reset to a fixed resetting position with rate *s*, and (ii) relocate to a long-distant position that we draw from a distribution (exponential and power-law) with rate *r*. By varying *r* and *s*, we calculate mean first-arrival time to the target and produce phase diagrams for *r* and *s* for given pairs of initial and resetting positions. We find that short relocation jumps are helpful for target search when initial and resetting position is close to the target. On the other hand, when initial and resetting position is far from the target long relocation jumps can make the searching effective.

Keywords:

intermittent search, resetting, diffusion

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P2-bp.023

Modeling on immature dendritic cell migration

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Abstract:

We analyze microfluidic channel experiments of migratory immature dendritic cells, antigen-presenting cells of mammalian immune system. Motivated from experimental results, we propose general scheme of cellular migration based on the Levy walk. On the way to develop the model, we found that experimental protocols possibly affect to widely used observables from single particle tracking analysis. In this poster, we briefly introduce our model scheme and discuss about experimental protocols to measuring more accurate observables.

Keywords:
Biophysical modeling, cell migration, immature dendritic cell

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P2-bp.024*

The Emergent Properties from Two Different Pathways in Rho-dependent Transcription Termination

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Abstract:

Transcription termination is a vital step in the control of gene expression. Transcription termination factor Rho mediates one of the major termination mechanism. There have been many studies on the mechanism of factor Rho, since this factor Rho is both typical case for factor-dependent transcription termination and promising candidate for application in drug industry. Owing to the previous studies, we have already known the several properties of this factor, such as helicase activity, ATPase, and RNA-binding. However, we yet to know how factor Rho terminates transcription, which is still controversial topic among the scientists. To solve this problem, we propose *in vitro* single molecule fluorescence transcription termination assay, which can observe transcript spatially in single-molecule scale and temporally in seconds. Using our assay, we validated that there are two pathways in Rho-dependent transcription termination, *RNAP (RNA polymerase)-mediated only* and *RNA-mediated only*. The former means that RNAP-bound factor Rho only can cause transcription termination, but the latter represents that factor Rho's directly binds to *rut* (Rho utilizing) site in transcript. Furthermore, we confirmed that when these two pathway activate at once, termination mechanism showed the enhancement both in speed and efficiency, which can be considered emergent property. We explained this enhancement by showing the increase in the ratio of sub-mechanism, RNAP-remaining pathway. which is faster than RNAP-release pathway common in Rho-dependent termination. We expect that our results can shed light on a detailed description of Rho-dependent transcription termination.

Keywords:

FRET, Single Molecule, Factor Rho, Rho dependent termination, rut site

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P2-bp.025*

Translocation Dynamics of ATPase Chromatin Remodelers

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Abstract:
ATPase remodelers translocate DNA which binded along nucleosome. These proteins composed of multi-subunits show several distinct dynamics related to DNA. Since remodeling of nucleosomal complexes is expected to be a crucial essence in epigenetics, full mechanism is not yet decided. We introduce some ATP-dependent chromatin remodelers, concentrated on Chd1, have several physical properties when they translocate nucleosomes. Using single-molecule Fluorescence Resonance Energy Transfer, molecule level distance translocation is induced by ATP hydrolysis. Furthermore, we do an approach to chromatin remodeling mechanism.

Keywords:
Chd1, CHD, Chromatin Remodeler, FRET, Epigenetic

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P2-bp.026*

Single Molecule Studies on Co-Transcriptionally Formed R-loop

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Abstract:

R-loop is one of the abnormal structures of nucleic acid able to be formed when transcription is performed by a RNA polymerase. As a three-stranded nucleic acid structure, it constitutes two components : one DNA:RNA hybrid, and a remnant ssDNA. Since the exposed ssDNA is frail, it could be said that there are some tentative downside in respect of genome stability. This R-loop structure is, however, not a purely malign factor which should be eliminated instantly, because it has crucial functions in some biological process. Recent studies on R-loop shed the light on its positive roles like R-loop driven ATR pathway required for proper chromosome segregation. Considering its positive and negative aspects, it is important that this structure should be appropriately regulated. So, for better understanding of these regulation processes, our study has focused on observing the formation and elimination of R-loop using single-molecule FRET technique. As a result, we succeeded in observing the co-trnascriptional formation of R-loop induced by G-quadruplex and its reaction to RNase H known for an enzyme eliminating the R-loop.

Keywords:
R-loop, G-quadruplex, Single-Molecule FRET, co-transcriptional effect, RNase H

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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RNA polymerase recycling after transcription termination for reinitiation with 1D diffusion

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Abstract:

It has been unknown how transcription terminating complexes are disassembled, especially in what order. The current single-molecule fluorescence study unveils that RNA product release precedes RNA polymerase dissociation from DNA template in factor-independent termination of *Escherichia coli* RNA polymerase transcription. After releasing RNA, RNA polymerases one-dimensionally diffuse on DNA template in both upstream and downstream directions for some time and significant portion of them reinitiates transcription at nearby promoters without dissociation from DNA. The reinitiation efficiency increases with addition of a sigma factor. Because transcription termination should be defined only by release of product RNA from transcription complex, subsequent bidirectional diffusion of the recycling RNA polymerase on DNA template for reinitiation can constitute a distinctly additional stage, proposedly termed as 'recycling,' after 'termination.'

Keywords:

transcription termination, single molecule FRET, RNA polymerase

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Spatial Patterning of Benthic Macroinvertebrate Communities in River Systems Based on Ecological Informatics and Machine Learning

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Abstract:

Ecological data are highly variable due to numerous sources of noises, both externally and internally. However, ecosystems are at stake, being exposed to both natural and anthropogenic disasters and disturbances especially since last century. Objective predictions are required in community dynamics to maintain biodiversity optimally in complex ecosystems. By utilizing machine learning techniques we analysed data for benthic macroinvertebrate communities collected in the large river systems in Korea including the Nakdong river basin. Geographic self-organizing map (Geo-SOM) was used to spatially identify community compositions. The spatial areas characterized by community compositions were more narrowly defined in the city areas while the areas were broader in natural areas. Supervised self-organized map was additionally utilized to address major contributions in environment-community relationships in both clean and polluted areas. Species abundance distributions, diversity indices, and species interactions were further discussed regarding metacommunity compositions and biodiversity maintenance in benthic macroinvertebrate communities in the river systems.

Keywords:

metacommunities, community diversity, biodiversity, self-organizing map, Nakdong river

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Community Responses to Natural and Anthropogenic Disturbances Unravelled by Species Abundance Distributions and Diversity Indices

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Abstract:

Stream communities respond variably in space and time in responding to natural and anthropogenic disturbances. Objective analyses of complex community responses are required to predict and manage biodiversity in ecosystems safely and sustainably. Benthic macroinvertebrate communities in streams were collected by the Surber sampler across different levels in the Suyoung River, Busan, Republic of Korea, since 1990's. Community abundance patterns were analysed by species abundance distributions (SADs) and diversity indices. Ecological responses to natural (e.g., seasonality) and anthropogenic (e.g., pollution) environmental variability were analysed in linking with metacommunities and informatics in ecological sciences. Community structure was overall observed in SADs in least polluted sites, consisting of a small number of dominant species, intermediately abundant species and rare species. In contrast community compositions changed characteristically when exposed to disturbances, including sharp decrease in species richness, extinction of rare species and severe damage to intermediately abundant species. In recovery community patterns were also characterized by increase in the number of rare species, occurrence of indicator species and abundance of intermediate species. Community persistence, species nestedness and spatial turnover were further analysed in relation with beta diversity indices in space and time.

Keywords:

Community structure, Water quality, Ecological integrity, Aquatic ecosystems, Environmental impact

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Study of the quantum criticality in the $S = 1/2$ square-lattice antiferromagnets $Sr_2Cu(Te_{1-x}W_x)O_6$ ($x = 0.05$ and 0.1)

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Abstract:

A square-lattice Heisenberg J_1- J_2 model harbors various exotic quantum phases including ferromagnetic, Néel, and columnar antiferromagnetic orders by controlling the ratio J_2/J_1. The B-site ordered double perovskites $Sr_2Cu(Te_{1-x}W_x)O_6$ with tetragonal $I4/m$ structure are regarded as an optimal realization of the $S = 1/2$ square-lattice Heisenberg J_1- J_2 model [1-4]. By varying the B'' cations between Te^{6+} and W^{6+} ions, $Sr_2Cu(Te_{1-x}W_x)O_6$ compounds exhibit the Néel order ($x = 0$), columnar antiferromagnetic order ($x = 1$), and quantum spin liquid ($x = 0.5$) [1].
In this presentation, we focus on the $Sr_2Cu(Te_{1-x}W_x)O_6$ ($x = 0.05$ and 0.1) which are located in the Néel ordered and quantum spin-liquid side, respectively. The magnetic susceptibility $\chi(T)$ of $x = 0.05$ and 0.1 exhibits a broad hump around 70 K, indicative of the short-range magnetic correlations. From fitting $\chi(T)$ to the Curie-Weiss law, the Curie-Weiss temperatures are estimated to about -90 K, suggesting the dominant antiferromagnetic exchange interaction. The magnetization curve of both compounds shows a gradual, nonlinear increase without saturation up to 55 T. For $x = 0.05$, $\chi(T)$ shows a small kink at 18 K, where the ZF muon relaxation rate λ(T) displays a weak anomaly. Obviously, this evidences the occurrence of the long-range magnetic order. On cooling from 18 K down to 4 K,λ(T) exhibits a steep increase without forming a sharp peak. This feature points to persisting spin fluctuations in the ordered state. λ(T) of the $x = 0.1$ compound displays persistent spin dynamics for temperatures below 1 K, reminiscent of a quantum spin liquid.

References
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Keywords:
Quantum spin liquid, muon spin relaxation, square-lattice J1-J2 model

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P2-co.102*

AC magnetic field sensing with diamond NV center using dynamical decoupling technique

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Abstract:

Diamond Nitrogen-Vacancy (NV) center has been introduced as an effective system for quantum sensing including magnetometry. It has high spatial resolution (~10 nm) and high magnetic field sensitivity (< 1 nT/Hz$^{1/2}$); while the maximum sensitivity that can be achieved is limited by the coherence time, which can be enhanced with introducing dynamical decoupling technique.

Here, we demonstrate ac magnetic field sensing with various pulse sequences including Hahn echo, CPMG and XY8. This sensing technique is also utilized to nuclear spin sensing and can be further improved toward manipulation of single nuclear spin or nano-MRI.

Keywords:

Diamond, nitrogen vacancy center, NV center, NV, spin echo, Hahn echo, dynamical decoupling

First Principles Study of Complex Magnetism of Quasi-one-dimensional Ferrimagnetic Insulator β-$V_2O(PO_4)$

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Abstract:

Recently, the crystal structure of the vanadium oxide phosphate V_2OPO_4, which is consisted of quasi-one-dimensional V-V chains, has been clarified experimentally. [1] This system shows a structure transition from tetragonal to monoclinic at T_s= 605 K and a ferrimagnetic order at T_c=165 K. The structure transition, leading to the two different V−O bond lengths in the face-sharing VO_6 octahedra, accompanies the V^{2+}/V^{3+} charge ordering along the chain. In the high T tetragonal phase, the negative thermal expansion was observed due to the large amplitude transverse motions of oxygens. The neutron powder diffraction measurements show a quasi-one-dimensional ferrimagnetic spin chain order. However, the observed net moment is one third of our calculated value for the ferrimagnetic order of V^{2+}($3d^3$, S=2/3) and V^{3+} ($3d^2$, S=1). [1,2]

Using correlated band theory, we have investigated the electronic and magnetic structures of the monoclinic V_2OPO_4 which undergoes the metal-insulator transition at the critical effective on-site repulsion at $U^c_{eff} \approx 3.5$eV in our calculations. In the insulating state, the structure transition leads to the charge-ordering of $V^{2+}-V^{3+}$, regardless of magnetic ordering. Additionally, an orbital ordering of ($a_{1g}^{1\downarrow}e'_{g,1}{}^{1\downarrow}$) appears in the V^{3+} ion. Furthermore, our results suggest that the substantially reduced net moment is due to frustration of the weakly-linked pyrochlore-like V4 tetrahedral structure. This is supported by the fact that the energy differences among a few magnetic states studied here strongly depend on value of correlation strength. In this presentation, we will discuss on the origin of its charge-ordering and magnetic properties in detail.

The research was supported by NRF of Korea Grant No. NRF-2016R1A2B4009579.

[Reference]
[1] E. Pachoud, J. Cumby, C. T. Lithgow, and J. P. Attfield, J. Am. Chem. Soc. 140, 636 (2018)
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Keywords:
ferrimagnetic spin chain, vanadium oxide phosphate, correlated band theory

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P2-co.104

Cr이 치환된 리튬 페라이트 $Li_{0.5}FeCr_{1.5}O_4$의 연 X선 방사광 분광 연구

양민영[1], 성승호[1], 이은숙[1], 김영학[2], 노우석[2], S.M. Yusuf[3], 강정수*[1]
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Abstract:

리튬 페라이트는 주목할만한 전자기적 특성으로 인한 리튬이온 전지로의 응용가능성 때문에 이 물질에 대한 연구가 활발하다 [1]. 최근 Cr이 치환된 $Li_{0.5}Cr_xFe_{2.5-x}O_4$ 에서 자기 보상 효과 (magnetic compensation effect) 가 관찰됨이 보고된 바 있는데 [2], 특히 $Li_{0.5}FeCr_{1.5}O_4$ 의 경우 온도가 내려감에 따라 자화 (magnetization) 값이 양의 값에서 음의 값으로 바뀌었다가 다시 양의 값을 가지는 현상이 관찰되었다 [3]. 이때 자화값이 거의 0이 되는 온도를 자기 보상 온도 (magnetic compensation temperature: T_K) 라고 부른다. 그러나 $Li_{0.5}FeCr_{1.5}O_4$ 의 전자 구조에 관한 연구는 아직 부족한 실정이다. 본 연구에서는 온도 변화에 따른 연 X-선 흡수 분광법 (soft X-ray absorption spectroscopy: XAS) 과 연 X-선 자기 원편광 이색성 (soft X-ray magnetic circular dichroism: XMCD) 실험을 수행함으로써 $Li_{0.5}FeCr_{1.5}O_4$의 전자 구조의 변화를 연구하였다. 이 연구로부터 Cr 이온과 Fe이온의 원자가는 온도와 무관하게 Cr 이온은 3가 상태 (Cr^{3+})로 존재하며, Fe 이온은 3가 상태 (Fe^{3+})와 2가 상태 (Fe^{2+})가 섞여 있는 혼합원자가 상태임을 알 수 있었다. 한편 모든 온도에서 Fe 이온의 자기모멘트의 방향과 Cr 이온의 자기모멘트의 방향이 서로 반대이지만 약 $T \approx 255$ K에서 Cr 2p XMCD 와 Fe 2p XMCD 의 부호가 바뀌고, 총 자화값의 부호도 바뀌는 것을 발견하였다. 이 발표에서는 온도에 따른 XAS 와 XMCD 실험 결과에 의거하여 $Li_{0.5}Cr_xFe_{2.5-x}O_4$ 에서의 자기 보상 현상의 원인에 관하여 논의할 예정이다.

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Keywords:
스피넬 산화물, Negative magnetization, 연 X-선 흡수 분광법, 연 X-선 자기원편광 이색성

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P2-co.105

Probing Dirac magnons in the 3D antiferromagnetic Cu3TeO6

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Abstract:
Recently, the three-dimensional spin web compound Cu_3TeO_6 has attracted much attention as it realizes a Dirac magnon model. This sample constitutes an almost coplanar hexagon formed by six Cu^{2+} spins; each of them is vertex-shared by two hexagons. A recent inelastic neutron scattering study unravels Dirac crossing points and nodal rings in bulk [1]. In order to characterize the Dirac magnons, we performed the high-field and -frequency ESR measurements. We observed multiple antiferromagnetic resonances (AFMR) stemming from a dozen of magnon modes. The temperature dependence of the AFMR mode measured at ν = 90 GHz showed a steep increase of its linewidth as the temperature increases. The anomalous temperature dependence of the AFMR cannot be captured within the conventional mechanism, indicative of a possible influence of Dirac statistics on its lifetime.

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Keywords:
Dirac magnon, Electron spin resonance, spin web lattice

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고온초전도체와 거대자기저항-스핀밸브 다층박막의 반강자성체 NiO층 두께와 전류전달량에 따른 반전된 자기저항특성

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Abstract:

반강자성체 NiO 기반 GMR-SV(giant magnetoresistance-spin valve) 다층박막을 rf와 dc 마그네트론 스퍼터링 시스템을 이용하여 고온초전도체 YBCO 박막 위에 제작하였다. 전형적인 GMR-SV 박막과 초전도체 특성을 갖는 YBCO 박막이 하이브리드형 다층구조로 형성된 시료에 대해 상온에서와 임계온도 이하인 77 K에서 2단자, 3단자, 4단자법으로 전류값을 1 mA에서 20 mA까지 증가시켜 측정된 자기저항곡선들을 서로 비교하였다. 또한 YBCO와 자성체 GMR-SV 사이 틈층(gap layer, GL)인 NiO층의 최적인 두께가 존재하여 이에 따른 터널저항과 위 금속층의 면저항의 값들의 최적화가 전류전달효과를 나타내는 영역한계 (boundary limit, BL)를 결정하였다. GMR-SV의 박막의 저항과 GL층의 저항 값에 따라 전류흐름이 결정지어지는 등가회로의 전류-전압 공식을 시뮬레이션 결과 ±수십~수백%이상의 최대 MR비 특성과 4%/Oe 이상의 자장감응도(MS)을 가질 수 있는 GL과 GMR-SV 다층박막의 저항의 최적화 조건을 박막 제조시 적용할 수 있을 보였다. 이로써 예측되는 새로운 초거대자기저항 특성을 자기정보저장 및 초고감도 바이오 융합소자 개발의 근거를 제시할 수 있다.

감사의 글: 이 논문은 교육부의 재원으로 한국연구재단(NRF)의 기초연구 사업 지원을 받아 수행된 연구(No. NRF-2016R1D1A1B03936289)의 결과입니다.

Keywords:

전류전달효과, 틈층, 하이브리드형, YBCO, 영역한계, 등가회로, 초거대자기저항, 자장감응도

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P2-co.107*

Influence of Mn vacancy in Magnetic Properties of Tetragonal DO_{22}-Mn_3 Ga

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Abstract:

The electronic structure and magnetic properties of binary Heusler compound Mn_3 Ga are investigated using first-principles calculations. Mn_3 Ga crystallizes in tetragonal DO_{22} structure, which exhibits ferrimagnetic ordering, where two inequivalent Mn sites, octahedral and tetrahedral ones denote as Mn-I and Mn-II, respectively, have different moments. It found that magnetic moments of two Mn We sites are -2.879 and 2.331 μ_B, the total magnetic moment of 1.724 μ_B, which is consistent with other work [1]. Furthermore, the tetragonal phase of Mn_{3-x}Ga series is also investigated, with varying from 0 to 1.0. Mn atoms were removed in either Mn-I or Mn-II sites, which show contrary magnetic behaviors. In this study, we have investigated the effect of Mn on the crystallinity of Mn_{3-x} Ga compound.

Keyword: Heusler compound, binary Heusler compound, tetragonal DO_{22} structure.

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Keywords:
Heusler compound, binary Heusler compound, tetragonal DO 22 structure.

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P2-co.108

Investigation of magnetic and dielectric properties in Lu_2NiMnO_6 and $Lu_{1.8}Sc_{0.2}NiMnO_6$

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Abstract:
Double-perovskite R_2NiMnO_6 compounds (R: rare-earths) were broadly studied because of various intriguing functional properties such as large magnetocaloric effect in Gd_2NiMnO_6[1] and strong magnetoelectric coupling effect in In_2NiMnO_6[2]. We have synthesized polycrystalline Lu_2NiMnO_6 and $Lu_{1.8}Sc_{0.2}NiMnO_6$, and investigated their magnetic and dielectric properties. Both of compounds crystallize in a double-perovskite structure with monoclinic $P2_1/n$ space group and show the long-range ferromagnetic order below ~ 40 K. The detailed variations of physical properties driven by Sc substitution were studied by the magnetic-field dependence of magnetic and dielectric properties at various temperatures.

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Keywords:
double perovskite, ferromagnet

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P2-co.109*

Magnetic properties of disordered perovskites $RCr_{0.5}Fe_{0.5}O_3$ (R = Gd, Ho, Er, and Lu)

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Abstract:
We have synthesized both of poly- and single-crystalline $RCr_{0.5}Fe_{0.5}O_3$ (R = Gd, Ho, Er, and Lu). The compounds crystallize in an orthorhombic perovskite with *Pbnm* structure in which Cr^{3+} and Fe^{3+} ions in octahedral units are randomly distributed due to the similar ionic radii of both transition-metals ions. From our investigation of magnetic properties in disordered perovskites, we found that the coexistence of various magnetic interactions resulting from disordered transition-metal ions leads to intricate temperature and magnetic-field dependences of magnetization.

Keywords:
perovskites, magnetic property, polycrystalline, single crystals, oxide

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P2-co.110*

The local enhancement of the spin wave induced by a pulsed-magnetic field in the multiple magnetic domain state

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Abstract:
Spin-wave or its quantum, magnon, is studied with renewed interest as a basis for wave-based classic information processing without using an electric charge. Our focus in this study is to investigate self-localization and local enhancement of the spin wave induced by global excitation with a pulsed magnetic field in the magnetic multi-domain state of ferromagnetic systems. We used micro-magnetic simulation to analyze these phenomena in ferromagnetic systems. After applying an oscillating pulsed-excitation field on the multi-domain state, we observed that the amplitudes of the excited spin wave were locally enhanced near the domain wall, and then the excited spin waves were spatially focused to the central area between domain walls. These behaviors are reminiscent of the self-localization phenomenon of the spin wave which is often observed when the magnetic system has the inhomogeneous internal magnetic field such as confined magnetic structures. In this context, we are going to discuss the origins of the self-localization and local enhancement of the excited spin waves in the multi-domain state and to compare them with the case for the single magnetic domain state.

Keywords:
Spin wave, Magnetic domain, Micromagnetic simulation

P2-co.111

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Ferromagnetic Interactions in Al-incorporated ZnO:Mn Diluted Magnetic Semiconductors

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Abstract:

We have employed electron paramagnetic resonance (EPR) spectroscopy and magnetization measurements in order to study the effect of Al-incorporation on the magnetic interactions in ZnO:Mn diluted magnetic semiconductors. Our experimental results manifested that Al atoms incorporated in the system act to break the antiferromagnetic pairs and to promote the formation of ferromagnetic Mn-e_D^--Mn pairs. Al atoms donating shallow donor electrons (e_D^-) were clearly observed by a narrow EPR line, which is correlated with a broad EPR line arising from unpaired paramagnetic Mn^{2+} ions.

(This work was supported by the KOMAC operation fund of KAERI by Ministry of Science ICT and Future Planning of Korean Government.)

Keywords:
diluted magnetic semiconductors, electron paramagnetic resonance, (Mn, Al)-doped ZnO

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Manipulation of Three-Dimensional Magnetic Domain Wall Structure

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Abstract:

To harness the magnetic textures such as skrymions and vortices in future spintronic devices, it is essential to understand the three-dimensional (3D) magnetic configurations and their topological properties [1-2] which can provide not only the detailed mechanisms of the magnetic texture switching but also an efficient method of the texture state control. One of the typical 3D magnetic configuration is the asymmetric Bloch wall (ABW) which forms at the center of the 180 degree DW of the elongated Landau domain structure in a rectangular patterned thin ferromagnetic film [3-6]. The Landau domain structure consists of two vortex configuration on the bottom and the top surfaces with oppositely shifted core position and thus, the core structure connecting two surface vortices is elongated along the thickness. At the center of this elongated core structure, the ABW is formed. Consequently, the clockwise or counter-clockwise rotating sense of the ABW is determined by the shift direction of the top and bottom surface-vortex cores. Since those two rotating sense states have exactly the same energy, they are degenerate states and they appear at the same probability. To manipulate those states, it is necessary to break the symmetry of two states. For example, asymmetric geometry was utilized for control the ABW states [7]. In this presentation, we propose an efficient way to manipulate the rotating states based on the symmetry breaking of the ABW through the external magnetic field only by using micromagnetic simulations. Furthermore, we successfully verified our method experimentally by using the magnetic transmission soft x-ray microscopy (MTXM).

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Keywords:

Spintronics, magnetic vortex, asymmetric Bloch wall, spin texture, soft X-ray imaging

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P2-co.113

반강자성체 특성을 가지는 유기-무기 혼성 층상 페로브스카이트 구조의 $(CH_3NH_3)_2MnCl_3$의 자기유전 효과 특성 연구.

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Abstract:
유기-무기 혼성이라는 특수한 조합을 가지는 Metal Organic Frameworks는 태양광전지와 강유전성, 강자성, 그리고 다강체의 가능성을 가지는 물질로서 연구되어 왔다. 그 가운데, A_2MX_4 (A= organic anion, M= metal divalent ion, X= halogen cation)의 조성은 유기물 층과 무기물 층이 교대로 쌓여 있는 특수한 구조를 가지고 있다. 그 중에서도 반강자성을 가지는 $(CH_3NH_3)_2MnCl_3$ 시료를 slow-evaporation 방법을 이용하여 제작하고, 온도에 따른 자기모멘트와, 외부 자기장에 따른 자화를 측정하여, 43 K 에서 반 강자성체 상전이가 나타나는 것을 확인하였다. 외부 자기장이 3.5 T 일 때, 자화가 급격하게 증가하는 spin-flop 효과가 나타남을 확인하고, 그리고 자기-유전효과를 측정하여 spin-flop효과에 의해서 나타나는 유전율의 변화를 통해 spin-flop효과가 층간 상호작용에 미치는 영향에 대해서 알아보았다.

Keywords:
Metal Organic Frameworks, magnetodielectric effect, antiferromagnetism

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P2-co.114*

Reexploring the magnetism of two-dimensional intrinsic magnetic materials, CrOX (X= Cl, Br) via first-principles calculations

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Abstract:

High Curie-temperature 2D intrinsic ferromagnets become spotlighted in spintronics or nanodevices with recent realization of 2D intrinsic magnetic materials [1, 2]. Many un-synthesized 2D materials are theoretically proposed as the candidates of high Curie-temperature 2D ferromagnets via first-principles calculations [3, 4, 5]. For subtle materials, the magnetic ground state predicted from density functional theory plus U (DFT+U) is sensitive to various DFT+U formalisms and interaction parameters such as U or J. We revisit the magnetism of CrOX (X= Cl, Br) which is suggested as high Curie-temperature 2D intrinsic ferromagnets. We carefully examine the magnetic ground state of both monolayer and bulk materials of CrOX (X= Cl, Br) with respect to both DFT+U formalisms, spin-unpolarized density and spin density generalized gradient approximation [6, 7]. Both Dudarev and Liechtenstein schemes are also applied to these materials. We investigate the magnetic ground states in magnetic phase diagrams within the reasonable range of U, J. Unlike previously reported results, we report that the possibilities of monolayers CrOX (X= Cl, Br) are antiferromagnetic rather than ferromagnetic.

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Keywords:
two-dimensional intrinsic magnetic materials, density functional theory, magnetism

P2-co.115*

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An ultra-high vacuum ESR spectrometer for the investigation of magnetic atoms and molecules at surfaces

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Abstract:

Magnetic atoms and molecules adsorbed on single crystal surfaces are model systems to investigate the quantum properties of matter at the smallest scale. When deposited on suitable surfaces such as MgO/Ag(100), they show relaxation times of thousands of seconds at 2.5 K [1,2]. The localization of spins at the surface, however, limits the number of techniques that can access their magnetic and coherence properties. Combining ESR with scanning tunneling microscopy allows the individual access of surface spins [3], but so far proved to effectively work only below 4 K. Here we propose a novel spectrometer operating in ultra-high vacuum that can perform ensemble-averaged electron spin resonance measurements on surface spins in a wide range of temperature (4-300 K). Using a coplanar waveguide scheme, it is possible to integrate surface preparation and in situ sample transfer to the measurement setup.

