한국물리학회 초록집

2021년 2021 KPS Spring Meeting

봄 학술논문발표회 및 제97회 정기총회

2021년 4월 21일(수) ~ 23일(금)

Virtual Conference

한국물리학회
The Korean Physical Society

구두발표논문

Oral session abstract

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.01

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

PARK Jiwon *[1], KIM Tae Jeong [1]
[1]Department of Physics, Hanyang University
minerva1993@gmail.com

Abstract:

We present the results of searching for flavor-changing neutral current (FCNC) in the interaction of top quark and Higgs boson 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 isolated lepton, at least three jets including more than two b jets. Multivariate analysis techniques are utilized in various stages of analysis to improve the sensitivity of signal events. As no significant deviation is observed from the predicted background, we set upper limits on cross section and branching fraction of FCNC interaction in tHq coupling.

Keywords:

top quark, Higgs boson, LHC, CMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.02

Search for a heavy neutrino in top quark decays using CMS detector

JEON Sihyun [1], BHYUN Jihwan [1], YANG Un-ki *[1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

We present a search for a heavy neutrino in top quark decays under type-I seesaw model at CMS. Top quarks are produced in pairs from proton-proton collisions at center of mass energy of 13 TeV. Final states with same-sign dilepton, trilepton, and tetralepton are considered. Feasibility of the heavy neutrino mass between 20 and 100 GeV at the CMS Run-2 condition is investigated.

Keywords:

CMS, LHC, top, heavy neutrino, type-I seesaw model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.03

Search for monotop events in pp collsions at 13 TeV from CMS experiment

DOGRA Sunil Manohar*[1], MOON Chang-Seong [1], HONG Jieun [1]
[1]Department of physics, Kyungpook National University
smdogra@gmail.com

Abstract:

The one of the important goals of the Large Hadron Collider (LHC) is to find the dark matter signature. Since the dark matter doesn't leave the measurable signature in the detector, one way to observe them is when they are produced in association with a visible Standard Model particle, called MET+X where MET is the missing transverse energy. Events containing a single top quark produced in association with a source of missing transverse energy are searched for in the leptonic and hadronic channel. If the spin-1 mediator has flavor-changing coupolings to top and light quarks, dark matter particles can be produced with a single top quark, called the monotop final state. The signal study of monotop signatures will be presented from 2016, 2017 and 2018 samples using a new analysis framework, Columnar Object Framework For Effective Analysis (COFFEA).

Keywords:

Dark Matter, CMS Experiment

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.04

Performance of the Muon Seed Classifier with Machine Learning Technique for CMS Run3

KIM Jihun [1], JUN Won [1], KO Sanghyun [1], KWON Hyejin [1], OH Minseok [1], YOO Hwidong [2], YANG Un-ki [*1]

[1]Department of physics and astronomy, Seoul National University
[2]Department of Physics, Yonsei University
ukyang@snu.ac.kr

Abstract:

We present the study on the performance of the muon seed classifier with Machine Learning technique to reduce the timing of CMS muon high level trigger(HLT) in Run3. The performance will be shown in terms of the number of seeds reduction, signal efficiency, purity, and the timing reduction in various working points with two possible approaches to build the muon tracks. The training results including the distribution of the seed MVA scores and ROC curve are also presented. The trained model is applied to Drell-Yan, ttbar Monte Carlo(MC) event simulation and 2018 HLT Physics dataset to evaluate the performance. Almost no signal loss has been observed, the purity is improved and the timing reduction is promising.

Keywords:

Machine Learning, Muon HLT

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.05

Search for Charged Higgs Boson Decaying to W Boson and Pseudo-scalar Higgs Boson at sqrt(s) = 13TeV with CMS Run2 dataset

YANG Un-ki *[1], CHOI Jin [1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

A search for charged Higgs boson decaying to W boson and pseudo-scalar Higgs boson is presented. The analysis is based on the dataset of proton-proton collision at center of mass energy 13TeV collected with CMS experiment at the CERN LHC, corresponding to an integrated luminosity of 137/fb. The search is performed with trilepton plus multijet final state events including at least 2 muons with opposite charge. Charged Higgs boson's mass from 70 to 160 GeV with corresponding pseudo-scalar Higgs boson's mass from 15 to m(Hc) - 5 GeV is investigated.

Keywords:

CMS, LHC, Run2, Charged Higgs

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.06

Measurement of CP violation by using an angular distribution in single top t-channel @ 13 TeV

KO Byeonghak [1], KIM Hyunsoo [2], PARK Inkyu *[1], LEE Jason Sang Hun[1], ROH Youn Jung [1], WATSON Ian James[1]
[1]University of Seoul
[2]Department of Physics, Sejong University
icpark@uos.ac.kr

Abstract:

The top quark, the heaviest known particle, can probe for new physics beyond the Standard Model (SM), and CP violation can solve the paradox of the baryon asymmetry of the universe. We have measured an asymmetry of an angular distribution between products of the top quark decay which contributes to the CP violation. In this study, we perform the CP violation contribution in the t-channel production of single top quarks in proton-proton collision at center-of-mass energy of 13 TeV using data corresponding to 35.9/fb collected by the CMS detector. The preliminary results have been compared to Monte Carlo simulation to probe its deviations from the SM predictions.

Keywords:

Top quark, CP violation, LHC, CMS, W helicity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.07

Spiking Neural Network for the Event Classification in High Energy Physics

KIM TAE JEONG *[1], RYOU Yeonsu [1]
[1]Department of Physics, Hanyang University
taekim@hanyang.ac.kr

Abstract:

In particle physics, after the Higgs discovery at CERN located between Switzerland and France, we are struggling to find a new particle that should exist to explain dark matter, asymmetry of matter-antimatter or unification of forces, etc. To tackle this problem, we have been using billion-events per second from the proton-proton collisions. More data will be coming at the High-Luminosity LHC in 2024 with more information such as the timing of the particles. We are facing the challenges to deal with this big data to select interesting events and eventually detect anomaly which is not necessarily predicted by theory. In this proposal, we would like to apply a spiking neural network (SNN) for the event classification in the top-quark pair events with additional heavy-flavor jets as an application. The performance of the SNN on the Loihi architecture will be compared with the traditional deep neural network. With the outcome of this study, we will discuss the feasibility of using the SNN for future colliders.

Keywords:

spiking neural network, trigger, future collider

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A1.08

Search for non-thermal Dark Matter in Monotop Events in Proton-Proton Collisions at 13 TeV

PARK Inkyu *[1], KIM Seulgi [1], LEE Jason Sang Hun[1], WATSON Ian James[1], ROH Youn Jung [1]
[1]University of Seoul
icpark@uos.ac.kr

Abstract:

We study a minimal non-thermal dark matter (DM) model which can explain both the existence of dark matter and baryon asymmetry in the universe. Two color-triplet scalars with O(TeV) mass and a singlet Majorana fermion are required in this study. A new fermion with mass of O(GeV) becomes stable and can play the role of a DM candidate when it is approximately the same mass as proton. In this model, the DM candidate interacts with top quark via the exchange of the colored scalar fields. We search for this non-thermal dark matter candidate using monotop events.

Keywords:

Dark Matter, Monotop

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.01

Annual modulation search from COSINE-100

PRIHTIADI Hafizh *[1]
[1]Physics, Center for Underground Physics, IBS
hafizh.physics@gmail.com

Abstract:

The positive measurement of an annual modulation in the event rate gives a presence of dark matter particles reported by the DAMA/LIBRA, interpreted as being due to WIMP interaction with the detector materials. However, none of the experiments other than the DAMA/LIBRA reported the excess signals of low-energy nuclear recoil events. COSINE-100 is a direct dark matter search experiment to carry out a model-independent test of DAMA's claim. Recently, COSINE has accumulated more than three years of physics data with an energy threshold lowered to 1 keV. In this report, we present our model-independent annual modulation analysis technique and compare its results with those obtained from the application of an analysis procedure that is as close as possible to the DAMA/LIBRA method to the same data.

Keywords:

COSINE-100, annual modulation search, model-independent, dark matter search

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.02

Deep Learning Event Selection for Low Energy Scintillation of the COSINE-100 Dark Matter Experiment

LEE Seung Mok [*1], KO Young Ju [2], LEE Hyun Su [2], KIM Kyoung Won [2], KIM Sun Kee [1], CHOI Jaejin [1], JOO Han Wool [1]

[1]Department of Physics & Astronomy, Seoul National University

[2]Center For Underground Physics, IBS

physmlee@gmail.com

Abstract:

COSINE-100, a dark matter search experiment, aims to confirm the annual modulation of low energy scintillation signals first reported by the DAMA/LIBRA group, but never been confirmed by other experiments. Developing a low energy threshold and high signal efficiency event selection algorithm is an important aspect of the experiment, especially since the DAMA/LIBRA modulation is confined to signals close to 1 keV. In this talk, I present high-performance results of multilayer perceptron, a deep-learning technique, applied to the noise/signal classification for COSINE-100 scintillation pulse data. The resulting distinction between noise and signal events is demonstrated to better than previously employed algorithms with the same energy threshold. The possibility for further lowering of the threshold will be studied using recently accumulated Na-22-source calibration data.

Keywords:

Dark Matter, Deep Learning, Event Selection, COSINE-100, DAMA

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.03

Status of COSINE-100

KIM SungHyun *[1]
[1]Center for Underground Physics, IBS
panic4th@hotmail.com

Abstract:

The COSINE-100 experiment searches for dark matter induced recoil interactions in NaI(Tl) crystals in order to perform a model-independent test of DAMA/LIBRA's claim of dark matter discovery.
The COSINE-100 detector, which located in the Yangyang Underground Laboratory (Y2L), consists of 106 kg of low background NaI(Tl) crystals submerged within a 2000 L of liquid scintillator, and plastic scintillator moun counters are covering the outmost structure.
Data taking started in September 2016, and the experiment has been operating stably for four and a half years.
In this talk, we report the current status of the COSINE-100 experiment.

Keywords:

COSINE-100, dark matter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.04

Background estimation for the AMoRE-II experiment

JEON Eun Ju *[1]
[1]Center for Underground Physics, Institute for Basic Science
ejjeon@ibs.re.kr

Abstract:

AMoRE-II is the second phase of the AMoRE (Advanced Mo-based Rare process Experiment) project that aims to search for the neutrinoless double beta decay of ^{100}Mo, planned to run at YEMI underground laboratory, in Korea. To achieve the ultimate goal for half-life sensitivity of neutrinoless double beta decay of ^{100}Mo, it requires to have as low as possible radioactive background (so-called “zero” background) that is limited by internal crystal backgrounds, external backgrounds from materials in a detector system, and cosmic muons and muon-induced backgrounds. To evaluate the effects of those backgrounds we performed Geant4 Monte Carlo simulations and estimated background levels for AMoRE-II, which will be presented in this talk.

Keywords:

AMoRE, neutrinoless double beta decay, background, Geant4 simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.05

Assay of MoO_3 powders with the CAGe

KIM Yeongduk *[1], PARK Su-yeon [1], HAHN Insik Kevin[2], KANG Woongu [1], KIM Gowoon [1], LEE Eunkyung [1], LEONARD Douglas Sidney[1], KAZALOV Vladimir [3], LEE Moohyun [1]
[1]IBS Center for Underground Physics, IBS
[2]IBS Center for Exotic Studies, IBS
[3]Baksan Neutrino Observatory, Institute for Nuclear Research of the Russian Academy of Science
ydkim@ibs.re.kr

Abstract:

The AMoRE searches for neutrinoless double-beta (0vββ) decay of Mo-100 using Mo-100-enriched (~96.5%) crystals. AMoRE-II, the next experimental setup, is being prepared and will be operated with ~200 kg of molybdate crystals (~100 kg of Mo-100). AMoRE-II needs crystals with low levels of radioactive contaminants to achieve "zero-background" in the region of interest (ROI) around the 0vββ decay energy of Mo-100. To make pure crystals, the materials (Mo-100-enriched powder) should be low in radioactive contamination. We have an array of fourteen HPGe detectors with 70% relative efficiency each, named the CAGe, at the Yangyang underground lab. We could measure activities as low as tens of uBq/kg. Mo-100 can have double-beta decays (2vββ, DBD) to excited states of Ru-100. When Mo-100 decays to the excited states of Ru-100, it de-excites to the ground state emitting gamma(s). By measuring gamma rates, we can estimate the DBD half-life of Mo-100 to each of the excited states of Ru-100.
Four enriched 100MoO3 powders of ~10 kg each were measured using the CAGe. We confirmed several contaminant radioisotopes, such as those from the Th-228, Ac-228, and Ra-226 decay chains. We also measured the DBD of Mo-100 to the excited states of Ru-100. We will present results for the contaminant activities and the DBD half-life of Mo-100 in the four Mo-100-enriched powders.