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Keywords:

Electron spin resonance, Quantum magnets, Quantum coherence, Surface magnetism

P2-co.116*

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A Restricted Prediction of Maximum Energy Product from the Magnetic Hysteresis Loop

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Abstract:

In recent years, as demand for devices using magnetic energy of permanent magnets such as electric vehicles and wind power generators has increased, researches for developing new high-efficiency and low-cost permanent magnets have been actively conducted [1-3]. The figure-of-merit of permanent magnets is the energy product which is the twice the energy stored in the stray field of the magnet. It can be obtained from the volume integral of the square of the stray field outside the magnet or from the volume integral of the dot product between the demagnetizing field, H_d and the magnetic field, B inside the magnet itself, and thus the "BH" indicates the energy product [4-5]. However, this energy product of magnets is often used without a clear understanding of its definition, even though it is a well-known basic concept for relevant industry workers and researchers. Basically, the energy product BH corresponds to the energy stored in the stray field produced by the magnet itself. Consequently, it should be measured from H_d and B at the remanent state, i.e., without any external field. Since the demagnetizing field depends on the shape of magnet, the energy product varies with the shape and thus, its maximum value (BH_{max}) can be obtained from the remanent state in the various shape of magnet. However, it has been found occasionally that the BH and BH_{max} are obtained from the BH loop, even from the MH loop. Here, we will discuss how to measure the energy product and how to predict correctly its maximum value (BH_{max}) from the hysteresis loop.

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Keywords:
Maximum energy product, Magnetic hysteresis loop, Permanent magnet, Demagnetization, Coercivity

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P2-co.117*

Structural and magnetic properties of epitaxial $ZnFe_2O_4$ films on various substrates

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Abstract:
Epitaxial $ZnFe_2O_4$ films were prepared on $SrTiO_3$(110), $MgAl_2O_4$(110), Al_2O_3(0001) and GaN(001) single crystal substrates by pulsed laser deposition. The thickness of $ZnFe_2O_4$ films were about ~45 nm and ~90 nm. Atomic force microscopy images showed that $ZnFe_2O_4$ films had a quite smooth surface. X-ray diffraction data for $ZnFe_2O_4$ suggested a successful (110) epitaxial growth on (110) $SrTiO_3$ and (110) $MgAl_2O_4$ and (111)-oriented epitaxial growth on (0001) Al_2O_3 and (001) GaN. The magnetic and electrical properties of $ZnFe_2O_4$ films were largely varied with the gas environment during deposition; insulating and antiferromagnetic properties in O_2, while conducting and ferrimagnetic properties in Ar. The magneto-optic Kerr effect (MOKE) measurement revealed that the magnetic hysteresis loops of the ferrimagnetic $ZnFe_2O_4$ films on $SrTiO_3$ and $MgAl_2O_4$ exhibited a rectangular shape and an anisotropic behavior with the direction, while $ZnFe_2O_4$ films on Al_2O_3 and GaN displayed a tilted shape and a weak anisotropic behavior. In the 90 nm thick $ZnFe_2O_4$ film on STO (110), we observed a negative magnetoresistance behavior in the in-plane hard axis direction.

Keywords:
epitaxial, ferimagnetic

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P2-co.118*

Magnetic properties of Co-doped $BaFe_{12}O_{19}$ hexferrites versus heat treatment

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Abstract:

We prepared $BaFe_{12-x}Co_xO_{19}$ (x = 0 and 1) hexaferrites using mechanical milling and heat treatment. Milling process was carried out in acetone for 10 h using the 8000D Mixer/Mill and stainless-steel vials and balls. Dried powders obtained after milling were divided into small parts and annealed in box furnaces at different temperatures (T_{an}) ranging from 800 to 1300 °C for 6 h in air. Structural analyses basing on powder XRD diffraction indicated that all Co-undoped samples (x = 0) were single phase in the P63/mmc hexagonal structure in the temperature range T_{an} = 900-1300 ^{O}C, while Co-doped samples (x = 1) were just single phase at T_{an} = 900-1100 ^{O}C. At high T_{an}, the second phase of Y-type hexaferrite appeared. For the x = 0 sample with T_{an} = 900 °C, lattice parameters a = 5.866 Å and c = 23.022 Å increased from T_{an} = 1000 °C, then decreased at T_{an} = 1300 °C. For x = 1, there was also T_{an}-dependent lattice parameters because of the second phase Y-type hexaferrite. Magnetization up to 10 kOe of external applied field was studied using a vibrating sample magnetometer (VSM). For x = 0, the maximum saturation magnetization M_s = 42.3 emu/g was achieved for T_{an} = 1200 °C while the maximum coercivity H_c = 3.66 kOe was obtained for T_{an} = 1000 °C. M_s increased with increase T_{an} due to the good formation of crystals. However, the decreasing of M_s with T_{an}˚ 1300 °C can be attributed to a small amount of formation of Y-type phase, which could not be detected by XRD. We believed that the variation of H_c depends on grain size and T_{an} = 1000 °C is the starting temperature for the formation of multi-grain. For x = 1, however, H_c was much smaller than that of x = 0 because of the substitution of Fe by Co. Similar to x = 0, M_s gradually decreased with increasing T_{an}. This may be due to the appearance of Y-type.

Keywords:
M-type hexaferrites, ball milling, crystal structure, magnetic properties

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P2-co.119

Spin-glass-like behavior of doped breathing pyrochlore $Li(In_xGa_{1-x})Cr_4O_8$ (x = 0.2 and 0.5)

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Abstract:

We performed *ac* and *dc* magnetic susceptibility, electron spin resonance (ESR), and muon spin relaxation (μSR) measurements on doped breathing pyrochlore system $Li(In_xGa_{1-x})Cr_4O_8$ (x = 0.2 and 0.5). This system realizes the alternating arrangement of small and large tetrahedra, included alternating bonds and geometrical frustrations. The magnetic phase of breathing pyrochlore is determined by “the breathing parameter $B_f = J'/J$”. By doping we elucidate the macroscopic and microscopic magnetic properties on intermediate phases of breathing pyrochlore between $B_f(\mathrm{In}) = 0.1 < B_f < B_f(\mathrm{Ga}) = 0.6$. In the different manner of the uniform pyrochlore and mother compounds, the magnetostructural phase transition is suppressed and not observed in doped compounds. The *ac* and *dc* magnetic susceptibility and μSR measurements show the magnetic transitions at T = 6 (4) K in x = 0.2 (0.5) compounds. However, the field- and frequency-dependent *ac* susceptibility shows the deviation from canonical spin-glass behavior, which χ' show the broad peaks as the magnetic field (frequency) increases. From the bandwidth of ESR, the critical exponents of the intermediate breathing pyrochlore show the values close to that of the 3D coupled spin tetrahedra $Cu_4Te_5O_{12}Cl_4$. Taken together, the modified breathing pyrochlores show the suppression of magnetostructural transition, the survival of magnetic transition, and the spin-glass-like behavior due to geometrical frustration and complex bond alternation.

Keywords:
ac and dc magnetic susceptibility, electron spin resonance, muon spin relaxation, breathing pyrochlore,

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P2-co.121*

Proximity induced bulk superconductivity in NbP/$NbSe_2$ Weyl-superconductor composites

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Abstract:

Superconductivity in Weyl semimetal is of great interest but there has been no report on bulk superconductivity on a Weyl semimetal. We observed a bulk superconductivity in a composite consisting with non-superconducting Weyl semimetal NbP and superconducting transition metal dichalcogenides $NbSe_2$ which becomes superconductors at T_c = 7.2 K with coexistence of charge density wave at T_{cdw} = 33 K. The composites $(NbP)_m$-$(NbSe_2)_n$ (m=1,2 and n=1) were synthesized by hot press sintering with molar ratios of NbP/$NbSe_2$ = 1:1 and 2:1. The electrical transport and magnetic properties show the bulk superconductivity which the superconducting transition temperature of the composite NbP/$NbSe_2$ is insensitive with the volume fraction of the NbP. We investigated that the bulk superconductivity of the composite is caused by a proximity effect. The magnetic-field-dependence of magnetization correspond a typical behavior of type II superconductor. The enhancement of the upper critical field H_{c2} and the reduction of coherence length ξ are observed in the composite. The critical current density J_c of the composite is decreased comparing with that of pristine $NbSe_2$. The flux pinning force f_p is not described well on the basis of Dew-Hughes model, which provides plausible estimation regarding a dominant pinning mechanism in the type II superconductor. We observed the asymmetric magnetic hysteresis loops occur from the *M(H)* curves, indicating the presence of surface barrier effect in a mixed bulk composite. The complex pinning mechanisms would yield the unconventional behaviors for the bulk composite system resulting from the bulk superconductivity of NbP/$NbSe_2$, induced by the proximity effect.

Keywords:

Weyl, superconductor, composite, proximity effect, critical current density, pinning force.

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P2-co.122

고온초전도 NMR 시스템 개발

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Abstract:

상용화된 범용 핵자기공명 (NMR) 장치는 주로 저온초전도 자석을 사용하고, 수소 NMR 주파수 기준으로 1 G Hz까지 개발되었다. 저온초전도 자석은 냉매를 지속적으로 유지시켜 주어야 하며, 초고자기장에서 초전도 상태를 유지할 수 없는 단점이 있다. 반면에 고온초전도 자석은 무냉매 냉각기술 적용에 유리하고 초고자기장에서도 초전도 상태를 잘 유지하므로 초고자기장으로 확장을 염두하고 고온초전도 자석을 개발하게 되었다. 자석을 고분해능 NMR에 사용하기 위해서는 NMR 프로브 주위에 자기장을 균일하게 하여야 한다. 이를 위해 경통에 테이프 형태의 강자성 물질을 고정시켜 균일도를 개선시키는 ferro-shim 과정을 수행하였고, 전류를 흘려 gradient field를 발생시키는 상온 능동 shim을 시도하는 과정을 수행하였다. 또한 자기장 유동 (field drift)을 없애기 위해 중수 NMR을 적용하는 field locking 기술을 개발 중이다.

자석뿐만 아니라 2채널 400 MHz NMR 콘솔을 개발하였다. 콘솔은 SBC, 송신보드1, 송신보드2, 수신보드, 10 MHz 클락으로 구성되어 있다. SBC는 single board computer로 제어 PC와 tcp/ip socket 통신을 한다. Embedded linux가 설치되어 있으며 콘솔의 송수신 보드를 제어한다. 2개의 송신보드는 최대 주파수 200 MHz까지 설정할 수 있으며 각각의 주파수는 rs232 통신을 통해 제어 가능하다. 송신보드는 us 단위의 펄스를 원하는 모양과 위상으로 생성 가능하며, chirp, ramp, pulse train 형태로 생성 가능하다. 400 MHz NMR 펄스는 100 MHz 근처의 펄스를 업컨버전하여 얻었고, 이를 고출력 RF 증폭기로 증폭해서 NMR 실험을 수행하였다.

Keywords:
고온초전도 자석, 핵자기공명장치

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Unconventional signatures of superconductivity in $SrTiO_3/LaAlO_3/SrTiO_3$

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Abstract:

The two dimensional Electron Gases observed at the $LaAlO_3/SrTiO_3$ (LAO/STO) exhibits superconductivity, which has phase diagram as function of carrier density like high-temperature superconductor. However, the temperature dependence of superconducting energy gap in LAO/STO follows Bardeen-Cooper-Schrieffer(BCS) theory, which means that the superconductivity in LAO/STO is conventional. Here we report the unconventional temperature dependence of superconducting energy gap in STO/LAO/STO. We have fabricated vertical Josephson junction to measure the superconducting energy gap. We estimated the superconducting energy gap from the Andreev reflection of the Josephson junction, and the temperature dependence of superconducting energy gap did not follow BCS theory from the gap ratio, $\Delta/k_B T_C$ = 1.31. Additionally, we found evidence of unconventional superconductivity from the magnetic field dependence of superconducting critical current. It has opposite hysteresis, when it was compared with the hysteresis of magnetoresistance in STO/LAO/STO.

Keywords:

superconductivity, oxide interface

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P2-co.124*

Optical study of electron-doped cuprate, $Pr_{0.85}LaCe_{0.15}CuO_{4-\delta}$

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Abstract:
Unlike the established phase diagram of electron-doped cuprates based on nominal Ce-doping levels, Song *et al.* [Phys. Rev. Lett. **118** 137001 (2017)] proposed a new phase diagram with respect to actual *n*-doping determined by angle resolved photoemission spectroscopy (ARPES). We investigated the same n-doped cuprate systems using optical spectroscopy technique. Single crystal samples were grown by a floating zone method, the doping concentrations (n = 0.11, 0.135, and 0.17) were controlled by a second annealing method. We measured reflectance spectra in a wide spectral range (60~40000 cm^{-1}) at various selected temperatures below above the superconducting transition temperatures. Using a Kramers-Kronig relation, we obtained the optical conductivity from the measured reflectance. We found that optically extracted doping levels seem to agree with those obtained by ARPES. We utilized an extended Drude mode to extract information on correlation between charge carriers. We will discuss our newly obtained optical results in this presentation.

Keywords:
cuprate, superconductivity, condensed matter physics

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P2-co.125*

Time-dependent Ginzburg-Landau equations for mesoscopic unconventional superconductors

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Abstract:
Time-dependent Ginzburg-Landau(TDGL) equations are useful tools to study the dynamics of vortices. In this poster, we aim to show the formation and its nucleation of double quantum flux (skyrmionic state) in a mesoscopic unconventional superconducting system by using TDGL equations. Also, varying external magnetic field, its magnetization and vorticities are investigated.

Keywords:
Time-dependent Ginzburg-Landau equations, vortex nucleation, double quantum flux

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P2-co.126

Analysis of magnetic properties of square-shaped GdBCO wires stacked in the vertical direction

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Abstract:

It is important to reduce the AC loss for using the application of high-temperature superconducting coated conductors. In this study, we analyzed the stacking effect which affects magnetic properties when stacking GdBCO wires in the vertical direction. The specimens cut into a square shape were stacked in the vertical direction at various intervals. The measurement was performed by using the Magnetic Property Measurement System (MPMS). We specified two temperatures lower than the critical temperature and applied the magnetic field in the perpendicular direction of the specimens. According to our investigation, at the low temperature and low maximum external field, we confirmed that the larger interval between the specimens affects the full penetration field smaller.

Keywords:

GdBCO stack superconducting wire Magnetization loss MPMS

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P2-co.127*

Magnetic field detwinning in FeTe

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Abstract:

Iron-based superconductors (IBS) has a nematic phase where rotational symmetry is spontaneously broken. The nematic phase has attracted much attention as it is believed to be closely linked to the superconductivity as in the cases of other unconventional superconductors. However, since IBS has twin domain in the nematic phase, it is hard to observe pure symmetry broken phase by using macroscopic experimental tool. Here, we report a novel method to detwin FeTe single crystal by magnetic field. Detwinning effect was measured by resistivity anisotropy using Montgomery method and FeTe was almost fully detwinned at 2T. Furthermore, detwinning effect is retained when the field is turned off after field cooling.

Keywords:

Superconductivity, Iron-based superconductors, Nematic phase, Detwinning, FeTe

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Towards Quantum Frequency Conversion between microwave and optical domains

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Abstract:

Transferring quantum states between microwave and optical domains is a key process to connect the low-temperature microwave quantum system, such as superconducting quantum processor, to room-temperature optical quantum system. From a different point of view, converting optical photons to mirowave photons would lead to longer coherent communication or standoff sensing distance aside from difficulty to detect microwave photons. Here we present the quantum frequency conversion scheme using ferromagnetic magnon mode coupled to the microwave cavity mode. This will allow us to convert microwave to optical photons and vice versa coherently. Our current status is to characterize ferromagnetic resonances of the magnon modes in free space. We will discuss our scheme and an initial design for quantum frequency conversion.

Keywords:

quantum frequency conversion, superconducting quantum system, optical quantum system, magnon mode, microwave cavity mode

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P2-co.129

Analysis of hysteresis losses in GdBCO coated conductors with coupled strips

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Abstract:
Reducing hysteresis loss is important issue in applications of 2G GdBCO coated conductor. And producing striated HTS coated conductors is known to reduce the hysteresis loss. Coupling effect can increase the hysteresis loss of HTS CCs. In this study, we patterned HTS coated conductors to various shape and and compared each sample. To analyze the hysteresis loss of variation of geometric distribution in the HTS coated conductors, we used three coupled samples with same effective width and measured local hysteresis loops. The local hysteresis loops of each type were obtained by LTSHPM. And we calculated hysteresis losses from the results. We compared hysteresis losses of three samples and investigated coupling effect of hysteresis loss quantitatively.

Keywords:
superconductivity, GdBCO coated conductor, hysteresis loss, coupling effect

P2-co.130

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Vortex pinning effect and quantum phase transition of superconducting Ta thin film with artificial periodic pinning centers

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Abstract:
The type of the magnetic field-tuned superconductor-insulator transition in disordered superconducting film depends on characteristics of disorder.[PRB. 77, 212501 (2008)] Ta thin film deposited by sputtering method is amorphous and homogeneous with sub-nm surface roughness, and one of good example of superconductor-Fermi insulator transition showing intermediate metallic phase at zero temperature limit with increasing magnetic field or disorder.[Sci. Rep. 7, 42969 (2017)] In order to study a role of vortex pinning effect on quantum phase transition and metallic state of Ta thin film, we investigated the low temperature transport properties of Ta thin films perforated with periodic triangular array of holes, comparing the result of reference sample(RS) without hole array. Periodic array of holes acting as artificial pinning centers enhances pinning effect of vortices and restricts movement of vortices. For the sample with the highest density of holes, the intermediate metallic state is considerably suppressed, whereas the superconducting phase remarkably expands.

Keywords:
quantum phase transition, disordered superconducting film, superconductor-insulator transition, metallic phase, periodic hole array, vortex pinning effect

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P2-co.201*

First-Principles Study of Adsorption of Lithium Polysulfides on Metal-Organic Framework

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Abstract:

Adsorption of lithium polysulfides on porous metal-organic framework (MOF) nanosheet has been studied using density-functional theory (DFT) calculations. The Cu paddle-wheel based HKUST-1 ($Cu_3(BTC)_2$) with a pore size of 8.9 Å was selected as the MOF, and S_8, Li_2S, Li_2S_2, Li_2S_4, Li_2S_6, and Li_2S_8 molecules were adsorbed on the (001) surface of MOF nanosheet with the thickness of 2.1 nm. While the adsorption strength of S_8 is weak with a small adsorption energy of 0.32 eV, that of Li_2S_n is very strong with large adsorption energies of 1.3-3.4 eV. The adsorbed Li_2S_n molecules prefer to locate near the Cu paddle-wheel sites of MOF with the formation of strong Li-O and S-Cu bonds. The adsorption energies are 3.44, 2.55, 1.56, 1.33, and 1.60 eV for Li_2S, Li_2S_2, Li_2S_4, Li_2S_6, and Li_2S_8, respectively, suggesting that the overall adsorption strength becomes stronger with decreasing molecular size. The calculated adsorption energies of Li_2S_n imply that lithium polysulfides should overcome large energy barriers to pass through the MOF nanosheet via its pores, and small Li_2S and Li_2S_2 molecules rather than large Li_2S_4, Li_2S_6, and Li_2S_8 molecules should overcome larger barriers. This study offers atomic level insight into the high efficiency of MOF in blocking lithium polysulfides that is critical as a separator for lithium-sulfur batteries.

Keywords:

lithium polysulfides, metal-organic framework, adsorption, density-functional theory

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Electronic Structure of Antiferromagnetic Spin S=1 Square Lattice in Nickelate

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Abstract:

For last several decades, transition metal oxides with a layered square lattice, which is isostructural to high Tc cuprates, have been extremely of interest. In particular, when they order antiferromagnetically, a high Tc superconductivity has been expected. In this point of view, layered spin-ordered nickelates with a square lattice have been searched.
In this presentation, using first principles calculations, we will address the electronic and magnetic structures of the layered oxychalcogenide, recently synthesized, having Ni^{2+} ions. This system shows a high spin S=1 configuration, which is rare in Ni^{2+} systems, leading to an antiferromagnetically ordered S=1 square lattice at the Neel temperature of T_N=150 K. One may expect that a strong quantum fluctuation in this square lattice. Furthermore, we will uncover the mechanism of the magnetism, and discuss similarities and contrasts with cuparates.

Acknowledgements: This research was supported by NRF-2016R1A2B4009579.

Keywords:
first principles, nickelate, square lattice, antiferromagnetism

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Ab initio study of the structural and electronic properties of AZnPn (A = alkali metals, Pn = Sb and Bi)

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Abstract:
Recently, much attention has been paid to van der Waals (vdw) layered materials which can be exfoliated to single or few layers. Layered Zintl compounds belonging to this class comprise of the cationic layers of group 1 or 2 elements and the anionic layers of *p*-block elements. Complex structures and diverse electronic properties of Zintl phases promise their potential applications to thermoelectrics, ferro-/piezo-electrics, and photovoltaics. In this work, we investigate systematically the structural and electronic properties of AZnPn (A = alkali metals, Pn = Sb and Bi) Zintl compounds through first-principles density functional calculations. We explore low-energy crystal structures of AZnPn compounds using an *ab initio* evolutionary crystal structure search method, as implemented in the AMADEUS code [1]. In general, although hexagonal ($P6_3mc$ and $P6_3/mmc$) and tetragonal ($P4/nmm$) phases compete for stability, we find a tendency that the hexagonal phases are more favorable against the tetragonal phase and change from $P6_3mc$ to $P6_3/mmc$ as the size of group 1 elements increases. Based on the results of vdw interactions and electronic structure, we discuss the exfoliation of AZnPn compounds and the possible formation of topological bands.

[1] I.-H. Lee, Y. J. Oh, S. Kim, J. Lee, and K. J. Chang, Comput. Phys. Commun. 203, 110 (2016).

Keywords:
Zintl compounds, layered materials, density functional calculations

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P2-co.204*

Influence of Defects on Magnetic Properties of MgO/Pt(100) and MgO/Pt(110) Junctions: An *Ab-initio* Study

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Abstract:

Recently, defected-induced room-temperature ferromagnetism have been observed in MgO, a classical metal-oxide. [1,2,3] On the other hand, Pt is widely studied in spintronics, which is nearly ferromagnetic. With MgO film deposited on Pt surface, the combination effects of interface and defect may lead to the change of magnetic properties. However, the effect is still unclear, making it difficult to control and characterize the electronic and structural properties of the MgO/Pt junctions. A better understanding of mechanism can offer opportunity to spintronic applications, especially for low-power consumption devices. [4]

In this study, *ab-initio* calculations based on density functional theory have been employed to study the electronic and structural characteristics of ultra-thin MgO films on Pt(100) and Pt(110) surfaces. Furthermore, the influence on the magnetic properties of O and Mg defects at the interface are also investigated. The energetics reveals that oxygen atom on top of Pt is the most favorable. Interestingly, only Mg vacancy brings about the magnetic moments of 0.5 μ_B and 0.1 μ_B, which originates from the spin polarization of the 2*p* electrons of O atoms and the 5*d* electrons of Pt atoms surrounding the vacancies, respectively. The ability of controlling the magnetism by Mg vacancy may find applications in multifunctional spintronic devices.

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Keywords:
magnetism, Mg vacancy, MgO/Pt junction, magnetic moments

P2-co.205

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Low thermal conductivity in phosphorene oxide: role of the flexible oxygen

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Abstract:
Combining first-principles density functional theory and phonon Boltzmann transport theory, we investigated the thermal transport properties of the oxidized form of phosphorene called phosphorene oxide (PO). We revealed that PO exhibits a much lower thermal conductivity (2.42-7.08 W/mK at 300K) than its pristine counterpart as well as other two-dimensional materials. To comprehend the physical origin of such low thermal conductivity, we scrutinized the contribution of each phonon branch to the thermal conductivity by evaluating various mode-dependent quantities including Gruneisen parameters, anharmonic three-phonon scattering rate, phase space of three-phonon scattering processes. Furthermore, to understand the effect of existence of flexible oxygen atoms on the acoustic phonon modes, we devised a model structure mimicking the PO system. Based on model calculation, we confirmed that the flexibility of oxygen atoms in PO leads to the softening of acoustic phonon modes resulting in the reduction in thermal conductivity.

Keywords:
density functional theory, Boltzmann transport theory, thermoelectric materials, phosphorene oxide, thermal conductivity

P2-co.206

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

A Theoretical Study on the Combination of Compositions for Efficient Implementation of Ternary Compounds Photovoltaic Materials

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Abstract:

Ternary compounds have attracted great interest because various optoelectronic properties can be controlled by the combination of the compositions having the proper band gap and large absorption coefficient for potential solar sensitizers. In 2016, Konstantatos *et al*. reported that solution-processed solar cells based on $AgBiS_2$ crystals achieve the power conversion efficiencies (PCEs) of 6.3 %, with no hysteresis[1]. However, there is still a lack of research as to whether any combination of ternary compounds leads to superior optoelectronic properties. Therefore, we have investigated the effect of the compositions constituting the I-V-VI_2 ternary compound in order to understand the suitability of the solar cell as an absorber through the first-principles calculations. Based on the rhombohedral crystal structure known as the most stable structure of the Ag-based ternary compound[2], the combination of compositions is systematically analyzed as a function of one class such as I, V, and VI (*i.e.*, I = alkali metals (Li, Na, and K) and transition metals (Cu and Ag), V = As, Sb, and Bi, and VI = S, Se, and Te). Conclusively we will demonstrate that the optoelectronic properties such as bandgap, effective mass and exciton binding energy of ternary compounds are most dependent on the monovalent metal.

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2. Khang Hoang, S. D. Mahanti, James R. Salvador, and Mercouri G. Kanatzidis, PRL 99, 156403 (2007).

Keywords:
Ternary compound, solar cell, composition, optoelectical property, first-principles calculation

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P2-co.207*

Effects of the molecule-electrode contact configurations on the single-molecule diode performance: A finite-bias first-principles study

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Abstract:
Being the fundamental building block of semiconductor devices, realizing large and robust diode effects has been a major goal in the field of single-molecule electronics. Particularly, while the molecule-electrode contact configurations should play a critical role in determining the rectification behavior, their atomistic understanding has been so far incomplete. Herein, carrying out finite-bias first-principles quantum transport calculations based on the multi-space constrained search density functional theory (MS-DFT) we have recently developed [1], we study the correlations between the S-Au linkage coordination numbers [2] and the diode effects in alkanethiolate-based molecular junctions. By analyzing the electrochemical potentials or quasi-Fermi level profile across the channel that are uniquely produced within MS-DFT, we find that the rectification of the molecular device is increased for the junctions based on low S-Au coordination-number contacts. Moreover, we find that inducing tunable dipoles into the alkanethiol core by fluorination increases the rectification ratio.

[1] H. S. Kim and Y.-H. Kim, arXiv:1808.03608 [cond-mat.mes-hall].
[2] Y.-H. Kim, H. S. Kim, J. Lee, M. Tsutsui, T. Kawai, J. Am. Chem. Soc. **139**, 24, 8286 (2017).