Keywords:

Double beta decay, Nuclear matrix element, Background radioactivity, Molybdate tri-oxide powder, HPGe detector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.06

AMoRE-I Analysis for Heat and Light Signals

KIM HAN BEOM [1,2], WOO Kyungrae *[1,3], ON The behalf of AMoRE Collaboration [1]
[1]Center for Underground Physics, IBS
[2]Department of Physics & Astronomy, Seoul National University
[3]Institute for Basic Science, UST
krwoo@ust.ac.kr

Abstract:

AMoRE (Advanced Mo-based Rare process experiment) is an international collaboration project to search for neutrinoless double beta decay (0νββ) of ^{100}Mo in Mo-based enriched scintillating crystals with the use of metallic magnetic calorimeters in a mK-scale cryogenic system. For AMoRE aims at zero background in the region of interest near 3.034 MeV, the phonon-photon simultaneous measurement and pulse shape discrimination techniques are preformed to achieve a high resolution and good background rejection. AMoRE-I, the phase following the succefully completed AMoRE-pilot, has been running with thirteen $^{48depleted}Ca^{100}MoO_4$ and five $Li_2{}^{100}MoO_4$ crystals in the Yangyang underground laboratory. We present the current status of the experiment, its analysis method and most resent analysis results.

Keywords:

AMoRE, Neutrinoless Double Beta Decay, Underground Experiment

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A2.07

First observation of new isomers in ^{228}Ac : Impact on dark matter searches

LEE Hyun Su *[1]
[1]Center for Underground Physics, IBS
hyunsulee@ibs.re.kr

Abstract:

We have observed new isomeric states of ^{228}Ac at 6.28 keV and 20.19 keV with lifetimes of 299 ±11 ns and 115±25 ns, respectively, using the COSINE-100 dark matter search detector. These states are produced by the beta-decay of ^{228}Ra, a component of the ^{232}Th decay chain, with beta Q-values of 39.52 keV and 25.61 keV, respectively. Due to its low Q-value as well as the relative abundance of ^{232}Th and their progeny in low background experiments, these observations potentially impact the low-energy background modeling of dark matter search experiments. Here we present a possible explanation of an excess observed by XENON-1T experiment assuming tiny contamination of 228Ra.

Keywords:

Dark matter; XENON1T excess

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.01

Analysis of virtual meson production in solvable (1+1) dimensional scalar field theory

CHOI Yongwoo *[1], JI Chueng-Ryong [2], CHOI Ho-Meoyng [3], OH Yongseok [1]
[1]Physics, Kyungpook National University
[2]Physics, North Carolina State University
[3]Department of Physics Education, Teachers College, Kyungpook National University
sunctchoi@naver.com

Abstract:

Light-front time-ordered amplitudes including the “handbag” and “cat’s ears” diagrams are investigated in the virtual meson production (VMP) process in (1+1) dimensions using the solvable scalar field theory extended from the conventional Wick-Cutkosky model. While there is only one Compton form factor (CFF) in our (1+1) dimensional computation of the VMP process, we compute both the real and imaginary parts of the CFF for the entire kinematic regions of Q^2>0 and t < -|tmin| <0 and analyze the contribution of each and every light-front amplitude to the CFF depending on the Q^2 and t ranges. In particular, we discuss the significance of the “cat’s ears” contribution for the gauge invariance and the validity of the “handbag” dominance for the formulation of the generalized parton distribution function (GPD) used typically in the analysis of deeply virtual meson production (DVMP) process. We explicitly derive the GPD from the “handbag” light-front time-ordered amplitudes in the -t/Q^2 <<1 limit and verify that the integration of the GPD over the light-front longitudinal momentum fraction for the DGLAP and ERBL regions correspond to the valence and non-valence contributions of the electromagnetic form factor that we have recently presented(arXiv:2101.03656; Phys. Rev. D in print). We also discuss the correspondence of the GPD to the parton distribution function (PDF) for the analysis of the deep inelastic lepton-hadron process and the utility of the new light-front longitudinal spatial variable “z-tilde”.

Keywords:

handbag diagram, cat's ears diagram, light-front dynamics, Compton form factor, generalized parton distribution function

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.02

Vector meson mass in the chiral symmetry restored vacuum

KIM Jisu [1], LEE Su Houng [*1]
[1]Yonsei University
suhoung@yonsei.ac.kr

Abstract:

We calculate the mass of the vector meson in the chiral symmetry restored vacuum. This is accomplished by separating the four quark operators appearing in the vector and axial vector meson sum rules into chiral symmetric and symmetry breaking parts depending on the contribution of the fermion zero modes. We then identify each part from the fit to the vector and axial vector meson masses. By taking the chiral symmetry breaking part to be zero while keeping the symmetric operators to the vacuum value, we find that the chiral symmetric part of the vector and axial vector meson mass to be between 550 and 600 MeV. This demonstrates that chiral symmetry breaking, while responsible for the mass difference between chiral partner, accounts only for a small fraction of the symmetric part of the mass.

Keywords:

chiral partner, QCD sum rules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.03

The medium modification of singly heavy baryon masses

WON Ho-Yeon [1], KIM Hyun-Chul *[1], YAKHSHIEV ULUGBEK [1]
[1]Inha University
hchkim@inha.ac.kr

Abstract:

We present the results for a recent investigation on properties of infinite isospin symmetry nuclear matter within the framework of the in-medium modified SU(3) Skyrme model with π, ρ and ω mesons. We consider the modification of the parameters of the model in the matter, using the empirical data on nuclear phenomenology: the results of the density dependence of the volume term in the mass formula and the incompressibility of symmetric nuclear matter and the equation of state in nuclear matter. We obtain the results for the in-medium mass spectrum of the singly-heavy baryons.

Keywords:

Nuclear matter, skyrme model, heavy baryon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.04

The effect of hidden-charm strange pentaquarks P_{cs} on the K^- p → J/ψ Λ reaction

CLYMTON Samson [1], KIM Hee-Jin [1], KIM Hyun-Chul *[1]
[1]Inha University
hchkim@inha.ac.kr

Abstract:

Recently, LHCb collaboration has discovered the hidden-charm pentaquarks $P_{cs}(4459)$ with strangeness from the $\Xi_b^- \to J/\psi\Lambda K^-$ decay. We investigate the production of P_{cs} from the $K^-p \to J/\psi\Lambda$ reaction, based on the effective Lagrangian and Regge approaches. Since the spin-parity quantum numbers of P_{cs} are not known experimentally yet, we assign six different sets for the spin and parity quantum numbers for P_{cs}, i.e., $1/2^{\pm}$, $3/2^{\pm}$ and $5/2^{\pm}$. We present and discuss the results for the differential and total cross sections of the $K^-p \to J/\psi\Lambda$ reaction, exmaining the dependence of the results on the spin-parity quantum numbers of P_{cs}. The present results may give a hint to determine the spin-parity of P_{cs} for possible future experiments.

Keywords:

Pentaquarks, Effective Lagrangian, Regge approach

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.05

Color-octet heavy-quark potential from the instanton vacuum

KIM Hyun-Chul *[1], HONG Ki-Hoon [1], YAKHSHIEV Ulugbek [1]
[1]Inha University
hchkim@inha.ac.kr

Abstract:

In this talk, we show the color-octet heavy quark and antiquark potential in the instanton vacuum.
We show that the color-octet Wilson loop is represented by inserting the SU(3) generators on the spatial Wilson lines. We obtain the non-perturbative color-octet potential, which is equal to color-singlet potential. However, the perturbative one-gluon exchange instanton effect gives $-1/(N_c^2 - 1)$ times the difference between the color-singlet. We conclude that the non-perturbative instanton effect is not affected by color-states, while the perturbative instanton does.

Keywords:

Instanton-induced interactions, heavy-quark potential, quarkonia

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.06

Baryonic matter and the medium modification of the baryon masses

KIM Hyun-Chul *[1], YANG Ghil-Seok [2], YAKHSHEIV Ulugbek [1], GHIM Nam-Yong [1]
[1]Inha University
[2]Department of General Education for Human Creativity, Hoseo University
hchkim@inha.ac.kr

Abstract:

We investigate the properties of baryonic matter within the framework of the in-medium modified chiral soliton model by taking into account the effects of surrounding baryonic environment on the properties of in-medium baryons. The internal parameters of the model are determined based on nuclear phenomenology at nonstrange sector and fitted by reproducing nuclear matter properties near the saturation point. We get the equations of state in different nuclear environments such as symmetric nuclear matter, neutron and strange matter. The results for symmetric nuclear and neutron matter are in good agreement with the phenomenology of nuclear matter. The present results can be further applied to the description of compact stars.

Keywords:

nuclear matter, neutron matter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.07

The Doubly-heavy Tetraquarks ($qq'\bar{Q}\bar{Q'}$) in a Constituent Quark Model with a Complete Set of Harmonic Oscillator Bases

NOH Sungsik [1], PARK Woosung [1], LEE Su Houng [*1]
[1]Yonsei University
suhoung@yonsei.ac.kr

Abstract:

We have improved our previous variational method based constituent quark model by introducing a complete set of 3-dimensional harmonic oscillator bases as the spatial part of the total wave function. To assess the validity of our approach, we compared the binding energy, thus calculated with the exact value for the hydrogen model. After fitting to the masses of the ground state hadrons, we apply our new method to analyze the doubly-heavy tetraquark states $qq'\bar{Q}\bar{Q'}$ and compared the result for the binding energies with that from other works. We also calculated the ground state masses of $T_{sc} (ud\bar{s}\bar{c})$ and $T_{sb} (ud\bar{s}\bar{b})$ with $(I,S) = (0,1), (0,2)$. We found that $T_{bb} (ud\bar{b}\bar{b})$ and $us\bar{b}\bar{b}$, both with $(I,S) = (0,1)$, are stable against the two lowest threshold meson states with binding energies -145 MeV and -42 MeV, respectively. We further found that $T_{cb} (ud\bar{c}\bar{b})$ is near the lowest threshold. The spatial sizes for the tetraquarks are also discussed.

Keywords:

Quark model, Tetraquark, Variational method

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.08

Electromagnetic radiative decays for the singly charmed baryons with spin 3/2

KIM Hyun-Chul *[1], KIM June-Young [2], YANG Ghil-Seok [4], OKA Makoto [3]
[1]Inha University
[2]Institute for Theoretical Physics II, Ruhr-University Bochum
[3]Department of General Education for Human Creativity, Hoseo University
[4]Advanced Science Research Center, Japan Atomic Energy Agency
hchkim@inha.ac.kr

Abstract:

We present the electromagnetic radiative transitions of the singly charmed baryons with spin 3/2 from a pion mean-field approach, taking into account the rotational 1/Nc corrections and the effects of flavor SU(3) symmetry breaking. We scrutinize the valence- and sea-quark contributions to the electromagnetic transition form factors. We find that the quadrupole form factors of the sea-quark contributions dominate over those of the valence-quark ones in the smaller region of the momentum transfer. On the other hand, the sea quarks only provide marginal contributions to the magnetic dipole transition form factors of the baryon sextet with spin 3/2. The effects of the flavor SU(3) symmetry breaking are tiny except for the forbidden transition by U-spin symmetry. We also present the results for the widths of the radiative decays for the baryon sextet with spin 3/2.

Keywords:

Electromagnetic transitions, heavy baryons, pion mean-field approach

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A3.09

Properties of the charged light pseudoscalar mesons at finite temperature and the presence of the external magnetic field

HUTAURUK Parada Tobel Paraduan[*1], NAM Seung-il [*1,2]
[1]Physics, Pukyong National University
[2]APCTP, APCTP
phutauruk@gmail.com, sinam@pknu.ac.kr

Abstract:

We present our systematic study on the properties of the charged light pseudoscalar mesons at finite temperature in the presence of the magnetic field in the Nambu-Jona-Lasinio model with the help of the proper-time regularization scheme, simulating the confinement through setting the infrared cutoff based on QCD limit. The properties of the pseudoscalar meson as the dressed quark-antiquark bound state are determined by the Bethe-Salpeter equation. Using the quark effective theory model, we analyze the dynamical masses of the quarks, meson masses, quark chiral condensate as well as mesons-quark coupling at nonvanishing temperature and under the presence of the external magnetic field, where the in-medium quark propagator is described by the Fock-Schwinger representation. Our results on the dynamical masses for the light and strange quarks, meson masses, chiral condensate as well as meson-quark coupling at finite temperature and the presence magnetic field will be discussed.