Keywords:
DFT, Molecule junction, Rectifier, Coordination number, Fluorination

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Out-of-plane Stark shifts of single-photon emitters in 2-dimensional hexagonal boron nitride

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Abstract:

Tunable and bright single photon emitters (SPEs) are crucial elements of photonic quantum technologies. Recently, intrinsic point defects in h-BN have been extensively investigated as reliable SPEs owing to their room-temperature functionality and stable emissions in the visible range. Furthermore, recent experiments demonstrated that it is possible to control the SPEs' optical energy by applying an electric field perpendicular to the h-BN plane. In our previous work, by considering a specific defect model, which is $V_N X_B$ (X=C, N, and O), we theoretically showed that the presence of the out-of-plane dipole of the SPEs may be originated from spontaneous symmetry breaking of the SPEs' defect structure. In this work, we expand our consideration to diverse defect candidates for SPEs in h-BN. We consider $V_N C_{2B}$, $V_N O_{2B}$, $O_N V_B$ to name a few. In this study, we discuss the potential mechanism of the symmetry lowering process of the defect models and its physical implications for their application as single photon emitters.

Keywords:

h-BN, single photon emitters, density functional theory, Stark shift

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P2-co.209*

New 2D massless Dirac fermion systems and quantum spin Hall insulators based on sp-sp^2 carbon sheets

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Abstract:
Graphene was identified as a quantum spin Hall (QSH) insulator when considering spin-orbit coupling (SOC), which opens a band gap at the Dirac points. This discovery has initiated new research efforts to study the QSH effect, towards its application for quantum computing and spintronics. Although the QSH effect has been observed in HgTe quantum wells, the SOC strength of graphene is too small (~1 μeV) to induce the topological insulator phase in an experimentally achievable temperature regime. Here, we perform a systematic atomistic simulation to design two-dimensional sp-sp^{2}hybrid carbon sheets to discover new Dirac systems, hosting the QSH phase. 21 out of 31 newly discovered carbon sheets are identified as Dirac fermion systems without SOC, distinct from graphene in the number, shape, and position of the Dirac cones occurring in the Brillouin zone. Moreover, we find 19 out of the 21 new Dirac fermion systems become QSH insulators with a sizable SOC gap enhanced up to an order of meV, thus allowing for the QSH effect at experimentally accessible temperatures. In addition, based on the 26 Dirac fermion systems, we make a connection between the number of Dirac points without SOC and the resultant QSH phase in the presence of SOC. Our findings present new prospects for the design of topological materials with desired properties.

Keywords:
2D, Dirac, Spin-orbit coupling, Quatum spin Hall, Carbon, Graphene, Graphyne,

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First-principles study of the ligand-dependent colloidal growth of CdSe nanoplatelets

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Abstract:
Even though two-dimensional (2D) colloidal nanocrystals have unusual electronic and optical properties, the studies of their growth mechanisms are still underdeveloped. Here, we investigate the growth mechanisms of 2D II-VI nanocrystal, such as CdSe nanoplatelets, through density-functional theory (DFT) calculations. At initial stage of growth process, the CdSe nanocrystal seed structure has several facets with wedge structures. First, in consideration of the seed structure, we optimize the wedge structures of CdSe nanoplatelets. We find the stable wedge structures which have possibilities of the lateral growth and calculate the binding energies of ligand molecules. We also analyze the electronic properties of wedge nanocrystal model with ligand binding. The complex wedge structures and ligand binding energies depending on the adsorption position can explain asymmetry growth of the CdSe nanoplatelets. Based on these result, we provides the basic understanding on the growth mechanism of colloidal nanocrystal structures.

Keywords:
DFT, First-principles study, II-VI, growth mechanisms

P2-co.211*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Wulff construction for novel oxide nanoparticles and first-principles study on their unusual physical properties

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Abstract:
In general, physical properties of oxide nanoparticles with the strong correlation among spin, orbital, charge and lattice degree of freedom are significantly dependent on the size, surface termination and even on their shape. Therefore, Wulff construction is the invaluable tool to design the desired shape of oxide nanoparticles exhibiting novel functionality. Here, by using Wulff construction and density functional theory calculations, we designed novel TiO_2, SnO_2, RuO_2 nanoparticles, and their atomic structure and unusual electrical, optical, magnetic properties will be presented and discussed in detail.

Keywords:
wulff-construction, surface energy, nanoparticle

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P2-co.212*

Consequences of symmetry misrepresentation of α-GeTe

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Abstract:

It is well known that α-GeTe, which is the most stable phase among various GeTe phases, is classified as R3m space group in the trigonal crystal systems. On the other hand, α-GeTe can be described by Cm space group in the monoclinic crystal systems, when establishing its unit cell differently, which is misrepresentation of its space group exhibiting lower symmetry. Such symmetry misrepresentation would happen during experimental characterizations. To help and guide experimental characterization, we describe various structural distinctions of the same α-GeTe phases but with different set of lattice vectors. We also use Density Functional Theory (DFT) calculation to verify various physical properties, which may misguide observers to regard the α-GeTe as different phase of GeTe.

Keywords:

GeTe, space group, Density Funtional Theory(DFT)

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P2-co.301

Current status of the Hard X-ray beamline at PAL-XFEL

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Abstract:

The Pohang Accelerator Laboratory-X-ray Free Electron Laser (PAL-XFEL) started user operations from 2017. PAL-XFEL provides coherent X-rays with a wide photon energy range from 2.2 to 15 keV and a pulse duration, ~ 25 fs. Each pulse contains ~ 10^{11} photons. So far, we have supported more than 60 experimental activities in broad fields. Here, we will give an introduction to X-ray science instruments to understand scientific phenomena in diverse fields and state the future plan to meet demands of X-ray user society for performing cutting-edge research using PAL-XFEL.

Keywords:

Pohang Accelerator Laboratory (PAL) X-ray free electron laser (XFEL) PAL-XFEL

P2-co.302

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Study of ultrafast thermodynamics probed by X-ray Free Electron Laser

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Abstract:
The crystal melting process is fundamental phenomena which has not been fully understood. Until now, these effort has been limited to model dependent interpretation or weakly perturbed, reversible process. So any investigation on transition irreversible phenomena has remained challenging so far. In addition, fundamental factors like atoms and electrons is changed in below picosecond timescale which can be probed by X-ray Free Electron Laser. So, we performed pump-probe XFEL diffraction imaging experiment and captured directly the change of the electron distribution in crystal. This provides deep understanding of ultrafast dynamics at fundamental timescales.

Keywords:
XFEL, Imaging

P2-co.303

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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An accessible Coherent Diffraction Imaging reconstruction software

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Abstract:

Coherent diffraction imaging (CDI) is a prominent high resolution imaging techinque. However, the process of reconstructing the image from the diffraction data is significantly less accessible when there is no experties. If the data obtained through the CDI experiment can be easily converted by anyone, it would be very helpful to expand the user base. In this poster we want to share the progress of CDI reconstruction software development with the user interface and share the results from the software.

Keywords:

CDI, Coherent Diffraction Imaging

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P2-co.304

A segmented crystal based von-Hamos x-ray emission spectrometer at synchrotron radiation light source

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Abstract:

A von-Hamos Bragg crystal spectrometer at synchrotron radiation beamline of Pohang accelerator laboratory for x-ray emission spectroscopy is described. Si crystals of different orientations (111,110,100) are diced with dicing saw that are cylindrically bent into 250/500mm radius of curvature to enhance focusing properties. X-rays are incident at Bragg angle in the range of 65^{o}-85^{o}. The emission spectrum is studied using von-Hamos spectrometer in which curved crystal dispersed the x-ray radiations and these radiations are measured by Mythen detector. Spectrometer efficiency and resolution are measured at x-ray photon energy in 8000-8080eV range. High efficiency, low cost and simplicity of this spectrometer also makes it suitable for various other high energy spectral measurements.

Keywords:

Crystal spectrometer, X-ray emission spectroscopy, Segmented crystal

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P2-co.305*

Construction of AFM/STM system operating at UHV and cryogenic environments

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Abstract:

The major research of the Center for Quantum Nanoscience (QNS) at Institute for Basic Science (IBS) focuses on quantum control and measurement of atoms and molecules on surfaces. Electron spin resonance (ERS) combined with scanning tunneling microscopy (STM) is a powerful and promising tool to measure spin states with extreme energy resolution on the atomic scale. As a part of QNS, optics combined atomic force microscopic (AFM) team put an effort to instrument beyond ESR-STM measurement.
Even though ESR-STM was successfully applied to measure the resonance excitation of electron spins with extreme energy resolution, the linewidth and quantum coherence time was limited by tunneling electrons, which interact with the target spins. Instead of using STM, AFM can be a candidate to increase quantum coherence time of atoms and molecules, enabling to measure on insulating substrates. Magnetic exchange force microscopy (MExM), an application of AFM, will provide the capability of measuring spin states at atomic scale using a spin polarized AFM force sensor. In our group, we developed a low temperature charge amplifier to operate q-plus sensors with low noise specification. Wires and a probe for q-plus sensors were glued by ourselves using micro-aligner under optical microscope and tip apex of the probe was sharpened by using focused ion beam (FIB) etching technique. The performance of the newly developed system in QNS will be discussed on this poster. We will present measuring resonance of q-plus sensors, analysis of noise levels from the internal preamps. We prepared clean metallic surfaces and imaged those surfaces at atomic resolution. We also measured the force distance curve by monitoring frequency shift signal as a function of tip-sample distance.

Keywords:

atomci force microscopy, scanning tunneling microscopy, q-plus force sensor

Current status of neutron triple-axis spectrometers in HANARO (III)

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Abstract:

The triple-axis spectrometer (TAS) is the most versatile instrument used for neutron scattering studies. The research using TASs has been of fundamental importance to many fields of condensed matter physics. In the research reactor HANARO of KAERI, two TASs have been installed; one is Cold TAS in the cold-neutron guided hall, and the other is Thermal TAS in the reactor hall. At present, the former is the final phase of commissioning, while the latter is the initial phase of commissioning. Here, we report the current status of each TAS after the short-term operation of HANARO in 2018.

Cold TAS (i) We succeeded in substantially suppressing the dose rate in the experimental area down to 1~3 μSv/h by reducing unwanted radiation sources at inside the monochromator shielding drum and by renewing the mustache shielding. (ii) A neutron velocity selector is now available as a band-pass filter.

Thermal TAS (i) Concerning the high dose rate in the experimental area, we replaced the former large monochromator with a small PG flat crystal to reduce unwanted neutron/γ-ray hitting process from the structure material. At present, however, the γ-ray dose rate is still high. Further modification of the shielding is now in progress at the inside of the monochromator drum. (ii) We started to check the optical lineup by using laser, and adjusted the rotation-center position of the analyzer and the parallel orientation of the 3rdcollimator.
Recently, we fabricated a mirror-type collimator for Cold TAS by applying the film coating techniques of KAERI. This collimator is composed of Ni/B_4C-coated 50 Si wafers, so that the total reflection by Ni layers is available. Because of the long shutdown of HANARO, we characterized the collimator performance by using neutron beam at ANSTO, Australia. In the presentation, we report this experimental result also and compare with the simulation result previously done [1].

Reference
[1] J. Lee, H. Hiraka, and S. Cho, IEEE Transactions on Magnetics **55**, 6400104 (2019).

Keywords:
Neutron, Triple-axis spectrometer, HANARO, Collimator

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P2-co.307

Quadrupole and higher order phonon modes in Au nanosphere by picosecond strain pulses

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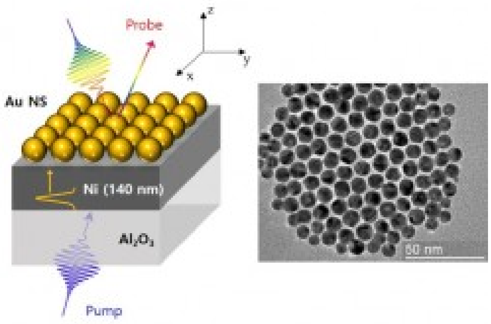
Abstract:

We confirm that picosecond strain pulses generated by femtosecond laser pumps excite acoustic phonon modes in Au nanosphere (NS). The measurement was performed by exciting the Ni film (140 nm thickness) through an sapphire substrate using femtosecond pump pulses and detecting the transient reflectivity of Au NS self-assembled on top of Ni using white-light continuum probes around the surface plasmon resonance band (Figure 1). As the acoustic pulse generated at the Ni/sapphire interface propagates to Au NS/Ni and transfers mechanical impact to Au NS, the dielectric function of Au NS and therefore its surface plasmon band will be modified at the same time.



Using picosecond strain pulses as an excitation source, we found new phonon eigenmodes in Au NS which are defined as the quadrupole (f_1 = 86 GHz, lowest spheroidal) mode and the higher order spheroidal mode (f_2 = 179 GHz), respectively. Especially, for the detection of the tiny signal of higher order spheroidal mode, two successive picosecond strain pulses are employed with the delay time of δ_{12} = 5.5 ps (~ $1/2f_1$) where the f_1 mode is suppressed mostly. These modes have not been detected so far as conventional direct laser pump sources can only excite the fundamental breathing mode due to the isotropic symmetry of thermal expansion in a NS. We therefore suggest that a picosecond strain pulse is an appropriate excitation source for the study of acoustic phonon eigenmodes in confined nanostructures.

Keywords:
Picosecond strain pulse, Acoustic phonon mode, Acousto-plasmonics.

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High-pressure elastic properties of amorphous polymers investigated up to 11 GPa by Brillouin light scattering

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Abstract:

We applied high-pressure Brillouin spectroscopy to study the mechanical proerties of representative amorphous polymers: poly-carbonate (PC), unplasticized poly-vinylchloride (uPVC), and poly-etherimide (PEI). The pressure dependence of optical and elastic properties, such as refractive index, acoustic phonon velocity, and P-V equation of state, was obtained by measuring at the forward symmetric and back scattering geometry up to about 11 GPa. While PC and PEI samples showed TA and LA modes simultaneously above certain pressure, uPVC sample showed a single LA mode only, which limited our access to further mechanical information. For PC and PEI samples, we successfully calculated Poisson's ratio, bulk modulus, shear modulus, and Young's modulus. Furthermore, we obtained the P-V equation of state by exploiting two differnt methods and they were in good agreement, which showed our data were reliable.

* This work was supported by Adency for Defense Development (ADD).

Keywords:

Brillouin light scattering, Diamond Anvil Cell, Polymer, Amorphous Phase

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2019-04-24 - 2019-04-26

P2-co.309

Luminescence of Lead Tungstate Single Crystal

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Abstract:

The thermoluminescence was measured from the x-ray induced lead tungstate single crystals grown by the Czochralski method in argon and air. The elements and impurities of PbWO4 single crystals grown in argon and air were analyzed by EPMA and ICP. The PbWO4 single crystals are irradiated with 25 keV x-ray at 25 K and annealed at 500 ℃ ~ 1050 ℃ for 8 hours. Experimental conditions for measuring thermoluminescence are 0.1 K/s of heating rate, 25 K ~ 280 K of temperature range and 200 nm ~ 800 nm of wavelength range. Besides thermoluminescence, optical absorption and radioluminescence are measured from annealed PbWO4 single crystals. Glow peaks below 110 K and above 154 K are related with intrinsic defects and excess of local oxygen, respectively. And yellow-green emission band, green emission band and blue emission band are caused by WO4 2- group with O2-, irregular WO3 group with F centers and STE, regular lattice WO4 2- group, respectively.

Keywords:

thermoluminescence, defect

P2-co.310*

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온도에 따른 네마틱 액정 위 글리세롤 방울들 위치에 관한 표면장력의 기하학적 해석

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Abstract:

글리세롤을 채운 용기에 소량의 네마틱 액정(5CB)을 떨어뜨리면, 글리세롤 표면 부분에 액정이 넓게 퍼진다. 액정 내에 녹아있던 글리세롤은 액정층의 표면에서 마이크로 미터 크기의 방울을 형성한다. 이 방울들은 액정의 탄성 변형 에너지에 의해 구조를 형성하며, 또한 여러 가지 크기 분포를 갖는다. 샘플의 온도를 변화시켜주면 글리세롤 방울의 구조와 크기가 변화하여 제어하는 것이 가능함을 확인하였다. 또한 액정보다 밀도가 큰 글리세롤이 액정 표면 위에 분포하는 것은 액정, 글리세롤과 공기 사이의 표면장력이 중요한 역할을 하기 때문이라는 가정하에 기하학적 분석을 진행하였다. 본 실험에서는 광학현미경 관찰을 통하여 온도에 따른 방울 분포에 대해 고찰하고, 글리세롤 방울이 액정 표면에 고정되는 정도와 방울의 구조에 대하여 분석하여 논의해보고자 한다.

Keywords:
액정, 글리세롤, 탄성 변형 에너지, 표면장력

P2-co.311*

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2019-04-24 - 2019-04-26

네마틱 액정 내에서 Carbon nanofiber의 방향 제어 연구

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Abstract:

액정 방향자가 균일한 방향으로 배향하며, 배향 방향에 대해 수직한 방향으로 전기장을 인가할 수 있게 셀을 제작하였다. Carbon nanofiber를 섞어준 네마틱 액정을 주입한 후 전기장을 인가하며 반응을 관찰하였다. Carbon nanofiber가 전기장에 반응하여 회전하였다. 전기장의 크기가 커질수록 carbon nanofiber의 회전 각도가 커지며 전기장 방향으로 포화되었다. 전기장에 따른 액정의 자유에너지 변화와 carbon nanofiber가 갖는 전기에너지의 합을 최소로 하는 각도를 이론적으로 계산하여 실험값과 비교해 보았다. 본 발표에서는 구체적인 실험 방법과 결과에 대해 설명한다.

Keywords:
네마틱 액정, 액정 콜로이드, carbon nanofiber

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P2-co.312*

Thermal Conductivity of Metal-coated Carbon Fiber

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Abstract:

In recent years, materials development in vehicle industry is essential for improving the performance, such as lightweight and endurance. Because of various properties of carbon fiber (lightness, durability, etc.), development of materials using this carbon fiber is actively under way. There is a research result that carbon fiber coated with metal is used as core of wire to reduce their weight and enhance electrical and thermal properties. However, there is a lack of research on thermal properties, one of the important characteristics.

We characterized the electrical and thermal conductivity of the single strand metal-coated carbon fiber (MCF) with different metal thickness, using AC current. Especially in 3ω method, AC current at angular frequency ω is applied to our sample to generate heat, and 3ω voltage resulting from the heat generation is measured. By analyzing 3ω voltage signal, the thermal conductivity (κ) of MCF can be estimated. We conclude that deposition of metal layer on the CF contributes an enhance of thermal conductivity of CF. And our result demonstrates that thermal conductivity of CF is enhanced as metal thickness increased. In temperature and magnetic dependence measurements, we see a relation between electron and heat transport by understanding of Lorenz number which explains the ratio of the electronic contribution of the thermal conductivity to the electrical conductivity. From this study, we will predict how the heat transfer will be distributed in the MCF. Our result will assist in understanding the heat transport in MCF and can be utilized to identify heat dissipation and conduction without compromising the electrical conductivity of metal coated carbon fiber.

Keywords:

Carbon-Metal core/shell structure, Thermal conductivity, Wiedemann-Franz law, Lorenz number

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P2-co.313

Quantum walk using 3D aluminum cavity and superconducting qubit coupling system

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Abstract:
Quantum walk is a basic qubit algorithm for simulating a quantum system. Due to the high Q factor of the 3D cavity, quantum state of qubit has a long lifetime. It is sufficient time to operate many quantum gates [1]. Cavity-qubit coupling system is suitable for studying the quantum walk due to its many positon states [2]. We have a research plan for Quantum walk and cavity-qubit system is in course of preparation. Cavity is made of aluminum, which is a kind of superconductor, and superconducting qubits will be fabricated through Al e-beam evaporation. Additional qubit is under consideration for simulating new model using interaction between qubits.
[1] Hanhee Paik, R. J. Schoelkopf, etc. 2011
[2] E. Flurin, I. Siddiqi etc. 2017

Keywords:
Quntum computer, Quantum walk, superconducting qubit

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P2-co.314

Digital-Analog Quantum simulation of Spin Interacting Models with Well-designed Superconducting Circuit

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Abstract:

Superconducting circuit (SC) with Transmon qubit is widely studied as a candidate for universal quantum simulator. Key features of SC are two: One is 'scalability', which means possibility of manufacturing a number of well-defined components and dressed-states of simulating system Hamiltonian, and the other is 'availability' of interaction among distant qubits. Two main components of SC are resonators with high Q factor and qubits with long T1/T2 characteristic time relative to measurement time.

In this research, there are two main objectives: First, Fabrication of SC elements designed by FEM computer simulation, and identification of the Q factor of resonators and characteristic time scale of qubits. Second, performing Digital-Analog Quantum Simulation (DAQS), a novel approach to quantum simulation that uses not only universal quantum gates but also analog quantum interactions among qubits, of various spin interacting models using our own SC architecture.

Keywords:

Superconducting circuit, Transmon qubit, Quantum simulation

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Study of structure phase transition of $SrRuO_3$ on $SrTiO_3$ (001) with ambient pressure XPS

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Abstract:

In research of nonvolatile ferroelectric devices, $SrRuO_3$ (SRO) has been a popular choice as bottom electrode materials due to its good lattice matching and functionalities. Consequently, the structural and electronic properties of SRO have been intensively studied and many interesting properties are reported. Especially, the structural phase transition of monoclinic $SrRuO_3$ (MSRO) to tetragonal SRO (TSRO) is highly interesting as the structural changes of electrode can be easily influence to the transport properties of devices. [1]

To understand the origin of structural phase transition and its correlation to electronic structure of SRO, ambient pressure x-ray photoelectron spectroscopy (AP-XPS) was utilized for few nm probing depth. The core level shifts of Sr, Ru, and O elements are investigated as a function of temperature under both vacuum and oxygen environment. In the case of MSRO, the spectra show no changes in vacuum annealing process. (up to 220 ℃, under 10^{-8} Torr) On the other hand, in oxygen annealing process (up to 220 ℃, O_2 100 mTorr), O 1s, Sr 3d peaks are gradually shifted to higher binding energy side and return to their previous positions after cooling. In the case of TSRO, no change was observed under both environments.

[1] Lee, Sung Su, et al., *Journal of the Korean Physical Society* 73.10 (2018)

Keywords:
SrRuO3 (SRO), Structural phase transition, Ambient Pressure XPS

P2-op.001

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Computational simulation on fiber-to-waveguide coupling efficiency of Si3N4

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Abstract:

Recently, Si3N4 has been explored as the nano-photonics platform due to its low absorption coefficient from visible to telecom wavelength range than silicon. Efficient fiber-to-waveguide grating couplers are regarded as one of fundamental components for integrated circuits and quantum nano-photonics. For these reasons, we execute computational simulations on grating couplers to find out optimum geometric conditions of fiber-to-waveguide coupling efficiency in telecom wavelength range. From our simulation results, the fiber-to-waveguide coupling efficiency reaches more than 60%.

Keywords:

Si3N4, Grating coupler

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P2-op.002*

Stimulated forward Brillouin scattering on silicon Brillouin acrive membrane waveguide

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Abstract:
Stimulated Brillouin scattering (SBS) is an exceedingly strong nonlinear process comparable to Raman scattering, but the SBS effects are hard to be observed in silicon-on-insulator (SOI) waveguides due to strong phonon dissipation through the substrate. Here, we obtained strong forward SBS on silicon waveguides by supporting and floating the waveguide with anchors. This structure is referred to as Brillouin active membrane (BAM) waveguides and shows large Brillouin gain due to strong optical forces and low phonon loss. We measured the Brillouin scattered light using heterodyne detection, and compared it to computer-simulated results using finite elements method. This result will be the basis for various applications in silicon photonics including non-reciprocal signal processing, Brillouin laser, and optomechanical engineering.

Keywords:
Nonlinear optics, Silicon photonics, Brillouin scattering

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P2-op.003

Time-bin interference for all-fiber quantum communication application

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Abstract:

In Quantum Key Distribution (QKD), the security of quantum communication is given by the quantum nature of resource, and a central experimental issue is how to distribute entangled states over large distances [1], that is not only for the entangled photon based protocol, like E91 [2], but also for the protocol which do not explicitly required entanglement, like BB84 [3]. For long distance communications, the use of existence optical fiber network is the most simple and promising way. Since the qubit encoding must be robust against decoherence in fibers, polarization encoding is not useful due to the random polarization rotation through a single-mode fiber. The most adequate way to encode qubits is the time-bin encoding method. Here, we measured the time-bin interference patterns using photon pairs generated via type-0 spontaneous parametric down-conversion (SPDC) in periodically poled lithium niobate (PPLN) waveguide. The measurement scheme can be used as the system of long distance all fiber QKD with the E91 protocol. The measured raw visibility is about 0.92 which is equivalent to the QBER = 4%. We believe that the results prove our ability to develop all-fiber QKD systems and that long-distance communication is possible with this demonstrated system.

reference

[1] I.Marcikic, et. al., Phys. Rev. Lett. 93, 180502 (2004).
[2] A.Ekert, Phys. Rev. Lett. 67, 661 (1991).
[3] C. Bennett and G. Brassard, in Proceedings of the IEEE International Conference on Computers, Systems and Signal Processing (ICCSSP), Bangalore (IEEE, New York, 1984), p. 175

Keywords:
Time-bin interference, quantum key distribution, Ekert protocol, Photon-pair, SPDC, phase encoding, all-fiber communication

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Study of third-order nonlinear optical response in stacked graphene layer

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Abstract:

높은 세기의 빛이 물질과 상호작용 시 발생하는 비선형 광 신호는 전통적으로 새로운 파장의 빛을 생성하거나 증폭하는데 활용되어 오고 있으며, 나아가 초고속 광 스위치, 비선형 바이오 영상 획득 및 양자정보기술 등의 분야에 활용될 수 있다. 그래핀의 경우 넓은 파장 영역에 걸쳐 높은 삼차 비선형 계수를 가진 것이 알려져 있으며 여기에서 발생하는 다양한 비선형 광학 현상에 대한 연구가 진행되어 오고 있다. 또한 전기적 제어를 통하여 단층 그래핀에서 발생하는 광신호의 세기를 매우 크게 향상될 수 있다는 연구가 최근 보고된 바 있다.

본 연구에서는 그래핀의 페르미 준위를 변화시키면서 단층 혹은 적층된 그래핀에서 발생하는 삼차 조화파 생성(third-harmonic generation) 현상에 대한 연구를 진행하였다. 특히 적층된 그래핀에서 층상간 상호작용과 이에 따른 전자구조 변화에 의하여 비선형 광특성이 어떻게 변하는 지 관찰하고 그 원인에 대하여 분석하고자 한다. 또한 그래핀에 인가한 전기장에 따라 변화하는 비선형 광신호의 특성을 관찰하고자 한다. 실험에서 100 fs 내외의 펄스폭을 가지는 근적외선 대역의 극초단 광펄스를 활용하였으며, CVD 방식으로 합성한 단층, 두층 또는 그 이상으로 적층된 그래핀 샘플을 이용하여 비선형 광특성을 살펴보고자 하였다.

Keywords:

Nonlinear optics, Third-harmonic generation, Stacked graphene layer, Ultrafast optics

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P2-op.005*

전기적 제어를 통한 망상구조 단일벽 탄소나노튜브의 비선형 광 특성 연구

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Abstract:

높은 비선형 광계수를 가지는 저차원 물질에서 발생하는 비선형 광신호를 전기적으로 제어하는 것은 능동적인 비선형 광소자 구현의 가능성뿐만 아니라 다양한 페르미 준위에서 저차원 물질의 비선형 광특성에 대한 심도 깊은 이해를 제공할 수 있으며 이로 인하여 최근 저차원 물질에서의 발생하는 다양한 비선형 광학 현상에 대한 연구가 활발히 진행되고 있다.