Keywords:

Nambu--Jona--Lasinio model, Quark effective theory, Proper-time regularization, Finite temperature, Pseudoscalar meson

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A5.01

Superconductor-semiconductor systems for advanced quantum devices

LEE Joon Sue *[1]
[1]Department of Physics and Astronomy, University of Tennessee
jslee@utk.edu

Abstract:

In superconductor-semiconductor hybrid systems, interface and junction with minimal disorder are crucial for investigating quantum phenomena associated with induced superconductivity. Advances in developing transparent interface by epitaxial superconductor grown on low-dimensional semiconductors as well as clean junction by in-situ shadowing have resulted in enhanced features of superconducting proximity effect. These schemes of "epitaxy" and "shadowing" of superconductors can be applied to quantum devices based on 1D nanowires, selectively grown in-plane 1D wires, and 2D electron gases. Materials/devices by these schemes will be demonstrated, and transport studies revealing hard superconducting gap, two-electron charging effect, and zero-bias conductance peaks will be discussed.

Keywords:

superconductor-semiconductor, induced superconductivity, epitaxy, shadowing, quantum device, transport

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A5.02

Higher order topological phases in twisted bilayer graphene and magnetic van-der Waals materials

LEE SungBin *1
[1]physics, KAIST
sungbin@kaist.ac.kr

Abstract:

We discuss higher order topological phases in twisted bilayer graphene and magnetic van-der Waals materials. We first propose the twisted bilayer graphene with large angles can serve as a strong candidate material of two-dimensional higher-order topological insulator having the corner states. The presence of the corner states leads to the instanton interference effect, where the intercorner tunneling exists for the instanton and the anti-instanton pairs that travel through the boundary. Focusing on magnetic van-der Waals materials, we also propose that non-collinear magnetic order can host a novel higher-order topological magnon phase with non-Hermitian topology and hinge magnon modes. In particular, for a three-dimensional system of interacting local moments on stacked-layers of honeycomb lattice, it initially favors a collinear magnetic order along an in-plane direction, which turns into a non-collinear order upon applying an external magnetic field perpendicular to the easy axis. We exploit the non-Hermitian nature of the magnon Hamiltonian to show that such field-induced transition corresponds to the transformation from a topological magnon insulator to a higher-order topological magnon state with a one-dimensional hinge mode.

Keywords:

topology, graphene, twisted bilayer, van-der Waals, magnetic, non-Hermitian, magnon, hinge mode

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A5.03

Antiferromagnetic Kitaev-Γ Model under Magnetic Field

LEE Ki Hoon *[1]
[1]Department of Physics, Incheon National University
ki.hoon.lee.email@gmail.com

Abstract:

Kitaev model is a paradigmatic quantum spin model with the soluble quantum spin liquid ground state. Most of the research interest focused near the ferromagnetic Kitaev point, relevant to many candidate materials such as $RuCl_3$. However, recently, it is reported that the U(1) quantum spin liquid phase appears between the fully polarized phase and the gapped antiferromagnetic Kitaev spin liquid phase under the magnetic field. Motivated by this report, we carefully study the phase diagram of the Kitaev-Γ model with antiferromagnetic Kitaev exchange under a perpendicular magnetic field. In the talk, we will illustrate our strategy and present preliminary results.

Keywords:

Kitaev model, topological phase, quantum spin liquid

A6.01

Anomalous phase of magnetic quantum oscillation by broken time-reversal symmetry

JUNG Myung Hwa *[1], LEE Sang-Eon [1], JI Sanghyun [1], JUN Jin Hyun [1]
[1]Sogang University
mhjung@sogang.ac.kr

Abstract:

Hall measurement is widely used to study systems whose time-reversal symmetry (TRS) is broken by their magnetic structure. However, it is subtle to distinguish between various Hall signals of the normal Hall signals and the anomalous Hall signals. Here, we show the new method to study the broken TRS from the magnetic structure by analyzing the magnetic quantum oscillations (MQOs). It is known that if the material is non-magnetic, the phases of MQOs can only be two distinct values of 0 or π from the orbits [1]. When the magnetic structure breaks the TRS, the phase of MQOs deviates from those values, and we call the deviation the anomalous phase. We observed the anomalous phase in Fe doped $NbSb_2$. In the system, paramagnetic Fe impurities break the TRS of $NbSb_2$. The phase of a high doped sample largely deviates from the phase of low doped and pristine samples indicating the anomalous phase. In the MQOs, a different type of magnetic structure gives different field dependence to the phase, which makes it easy to discern different magnetic structures [2]. This method can complement the Hall measurement or give useful information by itself for studying the magnetic structure of materials.
[1] A. Anlexandradinata et al, *Phys. Rev. X.* 8, 011027 (2018)
[2] Yang Gao, and Qian Niu, *Proc. Natl. Acad. Sci.U.S.A.* 114, 7295 (2017)

Keywords:

Magnetic quantum oscillation, Time-reversal symmetry, Dirac semimetal, Magnetic impurity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A6.02

Study of thin films of molecular spin qubits by surface-sensitive electron spin resonance spectrometer

DONATI Fabio *[1,2], YU Jisoo [1,2], CHO Franklin Hyunil[1,2], COLAZZO Luciano [1,2], JEONG Yejin [1,2], LIU Junjie [3], ARDAVAN Arzhang [3], BOERO Giovanni [4], HEINRICH Andreas Johachim[1,2]
[1]Department of Physics, Ewha Womans University
[2]Center for Quantum Nanoscience (QNS), Institute for Basic Science (IBS)
[3]The Clarendon Laboratory, Department of physics, University of Oxford
[4]Laboratory for Microsystems, Ecole Polytechnique Fédérale de Lausanne (EPFL)
donati.fabio@qns.science

Abstract:

Electron spin resonance (ESR) spectroscopy is a powerful tool to establish the quantum coherence of molecular spin qubits [1]. In order to determine their performance as quantum bits for quantum information processing, it is important to integrate them on solid-state substrates and characterize their interaction with the substrate electrons. However, this characterization requires tailored spectrometers with specific surface sensitivity.
Herein, we utilize a home-built surface-sensitive ESR spectrometer to characterize the thin film of *α,γ*-bisdiphenylene-β-phenylallyl (BDPA). This spectrometer operates in the X-band (10 GHz) both in continuous wave and pulsed mode in a wide range of temperature (2.5-300 K) and magnetic field (0-3.2 T). BDPA is the traditional standard in ESR technique and allows for a self-assembly process on surfaces [2]. In order to maximize the microwave field on a 2D spin system, we developed a coplanar-type resonator, onto whose surface we deposit the molecular films. We demonstrate a spin sensitivity of 10^{12} spins/G·√Hz in continuous wave mode at room temperature, which allows ESR measurements down to a single layer of molecular spins.

1. *Nat. Chem.* 11, 301 (2019).
2. *J. Phys. Chem. C* 116, 22857 (2012).

Keywords:

Quantum coherence, Spin magnetism, Electron spin resonance, Molecular spin qubits

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A6.03

Engineering anomalous Hall effect in $SrRuO_3$-based heterostructure by controlling kinetic bombardment during pulsed laser deposition

KO Eun Kyo [1,2], LEE Han Gyeol [1,2], LEE Sangmin [3], MUN Junsik [3], KIM Miyoung [3], CHANG Seo Hyoung [4], NOH Tae Won *[1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]Center for Correlated Electron Systems, CCES (IBS)
[3]Department of Materials Science and Engineering and Research Institute of Advanced Materials, Seoul National University
[4]Department of Physics, Chung-Ang University
twnoh@snu.ac.kr

Abstract:

With the emergence of heterostructure engineering, there have been extensive approaches to couple the various functionalities of perovskite oxides. The anomalous Hall effect in $SrRuO_3$ is one of the focused topics resulted from its subtle band structure and associated Berry curvature, which are extremely sensitive to other physical parameters. However, while the intriguing concept of coupling between physical parameters has got much attention, the intrinsic kinetic problems during heterostructure deposition have seldom been studied and even overlooked in this material. Hence, we investigated the kinetic effect in $SrRuO_3$-based heterostructure. By systematic control of kinetic bombardment during the heterostructure deposition, we achieved dramatic modification of the anomalous Hall transport in $SrRuO_3$. Further analysis with magnetometry and nano-compositional experiments verifies that the high-kinetic energy of capping layer adatoms induces interdiffusion at heterointerface resulting in multiple characters of magnetization and associated transport. Our findings imply that precise control of kinetics should be precedent for the oxide heterostructure engineering and even more important in Berry curvature-related phenomena.

Keywords:

SrRuO3, anomalous Hall effect, pulsed laser deposition, heterostructure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A6.04

Data generation using variational autoencoder and direct exploration in latent space to search desired physical states

WON Changyeon *[1], PARK Seong Min [1], KWON Hee Young [2], YOON Han Gyu [1], LEE Doo Bong [1]
[1]department of physics, Kyung Hee University
[2]Center for Spintronics, KIST
cywon@khu.ac.kr

Abstract:

With the advancement of machine learning technique, there is a lot of research applying the machine learning to scientific fields. Data generation is a promised advantage of machine learning, not only other fields but also scientific fields. We applied the variational autoencoder (VAE) to generate two-dimensional chiral spin configurations at a lower computational cost than traditional methods. We trained VAE using spin configurations generated by Monte-Carlo method and found that the trained VAE can produce similar spin configurations, but not provided in the training data. Nevertheless, the produced spin configurations had some node points which is physically unstable states. To obtain more stable spin configurations, we designed an algorithm that explore the latent space from a physically unstable state to a stable state. We assert this method as a useful approach to generate new data which has desired properties.

Keywords:

Machine learning, Chiral spin structure, Data generation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A6.05

Estimation the magnetic effective fields from spin configurations by machine learning algorithm and its applications

WON Changyeon *[1], LEE Doo Bong [1], KWON Hee Young [2], YOON Han Gyu [1], PARK Seong Min [1]
[1]department of physics, Kyung Hee University
[2]Center for Spintronics, KIST
cywon@khu.ac.kr

Abstract:

Recently, machine learning techniques have been adopted to solve various scientific issues. In particular, in the field of magnetism, it has been intensively applied to analyze the characteristics of unique and complex magnetic structures appearing on the chiral magnetic system with the Dzyaloshinskii-Moriya interaction. To understand the statistic and dynamic properties of the magnetic structures, it is essential to obtain the effective field information from a given spin configuration data, which is not provided through a direct experimental observation. In this study, we used a machine learning algorithm to estimate the magnetic effective field information from spin configurations. We constructed an artificial neural network structure, and trained it with the spin configuration dataset generated through a simulated annealing implemented by Monte-Carlo method. It is confirmed that the trained network successfully estimated the effective fields from given spin configurations, and we present several application methods to generate and correct the magnetism data with them.

Keywords:

Magnetism, Machine learning, chiral magnetic system

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A6.06

Generating intermediate states between two different chiral magnetic states using machine learning algorithms

WON Changyeon *[1], YOON Han Gyu [1], LEE Chanki [1], LEE Doo Bong [1], PARK Seong Min [1], CHOI Jun woo [2], KWON Hee Young [2]
[1]department of physics, Kyung Hee University
[2]Center for Spintronics, KIST
cywon@khu.ac.kr

Abstract:

An artificial neural network, Autoencoder, has been applied to create a spin structure interpolating and extrapolating between two different magnetic chiral states, the labyrinth structure and the skyrmion structure. The autoencoder was trained with two different magnetic chiral structures. Each input data is encoded into a latent code and we investigated the latent space to obtain information on their space structure. Based on the information obtained, we have successfully produced a variety of magnetic structures that exhibit plausible characteristics in various external fields not provided by the training data. The latent code has been modified with two algorithms. The first algorithm uses inversion and transform operations in the latent space, and the second algorithm uses a recursive flow with correction bias. The first generated structure preserved the chiral structure of the original data, and the second produced statistically plausible state.

Keywords:

machine learning, magnetism, autoencoder, spin state generation, interpolation and extrapolation.

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.01

Switchable bias-field effect in large tensile strained $BaTiO_3$ epitaxy film on lab-made $BaZrO_3$ substrate

LEE Jun Han [1], DUONG Nguyen Xuan[2], JUNG Min-Hyoung [3], KIM Junhyung [4], KIM Ahyoung [5], KIM Gye-Hyeon [6], CHO Byeong-Gwan [7], LEE Hyun-Jae [8], PARK Daehwan [1], KIM Young-Min [3], LEE Jun Hee [8], KOO Tae-Yeong [7], SOHN Changhee [1,6], YANG Sang Mo [5], PARK Kibog [1,4], JEONG Hu Young [9], KIM Tae Heon [2], OH Yoon Seok [*1]

[1]Department of Physics, UNIST
[2]Department of Physics and Energy Harvest Storage Research Center (EHSRC), University of Ulsan
[3]Department of Energy Science, Sungkyunkwan University
[4]School of Electrical and Computer Engineering, UNIST
[5]Department of Physics, Sogang University
[6]School of Natural Science, UNIST
[7]Pohang Accelerator Laboratory, POSTECH
[8]School of Energy and Chemical Engineering, UNIST
[9]UNIST Central Research Facilities, UNIST
ysoh@unist.ac.kr

Abstract:

Strain engineering for the heteroepitaxy film is a technique to apply strain on the oxide film through the lattice mismatch between the film and substrate[1]. The applied strain often leads to enhancement of their physical properties or sometimes creates new physical phenomena. Magnitude and symmetry of the applied strain strongly depend on the chosen substrate. However, the prevalent perovskite substrates have been limited in the well-known perovskite oxides system, such as $SrTiO_3$, scadates, aluminates, etc. Recently, we have developed a new perovskite oxide substrate $BaZrO_3$ and successfully grown $BaTiO_3$ film on the lab-made $BaZrO_3$ substrate. In this presentation, we introduce and discuss emerging physical phenomena in the epitaxial $BaTiO_3$ film on the $BaZrO_3$ single crystal substrate.

[1] R. Ramesh and D. G. Schlom, *Nature Reviews Materials* 4, 257 (2019)

Keywords:

Ferroelectric, Epitaxy film, BaTiO3, BaZrO3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.02

The built-in defect-dipole in square tensile strained $BaTiO_3$

OH Yoon Seok *[1], LEE Hyun-Jae [2], KUMAR Pawan [2], LEE Jun Hee [2]
[1]Department of Physics, UNIST
[2]Department of Energy and Chemical Engineering, UNIST
ysoh@unist.ac.kr

Abstract:

Oxygen vacancy, an inevitable defect in oxides compounds, plays a role in either enhancing physical properties or depressing functional performance. Recently, we have found the switchable bias-field effect in the square tensile strained $BaTiO_3$ film on $BaZrO_3$ substrate. Although it could be plausibly understood that the switchable bias-field effect is associated with the built-in defect-dipole and the oxygen vacancy, we couldn't find a clear explanation of cooperation between the defect-dipole and the oxygen vacancy based on the density functional theory calculations. In this talk, we will present computational calculation results of local structure distortion for the square tensile strained $BaTiO_3$ with and without oxygen vacancy. We discuss how the oxygen vacancy leads to the defect-dipole in the square tensile strained $BaTiO_3$.

Keywords:

defect-dipole, oxygen vacancy, BaTiO3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.03

Low mechanical loading force on new ferroelectric (111)-oriented CaTiO3 thin films

KIM Hong Joon [1], LEE Ji Hye [1], KIM Jeong Rae [1], LEE Daesu [2], NOH Tae Won *[1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Physics, POSTECH
twnoh@snu.ac.kr

Abstract:

The flexoelectricity is a universal property of dielectric materials and the enhanced effect at nano-scale has intensively been studied in recent years. Besides, the flexoelectricity suggested an alternative way to manipulation of ferroelectric domains (*i.e.*, in the absence of electric field). Especially, mechanical switching of ferroelectric polarization by scanning-probe has attracted interest in the application for ferroelectric-based devices. Therefore, ultra-low mechanical switching load can be a new strategy for low energy electronics because it could reduce the energy costs for information storage in mechanoelecric devices.
In this work, we study ferroelectric and mechanical properties of epitaxially-stabilized (111)-oriented new ferroelectric $CaTiO_3$ (CTO) thin films. These CTO thin films were grown on $LaNiO_3/LaALO_3$(111) substrate using the pulsed laser deposition method. In this CTO film, low mechanical switching force (F_L) down to ~100 nN is acquired using scanning probe microscopic measurement. This force value is remarkably lower than previously reported values (>300nN). As a result, reduced mechanically written domain line width around 10nm was obtained. This is indicating that the high recording density of up to 1 Tbit/cm^2 is feasible in this CTO thin film. The origin of this reduced critical loading force on (111)-oriented CTO films requires further study.

Keywords:

Ferroelectricity, Flexoelectricity, Piezoresponse force microscopy, Thin film, Oxide

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.04

Observation of relaxor-like behavior near magnetic Néel temperature in heavily La-substituted $BiFeO_3$

YANG Chan-Ho *[1], YEO Youngki [1], KIM Yongjin [1]
[1]Physics, KAIST
chyang@kaist.ac.kr

Abstract:

Polar nano regions (PNRs) induced by phase instability in relaxor ferroelectrics is widely studied because of their unique physical properties such as high permittivity and piezoelectric effects. Generally, chemical and valence mixing are thought to be the origin of phase instable PNRs [1]. In this study, we find phase-instability domains can be produced by the flexoelectricity. We report the direct observation of micron-sized polar domains within a super-tetragonal La-substituted $BiFeO_3$ (BLFO) film near strain-driven morphotropic phase boundaries (MPBs) which are expected to involve a large strain gradient [2, 3]. BLFO films grown on $LaAlO_3$ (001) have been employed to explore polar domains with the aid of angle-resolved lateral piezoresponse force microscopy [4]. The frequency-dependent dielectric anomaly follows the Vogel-Fulcher relation at low frequencies, which is a characteristic of the relaxor behaviors. Interestingly, the dielectric anomaly exists near the magnetic Néel temperature of BLFO. It is presumed that flexoelectrically induced phase competing domains are coupled to antiferromagnetic order. Our findings will offer valuable information to study the role of the flexoelectric effect on the formation of phase instable polar domains and antiferromagnetic domains.

References
[1] L.E. Cross, Ferroelectrics **76**, 241 (1987).
[2] K. Chu *et al.*, Nat. Nanotechnol. **10**, 972 (2015).
[3] B.-K Jang *et al.*, Nat. Phys. **13**, 189 (2017).
[4] K. Chu *et al.*, Rev. Sci. Instrum. **89**, 123704 (2018).

[Acknowledgements] This work was supported by Samsung Electronics Co., Ltd (IO 201211-08093-01) and by a National Research Foundation (NRF) of Korea Grant funded by the Korean Government through the Creative Research Center for Lattice Defectronics (Grant No. NRF-2017R1A3B1023686)

Keywords:

Relaxor, dielectric, Piezoforce microscopy, flexoelectricity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.05

First-principles study on the superlattice-induced ferroelectricity in charge-ordered $La_{1/3}Sr_{2/3}FeO_3$

PARK Se Young *[1,5,4], RABE Karin M[2], NEATON Jeffrey B[3]
[1]Department of physics, Soongsil University
[2]Department of physics and astronomy, Rutgers University
[3]Department of physics, UC Berkeley
[4]Center for correlated electron systems, CCES (IBS)
[5]Department of physics and astronomy, Seoul National University
park.seyoung@gmail.com

Abstract:

Charge-order-driven ferroelectrics are an emerging class of functional materials, where electron-dominated switching can occur at high frequency. Despite their promise, only a few systems exhibiting this behavior have been experimentally realized thus far, motivating the need for new materials. Here, we use density functional theory to study the effect of artificial structuring on mixed-valence solid-solution $La_{1/3}Sr_{2/3}FeO_3$ (LSFO), a system well-studied experimentally. Our calculations show that A-site (111)-layered LSFO exhibits a ferroelectric charge-ordered phase in which inversion symmetry is broken by changing the registry of the charge order with respect to the superlattice layering. We find that the phase is energetically degenerate with a ground-state centrosymmetric phase, and the computed switching polarization is 39 $\mu C/cm^2$, a significant value arising from electron transfer between Fe ions. Our calculations reveal that artificial structuring of LSFO and other mixed valence oxides with robust charge ordering in the solid solution phase can lead to charge-order-induced ferroelectricity.

Keywords:

density functional theory, charge ordering, ferroelectricity, oxide superlattices, transition metal oxides

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.06

Ferroelectric and piezoelectric power generation characteristics of poly(vinylidenefluoride-co-trifluoroethylene) (PVDF-TrFE) thin films according to the crystallinity of the Pt bottom electrode grown on mica substrate

SHIN Young-Han *[1], KEUM Yoon Hyung [2], SON Jong Yeog [2], SHIN Hyun Wook [2]
[1]Department of Physics, University of Ulsan
[2]Department of Applied Physics and Integrated Education Program for Frontier Materials (BK21 Four), Kyung Hee University
hoponpop@ulsan.ac.kr

Abstract:

We investigated the enhanced ferroelectricity and piezoelectric power characteristics of poly (vinylidenefluoride-co-trifluoroethylene) (PVDF-TrFE) thin films grown on Pt/mica substrates by improving the crystallinity of the Pt bottom electrode by reducing the deposition rate. From the results of the x-ray diffraction (XRD) experiments, it was confirmed that the crystallinity of the preferentially (111)-oriented Pt bottom electrode was further improved by decreasing the deposition rate and the β-phase formation of PVDF-TrFE thin films on the Pt bottom electrodes was well-formed. The flexible Pt/PVDF-TrFE/Pt/mica capacitors showed excellent ferroelectric properties with remanent polarization of about 9 μC/cm^2 (2Pr ~ 18 μC/cm^2), and ferroelectric properties did not show a significant change even with 1 mm bending. In the investigation of the piezoelectric power generation characteristics, it was confirmed that the piezoelectric power voltages corresponding to the external force of the PVDF-TrFE piezoelectric power elements showed a tendency to increase in response to the improvement of the ferroelectricity of the PVDF-TrFE thin film.

Keywords:

piezoelectric power generation, PVDF-TrFE, Pt bottom electrode, mica substrate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.07

Giant Tunneling Electroresistance in Epitaxial Ferroelectric Ultrathin Films Directly Integrated on Si

LEE Kyoungjun [1], BYUN Jinho [2], PARK Kunwoo [3,4], KANG Sungsu [3,4], PARK Jungwon [3,4], LEE Jaekwang [2], CHAE Seung Chul [*1]
[1]Dept. of Physics Education, Seoul National University
[2]Dept. of Physics, Pusan National University
[3]School of Chemical and Biological Engineering, Institute of Chemical Processes, Seoul National University
[4]Center for Nanoparticle Research, Institute for Basic Science (IBS)
scchae@snu.ac.kr

Abstract:

Recent discovery of non-volatile spontaneous polarization in a high CMOS compatible HfO_2 has been a promising ingredient for the information storage application including traditional non-volatile memory application and emerging neuromorphic synaptic device. However due to the large band gap of HfO_2, the direct resistance modulation in the form of ferroelectric tunnel junction exhibited poor performance compared to conventional perovskite ferroelectrics.
Here, we demonstrate a colossal resistance change in the ferroelectric tunnel junction with an On/Off ratio of 10^6. To achieve this large on/off ratio, we integrated the epitaxial fluorite-like HfO_2 thin film directly on the silicon substrate. Through the scanning transmission electron microscopy and X-ray diffraction, the thermally regrown SiO_x layers and the epitaxial growth of ultrathin HfO_2 layer were confirmed. The robust microscopic ferroelectricity of HfO_2 films was confirmed by piezoresponse force microscopy measurements. The capacitance-voltage measurements exhibited polarization modulated depletion layer of the semiconductor surface. The theoretical calculations confirmed the colossal tunneling electroresistance On/Off ratio of our designed metal-ferroelectric-insulator-semiconductor structure with experimentally confirmed components.

Keywords:

ferroelectric, HfO2, tunnel junction

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A7.08

Ferroelectricity of Excimer Laser Annealed $Hf_xZr_{1-x}O_2$ Thin Film

SONG Myeong Seop [1], CHAE Seung Chul *[1]
[1]Dept. of Physics Education, Seoul National University
scchae@snu.ac.kr

Abstract:

The ferroelectricity in HfO_2 thin film has attracted attention for the application to FeRAM and FeFET device due to its high compatibility with the conventional complementary metal-oxide-semiconductor (CMOS) process and scalability. The annealing process has been considered as an important ingredient for the stabilization of metastable ferroelectric orthorhombic phase. To crystallize the ferroelectric HfO_2 films, the high temperature annealing process (>450 ℃) is required. However, the inevitable high temperature thermal annealing process hinders the degree of freedom for the manufacturing process. Therefore, the low temperature process is of interest in light of the real application with current CMOS compatibility. Here, we report the ferroelectric $Hf_xZr_{1-x}O_2$ phase by excimer laser annealing process without conventional rapid thermal annealing (RTA) process. Laser annealed HZO film exhibited the remnant polarization P_r around ~10 mC/cm^2 and higher relative permittivity ε of ~33. To clarify the emergence of ferroelectricity under varying the excimer laser annealing condition, we characterized the structure and ferroelectric properties by using X-ray diffraction and standard polarization-voltage hysteresis. .

Keywords:

Hafnium Oxide, Ferroelectricity, laser annealing

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.01

Crucial Role of Sublattice Polarization on Electron-Phonon Coupling in Twisted Graphene Layers

CHOI Young Woo [1], CHOI Hyoung Joon *[1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Moiré superlattices have been demonstrated as an outstanding platform to explore correlated electron physics and superconductivity with unparalleled tunability. While correlated electron states are observed in diverse twisted graphene layer systems, robust superconductivity has been measured only in magic-angle twisted bilayer graphene (MATBG) and alternating-twist trilayer graphene (MATTG). This disparity raises the question on the relationship between superconductivity and the presence of flat bands at the Fermi level. In this work, we investigate electronic structure and electron-phonon coupling in twisted graphene layers based on atomistic calculations. We show that electron-phonon coupling strength λ of the flat-band states in twisted graphene layers can be dramatically different depending on the presence of sublattice polarization in their electronic structure. While λ is strong ($\lambda > 1$) for MATBG and MATTG that experimentally display robust superconductivity, it is an order of magnitude smaller in twisted double bilayer graphene (TDBG) and twisted monolayer-bilayer graphene (TMBG) where superconductivity is absent or not robust. We find that the Bernal-stacked layers in TDBG and TMBG induce sublattice polarization in the flat-band states, suppressing inter-sublattice electron-phonon scattering process. We also discuss implications of our results on superconductivity in twisted graphene layers.