본 연구에서는 망상구조를 가지는 단일벽 탄소나노튜브에서 발생하는 비선형 광신호 및 이의 전기적 제어 특성에 대하여 살펴보고자 한다. 단일벽 탄소나노튜브는 고유한 구조적 특성으로 인하여 그래핀과 유사한 수준의 큰 삼차 비선형 광 특성을 가지고 있는 것으로 알려져 있다. 특히 망상구조를 가지는 단일벽 탄소나노튜브의 경우 스핀코팅을 통한 간단한 공정으로 필름의 유효두께를 변화시킴으로써 빛과의 상호작용을 효과적으로 조절할 수 있으며, 이는 그래핀이 가지는 빛과의 제한적인 상호작용을 극복할 수 있을 것으로 예상된다. 본 실험에서 망상구조 단일벽 탄소나노튜브의 페르미 준위를 전기적으로 제어하고 이를 통하여 삼차 비선형 광 특성이 변조됨을 최초로 관찰하였다. 실험에 사용된 시료는 아크 방전 기법으로 제작된 망상구조 단일벽 탄소나노튜브이며 효율적인 페르미 에너지의 변조를 위하여 이온-젤을 유전체를 이용하였다. 또한 제작된 시료의 삼차 비선형 광 특성을 관찰하기 위해 근적외선 영역의 극초단 광섬유 레이저를 여기 광원으로 사용하였다.

Keywords:

Nonlinear optics, single walled carbon nanotube, third harmonic generation, Tunable optic device

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P2-op.006

양자암호 통신을 위한 실리카 평판도파로기반의 패러데이 거울 부착된 마이켈슨 간섭계 모듈

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Abstract:
본 논문에서는 평면광도파로기반(Planar Optical Waveguide)의 긴 지연 경로차를 갖는 마이켈슨 간섭계 소자를 제작 하였다. 유선 양자암호통신에서는 시분할 광간섭(Time-division Interference)방식을 주로 이용하는데 이를 위해서는 비대칭 광간섭계(Asymmetric Optical Interferometer)가 필요하다. 평면 도파로에서 출력하는 두 간섭 빔의 편광을 정확히 맞추기 위하여 도파로 출력단에 패러데이 거울 (FRM, Faraday rotator mirror) 소자를 부착하였다. 이 연구에서 적용한 마이켈슨 간섭계의 경로차는 40.606 cm 이며 초과 손실은 1.62 dB 이다. 이 간섭계를 적용한 양자암호통신 시스템은 대략 2% 의 양자비트 오류율 값을 보여주었다.

Keywords:
양자암호통신, 평판형광도파로(PLC), 마이켈슨간섭계

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P2-op.007*

Deterministic integration of solid-state quantum emitters with a fiber at telecom band

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Abstract:
A single photon source is an essential element in quantum-based technology, such as a quantum communication or optical-quantum information processing. InAs/InP quantum dots can generate on-demand single photons at telecom wavelength. Although the quantum dots itself have a high quantum efficiency, many losses occur due to limited light extraction efficiency, collection efficiency, and transmission efficiency through the optical systems, resulting poor single photon detection probability at the detector. To solve this problem, we propose an integration of the quantum emitters into a fiber platform directly with a high coupling efficiency. These fiber-integrated quantum dots with a photonic nanostructure can serve bright single photons into a fiber network over long distance. Therefore, our approach will provide a key component for efficient and plug and play type quantum light sources for the quantum network.

Keywords:
Fiber integration, Single photon source, Quantum dots

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P2-op.008*

The anisotropic effect of atomic potential for the attosecond delay of photoemission

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Abstract:
The photoemission process at the extremely early stage has been uncovered with the development of the pump-probe method recently. During the emission process, in both theory and experiment, pioneering researches find out there occurs emission delay which is on the scale of attosecond. In this study, we focus on the effects of atomic potential in a 2D material (e. g. Graphene) which is expected to have little crystal potential and electron-electron interaction with a photoelectron. To get an attosecond delay, we perform a model calculation and solve TDSE (Time-dependent Schrödinger Equation) with an atomic potential of graphene which is calculated by density functional theory. Furthermore, the anisotropic effect is modeled as a cylindrically symmetric potential and is calculated controlling decaying parameters.

Keywords:
Attosecond delay, photoemission

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P2-op.009

Ti:Sapphire laser systems for pump-probe experiments at PAL-XFEL

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Abstract:

We present optical laser systems for conducting pump-probe experiments with X-ray free-electron laser at Pohang Accelerator Laboratory (PAL-XFEL). The Ti:Sapphire laser delivering a maximum energy of a few mJ in femto-second scale is used as a pump source and the laser wavelength is varied in the range of 240 nm to 2600 nm by an optical parametric amplifier (OPA) in order to be applicable in many experimental conditions. With a great synchronization of optical laser and XFEL, the time-resolved experiments with sub-150 fs temporal resolution are realized. An active beam pointing stabilization system is used to decrease the laser pointing jitter, thus the pointing stability of laser pulse at the sample is achieved less than 3% (sigma) of the spot size.

Keywords:

Ti:Sapphire laser, pump-probe experiment, XFEL

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P2-op.010*

프리즘 및 복굴절 필터를 이용한 티타늄 사파이어 레이저의 파장 가변

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Abstract:
티타늄 사파이어를 이득매질로 프리즘과 슬릿을 이용한 파장가변 레이저 공진기와 복굴절 필터를 이용한 파장가변 레이저 공진기를 각각 구성하였다. 구성한 두개의 공진기의 특성을 각각 비교하였다.
프리즘을 통과한 빛은 분산되어 각각 다른 경로를 진행하게 된다. 이 때 슬릿을 이용하여 특정 파장의 경로에 위치시키면 슬릿을 통과하는 파장은 공진기 내부를 계속 공진하고 나머지 영역들은 슬릿에 막혀 손실된다. 슬릿을 마이크로미터를 이용해 위치를 조정해주어 슬릿을 통과하는 빛의 파장이 바뀌게 해주면 파장가변이 가능해진다. 또한 복굴절 물질 내부를 진행하는 빛은 편광방향에 따라 진행속도의 차이를 갖는다. 매질을 통과해서 나올 때에는 둘의 위상값에 차이가 생기게 되고 이는 파장에 의존한다. 결국 매질을 통과한 후 빛의 편광상태는 통과전의 편광상태와 달라지게 된다. 브루스터 각도로 복굴절 매질에 빛을 입사시키면 입사면에 대해 p-편광된 빛은 손실이 적고, s-편광된 빛은 손실이 크다. 투과율이 높은 특정 파장에서 이득이 커지고 다른 파장에서의 손실이 커지게 된다. 이러한 복굴절 매질을 회전시켜 투과율이 높은 파장을 이동시켜주면 파장가변이 가능해진다
공진기 내부에 프리즘과 슬릿을 두어 파장가변 영역을 측정했을 때 665nm부터 900nm까지 가변이 가능했으며, 공진기 내부에 복굴절 필터를 두어 측정했을 때에는 695nm부터 900nm까지 가변되었다.

Keywords:
Ti:Sapphire, Tunable Laser, Birefringence

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P2-op.011

양극산화법에 의한 고효율 III-V 태양전지 용 TiO2 나노 튜브 무반사 층 개발

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Abstract:

고효율 III-V 적층형 태양전지의 넓은 흡수 대역 용 무반사코팅층을 양극산화법에 의해 형성된 TiO2 나노 튜브를 이용하여 형성하는 방법에 대해 연구하였다. 실험을 위해서 우선 Ti를 전자빔 증착기를 사용하여 고효율 태양전지 위에 500nm 증착시킨 후 RTA(Rapid Thermal Annealing) 장비로 300℃에 90초간 열처리를 하였다. TiO2 나노튜브 제조에 사용된 양극산화용 전해물질은 Ethylene glycol : H3PO3 : H2O : NH4F = 1000 mL : 5.82 mL : 16.7 mL : 11.11g 으로 완전 용해시켜 제조하였다. 제조된 용액에 Ti가 증착된 태양전지를 담궈 전압 및 전류별로 30분씩 기초 양극산화 실험 후 최종적으로 전압 30V, 전류 0.0279A 조건으로 시간별로 실험을 진행하여 TiO2 형성 조건을 구하였고 이 형성된 샘플 별 Spectrophotometer와 태양광 시뮬레이터를 통해 반사율과 효율을 측정하였디. 실험 결과 30V, 0.0279A로 15분 양극산화 시킨 것은 증착시킨 500nm의 TiO2를 모두 티타니아 나노튜브로 제조 하였으나 30분 이상 양극산화 시킨 것들은 증착시킨 보다 더 심하게 산화가 진행되어 나노튜브 형태를 찾기 어려웠다. 이러한 연구를 통하여 양극산화에 의해 제조된 TiO2 나노튜브가 고효율 III-V 다중접합 태양전지 용 무반사 코팅층에 적용되어 효율을 향상시킬 수 있음을 확인하였다.


양극산화법에 의한 고효율 III-V 태양전지 용 TiO_2
나노 튜브 무반사 층 개발

Keywords:
나노튜브, TiO2, 무반사 코팅, 태양전지, 양극산화

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P2-op.012

마이크로시스를 적용한 옥내외 겸용 광케이블 개발

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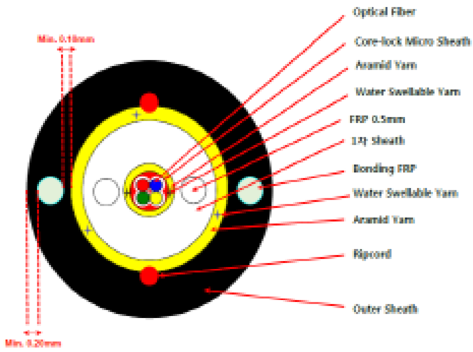
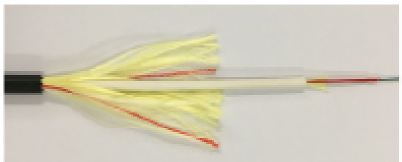
Abstract:

Fiber optic cable is changing in accordance with rapid development of telecommunication field. The recent trend of fiber optic cable is smaller outer diameter(OD), and simpler installation method, lower cost, and more user convenient etc.
In this study, we have developed a new type of Indoor-Outdoor Fiber Optic Cable with Core-lock Micro-sheath application, and dedicated in structural characteristic, performance characteristic, manufacturing technique, and application prospect of fiber optic cable.
In conclusion, this developed product is excellent in appearance, structure, attenuation variance, and sheath stripping property. Optical attenuation loss has been measured at 1310nm as 0.337dB/km, 1550nm as 0.202dB/km, and 1625nm as 0.191dB/km in normal condition. In addition to this, under mechanical environment tests condition(Temperature Cycling, Tensile Strength, Impact, Bending, Crush Test), attenuation variance was △0.1dB or less at 1550nm.





Keywords:

Indoor-outdoor, FTTH Cable, Core-lock, Gum space, Micro-sheath, Oscillator, Tension conditions

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P2-op.013

Subsidiary maxima in multiple-slit interference

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Abstract:
We present a theoretical study on the amplitudes and linewidths of the subsidiary and principal maxima in multiple-slit interference patterns in the Fraunhofer regime. In the limit of a large slit number, we observe that the calculated amplitudes of the subsidiary maxima relative to the principal maximum are slightly different from the values presented in textbooks.

Keywords:
Subsidiary maxima, Multiple-slit interference

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P2-op.014

Balanced path interferometer for scanning micro scope probe

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Abstract:

Since interferometer is one of most sensitive non-contact sensor, there are many research about scanning micro scope interferometer. But most of them do not make good use of the advantages of the interferometer. Axial resolution of scanning microscope interferometer is sligthly better than full-field imaging interferometer and imaging speed is much slower than full-field imaging system. We propose the design of the quadrature homodyne interferometer for probe of scanning microscope. It provide fast scanning speed, good axial resolution, and low drift with balanced path design. Preliminary research has been implemented. Based on the preliminary result we will built scanning micro scope interferometer and apply it to many surface imaging system.

Keywords:

Interferometer, Scanning micro scope, Imaging system

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P2-op.015*

DC-free digital holographic microscopy using all-optical phase shifting

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Abstract:
디지털 홀로그래피 현미경 기법 (DHM, Digital Holographic Microscopy)은 홀로그래픽 기법을 현미경에 적용한 방법으로 전통적인 사진 건판을 이용하는 대신 디지털화된 전기신호를 측정한다. DHM은 기계적인 스캐닝의 과정이 없이도 3차원 단차 정보를 얻는데 유용하게 사용되고 있다. DHM을 이용해서 측정한 단차 프로파일은 샘플의 외형정보와는 무관한 DC 신호로 인해서 신호대잡음비가 저해되기 때문에 고감도로 샘플의 정보를 복원하는데 어려움을 겪는다. 이러한 DC 신호를 제거하기 위해서 신호처리를 통해서 푸리에 변화된 신호에서 DC에 해당되는 공간주파수를 제외하는 방법을 이용하지만 이 방법의 경우 전체적인 복원된 신호의 세기가 감소되어 영상이 흐리게 보여지는 문제점을 보인다. 이러한 단점을 극복하기 위해서 몇 개의 위상차를 가지는 영상들을 연속적으로 취득하는 방법이 이용되고 있다. 본 논문에서는 이러한 위상차를 이용하는 방법으로 기계적인 위상차이를 발생하지 않고 광학적으로 위상차를 발생시켜 DC 신호를 효과적으로 제거할 수 있는 방법을 제안하고 실험적으로 측정한 결과를 제시하고자 한다. 펌프광에 의해서 유도된 굴절률 변화를 이용함으로써 미세 위상차를 제어할 수 있다. 이러한 현상을 이용하여 off-axis 구조를 가지는 DHM을 구현하고 여기에 위상차를 광학적으로 유도함으로써 위상차만 다른 두 영상을 측정하여 DC를 제거할 수 있다. 본 제안 기법을 이용하여 실리콘 웨이퍼에 가공된 단차 정보를 측정하여 전자현미경으로 획득한 결과와 비교하고자 한다. 광학적으로 제어가 가능한 위상천이는 광섬유 내부에서 발생하는 효과이므로 외부 조건에 대한 의존성이 없고 열적 효과를 이용하지 않으므로 안정적으로 재현할 수 있는 장점을 가질 수 있다.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No.2017R1A2B2009732).

Keywords:
위상차, DHM, phase shifting

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Study on optical pattern recognitions using synthesized phase objects

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Abstract:
We present a sensitive optical pattern recognition method using synthesized phase objects (SPO-method) with object-dependent phase distributions calculated using an iterative Fourier-transform algorithm. The essence of the proposed method is that synthesized phase objects instead of amplitude objects are used to do pattern recognitions. The sensitivity comparisons between the proposed and conventional pattern recognition methods to distortions of the structure of objects have been done with Vanderlugt and joint Fourier-transform 4F-correlators. From those results the SPO-method allows one: (a) to simplify the procedure of choice of main recognition criteria for objects; (b) to obtain one-type δ-like correlation signals irrespective of the type of objects; (c) to improve the signal-to-noise ratio for obtained correlation signals in range of 20-30 dB in optical experiments. The numerical and optical experiments show the applicability of the SPO-method for rotation invariant pattern recognition of amplitude objects.

Keywords:
pattern recognition, correlator, synthesized phase objects

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P2-op.017

Design and simulation of multifocal phase zone plate

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Abstract:

Fresnel zone plates (FZP) have been used for X-ray microscopy and holography in place of conventional focusing lenses. A typical application of FZP is to simulate a lens with multiple focal points by modulating either amplitude or phase. The amplitude zone plate does not absorb energy and thus is known to have higher efficiency than the phase zone plate. It is also known that the sinusoidal zone plate (SZP) focuses only at a desired spot and thus has higher efficiency than the binary zone plate. By using a sinusoidal phase zone plate (SPZP), which combines the advantage of the sinusoidal and the phase modulation, we designed a zone plate with multiple points using a random pixel method using a spatial light modulator (SLM). For this, we have devised a method to extract randomly 1/3 or 1/4 of the pixels in SLM and to allocate phase values corresponding to each focus. We found with this method that the beam intensity decreased with the increasing distance if the ratio corresponding to each focus was kept the same, but by adjusting this ratio we could keep the intensity of each focal point the same.

Keywords:

Fresnel zone plate, spatial light modulator, multifocal lens

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P2-op.018*

Highly birefringent slotted porous core photonic crystal fiber with elliptic-hole cladding for terahertz applications

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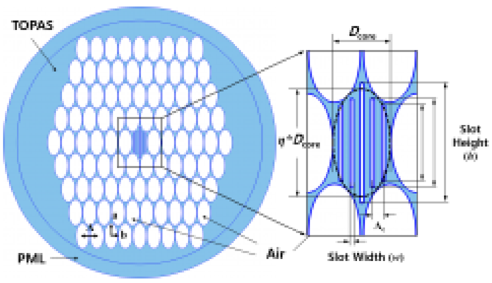
Abstract:

We proposed a photonic crystal fiber with a porous-core and the elliptic-hole cladding for high birefringence in the terahertz regime. An asymmetry in the guided mode was mainly obtained by using the elliptic-air hole arrays in the TOPAS cladding. The slotted porous core further increased the birefringence and provided a low optical loss simultaneously. The optical properties in the THz regime were thoroughly analyzed in numerical simulations using a full-vector finite element method with a perfectly matched layer condition. In an optimal design, the proposed PCF showed a high birefringence of 8.80×10^{-2} and an effective material loss of 0.07 cm^{-1} at the frequency of 1 THz, satisfying the single mode guidance condition at the same time. The proposed PCF would find various polarization management applications in the THz range.



Keywords:
Photonic crystal fiber, Terahertz, Birefringence

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핀홀 특성에 따른 SS-FF-OCT의 cross-talk 저하 효과

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Abstract:
파장 가변 전역 OCT (SS-FF-OCT, Swept source full-field optical coherence tomography)는 파장 가변 광원을 이용하여 깊이 방향의 스캐닝이 없이도 단층정보를 획득할 수 있다. 고속으로 3차원의 단층정보를 획득할 수 있는 장점으로 인해 최근에는 망막의 단층정보를 획득하거나 반도체 기판의 검사장비로 활용되고 있다. 하지만 이 기법은 인접한 광의 간섭효과로 인해서 단층영상의 선명도가 저하되는 문제점을 가지고 있다. 이러한 문제를 cross-talk이라고 부르는 것으로 이러한 단점을 해결하기 위한 방안이 몇 가지 제시되었다. 그 중에서 핀홀을 이용하여 cross-talk을 줄이기 위한 연구가 제안되었다. 본 논문에서는 핀홀의 크기와 간격을 달리하여 핀홀의 기하학적인 변화에 따른 cross-talk의 차이를 분석해 보았다. 먼저 SS-FF-OCT를 위한 파장 가변 광원을 구현하기 위해서 AOTF(acousto-optic tunable filter)를 기반으로 하는 광원을 개발하여 SS-FF-OCT 시스템의 개발에 이용하였다. 이 광원을 개발하여 광원의 특성을 측정하여 분석을 수행하였다. 이 정보를 기반으로 깊이 방향에 대한 단층영상을 획득할 수 있었다. 사용한 핀홀은 두 개의 원형으로 구현하였고 크기와 원형 사이의 거리를 달리 하여 제작하였다. 이 핀홀을 샘플 위에 위치시키거나 측정단에 위치시켜 간섭무늬를 측정하고 복원된 단층영상을 통해서 cross-talk 변화를 분석함으로써 최적의 핀홀 특성을 결정하고자 한다. 이러한 핀홀을 이용하게 된다면 가장 큰 단점으로 지적되었던 cross-talk을 효과적으로 줄이면서 동시에 단층영상의 선명도를 크게 향상 시킬 것으로 예상되는 바이다.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No.2017R1A2B2009732).

Keywords:
핀홀, swept source, FF-OCT

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P2-op.020*

공간광변조기의 위상 교정 및 온도에 따른 위상 변화 분석

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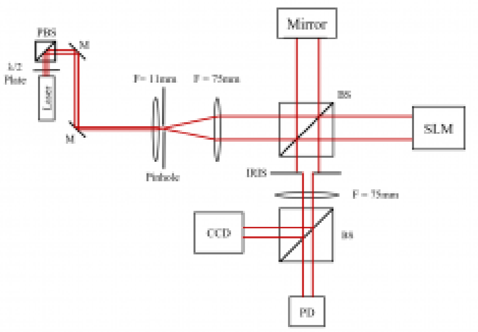
Abstract:

액정을 이용한 위상광변조기 (LCOS SLM)은 전압에 따른 액정의 굴절률 변화를 이용하여 입사하는 빛과 반사된 빛 사이의 위상을 변조한다. 컴퓨터에서 각 화소별로 그레이스케일을 입력하면 이를 전압으로 변환하여 액정에 가하게 되는데 결과적으로 나타나는 빛의 위상 변화가 입력 그레이 스케일(gray scale)에 대해 선형적으로 나타나지 않을 수 있다. 이를 교정하기 위하여 Twyman-Green interferometer를 구성하여 그레이 스케일에 따른 간섭 신호(빛의 세기)를 측정한다. 빛의 세기를 위상으로 변환하여 그레이 스케일과 위상 변화 사이의 관계를 측정하여 보정함으로써 원하는 위상에 대응하는 그레이 스케일을 찾을 수 있다.
교정을 위해 위상 변화를 측정하는 실험 과정에서 간섭 신호가 실험실 온도에 의해 영향 받는다는 사실이 발견되었다. 온도에 의한 간섭계의 광학 정렬 변화보다 SLM의 온도 변화에 의한 영향이 지배적이었으며 이는 온도에 따른 SLM chip의 부피 변화, 액정의 굴절률 변화 등이 원인으로 생각된다. 온도에 의한 영향을 분석하고 SLM의 온도를 안정화하여 실험실 온도에 의한 반사된 빛의 위상 변화를 억제하였다.



Keywords:
공간광변조기, 액정 온도 변화, 위상 변조

P2-op.021

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아스팔트 도로 노면의 다중 지점 기상상태 측정

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Abstract:

도로 노면의 기상상태에 변화로 인해 고속으로 달리는 도로에서는 큰 사고를 유발한다. 따라서 도로 노면의 기상상태를 정확히 안다면 큰 사고를 예방 할 수 있다. 외국에서 개발된 도로노면 기상관측 기술은 고정식 단일지점 관측 기술이다.[1] 그러나 도로의 단일지점 관측은 넓은 도로의 노면상태를 파악하기에는 제한적이다. 본 연구에서는 905 nm와 1550 nm 두 개의 레이저 다이오드를 이용하여 회전스캔과 선형스캔 측정을 통해 도로의 다중 지점에서 노면상태를 파악하는 기술을 연구하였다. 스캐닝을 이용한 노면상태의 측정은 국내는 물론 외국에서도 아직 사례가 없다.

그림 1-(a)는 노면으로부터 장비의 높이 5.0 m에서 AOI(Angle Of Incidence)를 30°부터 60°까지 장치를 좌에서 우로 회전하며 스캐닝을 하였고, 기상상태의 변화가 없으면 신호의 세기가 일정하게 측정되었다. 신호의 세기가 클수록 노면의 굴곡이나 파임 등 노면의 물리적인 변화에 민감하게 반응하는 것을 그림 1-(a)의 AOI 30°, 35°, 40° 그리고 45° 4개의 데이터에서 확인하였다. 선형스캔의 경우 장비를 모터로 위로 들어 올려서 노면과 이루는 각도를 변화시켜서 직선으로 노면을 스캐닝 하였으며, AOI가 커질수록 레이저 다이오드(LD)에서부터 도로노면까지의 거리가 멀어짐에 따라 그림 1-(b)와 같이 지수함수적으로 감소하였고 다음 식을 도출해 내었다.그림 1-(a)는 노면으로부터 장비의 높이 5.0 m에서 AOI(Angle Of Incidence)를 30°부터 60°까지 장치를 좌에서 우로 회전하며 스캐닝을 하였고, 기상상태의 변화가 없으면 신호의 세기가 일정하게 측정되었다. 신호의 세기가 클수록 노면의 굴곡이나 파임 등 노면의 물리적인 변화에 민감하게 반응하는 것을 그림 1-(a)의 AOI 30°, 35°, 40° 그리고 45° 4개의 데이터에서 확인하였다. 선형스캔의 경우 35°에 고정된 장비와 노면이 이루는 각도를 점점 증가시켜서 직선으로 노면을 스캐닝 하였으며, AOI가 커질수록 레이저 다이오드(LD)에서부터 도로노면까지의 거리가 멀어짐에 따라 그림 1-(b)와 같이 지수함수적으로 감소하였고 다음 식을 도출해 내었다.

$y = A\exp(-\alpha x)$ --- (1)

식 (1)을 이용하면 LD에서부터 도로노면까지의 거리만으로 디텍터에 수신되는 신호의 세기가 예측 가능하다. 식 (1)으로 계산된 값과 실험으로 측정된 값을 비교한 결과 그림 1-(b)의 5.0 V의 경우 0.28 mV(<1%)의 오차로 도출된 식의 정확성을 확인하였다. 식 (1)의 노면 신호감쇠율 값은 아스팔트 노면의 경우 0.45정도이며, 이 값은 기상 상태의 변화에 관계없이 일정한 값을 갖는다.

Keywords:
Road weather, Scanning, Laser Diode

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P2-pa.001

Simulation study on the free fall of antihydrogen at GBAR

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Abstract:
Time of flight detector in the GBAR experiment measures the free fall time of anti-hydrogen and rough position of its annihilation. It is necessary to reject false signals such as cosmic ray for an accurate measurement. We have simulated the free fall signal from anti-hydrogen annihilation and background signal from the cosmic ray muon with GEANT4. In the simulation distribution of free fall position due to thermal fluctuation as well as the momentum kick by positron detachment laser is taken into account. Using the simulated events, we develop a cosmic ray rejection algorithm via time information and hit pattern. We report the expected performance on cosmic ray rejection and signal detection efficiency.

Keywords:
GBAR, Simulation, Time of Flight, Gravity, Antiparticle

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P2-pa.002*

Control system of the GBAR antiproton trap

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Abstract:
The GBAR experiment (Gravitational Behaviour of Anti hydrogen at Rest) aims to measure the free fall acceleration of ultracold antihydrogens in the earth's gravitational field. Producing low-energy antihydrogen efficiently, antiproton should be cooled and compressed beforehand. With fast and precise timing control, the antiproton can be captured, cooled and compressed in the penning-malmberg trap under cold UHV. While potential barrier in a strong magnetic field capture the antiproton inside, electrons cool the antiproton with harmonic potential well. Applying rotating electric field on azimuthally segmented electrode can radially compress antiproton cloud. The timing sequence is realized with FPGA. We present the control system based on NI compactRIO and PXI with the LabVIEW software.

Keywords:
GBAR, Trap, Anitihydrogen, Vacuum

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P2-pa.004

Progress in DUNE 1: Far Detector and ProtoDUNE

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Abstract:
DUNE manufactures prototypes with single phase(SP) and dual phase(DP) Liquid-Ar Time Projection Chamber(LArTPC) technology. The collaboration plans to adopt both types for the far detector module. The SP ProtoDUNE has begun taking data from September 2018, and the DP will start in 2019. ProtoDUNE results determine the number and order of the final modules of each type. We report on ProtoDUNE's progress and issues related to the far detector.

Keywords:
DUNE, ProtoDUNE, LArTPC

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P2-pa.005

Progress in DUNE 2: Near Detector and its scientific target

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Abstract:
The concept of DUNE near detector is a combination consisting of a Liquid-Ar Time Projection Chamber(LArTPC) and a Multi-Purpose Detector(MPD). MPD includes a high-pressure gas TPC (HPg TPC), an electromagnetic calorimeter(ECAL) and 3D Scintillator Tracker(3DST). The issues and physics goals to consider for the final design of near detectors are introduced. Our efforts in event reconstruction in 3DST will also be presented.