This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335). Y.W.C. acknowledges support from NRF of Korea (Global Ph.D. Fellowship Program NRF-2017H1A2A1042152).

Keywords:

moiré superlattice, magic-angle twisted bilayer graphene, electron-phonon coupling, electronic structure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.02

Web platforms for conventional simulations of matters

KIM Seungchul *[1], KIM Doyeon [1], KEMBAY Assel [1], KIM Sowon [1,5], YUN Kayoung [1,4], LEE Chan-Woo [3], LEE Byeong-Joo [2], SEOL Donghyuk [2], KIM Yong-Hoon [6], JANG Semi [1,4], LEE Minho [4], LEE Jungho [4]
[1]Computational Science Research Center, KIST
[2]Department of Materials Science and Engineering, POSTECH
[3]Platform Technology Laboratory, KIER
[4]., Virtual Lab. Inc.
[5]Department of Chemistry, Hanyang University
[6]School of Electrical Engineering, KAIST
sckim@kist.re.kr

Abstract:

불과 몇 년 전까지 물질 전산모사는 고도로 훈련된 일부 전문가들의 전유물이었지만, 정형화된 계산이라면 이제는 누구나 프로그램 사용법만 익혀서 할 수 있다. 예를 들어, 밀도범함수 이론을 이용해 단결정의 전자 구조를 계산하거나 원자구조가 단순한 물질의 화학반응 에너지를 계산하는 데는 몇몇 주의 사항만 알고 있으면 전문교육 없이도 얼마든지 할 수 있다. 이번 발표에서는 이런 정형화된 전산모사를 실행할 수 있는 웹플랫폼으로서, 금속 촉매 계산에 특화된 플랫폼과 반도체 나노구조의 전자적 특성과 광학적 특성 계산에 특화된 플랫폼을 소개한다. 이 플랫폼에는 분자동력학과 Monte Carlo 를 이용한 이원계 금속의 열적 안정성 및 원자구조 예측, 밀도범함수를 이용한 총에너지, 전자구조, 화학에너지 계산과 모델 해밀토니안을 이용한 양자점의 전자구조와 광학적 특성을 계산하는 기능이 포함되어 있다. 이와 더불어 원자구조 모델링 프로그램과 데이터 분석용 그래프 프로그램도 포함되어 있어, 별도의 추가 프로그램 없이 전산모사 연구를 할 수 있다.

Keywords:

Simulation web platforms, conventional simulations, catalysts, quantum dots

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.03

Spin Hall Conductivities of W-N Alloys

NGUYEN Quynh Anh Thi [1], DO Duc Cuong [1], HONG Soon Cheol [1], RHIM Sonny [*1]
[1]Department of Physics, University of Ulsan
sonny@ulsan.ac.kr

Abstract:

Motivated by recent reports on high spin Hall angle in W alloys [1-3], spin Hall conductivities (SHC) of W-N alloys are investigated using *ab initio* calculations. Among W-N alloys, two compositions, W_2N and WN, are considered. In particular, W_2N exhibits large SHC of −966 $\hbar/e$ S/cm, approximately 18.7 % larger than β-W (−818 $\hbar/e$ S/cm). Interestingly, high SHC of W_2N is dominated by large Berry curvature from Γ X , which is a consequence of anti-crossing band. On the other hand, in WN case, three configurations, NaCl-type, hexagonal and NbO-type, are compared energetically with their SHC. SHC of NaCl- and hexagonal types are −619 and −696 $\hbar/e$ S/cm, respectively, whereas NbO-type possesses quite small SHC of −194 $\hbar/e$ S/cm.

References:

[1] K.-U. Demasius, T. Phung, W. Zhang, B. P. Hughes, S.-H. Yang, A. Kellock, W. Han, A. Pushp, and S. S. P. Parkin, Nat. Commun. **7**, 10644 (2016).
[2] X. Sui, C. Wang, J. Kim, J. Wang, S. H. Rhim, and W. Duan, Phys. Rev. B **96**, 241105(R) (2017).
[3] Y. J. Kim, M. H. Lee, G. W. Kim, T. Kim, I. H. Cha, Q. A. T. Nguyen, S. H. Rhim, and Y. K. Kim, Acta Mater. **200**, 551 (2020).

Keywords:

Spin Hall conductivity; spin Hall angle; ab initio calculations

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.04

Cooperative evolution of polar distortion and nonpolar rotation of oxygen octahedra in oxide heterostructures

MIN Taewon [1], CHOI Wooseon [2], SEO Jinsol [2], HAN Gyeongtak [2], SONG Kyung [3], RYU Sangwoo [4], LEE Hyungwoo [4], LEE Jungwoo [4], EOM Kitae [4], EOM Chang-Beom [4], JEONG Hu Young [5], KIM Young-Min [2], OH Sang Ho [2], LEE Jaekwang [*1]

[1]Department of Physics, Pusan National University
[2]Department of Energy Science, Sungkyunkwan University
[3]Materials Testing and Reliability Division, Korea institute of materials Science
[4]Department of Materials Science and Engineering, University of Wisconsin-Madison
[5]UNIST Central Research Facilities, Ulsan National Institute of Science and Technology
jaekwangl@pusan.ac.kr

Abstract:

The polarity discontinuity across $LaAlO_3/SrTiO_3$ (LAO/STO) heterostructure induces electronic reconstruction involving the formation of two-dimensional electron gas (2DEG). The heterostructure also exhibits structural distortion in close correlation with the 2DEG formation, which can be characterized by either antiferrodistortive (AFD) rotation, ferroelectric (FE) distortion, or both. Here, by combining density functional theory (DFT) calculations and scanning transmission electron microscopy (STEM), we reveal that the AFD and FE modes are cooperatively coupled in the (111)-oriented LAO/STO heterostructure; they coexist below the critical thickness (t_c) and disappear simultaneously above t_c with the formation of 2DEG. Electron energy loss spectroscopy (EELS) of the O-K edge and DFT calculations provide direct evidence of oxygen vacancy (V_O) formation at the LAO (111) surface, which acts as the source of 2DEG. Furthermore, we find that structural evolution is strongly correlated with the presence of V_O. Our studies show that LAO/STO heterostructure can serve as a platform to tune AFD-FE coupling by varying the interface orientation and thickness of the LAO film across t_c for 2DEG formation.

Keywords:

DFT calculations, Electron energy loss spectroscopy, LaAlO3/SrTiO3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.05

Thermoelectric efficiency of thermoelectric heat engine with temperature dependent transport properties

RYU Byungki *[1], CHUNG Jaywan [1], PARK SuDong [1]
[1]Energy Conversion Research Center, KERI
byungkiryu@keri.re.kr

Abstract:

Thermoelectric heat engine enables direct energy conversion from heat into electrictiy. Traditionally, the thermoelectric efficiency is roughly estimated by using the constant-property model (CPM). In this CPM, the efficiency is simply determined by the dimensionless thermoelectric figure of merit zT, where zT is a ratio between Seebeck coefficient, electrical conductivity, thermal conductivity, and temperautre. However, as charge and heat transport propeties are strongly temperature-varying, the efficiency prediction by zT has limitations in accurate efficiency prediction. In this work, we find that the efficiency is not simply determined by any single parameter. Rather, the efficiency is completely determined by three indepdent parameters. This finding suggets a alternative route in materials discovery and device design in thermoelectrics, beyond zT.

Keywords:

thermoelectric, efficiency, zT

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.06

Topological flat bands in rhombohedral four-layer graphene on boron nitride moire superlattices

PARK Youngju [1], CHITTARI Bheema Lingam[1,2], JUNG Jeil *[1,3]
[1]Department of Physics, University of Seoul
[2]Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata
[3]Department of Smart Cities, University of Seoul
jeiljung@uos.ac.kr

Abstract:

We show that rhombohedral four-layer graphene (4LG) nearly aligned with a hexagonal boron nitride (hBN) substrate has nearly flat low energy bands with generally non-zero valley Chern numbers. These bands are isolated even in the absence of a perpendicular electric field thanks to the opening of a primary bandgap at charge neutrality and secondary gaps near the moire Brillouin zone corners. The bandwidths are controllable through an electric field and they can become as narrow as ~5 meV for interlayer potential differences between top and bottom layers of $|\Delta| \approx 40$ meV. An optimal twist $\theta \sim 0.5^\circ$ at the graphene and boron nitride interface maximizes bandwidth narrowing and band isolation by enhancing the secondary gaps. Moreover, the narrow bands are switchable between valence/conduction bands by changing the direction of the vertical electric fields. The local density of states (LDOS) analysis shows that the nearly flat band states wave functions are associated with the non-dimer low energy sublattice sites at the top or bottom layer graphene and their degree of localization in the moire superlattice is strongly gate tunable. Similar behaviors are seen in nLG/BN for n = 5-8 where generally the valley Chern number of the first valence band of nLG/BN is equal to the number of graphene layers, $C_{V1}^{\nu=\pm1} = \pm n$.

Keywords:

Topological flat bands, moire superlattice

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A8.07

First-principles study of $CuInP_2S_6$ based van der Waals heterostructure at non-equilibrium state

KIM Yong-Hoon *[1], SONG Yumin [1], LEE Juho [1]
[1]School of Electrical Engineering, KAIST
y.h.kim@kaist.ac.kr

Abstract:

Vertically stacked van der Waals heterostructures composed of two-dimensional (2D) van der Waals (vdW) materials such as copper indium thiophosphate ($CuInP_2S_6$) has led to the development of ultrathin ferroelectric devices. Recently, $CuInP_2S_6$ with graphene contacts used as ferroelectric tunneling devices has been reported high tunneling resistance [1]. However, their first-principles characterizations of the $CuInP_2S_6$ with graphene is still mostly limited to equilibrium state. Also, quantum transport calculation within the DFT-NEGF scheme requires semi-infinite electrodes, which is lacking a direct connection to the experimental measurement. In this presentation, carrying out the recently developed multi-space constrained-search density functional theory (MS-DFT) [2-3], we study the bias-dependent structural and electronic properties of the $CuInP_2S_6$ based graphene electrodes. Also, taking the advantages of MS-DFT which is adopting the micro-canonical picture or finite electrodes, we performed quantum transport calculation on vertically stacked heterostructures composed of $CuInP_2S_6$ as a channel material sandwiched by graphene electrodes. Then, we analyze various electrode materials and provide design guidelines for the development of advanced vertical stacked van der Waals heterojunction-based nanodevices.

Reference

1. J. Wu *et al.* Proc. Nat. electron., **3**(8), 466-472 (2020)
2. J. Lee *et al.* Proc. Natl. Acad. Sci. U.S.A., **117**, 10142 (2020)
3. J. Lee *et al.* Adv. Sci., **7**, 2001038 (2020)

Keywords:

vertical heterostructure, two-dimensional materials, non-equilibrium calculation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A9.01

Single-photon emitters using strained two-dimensional materials

PARK Hong-Gyu *[1], SO Jae-Pil [1], JEONG Kwang-Yong [1]
[1]Korea University
hgpark@korea.ac.kr

Abstract:

The quantum confinement in atomically-thin transition metal dichalcogenides (TMDCs) has been investigated for single-photon emission based on naturally or artificially occurring defects. In particular, the precise control of the position of a single-photon emitter by applying mechanical strains to the TMDC is feasible. Strains have been induced in TMDCs using various nanostructures including dielectric pillars, nanobubbles, optical waveguide, metal nanogaps, and metal nanoparticles. However, polarization control and integration with a high-quality (Q) cavity to increase the Purcell factor remain elusive in TMDC-based single photon sources.
In this talk, we will present the deterministic control of both the position and polarization of single-photon emitters in atomically thin WSe_2 placed on a nanogap array. Manipulation of the band structure by a local strain gradient generates a potential well at the nanogap site, and position-controlled single-photon emission is subsequently achieved. Additionally, directional elongations of the potential well, which are tuned by changing the nanogap size, allow polarization-controlled single-photon emission. Moreover, single photons with a g(2) of ~0.1 are generated at 4-20 K. To take a full advantage of such deterministic control of the position and polarization of single-photon emitters, the emitters are integrated with one-dimensional photonic crystal cavities. Therefore, this approach is a unique way to develop next-generation, deterministic, controllable single-photon emitters based on TMDC materials, which outperform the present single-photon sources with random occurrence and uncontrolled polarization properties.