Keywords:
DUNE, Near detector, 3D-projection scintillator tracker

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
2019-04-24 - 2019-04-26

Search for ALP through B → K a (a → γγ) decay

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Abstract:
In this research, we are looking for spin 0 scalar AxionLikeP article(ALP), which is predicted to decay into a photon pair, through B → Ka(a → γγ) decay mode, which is not allowed in Standard Model. This research is based on Monte-Carlo search for B meson decays to 2 γs with Kaon using the full Υ(4S) sample of 772M B $\bar{\mathrm{B}}$ pairs collected with the Belle detector at the KEKB asymmetric energy e + e− collider. By reconstructing B meson from 2 γs and Kaon, We will find special signal box for this decay mode exclude well known other mode.

Keywords:
Belle , KEKB, B meson, ALP

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P2-pa.007

MC study of B^+ -> l τ decays at Belle

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Abstract:
We study the rare leptonic decays B+ -> l tau (tau to single charged particle and neutrino(s)), using Monte Carlo based simulation data from Belle detector at KEKB e+e- collider. One of the B meson from Upsilon(4S)->B+B- is fully reconstructed by FEI(either hadronic or semi-leptonic mode), while remaining particles are from signal B decay. The Toolkit for Multivariate Data Analysis with ROOT(TMVA) is used to improve signal purity. The momentum of primary lepton on B rest frame(p_l^b) is selected for signal extraction. B -> pi l nu decay is used for peaking background estimation in signal region. Expected upper limit is calculated by fit of plb distribution in signal region.

Keywords:
Belle, KEKB, B meson

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P2-pa.008

Status and Assembly Procedure of Silicon Vertex Detector for the Belle II experiment

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Abstract:

The Belle II experiment searches for a physics beyond the Standard Model by precisely measuring B, tau, and other particle decays produced at an electron-positron collider, SuperKEKB (Tsukuba, Japan). The silicon vertex detector (SVD) is an essential sub-detector for the new physics search for its providing with particle's decay-vertex position as precise as 20 um. The SVD consists of four cylindrical layers, layer 3 (L3) to layer 6 (L6), and each layer is made of cylindrical arrangement of "ladders", each of which is composed of two to five double-sided silicon strip detectors (DSSDs). The sensors other than at the ladder and are read out by the APV25 signal read-out chips mounted on the sensors, which is named a novel chip-on-sensor concept. The SVD had been installed in the Belle II detector last November, and the Belle II detector with all the sub-detectors equipped is now undergoing the cosmic ray commissioning. Physics data taking of the Belle II experiment will starts in March. So far, we deeply contributed to the SVD production and commissioning more than five years. In this poster, we present the ladder assembly procedures and performance of the SVD estimated with early collision data.

Keywords:

The Belle II Experiment, Silicon Vertex Detector, Ladder Assembly, Double-Sided Silicon Strip Detector, Chip-On-Sensor

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Monitoring Framework and Slow Control Software Preparation for Belle II Phase 3 Data Taking

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Abstract:
The Belle II experiment is one of the leading flavor intensity frontier experiment to search for physics beyond the Standard Model. Before final data taking, phase 2 run was performed and successfully completed. Based on phase 2 data taking experience, we found some problems to solve and upgrade our monitoring framework and slow control softwares. In this presentation, we introduce the problems during phase 2 breifly, and debugging and improvement status of monitoring framework including monitoring GUI, CS-Studio plugins, EPICS Archiver Appliance, and so on.

Keywords:
Belle II, DAQ, Slow Control

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Monte Carlo study for searching $B^0 \rightarrow K_S{}^0 K_S{}^0$gamma in the Belle experiment

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Abstract:

The Belle experiment, at KEK in Japan, recorded 711 fb^{-1} data collected at the Y(4S) resonance with an asymmetric-energy e+e- collider. $B^0 \rightarrow K_S{}^0 K_S{}^0$gamma is a rare decay mode, and can be explained by b→dgamma transition with penguin diagram at the lowest level in the standard model (SM). Therefore, $B^0 \rightarrow K_S{}^0 K_S{}^0$gamma is sensitive to new physics beyond the SM and has not been observed yet. We aim to search for $B^0 \rightarrow K_S{}^0 K_S{}^0$gamma using the full data sample of $B^0\overline{B^0}$ pairs. We report Monte Carlo study for signal and background of $B^0 \rightarrow K_S{}^0 K_S{}^0$gamma in order to suppress backgrounds.

Keywords:

Belle experiment, FCNC, rare decay, b→dγ

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Dark photon search using B->Kllll decay at Belle

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Abstract:

We are going to present status report for dark photon search using rare B meson decays to kaon and 4 leptons.
We used full $\Upsilon(4S)$ data sample of 772M $B\bar{B}$ pairs corresponds to Belle integrated luminosity collected with Belle detector at KEKB asymmetric energy e^+e^- collider. We reconstructed a dark photon using lepton pair and reconstructed B meson using a Kaon or excited states of Kaon and two dark photons. We show signal extraction procedure and expected upper limit of B meson braching fraction on Monte Carlo samples.

Keywords:
dark photon, B meson, KEKB, Belle

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P2-pa.012*

Simulation Study On Charge Particle Detector for the KOTO experiment

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Abstract:

We report on Geant4 simulation results for basic performances of the Downstream Charge Veto (DCV) for the KOTO which is performed at J-PARC $K_L \to \pi^0 + \nu + \bar{\nu}$ decay experiment. The DCV is composed of four plastic scintillators, each 1410 mm long with a cross section of 5 x 171.5 mm^2. Each scintillator has 18 grooves for wavelength shifting (WLS) fibers, which are guided to Al light-collection boxes at both ends.

The simulation includes a modelling of light propagation in the scintillator, WLS fiber, and light-collection box, as well as the MPPC response to WLS light. We will present preliminary simulation results in comparison with cosmic ray tests for the DCV.

Keywords:
Simulation, Charge particle detector, Plastic Scintillator, Geant4

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P2-pa.013

Preparation work for the JSNS^2 FADC boards

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Abstract:

The JSNS^2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source) experiment is to search for sterile neutrino oscillation at 24m baseline with delta Δm^2 near 1 eV^2. JSNS^2 uses an intense neutrino beam from muon decay-at-rest from the collision of 3 GeV proton to mercury target at J-PARC. It will reuse the 8-bit 500 MHz FADC boards of Double Chooz, each with 8 channels, for the signal processing electronics. Recently we debugged the boards to make them ready for use at JSNS^2. In this talk, we present the status of the JSNS^2 FADC boards.

Keywords:
JSNS2, neutrino, JPARC, FADC

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P2-pa.014*

Event reconstruction of JSNS2 experiment

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Abstract:

The JSNS^2 experiment aims to search for the existence of sterile neutrinos using the intense neutrino source at the Material and Life Science Facility at J-PARC. The experiment searches for anti muon-neutrino to anti electron-neutrino oscillations which are detected via the inverse beta decay interaction in a liquid scintillator detector, followed by gammas from neutron capture on Gadolinum (Gd). The signal is detected using 192 PMTs. In this presentation we describe the neutrino event reconstruction of the JSNS^2 detector. Using a MC simulation study, we can determine the performance of our event reconstruction algorithms.

Keywords:
JSNS2 sterile neutrino J-PARC

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Effect of Electronic Configuration in the JSNS2 experiment

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Abstract:

The JSNS2 experiment aims to search for the existence of sterile neutrino at J-PARC. A 1 MW beam of 3 GeV protons incident on a spallation neutron target produces an intense neutrino beam from muon decay at rest. The experiment will search for muon anti-neutrino to electron anti-neutrino oscillations which are detected by the inverse beta decay interaction, followed by gammas from neutron capture on Gd. The Front End Electronics (FEE) is used to broaden a dynamic range of FADC by amplifying the waveform with high & low gain and to generate triggers from analog sum of PMT channels. The effect of FEE, which is essential to PSD (Pulse Shape Discrimination) and trigger, is presesnted.

Keywords:

JSNS2 sterile neutrino electronics J-PARC MLF IBD

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Development of XY coupling beam dedicated stripline-based non-destructive beam profile monitoring system for muon g-2/EDM experiment at J-PARC

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Abstract:

The muon g-2/EDM experiment at J-PARC aims to measure the muon magnetic moment anomaly, $a_\mu = (g-2)/2$, and the muon electric dipole moment (EDM), d_μ by introducing a new approach excluding any electric field. The measurement goal is to reach 450 parts-per-billion for statistical uncertainty and 70 ppb for systematic uncertainty of a_μ and a sensitivity of $1.5 \times 10^{-21} e \cdot cm$ for d_μ. The J-PARC facility produces a muon beam with extremely small transverse emittance called a reaccelerated thermal muon beam using laser ionization of Muonium. The beam trajectory is vertically bent by the dipole magnets in the transmission line before the injection. Besides, the lattice includes several skew quadrupole magnets so that the beam gets the XY coupling manipulation. The positron from the muon decay are detected by a silicon-based positron detector in the storage magnet. The quality of the XY coupling can affect the transmission efficiency of muon beam inside the magnet so that the failure of beam manipulation causes a systematic error. It is significant to monitor the XY coupling status before the injection and track the muon beam trajectory inside the magnet in order to improve the precision of measurement. We are developing the non-destructive beam profile monitoring system to investigate the quality of XY coupling for the injecting muon beam so as to improve the measurement precision by reducing the source of systematic uncertainties. This paper will present the simulation result on how the profile would be reconstructed and the measurement result of prototype device with a wire test system including a signal processing electronics.

Keywords:
XY coupling, non-destructive beam profile monitor

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P2-pa.017*

Prospects for W' search in Vector Boson Fusion at the High-Luminosity LHC

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Abstract:

The High-luminosity LHC (HL-LHC) will be expected to deliver an integrated luminosity of up to 3000 fb^{-1},which will provide extremely challenging experimental conditions. This increases the probability of production new exotic particles via vector boson fusion (VBF) mode. In this study, Monte Carlo simulation was performed to assess HL-LHC sensitivity to W' VBF signatures. we consider the final state with one lepton + MET + 2 jets in pp collisions for integrated luminosities of 300, 1000 and 3000 fb^{-1}. Signal and Background events were generated by Madgraph and Delphes. The kinematic features and cross-sections were studied. An optimization of the signal event selection were performed. The result is used to provide the 95% C.L. limit on the mass of W' according to the integrated luminosities at HL-LHC.

Keywords:
High-Luminosity, LHC, CMS, VBF, W'

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P2-pa.018*

Search for Z' decaying into BSM particles in dilepton+MET final state at 13 TeV

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Abstract:
Searching for heavy neutral gauge bosons Z′ is one of the challenging goals of the experiments performed at the Large Hadron Collider (LHC). The LHC experiments have so far searched for Z′ and have set exclusion limits on its mass assuming that the Z′ decays into only Standard Model (SM). Possible decays Beyond the Standard Model (BSM), e.g. in supersymmetric particles, will significantly decrease the branching ratios into SM particles, and therefore the mass limits may have to be revisited. Furthermore, BSM production in Z′ decays has the advantage that the Z′ mass is a further kinematical constrain on its invariant mass. Search for Z' decaying into supersymmetric particles in the dilepton + MET final state is presented with the data recorded by the CMS detector at 13TeV.

Keywords:
Z', BSM

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P2-pa.019

HL-LHC and HE-LHC searches for new physics in hadronic final states with boosted W bosons or top quarks using razor variables

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Abstract:
We present High-Luminosity LHC (HL-LHC) and High-Energy LHC (HE-LHC) projections of the Run 2 search for new physics in hadronic final states with boosted W bosons or top quarks using razor variables. Data event yields and signal/background cross sections from the 2016 analysis are scaled to obtain the HL-LHC and HE-LHC sensitivity for center-of-mass energies of 14 and 27 TeV and integrated luminosities of 3 and 15 ab^{-1}, respectively. Different scenarios for systematic uncertainties are considered. The projection results are interpreted in terms of gluino pair production where each gluino decays to a top quark, an anti-top quark, and a neutralino or to a top quark and a top squark and direct top squark pair production where each top squark decays to a top quark and a neutralino.

Keywords:
CMS, HL-LHC, HE-LHC, SUSY

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P2-pa.020

Muon detector complementarity in Phase II CMS L1 Trigger: iRPC+CSC

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Abstract:

The Phase II CMS Level-1 (L1) Trigger architecture will possibly allow merging information from several muon sub-systems together before to build the trigger primitives. This new architecture would, among other advantages, give some handle to keep under control the very high rate expected from HL-LHC conditions. Indeed, in the end-cap region, fake segments arise in the CSC system each time a given chamber receives more than one hit within ± 1 bunch-crossing due to the two 1-dimensional measurements. The newly installed improved RPC (iRPC), RE3/1 and RE4/1, will provide a 2-dimensional measurement that can help to solve this ambiguity and reduce the trigger primitive rate sent by the ME3/1 and ME4/1 chambers. In addition, to reduce the trigger primitive rate, this may also prevent to promote low p_T to high p_T L1 candidate and would thus also to lower the muon rate.

Keywords:
CMS, Muon, detector, Trigger, RPC, CSC

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P2-pa.021*

CMS muon reconstruction and identification performance of Run2 data

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Abstract:
The performance of CMS muon system is crucial for many physics results in CMS. Throughout Run 1 and Run 2, many upgrades have been carried out to enhance the performance of muons. One of the major changes is the development of new algorithm in muon high-level trigger. The performance of muon reconstruction and identification has been studied with the data collected using the CMS detector at sqrt(s) = 13 TeV in 2018. Muon reconstruction and identification efficiencies are measured using tag and probe method, and the results are compared to previous performances.

Keywords:
CMS, LHC, muon

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P2-pa.022*

Measurement of top quark mass in the dileptonic channel using charmed meson in b-jet at 13 TeV

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Abstract:

In the measurement of top quark mass, jet energy uncertainty is one of the largest systematics. In many alternative solutions, jets are not concerned when extracting the top quark mass, so it reduces the jet energy uncertainties. We suggest the method using charmed mesons within b-quark jet and an isolated leading lepton. We use dileptonic decay channel and concentrate on the D^0, D^* and J/ψ meson which reconstructed in the b-quark jets using 2016 LHC 13 TeV data collected by the CMS detector. There are updates about measurement of top quark mass with fitting the lepton-charmed meson pair.

Keywords:
LHC, CMS, Top quark mass, charmed meson

P2-pa.023*

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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A new Muon segment building algorithm for improving the muon track reconstruction

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Abstract:

The CMS muon system needs to provide high eifficieny of muon track reconstruction and identification. GEM detectors will be implemented to upgrade the current muon system. The standard CSC segment buildling algorithm which is based on the road usage approach needs to take advantage of the additional hits provided by the GEM detectors. This should enhance the efficiency of segment reconstruction to be robust and stable at high luminosities where high pile-up is expected to produce high background rates.

Keywords:
GEM, CSC, muon segment

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P2-pa.024*

Background estimations of Jet faking photon for monophoton analysis

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Abstract:

The Dark matter (DM) remains one of the most puzzling mysteries in fundamental physics. Particle physics experiments at high energy colliders are expected to shed light to its nature and determine its properties. The DM is one of the most compelling pieces of evidence for new physics beyond the standard model (SM). Cosmological observations demonstrate that around 85% of the mass of the Universe is comprised of the DM. If non-gravitational interactions exist between the DM and the SM particles, the DM could be produced by colliding the SM particles at high energy colliders. Production of the DM events using a photon with large transverse momentum and large missing transverse momentum due to DM escaping without any signal in the detector at the CERN LHC is a sensitive probe to search for the DM. This final state is often referred to as the Monophoton signature. The final state of the Monophoton from proton-proton collisions has several irreducible sources of backgrounds. The estimation of backgrounds in the Monophoton analysis is essential to drive a reliable result. The QCD multiple jet from the hadronic activity is major background which mimics a fake photon. In this poster, the estimation of jet faking photon studies will be shown.

Keywords:
Dark matter, Monophoton, CMS, LHC

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P2-pa.025*

GEM Data Quality Monitoring with Machine Learning

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Abstract:
DQM is needed to verify high quality data for physics analysis. Till now, data quality was checked manually by monitoring hundreds of plots, requiring lots of time and manpower. AutoDQM is a statistical tool for DQM that automates this tedious process. GEM is a new muon detector in the CMS experiment and the implementation of AutoDQM and other machine learning tools are presented.

Keywords:
DQM, GEM, ML

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P2-pa.026*

Double Higgs Event Selection with kinematic variables

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Abstract:
In order to improve the separation of double higgs events from the biggest standard model background, top pair events, kinematic variables, especially MT2 variables are examined. MT2 is an event variable used to bound the masses of invisible particles using the momenta of the visible particles and the missing transverse momentum in an event. MT2 is expected to be a good variable for discriminating top (tt->bWbW (W->lv)) from double higgs (hh->bWbW (W->lv)) events. Machine Learning methods such as BDT were used for further discrimination using this variable. The result of this study is expected to be utilized for higgs self coupling study.

Keywords:
LHC, CMS, Higgs

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P2-pa.027*

Particle Identification in 3D-Projection Scintillator Tracker using TensorFlow.

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Abstract:

DUNE 실험의 근거리 검출기는 액체아르곤 Time-Projection Chamber(TPC), 고압기체아르곤 TPC, ECAL, 3D-Projection Scintillator Tracker(3DST)등으로 구성된 하이브리드 타입이다. 그 중 3DST에서 생기는 입자의 2차원 궤적들을 3차원 이미지로 재구축하여 전자와 뮤온을 구별하는 과정을 보이려 한다. Google에서 제공하는 TensorFlow라는 학습패키지에 전자와 뮤온 궤적을 구별하도록 학습시키고, 이후 궤적을 식별하는 정확도와 입자에너지에 대한 연구내용을 발표할 것이다.

Keywords:

3D projection scintillator tracker, Particle idintification, Deep learning, TensorFlow

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P2-pa.028

Measurement of Run-II RPC Chamber Efficiency

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Abstract:

Throughout the Run-I and II, the efficiencies of the CMS RPC chambers have been measured based on the extrapolation from DT/CSC segments. We can do similar measurements, based on extrapolation of inner tracks using tag and probe method. We present the measurement of the RPC chamber efficiency using Run-II data sample collected in pp collisions at √

Keywords:

Muon, RPC, Detector

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P2-pa.029*

GPGPU Fast Tracking in a COMET Phase-I Drift Chamber

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Abstract:
Track finding with GPGPU-implemented fourth order Runge-Kutta (RK) method is investigated to track electrons from muon decay in the COMET Phase-I drift chamber. The COMET Phase-I experiment is aiming for discovering the neutrinoless, coherent transition of a muon to an electron in the field of an aluminium nucleus, $\mu^- + N(\mathrm{A},\mathrm{Z}) \rightarrow e^- + N(\mathrm{A},\mathrm{Z})$, with a single event sensitivity of 3×10^{-15}. In the COMET drift chamber, about 30-40 % of signal events are composed of multiple turns where the correct discrimination of hits against the turn partition are significant in the track finding. Scanning all possible track seeds can resolve the hit-to-track assignment problem with a high robustness about the noise hits, but requires a huge computational cost; initial track seeds $(\theta, z, p_x, p_y, p_z)$ have broad uncertainties, so many initial seeds should be tried and compared. In this presentation, this problem of massive computations are mitigated with 1) the parallel computing of RK track propagation, which assigns each track to each GPU block unit, 2) a better initial guess on the track seeds using the Hough transform and the geometrical property of the cylindrical drift chamber.

Keywords:
lepton flavor violation, muon to electron conversion, particle tracking, COMET experiment

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1.7 MV 탄뎀 가속기의 외기 PIXE용 X-선 검출 및 분석시스템 개발

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Abstract:

외기 PIXE 분석기술은 입자빔만을 가속기에서 빔창(beam window)을 통해 대기 중으로 인출하여 시료를 대기 중에서 조사/분석하는 첨단 분석기술로 수 MeV 정도의 에너지로 가속된 입자빔을 시료에 조사할 때 이 시료의 원자에서 나오는 특성 X-선을 분석하여 시료의 구성 원자를 정성, 정량 분석할 수 있는 방법이다. 대기 중 분석으로 시료 교체 시간을 확연히 줄일 수 있으며, 액체 및 분말, 나아가 기체 시료까지도 분석이 가능한 기술이다. 대기 중에서 자연 공냉이 될 뿐만 아니라 추가적인 냉각시스템 구축이 쉬워, 입자빔 조사열에 의한 시료의 손상 가능성이 거의 없다. 이와 더불어 기존 진공챔버 내에서 시료를 분석하는 일반 PIXE의 경우 진공챔버 내에 위치시킬 수 있는 작은 시료만을 분석할 수 있었지만, 외기 PIXE의 경우 대기 중 측정으로 시료의 크기 제한이 없어져 획기적인 비파괴 정밀/정량 분석기술이라 할 수 있다. 한국원자력연구원 양성자가속기연구센터에서는 차후 문화재 복원 및 보존처리 활용 목적으로 기존 PIXE 빔라인을 외기 PIXE 빔라인으로 업그레이드 중에 있으며, 이번 학회에서는 이 외기 PIXE 빔라인에 대한 X-선 검출 및 분석시스템 개발에 대한 내용을 발표하고자 한다.

Acknowledgement
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Keywords:
외기 PIXE, 탄뎀가속기, 이온빔 분석, X-선 검출

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The current RF System performance verification and re-design of KAERI 20MeV Superconducting FEL Linear Accelerator

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Abstract:

KAERI has developed three types of free electron lasers (FELs) since 1992: a millimeter-wave (MMW) FEL driven by a 0.4-MeV electrostatic accelerator, a compact far-infrared (FIR) FEL driven by a 7-MeVmicrotron, and an infrared FEL with average power of ~1kW driven by a 40-MeV superconducting accelerator. Successful lasing of the MMW FEL and the compact FIR FEL were demonstrated in 1994 and 1999, respectively. A 2-MeV injector for the infrared FEL has been completed, and the main superconducting accelerator section is being re-constructed since several years ago to recover the burned out parts from the fire. This paper describes the current RF system performance, the results of the re-design to upgrade the current RF system with the superconducting RF Cavities.

Keywords:

RF System FEL superconducting

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P2-pa.033

The RF Stability and Operation results of PLS-II Storage Ring RF System at 400 mA 3.0 GeV

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Abstract:

The RF system for the Pohang Light Source (PLS) storage ring was greatly upgraded for PLS-II project of 400 mA, 3.0 GeV from 200 mA, 2.5 GeV. Three superconducting RF cavities with each 300 kW maximum klystron amplifier were commissioned with electron beam in way of one by one during the last 5 years for beam current of 400 mA to until March 2019. The RF system is designed to provide stable beam through precise RF phase and amplitude requirements to be less than 0.3% in amplitude and 0.3° in phase deviations with the higher availability. In order to accomplish these requirements, a digital feedback control technique is adopted for flexibility of the feedback algorithm implementation with a very stable RF signals generation. This paper describes the RF system stability and the operation results with the several implementations up to 400 mA at 3.0 GeV beam energy.

Keywords:

RF Stability feedback

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양성자 빔에 의한 공간에서의 선량분포 추정

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Abstract:
양성자가 일정한 에너지를 가지고 표적 물질에 조사될 때, 핵반응에 의해 중성자선 및 감마선등의 이차 방사선들이 발생된다. 일반적으로 발생된 중성자와 감마선은 방사선 모니터링 시스템 (RMS)에 의해 실시간으로 계측한다. 만약 입사될 양성자 빔에 의한 선량 분포를 어느 정도 예측할 수 있으면, 각종 측정 장비의 배치를 조정해서 측정 장비가 받는 선량을 줄이는 등의 효과를 가질 수 있다. 입사된 양성자 빔의 조건 변화에 따른 선량분포는 FLUKA 같은 몬테카를로 시뮬레이션을 이용하여 추정할 수 있고, 그 결과는 실험 공간에서 실제 측정된 양성자 및 중성자의 선량 값과 비교할 수 있다. 또한 이렇게 수집한 선량 분포들은 입사된 양성자에 의한 공간 내 어떤 지점의 선량분포를 예측하는 시뮬레이터에 이용할 수 있다. 본 연구에서는 FLUKA 시뮬레이션을 이용하여 양성자 빔의 에너지 변화에 따른 공간에서의 선량 분포 변화와 실제 선량을 비교한 결과를 서술하겠다.

Keywords:
양성자, 방사선량, FLUKA, 시뮬레이션

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InGaP/GaAs 이중접합 태양 전지의 수광면 최적 격자 패턴에 따른 효율 향상

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Abstract:

플렉서블 태양전지 중 고효율 III-V 태양전지는 동일한 무게 대비 높은 출력을 보유하고 있어 고고도 무인기, 인공위성 등에 가장 적합한 셀이다. 본 연구에서는 InGaP/GaAs 이중 접합 태양 전지에서 수광 표면의 최적 격자 패턴에 따른 효율 향상을 연구 하였다. 태양 전지의 그리드 전극 패턴은 대면적의 수광부를 갖고 생성되는 전류의 양이 많을수록 전극 형태로 인한 저항이 매우 중요한 요소가 될 수 있다. 이 저항의 종류에는 태양전지에서 생성된 전자 또는 홀이 그리드로 이동하는 동안 발생되는 시트 저항과 전극자체에서 이동 시 저항, 전극과 반도체의 접촉 오믹 저항 등이 포함되어 있다. 주사된 패턴은 4가지의 형태로 각각의 패턴에 대하여 동일한 그리드 점유율을 갖도록 그리드의 간격을 조절하였다. 또한 조사된 그리드의 폭은 5, 10 μm 에 대해서 조사하였다 포토 마스크는 2 인치 InGaP/GaAs 이중 접합 태양전지 에피 택셜 층 상에 5 x 5 mm^2 크기의 셀이 16 개의 상이한 그리드 패턴을 형성하도록 제조되었다. 수광면의 그리드 점유율은 각 형상에 대해 0.8 ~ 8 %로 설계되었다. 조사된 패턴 중 가장 좋은 효율은 갖는 그리드의 형태는 방사형으로 태양전지의 광전효율은 무반사 코팅 없을 경우 1 sun에서 약 24.3 % 의 태양전지 효율을 형성하였다.

Keywords:

태양전지, 그리드 패턴, 수광면, 이중접합, 3-5족

P2-se.002*

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Investigation of p-type NiWOx as hole transport material in perovskite solar cells

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Abstract:

Organic-inorganic halide perovskite solar cells (PSCs) possess excellent chemical, electronic, and optical properties that make them attractive for next-generation thin film solar cells research due to their high power conversion efficiencies over 23%. This 23 % efficiency is highly significant, the PSCs exhibit a higher efficiency than multi-crystalline Si (22.3 %) as well as it is comparable to cadmium telluride (CdTe, 22.1 %) and copper indium gallium selenide based (CIGS, 22.9%) solar cells. The high performance PSCs generally use organic materials and TiO_2 layer as extract hole and electron, respectively. In addition, the hole transport materials (HTM) are key factor for charge extraction and stability in solar cells. The 2,2′,7,7′-tetrakis-(N,N-di-4-methoxyphenylamino)-9,9′-spirobifluorene (Spiro-MeOTAD) film generally used for HTM due to its facile implementation and high performance. However, the Spiro-MeOTAD is thermally and chemically unstable. Herein, a vacuum deposited NiWOx based thin films were used as the HTM of planar structured PSCs for enhancement of stability. The NiWOx layers were deposited by reactive sputtering method from a high purity target in a mixture of oxygen and argon gases. The influence of process parameters including sputtering power, oxygen pressure, post-annealing, and working pressure on the film properties such as crystal structure, transmittance, and resistivity were investigated in detailed. In addition, the photo-conversion properties of PSCs with NiWOx based HTM were investigated.