Keywords:

single-photon emitter, polarization control, TMDC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A9.02

Engineered quantum light sources from 2D materials

KIM Je Hyung *[1]
[1]Department of Physics, UNIST
jehyungkim@unist.ac.kr

Abstract:

Atomically thin two-dimensional materials such as WSe_2 or MoS_2 are of great interest as emerging quantum emitters. In contrast to other solid-state quantum emitters such as epitaxial-grown quantum dots or defects embedded in a high refractive index medium, the emitters in monolayers can efficiently out-couple photons and are easily integrated with photonic structures such as waveguides and cavities. Furthermore, the atomically thin monolayer has remarkable flexibility, and therefore the external strain significantly influences the electronic and optical properties of the materials. Using these properties, they are capable of generating tunable and integrated quantum emitters based on 2D materials. Here, we demonstrate position- and frequency-controlled quantum emitters from WSe2 monolayers integrated with electrostatically actuated Si micro-cantilever

Keywords:

2D materials, excitons, single photons

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A9.03

First-principles theory of optically active spin defects in hexagonal boron nitrides

SEO Hosung *1
[1]Physics, Ajou University
hseo2017@ajou.ac.kr

Abstract:

Optically active quantum defects are gaining prominence in integrated quantum photonics using two-dimensional materials. Hexagonal boron nitride, a wide-band gap insulator among 2-dimensional (2D) van der Waals materials, has gained a great amount of attention due to the discovery of bright single-photon emitters (SPEs) operating at room temperature, and also the considerable focus has been devoted to the search of optically addressable spin qubits in h-BN. In this talk, we summarize our recent efforts to predict and understand quantum spin defects in h-BN using first-principles computational methods. In the first part of the talk, we discuss our combined theoretical and experimental study on polarization and localization of SPEs in h-BN wrinkles [1]. By using density functional theory (DFT) calculations, we find that the wrinkle's curvature plays a crucial role in localizing vacancy-based SPE candidates and aligning the defect's symmetry plane to the wrinkle direction. Our results not only provide a new route to controlling the atomic position and the optical property of the SPEs but also revealed the possible crystallographic origin of the SPEs in h-BN. In the second part of the talk, we propose a new type of spin qubit candidates in h-BN [2]. We combine DFT and quantum embedding theories to show that out-of-plane X_NY_i dimer defects (X, Y=C, N, P, Si) form a new class of high-symmetry spin-triplet defects in h-BN. Notably, we show that the X_NY_i dimer defects exhibit the same essential structural and electronic features as those of the diamond nitrogen-vacancy center, one of the prototypical solid-state spin qubits. Our results broaden the range of spin defect candidates that would be useful for the development of individually addressable spin qubits in two-dimensional hexagonal boron nitride.

[1] Dong-gyu Yim, Mihyang You, Gichang Noh, Jieun Lee*, and Hosung Seo*, ACS Applied Materials & Interfaces 12, 36362 (2020).
[2] Juyong Bhang, He Ma, Donggyu Yim, Giulia Galli, and Hosung Seo, under review (2021).

Keywords:

hexagonal boron nitride, quantum defects, single-photon emitters, solid-state spin qubits

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A10.01

Spin generation from ultrafast demagnetization of metallic ferromagnets

CHOI Gyungmin *[1]
[1]Department of Energy Science, Sungkyunkwan University
gmchoi@skku.edu

Abstract:

Manipulating magnetization by a spin current rather than a magnetic field is a fundamental issue in spintronics. Conventionally, spin currents have been generated from the spin-dependent transport of electrons as in spin filter effect or spin Hall effect. In this presentation, I will show that spin currents can be generated from ultrafast demagnetization. When a pulsed laser excites the ultrafast demagnetization of metallic ferromagnet or ferrimagnet, a spin is generated in electrons of ferromagnet and diffuse to an adjacent non-magnetic metal [1-3]. Analyzing the spin generation and diffusion processes, physical parameters of ferromagnets, such as spin diffusion length and electron-magnon coupling, are determined [4, 5]. Our results demonstrate the spin generation mechanisms on short timescale *via* exchange of angular momentum between electrons and magnons in metallic ferromagnets.

References

1. G.-M. Choi, B.-C. Min, K.-J. Lee, D. G. Cahill, Spin current generated by thermally driven ultrafast demagnetization, *Nature Commun*. **5**, 4334 (2014).
2. G.-M. Choi, C.-H. Moon, B.-C. Min, K.-J. Lee, D. G. Cahill, Thermal spin-transfer torque driven by the spin-dependent Seebeck effect in metallic spin-valves, *Nature Phys*. **11**, 576 (2015).
3. G.-M. Choi and B. C. Min, Laser-driven spin generation in the conduction bands of ferrimagnetic metals, *Phys. Rev. B* **97**, 014410 (2018).
4. K.-H. Ko and G.-M. Choi, Optical method of determining the spin diffusion length of ferromagnetic metals, *J. Magn. Mang. Mater*. **510**, 166945 (2020).
5. K. Kang and G.-M. Choi, Thermal coupling parameters between electron, phonon, and magnon of Nickel, *J. Magn. Mang. Mater*. **514**, 167156 (2020).

Keywords:

spin generation, ultrafast demagnetization, electron-magnon coupling, spin diffusion length

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A10.02

Nonequilibrium Heat Transport in Elemental Metals Probed by an Ultrathin Ferromagnetic Thermometer

JANG Hyejin *[1]
[1]Materials Science and Engineering, Seoul National University
hjang@snu.ac.kr

Abstract:

The interaction between electrons and phonons is responsible for a variety of physical properties of solids, such as electrical conductivity, superconductivity, polaron conduction, and piezoelectricity. In particular, the interaction between electrons and phonons in metals when they are not in thermal equilibrium play a key role in the field of ultrafast spintronics. However, experimental investigation of nonequilibrium dynamics in metals remains challenging as the dynamics occurs on sub-picosecond time scales and nanometer length scales, which limits our fundamental understanding and applications for fast and energy-efficient devices. In this work, I demonstrate that a magnetic thermometer, which is a sub-nm-thick cobalt layer, can effectively examine the nonequilibrium dynamics in adjacent metals. The magnetization of Co informs the magnon temperature specific to the position of the ultrathin Co layer, and can be conveniently detected via the magneto-optic Kerr effect (MOKE). I first characterize the carrier interaction parameters of Co and then investigate the nonequilibrium dynamics in Pt by using Co embedded in thicker Pt layers. I report that for transition metals, such as Pt and Ru, the electron-phonon nonequilibrium length scales are comparable to the optical absorption depths, and much shorter than the nonequilibrium length scales in noble metals, e.g., Au and Cu. Thus, the distribution of most of the injected energy in transition metals occurs via diffusion of thermalized electrons and phonons, in contrast to noble metals, in which electron diffusion governs overall heat transport.

Keywords:

hot electrons, magneto-optic Kerr effect, thermal transport

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A10.03

Ultrafast strain-induced spin dynamics

SHIN Yooleemi [1], KIM Jiwan *[1]
[1]Physics department, Kunsan National University
hwoarang.kim@gmail.com

Abstract:

Magnetoelasticity, the spin – strain interaction, is a universal phenomenon in magnetic materials and enables an active control of spin states by modifying material dimensions. With femtosecond laser pulses, there generates two types of strain which are the propagating one induced by the mechanical pressure of sudden lattice expansion and the quasi-static strain induced from long-lived thermal expansion of lattice within the penetration depth. The spins are affected dynamically by two types of strain via magnetoelastic interaction with different behaviors, respectively. In this talk, I present interesting properties of strains such as how they are generated and induces spin dynamics, and why the strain is the promising excitation source for spins. Especially, I address that the quasi-static strain effect on spin dynamics, which has been left out of consideration in this community, yields counter results to what we have known

Keywords:

Ultrafast strain, Magnetoelasticity, Pump-probe magneto-optical Kerr effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A10.04

Magnetic soliton rectifier via phase synchronization

KIM Duck-Ho *[1], KIM Dong-Hyun [2], KIM Dae-Yun [1,3], CHOE Sug-Bong [3], ONO Teruo [4], LEE Kyung-Jin [2,5], KIM Se Kwon [5]
[1]Center for Spintronics, Korea Institute of Science and Technology (KIST)
[2]Department of Semiconductor Systems Engineering, Korea University
[3]Department of Physics and Institute of Applied Physics, Seoul National University
[4]Institute for Chemical Research, Kyoto University
[5]Department of Physics, KAIST
uzes@kist.re.kr

Abstract:

Most of the existing research on the dynamics of magnetic solitons such as a domain wall (DW) has focused on the effect of DC forces, where the induced velocity is determined by the force strength. Here we show that AC forces such as an oscillating magnetic field or current are also able to move a DW straight via synchronization between the DW angle and the phase of the AC force. The resulting DW velocity is solely proportional to the driving frequency of the AC force, but the strength of the AC field just affects the frequency range for criteria for the phase-locking behavior. The AC-force-driven DW motion is shown to exhibit a phase locking-unlocking transition, a critical phenomenon akin to the Walker breakdown of a DC-bias-driven DW motion. Our work shows that a DW can be driven straight by synchronizing its angle to AC forces and thereby demonstrates a proof-of-concept of magnetic soliton rectifiers (i.e., DC motion induced by AC forces), shedding a light on the hitherto overlooked utility of internal degree of freedom for driving magnetic textures.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.01

Enhancement of light absorption, ionic migration, and stability in hybrid perovskite solar cells on passivated SnO_2 ETL

KIM Jihyun [1], NGUYEN Bich Phuong [2], KIM Gee Yeong [3], KIM Yeon Soo [2], JO William [*1,2]
[1]Department of Physics, Ewha Womans University
[2]New and Renewable Research Center, Ewha Womans University
[3]Advanced Photovoltaics Research Center, Korea Institute of Science and Technology
wmjo@ewha.ac.kr

Abstract:

The metal oxide semiconductor (SnO_2) is widely used as an electron transport layer (ETL) in hybrid perovskite planar solar cells (H-PSCs) because of its good transparency, band alignment to perovskite, and stability. But it has issues at the interface between perovskite and ITO substrate that electron recombination and current saturation by their surface defects as cracks and pinholes. Surface treatment of SnO_2, such as UV ozone (UVO) treatment, is shown to improve the efficiency and reduce junction issues as the ETL. In addition, we used a NH_4Cl for passivation of SnO_2. Herein, we propose an UVO treatment of SnO_2 and then NH_4Cl passivation (UVOSnO_2-Cl) as an excellent alternative to ETL at a low temperature process of 150 °C. We determined the resistance, mobility, conductivity and carrier concentration of UVOSnO_2-Cl based on H-PSCs by an electrical measurement. After passivation with NH_4Cl, the current density increased at an active area and the grain size of perovskite films also increased. The absorbance of perovskite films wase investigated by Ultraviolet–visible spectroscopy. The electrical properties show that the UVOSnO_2-Cl can effectively reduce the trap density and current saturation at the interface between perovskite and ITO substrate. Also, it can promote the electron transfer, and suppress the interface recombination rather than SnO_2 alone. The band structure and the carrier transport mechanism at perovskite/UVOSnO_2-Cl interface was explained by conductive atomic force microscopy, Kelvin probe force microscopy. The UVOSnO_2-Cl based H-PSCs has been found to eliminate severe current leakage inside the device, reducing interface defects and hysteresis.

Keywords:

NH4Cl passivation, SnO2 electron transport layer, hybid perovskite solar cell, UVO treatment

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.02

Enhancement of photo-conversion efficiency by defect passivation in Na-added $Cu_2ZnSn(S,Se)_4$ flexible solar cells

PARK Ha Kyung [1], CHO Yunae [1,3], KIM Juran [1], KIM Gee Yeong [4], JEONG Woo-Lim [2], KIM Kyung-Pil [2], LEE Dong-Seon [2], JO William [*1,3]

[1]Department of Physics, Ewha Womans University
[2]New and Renewable Energy Research Center (NREC), Ewha Womans University
[3]Advanced Photovoltaics Research Center, National Agenda Research Division, KIST
[4]School of Electrical Engineering and Computer Science, GIST
wmjo@ewha.ac.kr

Abstract:

Due to narrow stability of kesterite phases in $Cu_2ZnSn(S,Se)_4$ (CZTSSe), a variety of defects can be produced in the deposited thin films of CZTSSe. The defects act as a recombination center and may cause the deterioration of cells. Covering up the defects is achieved by adding a proper element into CZTSSe. Effects of Na on defect passivation in CZTSSe films on flexible Mo-foils has been carefully investigated by measuring electrical properties the grown films with different NaF precursors on top of the CZTSSe films. First, the amount of Na atoms remaining on the CZTSSe thin film was examined by X-ray photoelectron spectroscopy (XPS). Surface photovoltage (SPV) was obtained through photo-assisted Kelvin probe force microscopy (KPFM) using 405, 532 and 640 nm wavelength laser and work function shift was calculated based on SPV. In Na-deficient sample, formation of SPV was limited implying the carrier excitation is suppressed due to the recombination. In contrast, Na-sufficient sample showed noticeable work function shift with maximum 0.05 eV. In Na-sufficient sample, Na passivated the defects and prevented the photogenerated carrier recombination. In addition, SPV formation results was coherent with the V_{OC} deficit of cells. In conclusion, we observed defect passivation effect of Na resulting in reduction of V_{OC} deficit through carrier excitation analysis.

Keywords:

Na doping, defect passivation, flexible CZTSSe thin film solar cells, photo-assisted Kelvin probe force microscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.03

Polarization- and Electrode-optimized Polyvinylidene Fluoride Films for Harsh Environmental Piezoelectric Nanogenerator Applications

JIN Da Woon [1], KO Young Joon [1], AHN Chang Won [2], HUR Sunghoon [3], LEE Tae Kwon [1], JEONG Dong Geun [1], LEE Minbaek [1], KANG Chong-Yun [3,4], JUNG Jong Hoon [*1]
[1]Inha University
[2]Department of Physics and Energy Harvest-Storage Research Center, University of Ulsan
[3]Center for Electronic Materials, KIST
[4]KU-KIST Graduate School of Converging Science and Technology, Korea University
jhjung@inha.ac.kr

Abstract:

Piezoelectric nanogenerator (PENG) can effectively convert waste mechanical energy into electrical energy. In order to expand the application of the PENG, it is necessary to study the performance in various environments. Here, a multilayered polyvinylidene fluoride (PVDF) film-based piezoelectric nanogenerator (ML-PENG) is demonstrated to generate stable power outputs even at extremely low temperatures and pressures, and under strong ultraviolet. Up- and down-polarized PVDF films are alternatively stacked, and electrodes were intercalated in-between the two adjacent films. The multi-layered PVDF film-based PENG (ML-PENG) generates an open-circuit voltage of 1 V and a short-circuit current of 8 nA at −266 °C and 10^{-5} Torr. The outputs were quite stable against the wide range of temperature- and pressure-variation, and the irradiation of strong ultra-violet. In addition, the outputs were durable against excessive mechanical vibrations both for press-release type d_{33} mode and bending-unbending type d_{31} mode. This work suggests that polarization- and electrode-optimized ML-PENG could be a candidate for an efficient and reliable power source in harsh environments like the north/south poles and extraterrestrial Mars.

Keywords:

polyvinylidene fluoride, piezoelectric nanogenerator, harsh environment, inaccessible location, Mars

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.04

A Highly Efficient and Durable Kirigami Triboelectric Nano-generator for Rotational Energy Harvesting

KONG Dae Sol [1], HAN Jae Yeon [1], KO Young Joon [1], PARK Sang Hyeok [1], LEE Minbaek [1], JUNG Jong Hoon *[1]
[1]Inha University
jhjung@inha.ac.kr

Abstract:

Sliding mode triboelectric nanogenerator(S-TENG) is the most promising candidate for harvesting energy from rotational motion in triboelectric nanogenerator fields, but poor durability due to wear is a challenge to be solved. In order to solve the wear problem, several methods are being studied[1-3], and here, a high-efficiency, high-durability energy harvesting device was fabricated using a three-dimensional kirigami structure. The rotation-folding(R-F) Kirigami TENG is made of paper, an aluminum film(Al), and PTFE film in a 3D structure, and the organic movement of each side converts the rotational motion into folding-unfolding vibration. The R-F kirigami TENG generated an open-circuit voltage of 31 V, a short-circuit current of 0.67 μA and instantaneous power (power density) of 1.2 μW (0.13 μW/cm^2) at 200 rpm, which was sufficient to turn on 25 light-emitting diodes and a thermo-hygrometer. The triboelectric outputs of the R-F kirigami TENG were only slightly decreased even after 288,000 continuous rotations, i.e., the output remained at 86% of its initial value. This work demonstrates that an R-F kirigami TENG could be a plausible candidate to efficiently harvest various forms of rotational energy with a long-term durability.

References

[1] Zhou, L.; Liu, D.; Zhao, Z.; Li, S.; Liu, Y.; Liu, L.; Gao, Y.; Wang, Z.L.; Wang, J. Adv. Energy Mater. 2020, 10, 2002920 25.
[2] Chen, J.; Guo, H.; Hu, C.; Wang, Z.L. Adv. Energy Mater. 2020, 10, 2000886.
[3] Tang, Q.; Pu, X.; Zheng, Q.; Yang, H.; Li, J.; Wu, Y.; Guo, H.; Huang, Z.; Hu, C. Nano Energy 2019, 66, 104087.

Keywords:

Energy harvesting, Triboelectric, Kirigami structure, Rotational motion

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.05

Suppression of extrinsic recombination process in anatase and rutile TiO_2 epitaxial thin films for efficient electron transport layers

KIM Yeon Soo [1], JIN Hye-Jin [2], JUNG Hye Ri [2], KIM Jihyun [2], NGUYEN Bich Phuong [1], KIM Juran [2], JO William *[1,2]

[1]New and Renewable Energy Research Center (NREC), Ewha Womans University

[2]Department of Physics, Ewha Womans University

wmjo@ewha.ac.kr

Abstract:

TiO_2 is one of the most widely used materials for the electron transport layers (ETLs) because of its band alignment with light absorbers, adequate optical transmittance, and high electron mobility. Thermodynamically stable two crystal phases of TiO_2 are anatase and rutile, which are still in the debate on whether one of them is more effective as the ETL. In this paper, we demonstrate the different effects of using epitaxial anatase TiO_2 and epitaxial rutile TiO_2 (both grown using pulsed laser deposition) as the ETL material on the electrical and optical properties. Epitaxial Nb-doped TiO_2 layers were used as the common electrode material for both the epitaxial ETLs for which the crystalline structural analysis revealed high crystalline qualities and good coherency for both phases. By analyzing the recombination kinetics, the anatase phase shows a preferable performance in comparison with the rutile phase, although both epitaxial phases show remarkably reduced extrinsic recombination properties, such as trap-assisted recombination. This study demonstrates not only a better electron transporting performance of anatase phase but also reduced extrinsic recombination through epitaxy growth.

Keywords:

epitaxy, TiO2, anatase, rutile, electron transport layer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A11.06

Ion migration and hysteresis in mixture of 2D/3D perovskites

NGUYEN Bich Phuong[2], KIM Jihyun [1], JO William *[1,2], KIM Gee Yeong [3]
[1]Department of Physics, Ewha Womans University
[2]New and Renewable Energy Research Center, Ewha Womans University
[3]Advanced Photovoltaics Research Center, Korea Institute of Science and Technology
wmjo@ewha.ac.kr

Abstract:

Two-dimensional (2D) organic-inorganic halide perovskites are emerging as an alternative for robust and stable photovoltaic devices when they are properly combined with conventional three-dimensional (3D) perovskites. However, light absorption and carrier motion in 2D perovskite are limited due to the insulating nature of the larger organic cation. In this study, we report ion immigration characteristics through the 2D/3D composite films and a method to suppress hysteresis which is a signature of ionic transport in perovskites. A small amount of 2D BA_2PbI_4 (BA = $C_4H_9NH_3$) is immersed into 3D $MAPbI_3$ (MA = CH_3NH_3). The current mapping reveals that grains in the mixed perovskites become smaller and grain boundaries gradually mitigated. In particular, the exponent of the power law from current-voltage curves supports the idea that ionic conduction is predominant in 2D/3D mixed perovskites.

Keywords:

perovskite, 2D/3D mixture, ionic conduction

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A12.01

Unraveling degradation mechanism of Pt_3Co nanoparticle electrocatalyst by combining kinetic Monte Carlo simulation and machine-learning potential

JUNG Jisu [1], JU Suyeon [1], KIM Purun-hanul [1], KANG Sungwoo [1], JUNG Wonseok [1], HAN Seung Wu [*1]
[1]Seoul National University
hansw@snu.ac.kr

Abstract:

The proton-exchange membrane fuel cell (PEMFC) is garnering wide attention as an environmentally friendly renewable energy devices that is used in hydrogen-fueled vehicles. The performance of PEMFCs largely depends on the catalytic activity and durability of nanoscale electrocatalysts. Recently, the Pt nanoparticles alloyed with transition metals have been widely used as the electrocatalysts owing to the higher electrochemical activity and lower cost compared to pure Pt nanoparticles. However, the degradation by electrochemical dissolution of metal nanoparticles remains to be resolved. Therefore, the understanding of the dissolution mechanism at the atomic level would be important for improving the stability of the Pt-based electrocatalysts. While several works employed kinetic Monte Carlo (kMC) simulations for examining long-term evolution of electrocatalyst under electric bias, they are rather limited by inaccurate classical potentials or the high computational cost of DFT calculations. Recently, neural network potentials (NNPs) are increasingly popular because they can deliver the accuracy of quantum calculation at a much lower cost. In this talk, we combine NNPs and kMC simulation to explore the degradation mechanism of Pt-Co nanoparticle electrocatalysts. It is found that the simulation results agree with experimental observations and provide atomistic picture of degradation mechanism. This will enable the design of more durable nanoparticle electrocatalysts.

Keywords:

Electrocatalyst, kinetic Monte Carlo, Machine-learning potential

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A12.02

Designing Interface for Selective Electrochemical CO_2 Conversion

KWON Youngkook *[1]
[1]School of Energy and Chemical Engineering, UNIST
ykwon@unist.ac.kr

Abstract:

Electrochemical conversion of CO_2 to fuels or stock chemicals with high-energy density would be a major step forward in the introduction of a carbon neutral energy cycle. One of the achievements in electrochemical CO_2 reduction is the clarification of the catalysts toward two-electron involved products such as CO and formate. Interestingly, CO/formate ratio can be selectively controlled on formate selective catalyst such as Sn by tuning the interfacial electric field. On the other hand, on copper catalyst, the selection of alkali cations has direct influence on activity and product selectivity; increasing the size of mono-valent cations can increase the activity and selectivity toward C-C coupled products by modulating the interaction energy between adsorbates and electric fields at the interface. In addition, copper catalyst with a specific atomic-scale gap accelerates the reaction kinetics and selectivity to C_{2+} products. Therefore, understanding the roles of catalyst, support and electrolyte offers the design of efficient, yet cheap electrochemical CO_2 reduction systems.

Keywords:

CO2 Reduction, Interfacial Electric Field, Catalyst Design

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A12.03

On the microscopic details of electric double layer

SHIN Seung-Jae [1], KIM Hyungjun *[1]
[1]Department of Chemistry, KAIST
linus16@kaist.ac.kr

Abstract:

Electrochemistry is becoming a central technology for sustainable energy conversion systems. During electrochemistry, the interconversion of electrical and chemical energy occurs at the electrode-electrolyte interface, at which the so-called electric double layer (EDL) is known to be formed. Ever since the early 1900's when the concept of EDL was first formulated, the structural changes of the EDL upon the applied potential has been widely questioned, but only few details are known to date. For example, the EDL capacitance, which is a characteristic physical quantity reflecting the EDL structures, demonstrates several distinctive behaviors that are not yet explained at a microscopic level. In this talk, I will present our first-principles-based multiscale simulation method for modeling the electrified interfaces at all-atom resolution. Using our new simulations, we elucidate the microscopic origin of the prototypical behavior of the EDL capacitance measured in the dilute electrolytes. Furthermore, I hope to bring a new perspective for developing better electrochemical systems by tailoring the interface: there's plenty of room in between.

Keywords:

Electric double layer, First-principles-based multiscale simulation, Electrified interface

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A12.04

First-principles study on the electrode materials for Li-ion batteries

SEO Dong-Hwa *[1]
[1]School of Energy and Chemical Engineering, UNIST
dseo@unist.ac.kr

Abstract:

Electrochemical energy storage devices are attracting tremendous interest due to the recent growing importance of sustainability and environmental concerns. The lithium rechargeable batteries are one of the most advanced energy storage systems and serve as a major power source for various small electronic devices. With the growing interest in power sources for large applications such as the HEV (hybrid electric vehicle) or PHEV (plug-in hybrid electric vehicle), lithium rechargeable batteries are finding new opportunities in this emerging area. Intensive research efforts are focused on developing suitable electrode material, the key component of lithium rechargeable battery, for these applications. The new electrode materials for lithium rechargeable battery for use in HEVs and PHEVs requires high stability, high power, high energy and low cost. In this talk, I will present the first-principles results on the oxygen redox activity in Li-excess cathode materials [1] and the reaction mechanism of Li4+xTi5O12 anode materials [2]. Fundamental understanding on the electrode's properties based on first principles can accelerate to develop new electrode materials.