Keywords:

organic-inorganic hybrid perovskite, photovoltaic devices, metal oxide semiconductor, hole transport material (HTM), NiWOx

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P2-se.003*

Plasma-Treated Continuous Monolayer MoS_2 Film for Improving Hydrogen Evolution Reaction

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Abstract:
High density of (1010) Mo-edge to basal sites and near zero Gibbs free energy of atomic-thick MoS_2 are the two essential parameters thatrenders it for low-cost hydrogen evolution reaction (HER) compared to the noble metal counterpart. Here,we investigate the HER performance of continuous atomic-thick MoS_2synthesized via metal organic chemical vapor deposition (MOCVD). Interestingly, the density of active sites can be further enhancedby treating it with nitrogen plasmain a controlled manner to enhance the HER performance. In this regard, we expose the monolayer MoS_2 samples tonitrogen plasmafor various times (0, 10, 20, 30, 40, and 50 min), and subsequently, investigate their in-situ optical and morphological properties.The 20 min treated sample show maximum basal site density, as evident in the morphological characterizations. Finally, the HER measurements also shows that 20 min plasma treated sample perform maximum activity with the onset overpotential of -240 mV and Tafel slope of 100 mV/decade in comparison with others.

Keywords:
Hydrogen Evolution Reaction, Monolayer MoS2, Active sities

P2-se.004

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그래핀 기판 위에 성장한 PbS 박막 특성과 이를 이용한 광전압형 적외선 소자

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Abstract:

그래핀은 최근 10년간 많이 연구되어진 물질 중 하나로 높은 전자이동도, 열전도 특성을 가지면서 유연성, 신축성이 좋아 응용분야가 다양하다. 예를 들어 높은 열전도성을 이용한 방열소재로 활용되거나 높은 전도성과 작은 흡수율을 이용한 투명전극이나 센서로 사용된다. 또 수열합성법을 이용한 ZnO의 전극뿐만 아니라 Seed layer로 사용되어 LED나 태양전지에 응용되고 있다. 본 연구는 그래핀의 높은 전도도와 투과도를 이용한 투명 전극으로서의 장점을 이용하기 위하여 PbS를 Chemical Bath Deposition방법으로 Graphene 위에 성장하였다. XRD 결과분석으로 PbS가 <200> 방향으로 주로 성장하는 것을 확인 하였다. 수직 광 전압형 광검출기 소자를 제작하여 IR영역에서의 광전류 스펙트럼을 측정하였다. 그래핀은 PbS 광 소자에서 투명 전극과 Seed Layer로 사용 할 수 있음을 보였다.

Keywords:

그래핀, PbS, 광검출기, 광전류

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P2-se.005*

Photovoltaic PbS infra-red detectors using silver nanowires as top plasmonic nano antenna electrodes

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Abstract:
There is growing interest in mid-infrared, 3-5 μm wavelengths detectors due to their promising applications in biosensors and hyperspectral imaging. Lead sulfide (PbS) has a narrow direct band gap energy (0.41 eV for bulk), which is a good candidate for the 3-5 μm wavelengths detection. On the other hand, metal nanowires such as silver nanowires may be used as transparent top electrodes in the IR range due to their high transparency and conductivity as well as plasmonic nano antennas for inducing surface plasmon polaritons. These surface plasmons enhance the photocurrent by amplifying the electric field.
We fabricated infrared photovoltaic devices based on the Schottky junction between Ti and lead sulphide (PbS) and measured their photocurrent spectra. Bath deposition Chemical (the CBD) The which an Inexpensive and the Simple method of Thin Film film deposition was USED to grow and PbS Films' Is the Glass Hall on Mobility substrate was Estimated to be the AS the AS of the High 60 cm^2 / V sec at room temperature, which is the highest reported value for films grown by the same method. For transparent top electrodes, silver (Ag) nanowires were drop cast on PbS and using a Fourier transformed infrared (FTIR) set-up. By FDTD simulations, we have shown that Ag nanowires worked as plasmonic nano antennas and photocurrents can be enhanced for photon energies close to the bandgap where the absorption coefficient is originally small.

Keywords:
Lead sulfide, Photovoltaic, Surface plasmon, Photocurrent, FDTD simulation

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P2-se.007*

Improvement of bias instability in tungsten-indium-zinc oxide thin film transistor via simultaneous ultra-violet and thermal annealing

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Abstract:

This study suggests a simultaneous ultra-violet and thermal annealing (SUT) as an excellent post-treatment method to improve the device bias instability of W (tungsten) doped InZnO thin film transistors (WIZO-TFTs). SUT at 200 °C significantly enhanced the device performance and stability of WIZO-TFTs, compared with other post-treatment methods, such as air ambient annealing at 250 °C. To understand the enhanced device performance and stability of WIZO-TFT with SUT, we investigate the correlations between device performance and stability and electronic structure by using static analysis and dynamic analysis related to the conduction band, and band edge states below the conduction band. The improved stability of WIZO-TFTs with SUT is related to the modification of electronic structure. In addition, the dominant mechanism responsible for the enhanced device performance and stability of WIZO-TFTs is considered to be a change in the shallow-level and deep-level band edge states below the conduction band.

Keywords:

tungsten-indium-zinx oxide, thin film transistor, bias instability

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P2-se.008

Study of Shunt Resistance, Leakage Current and Correlation of PL to EL in Green Micro-LEDs by Micro-photocurrent and other optical Methods

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Abstract:

Micro LEDs are small-sized light emitting diodes (LEDs) with a chip size of 5 ~ 100μm. Since micro-LEDs have small volume, high contrast, high efficiency, and fast response time, many researches are being conducted to apply them as a next generation display. For the display applications of micro-LED, a single display panel uses millions and sometimes even tens of millions of LED chips, and therefore a mass transfer method should be used. In this case, the conventional chip-by-chip inspection technique that measures electroluminescence (EL) by connecting electrodes to all the chips becomes too much time and cost consuming, which is one of the biggest obstacles to realization of the display application. On the other hand, optical methods such as photoluminescence can measure the luminescence characteristics of the chip at a very high speed without electrical connection. However, the emission wavelength and intensity of PL cannot predict the actual emission wavelength and intensity of the EL at the desired accuracy. One of the main causes of the difference between EL and PL characteristics is that leakage path may be generated due to side wall damage during the chip process, and the shunt resistance effect by this leakage path becomes significant, resulting in the difference in EL characteristic even between adjacent chips that have similar PL characteristics. In this study, we have investigated the leakage current and the shunt resistance in green micro-LED structures using micro-photocurrent mapping technique. By this method, we can quantify the leakage current and its related shunt resistance in the individual chip. Furthermore, we analyzed the effect of piezoelectric field and applied voltage on the luminescence characteristics through PL analysis by changing the applied bias, excitation wavelength and intensity. From the above results, we will discuss the overall correlation between PL and EL characteristics in green InGaN/GaN micro-LEDs.

Keywords:
Micro LED, Leakage current

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P2-se.009*

Study on Depth Dependent Strain in AlGaN-Based Light Emitting Diodes Using Surface-Plasmon Enhanced Raman Spectroscopy

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Abstract:

Deep ultraviolet light emitting diodes (DUV LEDs) have been actively studied for applications in, such as, sterilization, virus removal and photolithography light source. At present, in DUV LEDs, AlGaN layers with high Al contents are used as the active layer. When AlGaN active layers with high Al contents or AlN buffer layers are grown on c-sapphire substrate, strong tensile strain is generated throughout the layer and this strain plays an important role in generating defects in the active layer and consequently lowering the quantum efficiency of the device. Therefore, the measuring and engineering of this strain becomes crucial topic to enhance the device performance. In addition, the strain distribution can be varied as a function of the distance from the sample surface, which is one of the important factors to optimize the overall device structure. Raman spectroscopy has been used to determine the residual strain by monitoring the position of E2-high mode, which is sensitive to the strain of the surrounding area. In general cases the average strain of all layers are measured since the incident light are mostly transmitted through the all layers of LEDs.

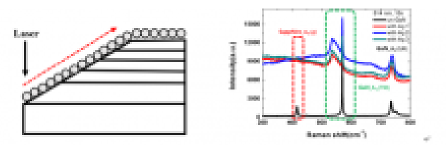

Fig 1. The schematic diagram of SERS line scanning measurement on a truncated LED
Fig 2. Raman enhancement by surface plasmons in Ag nanoparticles

In this study, we utilized the surface-plasmon enhanced Raman spectroscopy (SERS) to analyze the strain as a function of the distance from the DUV LED sample surface with 20 nm spatial resolution. SERS is a technique to selectively enhance the Raman signal of materials near metal nanoparticles. When the plasmons are properly excited in the metal nanoparticles, the Raman signal of the surrounding materials in the plasmon field can be dramatically enhanced. For our analysis, we fabricated a obliquely polished DUV LED structure to obtain the sample that has different surface exposed layers as a function of lateral distance. We prepared samples in which 3 μm lateral distance corresponds to 5 nm of vertical distance. Then SERS templates were prepared with Ag nanoparticles on the surface to resonantly enhance the Raman signal at the surface. The schematic of experimental procedure is shown in in figure 1. By monitoring and analyzing the E2-high mode of AlN-like and GaN-like Raman signal, we could measure and analyzed the strain distributions as a function of the distance from the surface. We observed the strain variations in AlN and AlGaN layers as a function of the distance from the sapphire substrate. Our results can provide very useful analyzing tool for depth dependent strain analyzing in AlGaN based DUV LED structures.

Keywords:
Surface plasmon enhanced raman spectroscopy, AlGaN, Strain

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Optical and Electrical Properties of P-Type Tin Oxide Thin Films Grown Using Sputtering Deposition with Mixed H_2/Ar Gas

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Abstract:

We investigated the optical and electrical properties of Tin Oxide (SnO) thin films grown on SiO_2 (200nm)/Si substrates via a RF sputtering deposition, using SnO target. SnO thin film is p-type material, having hole majority carriers.

The ellipsometric angles, Ψ and Δ of tin oxide thin films were measured via spectroscopic ellipsometry. Dielectric functions and optical gap energies of tin oxide thin films were obtained from the ellipsometric angles using the parametric optical constant models.

We fabricated p-type bottom gate tin oxide thin film transistors (TFTs) with varying hydrogen/argon gas ratio. The source and drain electrodes (Pt) were fabricated using DC sputtering deposition at room temperature and the tin oxide thin film transistors were post-annealed for 3h at 400℃. We determined threshold voltage (V_{th}), field effect mobility (μ_{FE}), and subthreshold swing (SS) with varying hydrogen/argon gas flow rates.

Keywords:
SnO, TFT, Oxide TFT, p-ype TFT

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Cu가 치환된 Mott-Hubbard 절연체 NiO의 p형 전도물성 연구

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Abstract:

투명 전도성 산화물은 높은 전기 전도도와 더불어 우수한 광 투과도를 갖는 소재로서, 다양한 전자소자및 광소자에 응용되어 오고 있다. 그러나 현재까지 발굴된 투명 전도성 산화물은 majority carrier가electron인 n-type이 대부분이며, 상대적으로 p-type 투명 전도성 산화물은 부재한 상황이다. 이는 대부분 산화물의 hole 전도 경로가 되는 valence band maximum (VBM)이 국부화 특성이 강한 O 2p 궤도에서 기인함으로 인해, 근본적으로 산화물에서의 hole 전도 발현이 어렵기 때문인 것으로 보고되고 있다.이러한 문제를 해결하기 위해 O 2p 궤도보다 높은 준위의 Cu 3d 궤도를 가지는 소재를 활용하여, hole전도도가 향상된 산화물 소재를 개발하는 연구가 진행되었으나, 소재 자체의 작은 에너지 갭에서 기인한가시광 투과도 저하 문제가 여전히 해결되지 못하고 있다. 본 연구에서는 전자간 상호작용에 의해 3eV이상의 밴드갭이 형성될 수 있는 Mott-Hubbard 절연체 NiO 소재에 Cu를 치환 도핑 시킴으로써 hole전도도의 향상 가능성을 고찰하였다. NiO와 CuO 분말을 정량비에 맞게 혼합하여, 고상합성법을 통해$Ni_{1-x}Cu_xO$ (0<0<0.22) 샘플을 합성하였으며, X-ray diffraction (XRD)와 electron probe micro analyzer (EPMA) 분석을 통해 NiO의 Ni-site에 Cu가 치환도핑 되었음을 확인하였다. 4-point probe 측정 및 Hall 측정 결과 비저항이 2.73×108 에서 6.51×104 Ω·cm까지 감소하였고, 홀 농도는 2.11×1011 에서 2.04×1016 cm-3까지 증가하였음을 확인하였다.
Ellipsometry 측정으로 Cu가 치환도핑 되었음에도 3.4 eV 이상의 밴드 갭을 유지하고 있음을 확인하였으며, 자기 모멘트 측정 결과 반강자성 전이온도가 450K까지 유지되고 있음을 관찰하였다. Density functional theory (DFT) 계산을 통하여, 이는 전자간 상호작용력의 크기가 고농도의 Cu 치환에도 크게 저하되지 않기 때문임을 규명하였다.

Keywords:
p-type 투명 전도성 산화물, O 2p 궤도 국부화, Mott-Hubbard 절연체

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Strain-induced photoluminescence behavior of $MoSe_2/WSe_2$ lateral heterostructure.

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Abstract:

Two-dimensional (2D) heterostructures consisting of transition metal dichalcogenides (TMDCs) are emerging for having great potential in novel functional devices because of the energy difference in band alignment and unique band transition that occurs at the interface between two different materials. Many researches related to 2D TMDC heterostructures is recently focused on strain-dependent optical analysis for exploring new functional properties. Photoluminescence (PL) measurement with applying strain is powerful tool to characterize optoelectric phenomena in 2D heterostructure. Recently, strain-induced PL has been studied for modulating band structure behaviour in MoS_2/WS_2 vertical heterostructure.[1] In our work, we carried out PL measurement with applying with tensile and compressive strain at $MoSe_2$ and WSe_2 as displayed in Fig. 1(a), respectively. Strain-induced energy shift in PL spectra were observed in $MoSe_2$ and WSe_2, as shown in Fig. 1 (b) and (c), respectively. As tracing PL peak energy shift depending on strain, we observed that energy change (46 meV/%) in WSe_2 is larger than that (37eV/%) in $MoSe_2$. Valence band offset is changed in terms of strain from 0.234 eV (compressive strain, -1.77 %) to 0.202 eV (compressive strain, +1.77%) due to the change of bandgap between $MoSe_2$ and WSe_2.

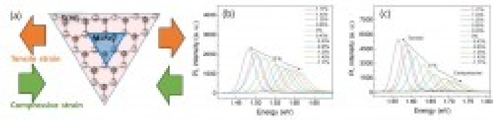

Figure 1. (a) Schematic of $MoSe_2/WSe_2$ heterostructure with tensile and compressive strain. PL spectra varying with strain in (b) $MoSe_2$ and (b) WSe_2.

Reference:
[1] S. Y. Pak *et al.*, "Strain-Mediated Interlayer Coupling Effects on the Excitonic Behaviors in an Epitaxially Grown MoS_2/WS_2 van der Waals Heterobilayer", Nano Lett. 17, 5634 (2017)

Keywords:
Strain, photoluminescence, heterostructure, MoSe2, WSe2

P2-se.013*

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Optical phonon and exciton characteristics in layered MoS_2

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Abstract:

화학 증기 증착 방법으로 성장된 MoS_2 층상구조에 대한 공간 분해된 라만 산란 및 광 발광 실험 결과를 보고한다. 라만 산란 실험으로 확인한 MoS_2 층상구조는 삼각형 모양의 monolayer 중심 위에 작은 삼각형 모양의 monolayer 하나가 얹힌 형태를 지니며, monolayer 위의 bilayer 영역 테두리에 monolayer/bilayer 경계가 형성되어 있다. 공간 분해된 광 발광 실험 결과 monolayer 영역에서 트라이온 발광 세기는 공간적으로 변화가 거의 없는 반면, 엑시톤 발광 세기는 monolayer/bilayer 경계 근처에서 크게 증가하였다. 이를 해석하기 위해 밀도범함수 이론 계산을 한 결과 monolayer MoS_2의 일함수가 bilayer MoS_2의 일함수보다 작음을 알 수 있었다. 따라서 monolayer/bilayer 경계 근처 monolayer 영역에서의 엑시톤 발광 세기 증가는 일함수 차이에 의해 monolayer의 전자가 bilayer MoS_2로 이동함에 따른 것으로 생각된다. [이 연구는 2016년도 정부(교육부)의 재원으로 한국연구재단의 기초연구사업의 지원을 받아 수행된 것임 (과제번호: 2016R1D1A1B03935270)]

Keywords:

MoS2, 엑시톤, 광 발광, 라만

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백색광을 위한 europium(III) 활성화 스트론튬 화합물의 합성 및 특성

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Abstract:

환경에 대한 인식이 높아짐에 따라 희토류 (rare-earth: RE) 이온이 활성화된 호스트 재료는 전통적인 램프 전구와 비교해 높은 color rendering index (CRI), 우수한 luminosity 효율 및 환경 친화적인 특성과 같은 우수한 특성으로 인해 4세대 고체 광원으로 유망하다. 이러한 발표에서는 희토류의 가장 중요한 구성원 중 하나 인 europium (Eu^{3+}) 이온은 전통적인 고온 고체 상태 반응 방법으로 합성된 Sr_3MoO_6을 활성화시키는 데 사용되었다. 농도 quenching 메카니즘을 조사하였고 최적의 도핑 농도는 30 몰%였다. 또한, 생성된 시료는 자외선 (NUV) 및 청색 칩에 의해 여기되어 우수한 발광 특성을 가진다. 색좌표는 표준 적색광 (0.670, 0.330)에 가깝지만 색상 순도는 94.78%에 달했다. 또한 상업용 적색 형광체와 녹색 형광체를 조합하여 조명 장치에 활용될 때 CRI 값은 NUV 칩에서 높았다. 적색 발광 Sr_3MoO_6 형광체가 뛰어난 발광 특성을 갖는 백색광에 사용될 수 있을 것으로 사료된다.

Keywords:
형광체, 발광특성

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P2-se.015*

CO_2/N_2 혼합비율이 ZnS nanospiral 성장에 미치는 영향

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Abstract:
ZnS nanospiral 은 광학적 특성과 화학적 특성에 있어서 다양한 활용 가능성을 가지고 있다. 본 연구에서는 ZnS nanospiral의 성장조건 및 특성을 연구하였다.
물리 기상 수송 증착법 (Physical Vapor Transport Deposition)을 이용하였으며 금 촉매 (직경 50 nm) 가 분산된 SiO_2 기판을 390 ℃ ~ 690 ℃에 위치시키고 ZnS를 담은 석영 보트는 1000 ℃에 위치시킨 후 압력을 600 torr로 고정하고 각 시료마다 수송 기체(N_2, CO_2)의 비율을 100 : 0 sccm, 90 : 10 sccm, 80 : 20 sccm, 70 : 30 sccm 으로 바꿔가며 10분간 성장한 후 수송 기체 비율에 따른 nanospiral의 형상변화를 전자현미경(FESEM) 과 투과전자현미경(TEM)로 관찰하고 결정학적 특성을 micro-raman 과 X-ray diffraction (XRD)로 비교 분석하였다. 고온에서 분해된 CO_2 에서 생성된 산소화학종에 의하여 ZnS 의 측벽에 ZnO가 형성되어 응력에 의하여 nanospiral이 형성됨을 확인하였다.
이 연구는 2018년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임 (No. NRF-2018R1A2B6001011).

Keywords:
ZnS, ZnO, nanospiral, N2, CO2, FESEM, TEM, XRD, micro-raman

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Chemical vapor deposition and electrical charaterization of phosphorous doped MoS_2 layers

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Abstract:
Transition metal dichalcogenides (TMDs) such as MoS_2, WS_2, WSe_2, etc., have gained intense attention beyond graphene because of their unique properties and great potential. As an example, bulk or few layers MoS2 are semiconductor material with indirect band gap of 1.2eV whereas monoalyer MoS_2 has direct band gap of 1.8 eV. Among the synthesis methods of TMDs, chemical vapor deposition (CVD) is the most widely used method for large-area and high crystal quality. Also, carrier doping technique is very important for the functionality of TMDs by providing routes to tune their intrinsic properties. In this work,
we attempted monolayer MoS_2 growth on cleaned SiO_2/Si substrates by using CVD method with molybdenum trioxide (MoO_3) and sulfur powders as the precursor and the reactant materials, respectively.

During the growth of MoS_2, p-type doping was tried also with phosphorous pentoxide (P_2O_5). Thickness and grain size of phosphorous doped monolayer MoS_2 were measured by a non-contact mode of atomic force microscopy and an optical microscopy. Also X-ray photoelectron spectroscopy and Raman spectroscopy were used to analyze the doping characteristics. Finally, the back-gated field-effect transistors with doped MoS2 channel were fabricated and measured an electrical characteristics.

Keywords:
chemical vapor deposition, MoS2, p-type doping, P2O5

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Electrical characterization of MoO_x/MoS_2 junction diodes fabricated by thermal oxidation

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Abstract:

Transition metal dichalcogenides (TMDCs) have been widely investigated because of their unique properties and great potential. As a typical example, bulk MoS_2 has an indirect bandgap of 1.2eV, whereas single-layer MoS_2 has a direct bandgap of 1.8eV. Also, the oxidized TMDCs are great importance for electronic and optoelectronic devices. Previous studies have shown that MoS_2 transistor with molybdenum trioxide (MoO_x) contacts appears p-type transport behavior. Thus oxidation can play an important role in electronic devices. However not much research has been progressed on oxidation of TMDCs. In this work, we fabricated MoO_x/MoS_2 diodes by thermal oxidation process. Before oxidation process, the mechanically exfoliated MoS_2 nanosheets were placed on SiO_2/Si substrate by using adhesive tap technique. Using atomic force microscopy, X-ray photoelectron spectroscopy their structural and physical properties are characterized. And finally electrical characterization was also performed. We will discuss the application of MoO_x/MoS_2 for memory device and p-type MoS_2 transistor.

Keywords:
MoS2, MoOx, thermal oxidation, transistor, memory, diode

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Au 촉매를 사용한 ZnS 나노나선 성장

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Abstract:

ZnS 나노나선 (nanohelix) 은 미래의 마이크로/나노 크기의 광학 시스템에 활용이 기대되는 새로운 나노구조체이다. 본 실험에서는 물리기상 수송 증착(physical vapor transport deposition) 법을 이용하여 나노나선을 성장하였다. HF처리한 Si기판을 사용하였고 촉매로는 50nm 크기의 금 입자를 사용하였다. 원료는 ZnS 분말을 사용하였다. ZnS 원료는 1000℃까지 올렸으며 이때 기판의 온도는 640℃ ~ 930℃ 이었다. 수송기체는 질소 50 sccm 이었고 압력은 20 ~ 300 torr로 변화시켰다. 실험결과 성장압력 20 torr, 기판온도 850℃ 부근에서 나노나선을 관측하였다. 나노나선을 전계 방출 주사 전자 현미경(FESEM) 및 투과전자현미경 (TEM) 으로 관찰하였다. 성장압력이 나노나선의 반경과 주기에 미치는 영향을 연구하였다.

이 연구는 2018년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임(No. NRF-2018R1A2B6001011).

Keywords:

ZnS nanohelix, FESEM

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P2-se.019*

Bromine 불순물 치환 도핑 된 이차원 층상구조 $SnSe_2$ 단결정의 물리적 특성 제어

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Abstract:

Graphene과 더불어 다양한 이차원 층상구조 물질에 대한 연구가 보고되어 오고 있으며, 특히 MoS_2 등의 전이금속 기반의 이차원 transition metal dichalcogenide (TMD)는 유한한 밴드갭 (> 1.0 eV) 및 높은 전하 이동도 특성 (>500 cm^2/Vs)에 의해 차세대 반도체 소재로의 응용 가능성이 높을 것으로 기대되고 있다. 근래에 층상구조 $SnSe_2$ 다결정 소재에 도핑을 통한 전기전도 및 열전도 물성에 대한 연구가 보고 되고 있으나, 소재의 진성 (intrinsic) 물성을 파악하기 위한 단결정 소재에 관한 연구는 아직 부족한 상황이다. 본 연구에서는 Br 불순물이 Se-site에 치환형 도핑 된 이차원 층상구조 $SnSe_2$ 소재의 단결정을 성장시켜, 그 물리적 특성을 관찰하였다. Sn, Se, $SnBr_2$ 원료를 혼합하여 melt-solidification 법을 통해 단결정을 성장시켰으며, X-ray diffraction (XRD)를 통하여 결정 구조를 분석하였다. Hall 측정을 통하여 온도에 따른 전기 전도도, 전자농도, 이동도 특성을 관찰하였다.

Keywords:

2차원 층상구조, 전도도 제어, 단결정, Hall measurement

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Effect of thermal annealing on the morphology of $Bi_{12}O_{17}Cl_2$ nanostructures for visible light photocatalyst

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Abstract:

In this study, $Bi_{12}O_{17}Cl_2$ with a microsphere and nano-sheet network have been prepared through a simple solvothermal approach. The effects of different temperatures on the morphological changes was examined. The microsphere and nano-sheet-like morphology was proved from the SEM analysis. The crystallinity of the synthesized $Bi_{12}O_{17}Cl_2$ was confirmed based on Raman spectroscopy and XRD pattern. The photocatalytic activity of the synthesized $Bi_{12}O_{17}Cl_2$ was characterized through degradation of the organic pollutant Rhodamine B (RhB) and Bisphenol A (BPA). Due to the microsphere and nano-sheet network, the surface area of the prepared materials was enhanced. We found that our developed $Bi_{12}O_{17}Cl_2$ exhibited rapid degradation performance along with long term cyclic-stability for both organic polluted RhB and BPA.

Keywords:

Bismuth oxychloride, Bi12O17Cl2, Catalytic properties

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Sulfur 치환을 통한 층상구조 $PdSe_2$ 소재의 격자구조 및 전도 물성간 상관관계 연구

Study on the correlation between lattice parameter and electrical property in layered $PdSe_2$ by sulfur substitution

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Abstract:

이차원 (two-dimensional: 2D) transition metal dichalcogenide (TMD) 물질은 높은 전하 이동도 및 제어가 용이한 밴드갭 특성으로 인해, 차세대 전계효과 트랜지스터 및 광전소자로의 응용 가능성이 근래까지도 집중적으로 연구되어 오고 있다. 그 중에서 기존의 honeycomb 구조를 갖는 2D TMD 물질과는 달리, 2D pentagonal 구조를 가지고 있는$PdSe_2$는 높은 이방성 및 대기 안정성 특성으로 인하여, 나노 piezoelectric 및 valleytronic 소자로의 응용 가능성이 높을 것으로 기대되고 있다. 본 연구에서는 2D pentagonal $PdSe_2$ 소재의 Se-site에 S 원소 치환을 통한 격자 구조 제어 및 그에 따른 전도 물성 변화를 관찰하였다. 원조성 Pd, Se, S 간의 고상합성을 통해 $PdSe_{2-x}S_x$ 조성 소재를 합성 하였으며, X-ray diffraction (XRD), Hall measurement 및 Raman spectroscopy를 통해 결정구조와 전도물성을 분석하였다. 이를 통하여, S치환을 통한 $PdSe_2$ 층상구조 반도체의 격자구조 변화와 전도도, 전하 농도, 이동도 간의 상관관계에 대하여 고찰하였다.

Keywords:

2차원 전자소재, 격자구조제어, 전도 물성 제어

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Parametric Model of the Dielectric Function of Monolayer MoS_2 on Temperature Dependence

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Abstract:

Recently, two-dimensional (2D) layered materials based on transition metal dichalcogenides (TMDCs); MX_2 (M = Mo, W; X = S, Se) emerges as the promising materials because of highly important potential applications in flexible nanoelectronics, sensors, and photodetectors as a substitute for silicon or organic semiconductors. To apply properly for device applications, the dielectric function of 2D-MoS_2 had better be well known at an arbitrary temperature. We report the dielectric function parametric model of ε of MoS_2 from 1.4 to 6.4 eV and for temperatures from 35 to 350 K measured by spectroscopic ellipsometry. The existence of ten critical point (A^-, A^0, B, E_0, C, and $E_{I\text{-}V}$) structures could be observed clearly. The parameters were extracted by fitting the spectra with the reconstruction from ten dispersive oscillators at each measured data. We observed the fundamental absorption peak E_0, which occurs at the K-point of the Brillouin zone. The dependence of temperature is achieved from the model parameters that are fitted by the polynomial and then the dielectric functions of MoS_2 for arbitrary temperature. These results are expected to be useful in design and understanding in applied device technologies based on MoS_2.

Keywords:

Dielectric function, monolayer MoS2, parametric model

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Revealing defect-induced Raman mode of tungsten disulfide monolayer by tip-enhanced Raman spectroscopy

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Abstract:

Tungsten disulfide (WS_2) has emerged as a layered material for optoelectronic devices because of its high quantum yield of photoluminescence. To fabricate the high performance of devices, the defect-free WS_2 is highly required. Accordingly, it is necessary to establish a quality evaluation method by investigating the defects of monolayer WS_2. In the case of graphene, a D mode in the Raman scattering is widely used to evaluate the sample quality, since Raman spectroscopy is a simple and nondestructive technique compared to other complicated methods such as electron microscopy. However, an exact indicator to easily judge the quality of monolayer WS_2 has not been determined yet.

We perform tip-enhanced Raman spectroscopy (TERS) experiments. The high-resolution images of the TERS and scanning tunneling microscopy show a correlation between TERS signal and surface morphology. We also demonstrate that the red-shifted A_{1g} mode with the D and D′ modes can be attributed to the defect in monolayer WS_2. Furthermore, we identify that the origin of the shifted and new modes can be introduced by sulfur vacancies through our density functional theory calculations.

Keywords:
tip-enhanced Raman scattering, tungsten disulfide, transition metal dichalcogenides, defects, sulfur vacancies

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수열 합성법을 이용한 다양한 ZnO 나노구조의 제작 및 특성 분석

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Abstract:

나노물질의 구조가 나노미터 크기로 작아지면 bulk 와는 다르게 새로운 특성이 나타난다. 특히 ZnO 계열의 나노구조는 상온에서 3.37 eV의 넓은 밴드갭을 갖고 있으며 불순물의 첨가에 의해 전도도를 쉽게 향상시킬 수 있다. 이러한 특성 때문에 나노물질은 소재, 생물, 센서, 촉매 등 여러 방면에서 주로 응용이 되고 있다. 주로 연구되는 ZnO 계열은 가스 센서와 광촉매로써 가스 센서는 분자의 흡착을 이용하기 때문에 표면적과 성장 정도가 중요하고, 광촉매는 빛을 받아 전자가 여기되면서 엑시톤이 형성되어 나타나는 산화-환원반응을 이용한다. 표면적이 클수록 효율이 높기 때문에 수열 합성법, 화학 증기상 운반법, 화학 기상 증착법, 물리 증착법을 이용하여 여러 모양의 ZnO 나노구조를 제작하는 연구가 진행되고 있다. ZnO 나노구조는 사용되는 물질의 비율과 계면활성제의 종류에 따라서 C축 방향의 성장을 조절하여 ZnO 나노구조의 형태를 조절할 수 있다. 본 연구에서는 수열 합성법으로 합성 조건을 다르게 하여 나노 막대, 나노 꽃 등 다양한 ZnO 나노구조를 제작하였다. 제작된 ZnO 나노 구조는 흡수와 형광 측정을 통해 광학적 특성을 분석하였고, XRD와 FE-SEM 측정을 통해 나노구조의 구조적 특성을 분석하였다.

Keywords:

ZnO, 나노구조, 수열합성법, 구조적 특성, 광학적 특성

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Site-and polarization-controlled single photon sources based on 2D materials

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Abstract:

Atomically thin layers of TMDC (Transition metal di-chalcogenides) is well known for using as optoelectronics. But recently, many studies have discovered that 2D materials can be used as not only electronics but also quantum emitters which emit single photons in a deterministic way. Also, using TMDC 2D materials as quantum emitters has many strengths to integrate with dissimilar platforms since they can be easily exfoliated ion and transferred to any target substrates which is a challenging task in other solid-state quantum emitters. Especially, when they are placed on patterned substrates, the local strain modulates their bandstructures forming a locally confined exciton and thus creating site-controlled quantum emitters. This approach allows us to integrate the emitters with various nanophotonic structures such as cavities and photonic waveguides. Here, we generate site-controlled quantum emitters by using WSe_2, and perform the optical characterization showing the single photon characteristic and strong linear polarization. Also, we are in progress to research on controlling linear polarization by combining emitters with various kinds of nanostructures. Our results pave the way for achieving bright single photons with controlled position and linear polarization, useful for future engineered quantum light sources.

Keywords:
2D material, TMDC, Single photon source, Quantum emitter

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원자 두께의 WSe_2 물질을 이용한 양자광원의 생성 및 제어

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Abstract:

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광자는 정보를 먼 거리까지 수송할 수 있고, 이를 선형 광학계를 이용해 양자 연산을 비교적 쉽게 구현하는 것이 가능하다. 이를 기반으로 양자 정보 및 통신의 연구가 많이 진행되어 왔으며, 실질적인 응용을 위해서 다수의 양자광원 간의 상호작용이 요구되고 있다. 고체 기반 양자점의 경우, 원하는 순간에 양자광을 생성할 수 있는 장점이 있지만, 위치와 파장의 불균일성이 확장성에 큰 장애물이 되고 있어 최근까지도 다수의 동일한 양자광 특성을 지닌 광원들을 동시 생성할 수 있는 플랫폼에 대한 연구가 많이 진행되고 있다. 2D 물질들은 국소적인 응력을 이용해 전자구조를 제어할 수 있고, 양자점과 비슷한 형태의 띠구조를 유도하여 원하는 위치에 양자광원을 생성할 수 있으며 응력의 정도에 따라 방출 파장을 변조하는 것이 가능하다. 본 연구에서는 전이금속 칼코겐나이드 반도체 물질 군에 속하는 WSe_2를 이차원 원자층 두께로 박리하여 국소적으로 힘을 가하였고, 전자-정공쌍(엑시톤)이 국소화 된 양자광원을 제작하였다. 또한 전자빔 리소그래피를 비롯한 반도체 공정을 통해 양자광원을 원하는 위치에 만들고, 광원의 파장을 제어할 수 있도록 응력을 제어할 수 있는 시스템을 구축하였다. 이는 집적광회로로 양자소자 개발의 실현 가능성과 반도체 환경에서의 양자광학적 상호작용을 연구하는 데에 좋은 발판을 마련할 수 있는 기회를 제공한다.

Keywords:
Semiconductor physics, 2D material, Single photon emitter

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Mn을 도핑한 ZnSe 콜로이드 양자점의 광학적, 구조적 특성 분석

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Abstract:

양자점은 나노미터 크기를 가지는 화합물 반도체로, 양자구속효과에 의해서 벌크상태와는 다른 독특한 특성을 가지는 물질이다. 하지만 양자점을 합성할 때 사용되는 카드뮴, 납 그리고 phosphine 계열의 물질들의 강한 독성으로 인해 양자점을 이용한 LED, 태양전지, 바이오센서 등 디바이스의 상용화에 큰 걸림돌이 되고 있다. 이러한 단점을 극복하기 위해서 중금속과 phosphine 계열의 물질을 사용하지 않은 콜로이드 양자점을 합성하는 연구가 진행되고 있다. 그 중에서 ZnSe 양자점은 독성이 없고, 합성이 쉽다는 장점이 있지만 발광 영역이 보라색-파란색 계열로 좁다는 단점이 있다. 따라서 발광 영역을 확장하기 위해서 ZnSe 양자점에 전이 금속 이온을 도핑하는 연구가 진행되어 왔다. 전이금속 이온인 Mn^{2+}을 도핑하면 보라색-파란색 계열의 좁은 방출 영역을 Mn^{2+}의 $^4T_1$ 에서 $^6A_1$으로의 전이로 인하여 주황색 계열까지 확장이 가능하다. 본 연구에서는 전이금속 이온인Mn^{2+}을 도핑한 ZnSe 콜로이드 양자점을 고온주입법을 통해서 phosphine 계열 물질을 사용하지 않고 합성하였다. Mn^{2+}을 도핑하는 방법으로는 핵 형성 도핑 과정을 선택하였다. Mn이 도핑된 ZnSe 콜로이드 양자점의 특성을 분석하기 위해서 흡수와 형광 측정을 통해 광학적 특성을 분석하였고, HR-TEM과 XRD측정을 통해 양자점의 크기와 구조적 특성을 분석하였다.

Keywords:

콜로이드 양자점, ZnSe, Mn 도핑, 구조적 특성, 광학적 특성

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Kelvin probe force microscopy studies of transition metal dichalcogenides: exfoliated flakes vs. CVD-grown thin films

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Abstract:

There have been intensive researches in two-dimensional (2D) transition metal dichalcogenides (TMDCs) for their versatile optical and electrical properties. Especially, monolayers of TMDC, such as MoS_2, WS_2, $MoSe_2$, and WSe_2, exhibit unique optoelectronic properties due to the coupling between the spin and valley degrees of freedom originating from the inversion symmetry breaking, strong spin-orbit coupling, and time-reverse symmetry. By stacking these TMDC layers, we can fabricate van der Waals heterostructures, which are expected to show interesting physical properties. In this work, we prepared MoS_2 layers using a one-step chemical vapor deposition and a mechanical exfoliation method. Using Kelvin probe force microscopy, we measured surface work function of the MoS_2 layers. Uncontrolled stacking orientation and possible contamination at the exfoliated MoS_2/substrate interface could lead to distinct physical properties of the two kinds of samples. This work can provide us valuable insights into the nature of the 2D material-based heterostructures.

Keywords:

Transition metal dichalcogenides Kelvin probe force microscopy Chemical vapor deposition Mechanical exfoliation

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Effects of Electron Beam Irradiation on the Friction and Work Function of the Wrinkled Graphene

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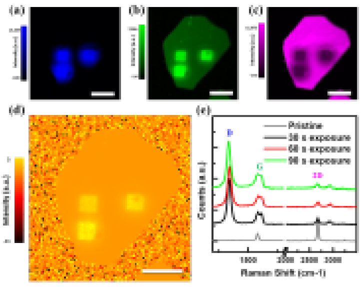
Abstract:



The ability to control the tribological and electrical properties of graphene is critical to the fabrication of micro- and nanoelectromechanical systems (MEMS / NEMS) devices. Due to its high energy, electron beam irradiation has been widely used to adjust the local electrical properties of the graphene, such as inducing local defects or n-type doping. However, whether electron beam irradiation can affect the local tribological properties of wrinkled graphene has not been investigated yet. In this research, we demonstrated that the lateral force signal and the work function of the wrinkled monolayer graphene were affected by the electron beam irradiation.

By using Kelvin-probe force microscopy (KPFM) and Raman spectroscopy, we measured the local electrical properties of the wrinkled monolayer graphene and confirmed that the electron-beam exposed area was changed as n-doped graphene. We compared the lateral force signal with surface potential data and concluded that the n-type doping induced by electron beam affected the tribological characteristics. Our work suggests a new way to characterize the electron-beam exposed wrinkled graphene and provides a physical insight that the electrical and tribological characteristics of wrinkled graphene are correlated.

Keywords:
Wrinkled graphene, Electron beam irradiation, Friction, Work function

P2-se.030

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$AuCl_3$가 도핑된 그래핀을 보호층으로 사용한 페로브스카이트 태양전지의 안정성 향상 연구

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Abstract:

최근, 페로브스카이트 태양전지는 긴 전하 이동, 높은 광흡수 계수, 높은 개방 전압, 저온 용액 공정과 같은 우수한 요인들에 의해서 태양전지 연구 분야에서 많은 관심을 끌고 있다. 그러나 페로브스카이트 태양전지는 22% 이상의 높은 광전변환효율 (power conversion efficiency, PCE)에 도달하였음에도 불구하고, 시간, 온도, 습도 등과 같은 물리적 변수에 따른 소자 안정성 문제로 인하여 상용화에 큰 어려움을 겪고 있다. p-i-n 형 페로브스카이트 태양전지는 n-i-p 형 구조보다 저온 공정이 가능하기 때문에 많은 연구가 진행이 되어 왔으나, 가장 많이 사용되는 홀전송층 물질인 poly(3,4-ethyle nedioxy thiophene):poly(styrenesulfonate) (PEDOT:PSS)의 산성 특성으로 인해 ITO 기판의 성능을 떨어뜨리는 본질적인 문제를 가지고 있다. 이를 억제하기 하기 위해서 본 연구에서는 처음으로 $AuCl_3$ 가 도핑된 그래핀을 ITO와 PEDOT:PSS 물질 사이에 보호층으로 삽입함으로써 태양전지의 PCE와 내구성을 향상시켰다. 10 mM의 $AuCl_3$가 도핑된 그래핀을 사용한 페로브스카이트 태양전지의 PCE는 최고 15.9%에 도달하였는데 이는 그래핀을 사용하지 않았을 때보다 높은 효율이다. 또한, 제작된 소자의 시간 안정성에 있어서도 30 일이 지난 후에 처음 효율의 67% 수준을 유지하는 등, 크게 향상된 것을 확인하였다. 이러한 결과들로부터 $AuCl_3$가 도핑된 그래핀이 ITO의 보호층 역할뿐만 아니라 정공의 수집 능력도 향상시킨다는 것을 알 수 있다.

Keywords:

페로브스카이트, 태양전지, 그래핀, AuCl3, 도핑, 보호층, 안정성

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P2-se.031*

NaCl에 의하여 성장이 촉진된 화학기상증착법에 의한 MoS_2의 제작 및 특성 분석

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Abstract:

2차원 나노판상 구조인 육방정계 질화붕소(h-BN), 이황화몰리브덴(MoS_2), 이황화텅스텐(WS_2), 이셀레늄화몰리브덴($MoSe_2$), 이셀레늄화텅스텐(WSe_2) 등 다양한 2차원 물질들은 독특한 전기적 및 광학적 특성, 유연성, 탄력성 등으로 새로운 물리현상을 기대할 수 있을 뿐만 아니라 차세대 전자 및 광학 소자 응용 가능성으로 큰 관심을 받고 있다. 특히 2차원 물질을 실용화하기 위해서는 고품질 대면적 박막으로 제작하는 것이 매우 중요하다. 대표적인 2차원 물질인 MoS_2는 화학기상증착법(Chemical Vapor Deposition, CVD)에 의해 MoO_3와 함께 황(sulfer)이 포함된 분말을 이용하여 다양한 혼합가스 분위기 하에서 700~900^oC의 성장온도로 제작되어 왔다. 최근에는 여기에 NaCl을 혼합하여 첨가함으로써 성장 온도 및 시간을 감소시켜 더 좋은 품질의 2차원 물질들을 제작할 수 있다는 것이 제안되고 있다. 본 연구에서는 CVD 기법을 활용하여 NaCl이 첨가된 MoO_3와 함께 황을 다양한 성장조건(가스, 온도, 성장시간, 냉각조건, 소스간의 거리 등)에서 반응시켜서 SiO_2 기판위에 MoS_2 박막을 제작하였다. 제작된 MoS_2 박막을 원자현미경, 전자현미경, 라만산란, 포토루미네센스 등을 이용하여 구조적 및 광학적 특성을 규명하였으며, 이를 바탕으로 NaCl에 따른 MoS_2의 성장 메커니즘 규명 및 최적의 성장조건을 도출하였다. 다양한 성장조건에 의하여 MoS_2의 층수 및 grain의 크기가 조절되었으며, 특히 NaCl의 첨가에 의하여 성장 온도 및 시간이 상대적으로 감소하였다. 또한 NaCl의 양에 의하여 MoS_2의 grain의 크기 및 모양이 결정되는 것을 확인할 수 있었다.

Keywords:

MoS2, 2차원 물질, NaCl, CVD,

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아민(amine) 계열 분자가 도핑된 n형 그래핀 투명전극을 이용한 n-i-p 형 페로브스카이트 광검출소자

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Abstract:

최근 인듐 주석 산화물(ITO) 전도성전극을 사용한 페로브스카이트 광검출소자는 상용화되어 있는 Si 기반 광검출소자와 견줄만한 특성 및 성능들이 보고되고 있다. 그러나, ITO의 주요원재료인 인듐은 희귀금속 중의 하나이며, 매장량이 한정되어 있어서 매년 20%의 가격이 인상될 뿐만 아니라 일반적으로 고가의 고온 진공증착법으로 제조되기 때문에 ITO를 대체하기 위한 연구가 활발히 진행되고 있다. 그래핀은 ITO를 대체하기 위한 투명전극 후보물질 중의 하나로서, 일반적으로 공기중에서 p형 특성을 나타낼 뿐만 아니라 p형이 n형보다 상대적으로 제조하기도 더 쉽다. 그래서 몇몇 연구팀들에 의하여 p형 그래핀을 사용한 p-i-n 형 광검출소자에 대한 연구결과가 보고되고 있으나 현재까지 n형 그래핀을 사용한 n-i-p 형 광검출소자에 대한 연구결과는 거의 없었다. 아민(amine) 계열 분자들은 그래핀의 매우 우수한 n형 도핑물질로 제안되고 있으며, 최근에는 화학적인 도핑공정을 통하여 우수한 특성의 n형 그래핀 제작에 사용되었다. 본 연구에서는 처음으로 n형 그래핀 투명전극을 사용한 n-i-p 형 페로브스카이트 광검출소자의 연구결과를 보고한다. 다양한 도핑농도의 n형 그래핀을2, 3, 4 개의 아민그룹을 각각 포함하고 있는 에틸렌다이아민 (ethylene diamine), 다이에틸렌트리아민 (diethylene triamine), 트리에틸렌테트라민 (triethylene tetramine)을 흡착시켜 제작하였다. 아민그룹의 수(A_n)가 4까지 증가함에 따라서 그래핀 투명전극의 일함수는 ~4.46 eV까지 점진적으로 증가하며, 면저항은 ~205 Ω/sq까지 감소한 반면에 투과도는 ~1 %만 감소하였다. A_n = 4에서 최적화된 광검출소자는 10^6의 광전류/암전류비, 0.343 AW^{-1}의 광반응도, 5.82 x 10^9 $cmHz^{1/2}W^{-1}$의 검출능, 108 dB의 선형 작동범위, 1.02 μs의 광반응시간 등, 이전 ITO 기반의 페로브스카이트 광검출소자와 비교하여 더욱 우수한 성능을 나타냈다. 또한 이렇게 최적화된 조건을 바탕으로 플렉서블 페로브스카이트 광검출소자를 제작한 결과, 1000사이클의 구부림 테스트 후에도 70 % 이상의 성능이 유지됨을 확인하였다.

Keywords:

페로브스카이트, 광검출소자, n-i-p, 그래핀, 투명전극, amine, 도핑

P2-st.001

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Accuracies of Partition Function Zeros with Partial Partition Functions

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Abstract:

The theory of partition function zeros is a powerful and efficient method to study phase transitions and critical phenomena of various physical systems.
To obtain partition function zeros accurately, we need to know the complete partition function of a given physical system because partition function zeros are roots in a complex physical quantity (for example, temperature, magnetic field, and chemical potential) of the complete partition function.
However, in many cases, it is difficult to obtain the complete partition function of a given physical system.
Therefore, partition function zeros have been frequently obtained with partial partition functions of a given physical system.
Here, we study accuracies of the partition function zeros obtained from partial partition functions by using the partition function zeros in the complex temperature plane of the square-lattice Ising model.

Keywords:

Critical phenomena, Partial partition functions, Partition function zeros

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P2-st.002

Variational ground states through a genetic algorithm for frustrated spin systems

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Abstract:

Quantum monte carlo simulations are the most common numerical approaches to quantum spin systems. However, in frustrated systems non-variational QMC approaches suffer from some problems including the sign problem, which becomes more acute at low temperatures.

As an alternative approach to studying the ground states of frustrated spin systems we present variational method based upon a genetic algorithm, with variational states and crossover mechanism tailored to correctly describe and maintain the spin-spin correlations. This approach allows us to consider a larger variational parameter space than conventional variational quantum monte carlo (vQMC) techniques. We apply this method to the J_1-J_2 model and compare the results to those from existing vQMC methods, exact diagonalization and the known analytic solutions at $J_1/J_2=0$, 1/2, ∞. Finally, we explore the behavior of the variational ground states near the transition at $J_1/J_2=0.241$

Keywords:
variational quantum monte carlo simulation, Genetic algorithm, Frustrated spin

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P2-st.003

Scaling Behaviors of the Thermodynamic Functions for the Ising Model on a Kagome Lattice

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Abstract:
Kagome lattice is made of interlaced honeycombs and triangles. Kagome, a bamboo basket, has been traditionally and extensively used in Asia.
Various thermodynamic functions such as specific heat, magnetization, and susceptibility are obtained as a continuous function of temperature for the Ising model on a kagome lattice, using Wang-Landau Monte Carlo simulation method.
The scaling behaviors of the thermodynamic functions for the Ising model on a kagome lattice have been studied, based on specific heat, magnetization, and susceptibility, as a continuous function of temperature, obtained from Wang-Landau Monte Carlo simulation method.

Keywords:
Kagome lattice, Thermodynamic Functions, Scaling behaviors

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P2-st.004

Yang-Lee Zeros of the Kagome-Lattice Ising Model

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Abstract:
Partition function zeros in the complex temperature plane, the so-called Fisher zeros, have been extensively used to understand phase transitions and critical phenomena.
Fisher zeros are very efficient in finding critical temperature and the related critical exponents.
However, the properties of the Ising model in an external magnetic field have never been known well.
To understand the properties of the Ising model in an external magnetic field, Yang and Lee, Nobel prize winners, introduced the partition function zeros in the complex magnetic-field plane, the so-called Yang-Lee zeros, of the Ising model in an external magnetic field.
We obtained Yang-Lee zeros in the complex magnetic-field plane of the Ising model on a kagome lattice in an external magnetic field.
The physical properties of the Ising model on a kagome lattice in an external magnetic field have been studied, based on its Yang-Lee zeros in the complex magnetic-field plane.

Keywords:
Phase transition, Partition function zeros, External magnetic field

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P2-st.005*

Variational Monte Carlo study of quantum phase transition based on multilayer neural network ansatz

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Abstract:

We present how well a multilayer neural network model can describe a ground-state wave function throughout a quantum phase transition by providing a variational Monte Carlo (VMC) study in the transverse-field Ising (TFIM) model in one and two dimensions. We examine the neural network models with a single, double, and triple hidden layers, and we find that the one with double hidden layers provides enough accuracy to describe the critical behavior of the TFIM. By performing the standard finite-size-scaling analysis with magnetization, magnetic susceptibility, and fidelity susceptibility, we successfully obtain the critical exponents that are compatible with the known values of the Ising universality class, demonstrating the applicability of a neural-network-based VMC method to the description of quantum critical phenomena.

Keywords:

neural network, quantum Monte Carlo, phase transition, critical phenomena, finite size scaling

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P2-st.006*

Janus Colloidal Crystal, a New Model System for Spin Crystallization and Glass

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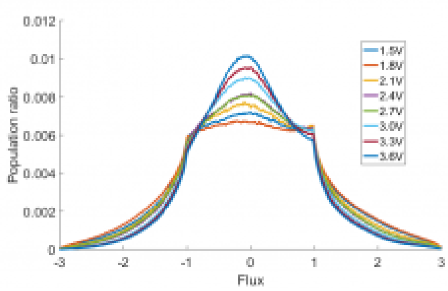
Abstract:

Magnetism is an overall reflection from microscopic behaviors, which follows the quantum mechanics rules. Especially, electron spins' behavior is deeply related to the macroscopic phenomena. However, in reality, it is hard to observe electrons' individual dynamics in detail because of its extremely fast change and its weak signal from each of them. This limits gave rise to the need of computer simulation and other experimental models mimicking spin motion. One of them, colloids have been used for a good model to emulate the real atoms in a solid and have achieved a successful results about that. Here, we employed Janus particle to imitate the spins' asymmetric orientational interaction. We expect that it can pave the way for exploring science behind not only rotational glass dynamics but also spin systems.



Keywords:
Janus Colloid, Magnetism, Spin

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P2-st.007*

Differences between quantum and classical Otto heat engine

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Abstract:
A quantum heat engine is a device that converts heat currents into useful work with quantum working fluid. Many researchers have studied various quantum heat engines to understand the role of quantumness on thermodynamics. In this study, we directly compare a quantum heat engine with a corresponding classical heat engine. We choose a harmonic oscillator as the working fluid. We operate the heat engine with Otto-cycle, which consists of thermal process and isochoric process [1]. We examine properties of heat bath including efficiency and power in cyclic steady states. In addition, we discuss the reason why there are differences between the properties of quantum and classical engine.

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Keywords:
quatum thermodynamics, quantum master equation, Fokker-Planck equation, heat engine, coherence

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P2-st.008

Neural network and regression models for two meteorological factors

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Abstract:
This paper is concerned with the temporal variation characteristics of two meteorological factors (temperature and humidity) in four metropolitan cities (Seoul, Busan, Daegu, Daejeon) in South Korea. Data are extracted from seven years (2008 to 2014) of hourly time series data in meteorological offices of the Korea Meteorological Administration. Using the detrended cross-correlation analysis (DCCA) method, the DCCA coefficient of temperature is compared to that of humidity from daily time series data during four seasons in the four metropolitan cities. In particular, as window size s increases, the DCCA cross-correlation coefficient approaches 0.034 at a time lag of 14 days in the case of spring in Seoul. When we have no cross-correlation between temperature and humidity, two errors for an artificial neural network (ANN), E_H and E_T, seems to be relatively larger values than those for a multiple regression model (MRM). There exist anomalously large error values in the ANN, but the error E_H for humidity has a smaller value than the error E_T for temperature in both E_H and E_T.

Keywords:
Detrended cross-correlation analsis coefficient, Neural network model, Multiple regression model, Temperature

P2-st.009

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Dynamical behavior of detrended cross-correlation analyses in random walks and Levy flights

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Abstract:

The utility and the correlation technique of the detrended cross-correlation analysis and the combined detrended cross-correlation analysis methods are treated for the stochastic properties of the random walk and the Levy flight via nucleotide sequence data. Data are extracted definitely from twelve genomic DNA sequences (HUMHBB1-6, Amazonmolly, Bushbaby, Cow, Dolphin, Elephant, and Tarsier) of the GenBank databank. We mainly simulate and analyze scaling exponents for three methods in 1D and 2D random walks and Levy flights. To compare each other between one gene and the other gene in the twelve genomic DNA sequences, the value of the detrended cross-correlation coefficient in HUMHBB3 and Dolphin genes is shown the largest value 0.214 in the 1D Levy flight with μ=1.5 compared to other sets. The detrended cross-correlation coefficient in HUMHBB3 and Elephant genes is shown the smallest value -0.229 in the 1D random walk. The combined detrended cross-correlation coefficient in the two sets of HUMHBB3 and Bushbaby, HUMHBB6 and Dolphin is particularly shown the largest value 0.331 in the 1D random walk compared to other sets, while that in HUMHBB3 and Tarsier, HUMHBB4 and Elephant is shown the smallest value -0.295 in the 1D Levy flight with μ=1.5.

Keywords:

Detrended fluctuation analysis, Detrended cross-correlation analysis, Combined detrended cross-correlation analysis, Random walk, Levy flight, DNA sequence

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P2-st.010*

확장된 생명 게임과 협조 발현

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Abstract:

확장된 생명 게임을 1차원 격자위에서 연구하여 적당한 외부 환경 조건에서 협조가 발현될 수 있음을 보였다. 전통적인 생명 게임은 격자칸 오토마타로 각 격자칸은 1과 0의 두 가지 타입으로 표현된다. 격자칸 타입의 변화는, 자신과 인접 부분의 격자칸 타입들에 의해 결정되는 격자칸의 상태와 다음 시간의 격자 타입을 결정하는 진화 법칙에 의해 결정된다.생명 게임의 오토마타 룰은 이렇게 간단하지만,자연에서 나타나는 다양한 복잡계 현상의 핵심을 상당 부분 설명할 수 있었다.
격자칸의 타입 변화를 살펴본 기존 연구를, 여기서는 격자칸에 살고 있는 생명체의 성질이 유전되는 생명체 유전 게임으로 확장하였다.타입 1로 표현된 칸에 있는 생명체가 자손을 낳아 다음 세대를 이룬다. 자신의 자리에는 항상 자손을 낳고 인접한 좌우 자리에는 자신의 상태와 진화룰에 따라 번식 여부가 결정된다. 상태는 좌우 두 격자칸의 타입에 의해 결정되어 2^2=4가지가 있고, 번식 룰은 4가지 상태 각각에 대하여 좌우 두 격자칸에 자식을 낳을 지 여부를 결정하는 것이므로 4^4=256가지가 있다. 번식룰은 개인에 따라 다른 법칙을 가지는데 초기에는 256가지 룰 중 랜덤하게 주어지고 이후에는 유전된다. 인접한 생명체가 한 자리에 서로 자식을 낳았을 때는, 랜덤하게 선택된 한 생명만이 살아남거나 경쟁 과정에 모두 죽을 수 있다. 외부 환경 및 경쟁이 심하여 모두 죽는 확률을 d라 할 때, d에 따라 어떤 번식룰을 가지는 집단으로 진화하는 지 연구하였다. d가 작은 좋은 환경에서는, 자신 자리에 인접한 옆 자리에 모두 자식을 낳는 욕심장이 전략으로 진화하지만 집단의 전체 인구 밀도는 오히려 줄어들게 된다. 적당한 d의 영역에서는 옆자리가 빈 경우에만 자식을 낳는 협조 전략으로 진화하게 되어 집단의 인구 밀도가 최대가 됨을 보였다.

Keywords:

진화 게임 이론, 생명 게임, 전략 유전, 협조 진화

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P2-st.011*

Prisoner’s dilemma game on signed networks

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Abstract:
We studied Prisoner’s Dilemma (PD) game on signed networks. In signed Networks, there are two types of link, positive and negative. We choose the payoff matrix between the players connected with the negative link as multiplying the minus to the payoff matrix between the players connected with the positive link. To investigate the effect of negative links to cooperating behavior, we perform simulations for different negative link densities. When the negative link density is low, the density of cooperator becomes zero as increasing temptation payoff b. Here, the parameter b is the payoff of the defector received from a game with cooperator. On the other hand, when the negative link density is high, the cooperator density becomes 1 as b increases. It is due to that the players with negative link will suffer more payoff damage if they do not cooperate with each other. The negative links force players cooperate so that cooperating behavior is enhanced.

Keywords:
Game Theory, Prisoner's Dilemma Game, Signed Network

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P2-st.012

EFFECTS OF DIRECTION ON GRIFFITHS PHASES IN RANDOM NETWORKS

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Abstract:

In critical phenomena we need to adjust control-parameters such as temperature, pressure to observe the physical properties on phase transition. The Griffiths phases, that the power law appears in a wide critical region, can play an important role to maintain criticality. Recently, the Griffiths phases have been studied on several types of undirected complex networks. The Griffiths phases are also observed in brain networks which are composed of both undirected and directed edges. We study the Griffiths phases on different directed random networks and observe the rare-regions, which are responsible for the Griffiths phases.

Keywords:

Griffiths phases, random networks, directed.

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P2-st.013

Self-Organized Criticality of Neural Avalanche in a Neural Model on Complex Networks

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Abstract:
The distribution of neural avalanche in some neural systems shows the power-law. Neural avalanches in cultured neocortical network show self-organized criticality over long stable period with exponent 1.5 of the power-law for the distribution of the neural avalanche. We consider an integrate-and-fire neural model that includes plasticity (LHG model, Levina *et al*, Nat. Phys. 2007). In this model the external input is applied at random and each neuron accumulates the action potential from the nearest neighbors and random input. We consider the self-organized critical dynamics of LHG model on complex networks. We extend the LHG model on the fully-connected network as well as complex networks such as random network, small-world network, and scale-free network. The exponents of the power-law and critical region depend on the network structure of the neural systems.

Keywords:
neural network, STDP, SOC, avalanche, power-law, scale-free, small-world

P2-st.014*

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Relation between transmission of malaria and climate network in Africa

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Abstract:

Change of climate is associated to infectious diseases for example malaria which is greatest public health problem. Malaria is often known as disease related to climate change. Temperature and rainfall are the most key parameters for climate change and transmission of malaria. Fluctuation of temperature affects the transmission and spreading of malaria. Temperature fluctuation around low mean temperature acts to speed up the rate of transmission of malaria while temperature fluctuation around high mean temperature acts to speed down rate of transmission of malaria. The climate networks are constructed from the cross-correlation between average temperatures of grids on the surface of the earth. In this study we construct and analyze the climate network which relate to the transmission of malaria in African countries.

Keywords:

climate, temperature, climate network, malaria

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Analysis of e-Bidding Time Series on KONEPS and Agent-Based Model of e-Bidding

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Abstract:

We analyze the time series of e-bidding on KONEPS (Korea ON-Line e-Procurement System) from Jan. 1, 2016 to Dec. 31, 2018. The statistical analysis and concepts of the complex systems are applied to understand the behaviors of the agent on the e-bidding market. The bidding market is an irrational, adaptive and nonlinear market. We observed some distinguishing e-bidding patterns of the agents. Many agents behavior randomly on the bidding. However, some agents have their own strategies to submit e-bidding. We observed that some strategic e-biddings show high scores on the market. We calculate the cross-correlation of the bidding time series and derive networks from the correlation such as the minimal spanning tree and threshold networks. We suggest a simple agent-based model of e-bidding market.

Keywords:

Bid, Minority Game, ABM

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P2-st.016*

Quantifying individual fame in large-scale historical documents

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Abstract:

The Annals of the Joseon Dynasty (the Annals) listed in UNESCO's Memory of the World registry is the longest historical record in the world, which had been written over 472 years.
Analyzing the appearance pattern of a total of 53,972 people in the Annals, We study the dynamics of the fame of individuals quantified by the number of mentions.
We find that individual fame followed the preferential attachment and the log-normal aging effect which is commonly found in citation dynamics.
Based on these results, we characterize individual fame applying reinforced Poisson process. Our result shows that there are several different behaviors compare to the well-known citation dynamics.
We expect this work may shed light on our understanding on how historical figures are remembered.

Keywords:

History, Success, Big data, Complex system

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P2-st.017*

Role of activity and memory on epidemic process in temporal networks

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Abstract:
We investigate the interplay of activity and memory on the epidemic process by considering the susceptible-infected-removed (SIR) epidemic model on the activity-driven temporal network with memory. We show that highly active nodes play an important role in determining the epidemic threshold, and the strong ties slow down the spread of disease. In particular, the epidemic threshold is deeply related to the growth patterns of the largest cluster size and the maximum degree in temporal networks. In addition, we find that highly active nodes can promote the spreading in an early period, but eventually prevent the spread of disease to the entire node. Finally, we discuss the optimization condition between the epidemic threshold for the early onset of epidemics and the prevalence of the disease for the entire node.

Keywords:
temporal network, epidemic process, optimaization

P2-st.018

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Competition and dual users in complex contagion processes

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Abstract:

We study complex contagion processes considering the competition of two spreading innovations focusing on the role of dual users who use both innovations. Competition with a preexisting technology Competition with a preexisting technology effectively suppresses the spread of a new innovation, but phases of coexistence are possible. The existence of dual users largely modifies the transient dynamics creating new phases that promote the spread of a new innovation and extinction of a preexisting one. Specifically, dual users act as catalysts of extinction transitions and coexistence phases, promoting the spread of a new innovation and counterbalancing the first-mover advantage.

Keywords:
complex contagion, dual users, compatibility

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P2-st.019*

Disentangling single agent from complex system using neural network

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Abstract:

In complex systems, interactions between small components lead to an interesting large-scale phenomenon. Nonetheless, identifying the microdynamics of a single agent from observables from a complex system is often infeasible. For instance, one simply cannot identify the driver's decision policy just from several snapshots of freeway traffic. Microscopic mathematical modeling such as Vicsek model[1] and Nagel-Shreckenberg model[2] was employed to explain microdynamics of the individuals, but constructing such model largely depended on reasoning and insights of human intelligence. Recently emerged deep learning technique can shed new light on attempts to systematically tackle these problems.

We present the methodology to disentangle individual components from a complex system by the neural network with various exemplary cases. Our approach is purely data-driven with minimum prior knowledge of the system, demonstrating how modern machine learning technique can assist microscopic modeling for a complex system in natural science.

[1] Vicsek, Tamás; Czirók, András; Ben-Jacob, Eshel; Cohen, Inon; Shochet, Ofer (1995-08-07). "Novel Type of Phase Transition in a System of Self-Driven Particles". *Physical Review Letters*. **75** (6): 1226-1229.
[2] *Nagel, K.; Schreckenberg, M. (1992). "A cellular automaton model for freeway traffic" (PDF). Journal de Physique I.* ***2*** *(12): 2221.*

Keywords:
Complex system, Agent based system, Microscopic modeling, Neural Network

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Cost-effective wiring in neural network circuits for visual information processing

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Abstract:

Both the human brain and contemporary deep neural networks (DNNs) can classify objects of natural images with high accuracy [1]. However, the visual cortex of the brain is composed of fewer layers and has sparser connectivity than a DNN, presumably due to the limited volume of the brain [2]. What is the strategy of the brain to construct a high-functioning network using a much smaller number of inter-neural connections than those in a DNN? Here, we suggest that long-range horizontal connectivity, which has been observed in the early visual cortex of various mammals, is a critical factor to the cost-effectiveness of brain function. We hypothesize that long-range connections can minimize the number of connections in the visual system while maintaining the ability to accurately recognize natural images. To confirm our hypothesis, we designed a simplified neural network model of the visual pathway, which has a three-layer convergence structure and lateral connections, to perform image classification task. The network is trained with a new objective function, which is defined as a classification error minimization term added by a connection length-penalty term, which represents the visual recognition function and the physical length constraint of the brain, respectively. First, we observed how recurrent connectivity is developed when the total length of the connections is limited. After optimizing the network using natural images, we observed that most of the initial connections had disappeared, but a few long-range connections (LRCs), which are defined as connections longer than the convergence range, remained. Remarkably, the number of LRCs optimized for natural images was significantly larger than the number of LRCs optimized for random images. Disconnecting the LRC in the trained network noticeably reduced the natural image classification performance compared to that for random connections. Second, to find which features of natural images are extracted by LRCs, we designed new training datasets by arranging a pair of numerical images (local features) at different positions (global features). After training the networks using various datasets which have different local and global features, we compared the remained ratio of LRCs between the trained networks. As a result, the local features did not affect the ratio of LRCs, but we found that the network trained by dataset with longer inter-global feature distance had a greater LRCs ratio. This implies that long-range connections may be required to extract the low-frequency components of images, not high-frequency. Overall, we propose that long-range recurrent connectivity is a critical component to optimize the balance between maximizing natural image perception performance and minimizing wiring cost.

References:

[1] K. He, X. Zhang, S. Ren and J. Sun (2015). Deep Residual Learning for Image Recognition, *arXiv.org*.[Online]. Available: https://arxiv.org/abs/1512.03385.
[2] Samu, D., Seth, A. K., & Nowotny, T. (2014). Influence of Wiring Cost on the Large-Scale Architecture of Human Cortical Connectivity. *PLoS Computational Biology*, *10*(4). https://doi.org/10.1371/journal.pcbi.1003557

Keywords:

Neural network, Image classification, Long-range connection, Wiring cost

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P2-st.021

Connection efficiency of street networks in Korean cities

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Abstract:

The aim of street network is to facilitate efficient mobility of human and goods. Thus, street network has been co-developed with development of human settlements and industry sites. Especially, urban street network has been understood as a footprint of city since it reveals how city is shaped and how people move around within the city. While a number of previous literature studies the structures, network properties and micro-scaled shape of urban street networks, few explore overall shapes (or morphology) of street network.

We study the morphology of 30 Korean cities' street networks by simplifying the networks. Since the performance of street network can be evaluated by its efficiency, we focus on how efficiently each part of urban area is connected by street network. To calculate efficiency of connections, we use detour index of empirical driving routes between randomly scattered origin and destination locations within urban area boundaries. Then, we introduce a new way of mapping the street network to visualize the overview of efficiency level and simplify the networks by aggregating the OD points into 10 by 10 grid nets.

The result shows overview picture of connectivity level of urban street networks. Although each city has their own special shape composed of high and low efficient connection (edges), the simplified network enables us to group cities with similar patterns such as high connection between east-west. Lastly, we compare the characteristics of street network with social economic characters of the cities.

Keywords:
street network, Network efficiency, Network visualization

P2-st.022

2019 봄 학술논문발표회 및 정기총회(2019 KPS Spring Meeting)
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Scaling of the Price Fluctuation and Spatiotemporal Dynamics in Korean House Market

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Abstract:
본 연구에서는 한국 주택 시장 내 가격 변동의 다양한 특성들에 대한 분석을 수행하였다. 분석을 통해, 한국 주택 가격에 대한 모든 데이터의 정규화 된 수익률의 분포에서 fat-tail이 나타남을 확인하였고, $\alpha \simeq 3$인 $P(r) \sim r^{-(\alpha+1)}$의 power-law 분포를 보임을 확인하였다. 그러나, 거래 패턴을 기반으로 한국 주택 시장 내 지역별 그룹을 나누었을 때, 각 그룹에서 postivie tail과 negative tail에서 서로 다른 α 값을 가짐을 확인하였다. 또한, 주택 시장의 자기상관 함수의 감소가 주식시장의 자기상관 함수의 감소에 비해 매우 느리게 발생함을 확인하였다. 이를 기반으로는 주택 시장의 가격변동은 다른 금융 시스템에 비해 다른 특성을 보임을 확인하였다. 마지막으로, 한국의 주택 시장 내 상관관계 행렬에 대한 분석 및 고유값 분석을 통해 주택 시장에서의 다양한 거동을 확인하였다.

Keywords:
Econophysics, Housing Market, Return Distribution

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P2-st.023

은닉 마코프 모델을 이용한 미세먼지 예측

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Abstract:
최근 증가된 미세먼지는 호흡기를 통해 체내에 흡입되어 다양한 질병을 일으키는 원인으로 보고되고 있다. 이러한 미세먼지는 차량운행 제한, 대기오염물질 배출시설 가동시간 조정 및 휴업 등 경제적, 사회적 손실까지 야기하고 있지만, 내, 외부활동에 있어서 미세먼지에 노출되는 것은 불가피하다. 따라서 미세먼지를 예측하여 경제적, 사회적 손실을 최소화 할 수 있는 효과적인 방법을 찾아내는 것이 중요한 이슈가 되고 있다. 미세먼지의 정도를 예측하기 위해서는 지리적 데이터 및 물리적 데이터 등 수 많은 데이터를 필요로 한다. 본 논문은 실측된 풍향 및 풍속 등의 물리적 데이터와 기상예보를 통해 예측된 기상 데이터를 이용하여 은닉 마코프 모델을 통해 미세먼지를 예측하는 방법과 특정 지역의 미세먼지 예측을 통해 정확도를 제시한다.

Keywords:
Hidden Markov Model(HMM), Fine Dust

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Cavity dependence of Ice flow dynamics of Tete Rousse Glaciers in Alphs

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Abstract:
We present the simulation results for the ice dynamics in mountainous areas. As an example, we show the dynamic behaviors of glacier stream in the Teterousse region of Mont Blanc, the French Alps. In particular, when there is an empty cavity under the glacier, cavity dependences of the flow of glaciers are depicted, such as the size of the cavity, the water pressure change which is filled in the cavity. In addition, changes in glacier thickness due to increased snowfall and changes of temperature at the ice-atmosphere contact are observed. To do this, we simulate the Elmer/Ice model to solve the three-dimensional Stokes equation by using the finite element method and observe the results for the glacier stress condition change, the glacier movement speed change, and the glacier stability.

Keywords:
glacier flow, Elmer/Ice, Ice dynamics

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Ice sheet dynamics simulations based on the ISSM(Ice Sheet System Model) program

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Abstract:

In this paper, we introduce some results implemented by Ice Sheet System Model(ISSM) code. ISSM was developed by NASA / JPL and has the ability to numerically calculate ice sheet and glacier dynamics. To understand the ice sheet flow in numerical terms, ISSM consists of Full-Stokes(FS), Blatter-Pattyn approximation(BP), Shallow-Shelf Approximation(SSA) and Shallow Ice Approximation(SIA) which are four different ice flow models and basically use the simplified FS equations. In order to calculate the ice flow rate in the continental scale domain, we applied an anisotropic adaptive mesh, which is a high resolution mesh method. Anisotropic Adaptive mesh minimizes the number of independent variables that can indicate the state of an object. This method can ideally reduce the error rate and the simulation operation time discretely. Through this implementation, we have obtained the ice flow velocity, basal drag coefficient, and the claving rate. We also introduce sensitivity analysis as part of the uncertainty quantification. Evaluating the output value error of the ice flow model is an important challenge to increase confidence in the continental mass balance prediction. This uncertainty quantification method is based on the Dakota software and focuses on how the results for input errors are propagated. Dakota collects section information about the input and iterates the same model several times to compare and analyze the results. Finally, I will use the ISSM to discuss the direction of research on ice sheets and glaciers.

Keywords:

Ice Sheet Dynamics, Uncertainty Quantification, Cryosphere

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P2-st.026*

Reservoir Computing Recurrent Neural Networks를 이용한 비선형 시스템 예측

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Abstract:

혼돈계는 나비효과처럼 초기 조건 민감성에 의해 예측의 작은 오차가 오랜 시간이 흐른 후에 큰 차이를 만들기 때문에 미래 예측이 쉽지 않다. 반복순환신경망 (Recurrent Neural Network; RNN)은 일간 날씨 예보와 같은 시계열 데이터를 학습하고 미래를 예측하는데 적합한 기계학습 모델이다. 그 중에서 Reservoir Computing (RC) RNN은 혼돈계를 학습하고 예측을 하는데 뛰어난 성능을 보인다고 알려져 있다. 우리는 Reservoir의 무작위 시간적 네트워크의 크기와 네트워크의 노드 사이의 연결될 확률을 조정해가며 예측에 최적화된 네트워크를 찾고 그 RC RNN을 학습시켜 로렌츠 끌개를 예측해본다. Reservoir 내부의 네트워크 크기는 입력 노드의 수에 비해 매우 크다. 이는 RC RNN이 학습을 잘하도록 입력 차원보다 큰 고차원 역학 공간으로 데이터를 퍼트려주기 때문이다. 하지만 입력 노드보다 얼마나 크고 노드 사이의 연결될 확률이 얼마일 때 학습을 잘하고 예측을 잘하는지는 아직 명확하지 않다. 우리는 비선형 시스템을 가장 잘 예측하는 네트워크 크기와 연결 확률을 알아본다.

Keywords:

Reservoir Computing RNN; 비선형 시스템; 네트워크

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P2-st.027*

Significance of conduction delays on the morphology and spiking dynamics of neural networks

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Abstract:

The connectivity of biological neural network evolves as its synaptic strengths evolve following the spatiotemporal spiking dynamics that is supported by the network itself; in turn, the changing network morphology alters the spiking dynamics. In other words, the network morphology and spiking activity coevolve. It is now well accepted that the relative timing of pre- and postsynaptic spikes is crucial as for altering synaptic strengths -- a phenomenon coined as spike-timing-dependent plasticity (STDP). In a minimal setting, STDP neglects the dendritic as well as axonal conduction delays, and it usually leads to a network inhibition having no (or not much of) recurrent loop formation. Incorporating conduction delays into STDP would have a similar effect of laterally shifting nonlinear 'STDP function' either to the left or right, depending on which the network could either be inhibited or potentiated. In this poster, based on an Izhikevich neural network model, we systematically investigate how recurrent loop formations and neural bursting dynamics change depending on the amount of conduction delays. In addition, we find that the system is actually multi-stable that the initial state of the network is also a crucial determining factor of the steady state network morphology.

Keywords:

plastic neural network, conduction delays, synaptic landscape

P2-st.028*

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청각 유모 세포의 소포 융합의 이론 모델

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Abstract:
인간의 청각유모세포에서 신경 신호의 정확한 타이밍은 소리의 위치 파악과 음성 인식과 청력의 역학에 매우 중요하다. 그러므로, 세포 내의 신호 전달의 본질을 이해하는 것은 청력 구조를 정확하게 이해함에 필수적이다. 시냅스 지연은 외부 자극이 클수록 줄어드는 것은 잘 알려져 있지만, 주기적인 신호에서는 반응의 위상이 세기와 상관없이 일정하다. 우리는 다양한 가정들을 이용한 모델들을 통하여 실험으로 관측된 결과와 비교하였다. 소포 내부 전압에 의존하는 비선형적인 소포구멍의 전도도를 이용하여 신경전달물질의 전류가 수 밀리초 이내에 감소하는 현상이 일어난다.

Keywords:
청각 유모세포, 소포 방출, 청각

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P2-st.029*

Tumor metastasis to normal tissue led by senescent cells

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Abstract:

Cellular senescence is a cell-state to which a normal cell can enter, and senescent cells undergo diverse changes, including cell-cycle arrest, morphological transformation, and most notably, release of chemicals known as senescence-associated secretory phenotypes (or SASPs). The role of cellular senescence lies in a wide range of biological phenomena; ranging from limb formation of embryo to numerous age-related diseases. Of a particular interest is the involvement of cellular senescence in tumor spreading, as recent experiments have shown. Some secretions of senescent cells are known to function as growth factor for tumor cells. Interestingly, a recent experimental study reveals that senescent tumor cells actively lead the invasion of thyroid cancer at the interface with non-tumorous normal tissue. In this poster presentation, based on a cellular Potts model we elucidate the biophysical mechanism of senescent cells being the leader of collective tumor invasion. Specifically, we investigate the sequential progression of senescent cells moving towards the fringe of tumor colony via process known as cell sorting, and then guiding tumor invasion. We observe that fundamentally distinct forms of invasion can arise by varying two essential parameters: chemotactic strength and persistency in the motion of senescent cell. We then analyze the most effective form of invasion which can be achieved via the balance between the two factors.

Keywords:

Cellular senescence, cell sorting, tumor metastasis

P2-te.001

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Physical understanding of artworks of Naum Gabo: vibration of vertical cantilever with axial force

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Abstract:
In the twentieth century, many artists were interested in science and technology and tried to bring scientific concepts to artworks. Naum Gabo, a pioneer of Russian constructivism, made a masterpiece named kinetic construction, which dealt with the forced oscillation of a vertical beam. Representation of artworks and physical explanation will bring about many good points to physics teaching and learning and the researcher developed a model similar to his artwork and conducted a comparison between theoretical and empirical results relying on an open-source simulation tool.

Keywords:
Naum Gabo, Reyleigh beam, forced oscillation, kinetic construction

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P2-te.002

원형 막대자석과 강자성 물체 사이에 작용하는 접촉 자기력

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Abstract:
이 연구는 물리교육을 위하여 영구자석과 강자성 물체 사이의 자기력에 대한 배경지식을 제공하다는 취지에서 이루어진다. 이미 선행연구에서 격리상태에 있는 원형 막대자석과 강자성 원형 막대 물체에 작용하는 격리 자기력을 자기화 이론, 자기에 대한 Gilbert 모형, Ampere 모형을 바탕으로 유도되었다 [NPSM 68, 1249 (2018)]. 그러나 자기에 대한 Gilbert 모형의 근본적인 한계 때문에 접촉상태에 있는 자석과 강자성 물체에 작용하는 자기력을 구할 수 없다. 이 연구의 목적은 접촉상태에 있는 영구자석과 강자성 물체 사이의 접촉 자기력에 대한 정량적인 표현을 유도하고, 유도된 자기력을 적용하여 영구자석인 AlNiCo V 자석과 Ferrite 자석이 접촉상태에 있는 cast iron(CI), cast steel(CS), sheet steel(SS)을 재질로 하는 강자성 물체에 작용하는 접촉 자기력을 구하고 그 결과를 논의할 것이다.

Keywords:
원형막대 자석, 강자성 물체, 접촉 자기력, AlNiCo V 자석, Ferrite 자석

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P2-te.003

Movement of Compass Needle around Current-carrying Wire in Primary School Science

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Abstract:

In 6th learning unit of 6-2 science revised 2009 primary school curriculum, the movement of compass needle around current-carrying straight lines and circular coils have been carried to be understand the magnetic field. The magnitudes of the magnetic field around wire by Ampere's law are depended on the current, the distance between measure point and the coil, the coil turns, and the geometric shape of coils. The compass is used to measure the magnitudes of the magnetic field around wire instead of gauss meter in primary school. The compass needle pointed north by the earth's magnetic field is not linearly rotated due to magnetic field generated wire carrying current. From normalization of measured data, the magnitudes of magnetic field around wire are linearly depended on currents to be satisfy Ampere's law.

Keywords:

magnetic field, compass

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P2-te.004*

방사형 거미줄 모형의 각 방향 탄성계수에 따른 장력분포 특성

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Abstract:

거미줄은 줄 한두 개가 끊어져도 전체적인 형태를 유지할 수 있는 구조적 내구성을 가지고 있다. 나선방향 거미줄로 먹이를 사냥하는 거미의 생존에 유리하도록 지름방향이 손상되는 것보다는 나선방향 손상에 의한 영향이 훨씬 덜하다는 것이 알려져 있는데, 이를 방사형 거미줄 모형을 제작하여 실험적으로 확인하였다.
학생들도 손쉽게 구할 수 있는 고무줄과 열쇠고리를 이용하여 방사형 거미줄 모형을 제작하였다. 각 구성요소의 장력-길이 곡선을 측정하여 가장 선형적인 구간을 택하여 모형을 설계했고, 같은 구간에 고무줄을 중복하여 걸어주는 횟수로 탄성계수를 조절하였다. 나선방향의 거미줄에 대한 지름방향의 거미줄의 단위길이당 탄성계수 비율이 증가함에 따라, 나선방향에 비해 지름방향에 걸린 장력이 상대적으로 커지고 나선방향의 거미줄이 손상되었을 때의 영향이 작아진다.

Keywords:
거미줄, 탄성

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뮤온 입사량과 기상요인의 상관관계 분석

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Abstract:

본 연구는 우주에서 날아오는 고에너지 입자로 인한 2차 우주선인 뮤온을 서라벌 고등학교 실험실에 설치된 플라스틱 신틸레이터를 이용하여 실험을 수행하였고, 기상 요인(온도, 습도, 미세먼지)에 따른 뮤온 입사량을 분석하였다. 실험을 통해서 뮤온 입사량이 기상요인과 상관관계가 있음을 확인하였다.

Keywords:

뮤온 입사량, 기상요인