References

[1] D.-H. Seo et al., "The structural and chemical origin of the oxygen redox activity in layered and cation-disordered Li-excess cathode materials", Nature Chem., 8 692 (2016)

[2] D.-H. Seo et al., "Kinetic Pathways of Ionic Transport in Fast Charging Lithium Titanate", Science, 367 (6481) 1030 (2020)

Keywords:

Li-ion batteries, anionic redox, first-principles calculation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.01

Structure and function of the neural circuits in the little brain: Discoveries from connectomic analysis of electron microscope images

박창주 [1,2], 임윤석 [1,2,3], 김자원 [2], 반상규 [2], 이상훈 [2], 박준수 [1], 유성봉 [1], 이기석 [4], 손정은 [2], 이계주 [2], 김진섭*[1,2]

[1] 성균관대학교 생명과학과
[2] 한국뇌연구원 신경회로연구그룹
[3] 서울대학교 물리학과
[4] 프린스턴대학교 신경과학연구소
jinseopskim@skku.edu

Abstract:

The brain is a sophisticated network of huge number of neurons, which are connected to one another through the synapses. Different brain regions for different functions have various types of neurons and specialized connectivity, however, the details are still largely unknown. Identifying the neuronal types and mapping the connectivity among them is critical to understanding of the principles of brain functions. High resolution electron microscope (EM) has been used to study the ultrastructure of neurons and their connectivity. EM is the only available technology which enables the observation of the complete synaptic connectivity of entire neurons in a brain sample, the connectome. Terabytes to petabytes of brain images can be scanned thanks to the advancement in high-throughput serial EM imaging technologies. Computational methods to analyze those images are also attainable. Recently we employed these technologies to study a small sample of the “little brain”, cerebellum, of a mouse which plays important roles in motion control and learning. We discovered a novel type of neurons and previously unknown synaptic connectivities. They have crucial implication on the neural information processing of the cerebellum, which supports a model for the functional mechanism of motor control and learning. As a perspective, I will argue from this example that computational and connectomic analysis of EM image data is a way to study the fundamental principles of the brain.

Keywords:

neural networks, connectome, electron microscope, image analysis, computation, cerebellum, motor control and learning, principles of brain function

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.02

Bio-inspired deep neural networks for hearing

KIM Sung-Won [1], PARK Sang-hyun [1], KIM Jaehyeon [1], KIM Hyunjae [1], KIM Gibeom [1], PARK Maruchan [1], LIM Woojae [1], LEE Changwon [1], PARK Hyoseok [1], BOICHENKO Nelly [1], YOO Jaeyun [1], LEE Wooseok [1], AHN Kang Hun [*1]
[1]Bio-inspired Artificial Intelligence Lab., Department of Physics, Chungnam National University
ahnkh@cnu.ac.kr

Abstract:

Humans can understand speech in noisy environments in the presence of multiple talkers. Here, we introduce our efforts on the study of the mechanism of hearing in noise since 2017 and their realization as deep neural networks on electronic devices. A.W. Mills in 1958 introduced the ability of humans to localize sound with a resolution of 1 degree for a 500 Hz signal. This amazing ability relies on the interaural time difference between the ears, where the time difference is much smaller than the synaptic delay. This seemingly contradictory ability is possible due to the biological neural network in our central auditory system. We propose a deep neural network, called MillsNet, for beamforming implementation using only the phase difference of the spectra of each of two microphones, representing an analog of the human brain using the interaural time difference. In terms of spectral analysis, the ear relies on a basilar membrane. The peak location of the amplitude of the membrane contains the information of the sound frequency. This information gives us hints on how to extract features of the sound. Feature extraction allows us to minimize the sound necessary for analysis with deep neural networks, a curucial requirement for hearing aids. We propose a speech enhancement method called SESNet that operates with remarkably small computational cost and low latency by modifying a speech classification network, SwishNet, which is an efficiently designed one-dimensional convolutional neural network applying depth-wise convolution and gated activation function. The proposed method, with only 7k parameters, achieves better measurement scores than well-known speech enhancement networks.

[1] S.Pascuel, M.Park, J. Serra, A. Bonafonte, K.-H. Ahn, ICASSP (2018)
[2] W. Lee , H. Kim, A.N. Cleland, K.-H. Ahn, Bioinspiration&Biomimetics (2021)
[3] S.-W. Kim, K.-H. Ahn, submitted to Interspeech (2021)
[4] S.Park, K.-H. Ahn, submitted to Interspeech (2021)

Keywords:

Deep Learning, Hearing

A13.03

Tubulin-based Architectures by Cationic Molecular Switch and 2D Shape-controllable Building Blocks

LEE Juncheol [2], SONG Chaeyeon [2], LEE Jimin [2], MILLER Herbert P.[3], CHO Hasaeam [2], GIM Bopil [2], LI Youli [4], FEINSTEIN Stuart C.[3], WILSON Leslie [3], SAFINYA Cyrus R.[5], KIM Jinjoo [6], KEUM Hyeongseop [6], KIM Yumi [2], KIM Yujin [6], YU Byeongjun [6], LEE Sang Yeop [2], TANAKA Junichi [7], JON Sangyong [6], CHOI Myung Chul [*2]
[1]KAIST
[2]Department of Bio and Brain Engineering, KAIST
[3]Molecular, Cellular and Developmental Biology Department and Neuroscience Research Institute, UCSB
[4]Materials Research Laboratory, UCSB
[5]Materials, Physics, Molecular, Cellular and Developmental Biology Departments, UCSB
[6]Department of Biological Sciences, KAIST
[7]Department of Chemistry, Biology and Marine Science, University of the Ryukyus
mcchoi@kaist.ac.kr

Abstract:

Tubulins are protein building blocks that are naturally preprogrammed to assemble into cytoskeletal microtubules (MTs). MTs undergo dynamic transitions in structure for important cellular functions (e.g., cell division), which are achieved by 2D conformational changes of tubulins. We used cationic polymers as a molecular switch, which electrostatically interact with tubulins and alter their conformations, and controlled higher-order tubulin assemblies. Synchrotron small-angle X-ray scattering (SAXS) and transmission electron microscopy (TEM) reveal the tubulin-based architectures in nanoscale – especially, tubulin double helix structure. These findings provide insight into the design of 1) protein-based functional materials that keep intrinsic properties of tubulins such as a high binding affinity with MT-associated proteins or anticancer drugs or 2) metallization templates for nanoscale electronic devices. (J. Lee et al., *Small*, 2020 (cover issue), J. Lee et al., *Advanced Materials*, 2020 (cover issue))

Keywords:

protein nanotube, tubulin, molecular switch, drug delivery, small-angle X-ray scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.04

Tensile elasticity of a freely jointed chain with reversible hinges

NOH Geunho [1], BENETATOS Panayotis [*1]
[1]Department of Physics, Kyungpook National University
pben@knu.ac.kr

Abstract:

Double stranded DNA can unzip locally forming bubbles which open and close randomly. This reversible conformational transition within the polymer structure affects its local bending stiffness and its response to a stretching force. Other biopolymer systems also exhibit similar behaviour due to the reversible attachment of ligands along their backbones or the reversible binding of cross-links to their filaments. In order to analyse such systems in general, we introduced and examined the minimal theoretical model of a freely jointed chain with reversible hinges (rFJC) [G. Noh and P. Benetatos, Soft Mater, 2021, DOI: 10.1039/d1sm00053e]. Each hinge can be open, as in the usual freely jointed chain (uFJC), or closed, aligning the adjacent segments to form a rigid segment with twice the original length. In the Gibbs ensemble (fixed force ensemble), there is a crossover between two states with different responses. Even though the generating function method shows that this is not a phase transition, there is a remarkable change in the force-extension behaviour from the corresponding one of the uFJC. In the low force regime, the rFJC has a higher tensile compliance compared to the uFJC. On the other hand, in the strong force regime, the rFJC has a much lower tensile compliance compared to the uFJC. Furthermore, the rFJC exhibits inequivalence between the Gibbs ensemble and the Helmholtz ensemble (fixed extension ensemble), whereas the uFJC exhibits ensemble equivalence.

We acknowledge support by the National Research Foundation of Korea (NRF No. 2019R1F1A1062360) funded by the Ministry of Science and ICT, Korea (MIST).

Keywords:

Semiflexible polymers, Elasticity, DNA, Generating function method, Statistical ensembles

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.05

Theoretical analysis of kymographs : influence of time window and resolution

DURANG Xavier [1], PARK Hye Yoon [2], JEON Jae-Hyung [*1]
[1]Department of Physics, POSTECH
[2]Department of Physics & Astronomy, Seoul National University
jeonjh@gmail.com

Abstract:

Kymographs are graphical representations of the spatial position over time. They are often used in biology to visualise the motion of fluorescent particles, molecules or vesicles moving along a path. As the single particle tracking provides the trajectory of the traced particle during the time window of the experiment, it allows one to evaluate different observables and to quantify the dynamics of the system under observation. We here take the example of a Levy walk which consists of a succession of runs and rests whose durations follow given distributions. We show how to extract the original distribution from the kymographs by carefully taking into account the time window and the resolution. We provide analytical expressions for different distributions and compare with simulations.

Keywords:

Single particle tracking, Levy walk, Anomalous diffusion, Power law distribution

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.06

Dynamical Origin for The Winner-Take-All Competition and Emergence of Sparsely Synchronized Rhythms in The Hippocampal Dentate Gyrus

KIM Sang-Yoon [1], LIM Woochang [*1]
[1]Daegu National University Of Education
wclim@icn.re.kr

Abstract:

We consider a biological network of the hippocampal dentate gyrus (DG). The DG is a preprocessor for pattern separation which facilitates pattern storage and retrieval in the CA3 area of the hippocampus. The main encoding cells in the DG are the granule cells (GCs) which receive the sensory information from the entorhinal cortex (EC) and send their output to the CA3. The activation degree of GCs is so low (~ 5%). This sparsity has been thought to enhance the pattern separation. We investigate the dynamical origin for the winner-take-all competition which leads to the sparse activation of the GCs. The whole GCs are grouped into clusters. In each GC cluster, there is one inhibitory (I) basket cell (BC) along with excitatory (E) GCs. There are three kinds of external inputs into the GCs; the direct excitatory EC input, the indirect inhibitory EC input, mediated by the HIPP cells, and the excitatory input from the hilar mossy cells (MCs). The firing activities of the GCs are determined via competition between the external E and I inputs. The ratio of the external E to I conductance ($R_{E-I}^{(con)}$) may represents well the degree of such external E-I input competition. It is thus found that GCs become active when their $R_{E-I}^{(con)}$ is larger than a threshold, and then the mean firing rates of the active GCs are strongly correlated with $R_{E-I}^{(con)}$. In each GC cluster, the feedback inhibition of the BC may select the winner GCs. GCs with larger $R_{E-I}^{(con)}$ survive, and they become winners; all the other GCs with smaller $R_{E-I}^{(con)}$ become silent. In this way, winner-take-all occurs via interaction of the excitation of the GCs and the feedback inhibition of the BC in each GC cluster. The hilar MCs play a role of enhancing the activity of the GC-BC loop. Moreover, the feedback inhibition from the BCs also leads to emergence of sparsely synchronized rhythms in the GC-BC loop. Successive synchronized stripes appear with the population frequency f_p (=13 Hz) in the raster plots of spikes in each population of GCs and BCs. Such population rhythm also appears in the population of MCs via interaction with the GCs (i.e., GC-MC loop). The population firing activities are also quantitatively characterized in terms of their occupation degrees, the pacing degrees, and the spiking measures. In addition to population behavior, we study individual firing activity of GCs, BCs, and MCs. Individual GCs exhibit random spike skipping, leading to a multi-peaked inter-spike-interval histogram. In this case, population-averaged mean-firing-rate (MFR) is less than the population frequency f_p, which leads to normal sparse synchronization. On the other hand, both BCs and MCs show intrastripe spiking, in addition to the stochastic spike skipping. Thus, the population-averaged MFR is larger than f_p, which results in abnormal sparse synchronization.

Keywords:

Hippocampal dentate gyrus, Winner-take-all competition, Sparsely synchronized rhythm

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.07

Simple model of artificial selection of microbial groups on the group composition

LEE Juhee [1], PARK Hye Jin *[1]
[1]APCTP
phj.hyejin@gmail.com

Abstract:

Desirable species' traits have been obtained by selectively breeding individuals--so-called artificial selection. Instead of individuals' phenotypic traits, recently, a function that arises from interactions between different species has received wide attention. It leads to high demand for selection on groups, but such group-level artificial selection has not been understood well. Especially, the success of artificial group selection is not guaranteed when the coexistence of the faster-growing and slower-growing species is required.
To design the successful artificial group selection, we develop a simple two-species model and analyze conditions under which a target function is achieved. We repeatedly select a group close to the group composition, which gives the desired function having a fixed ratio of the slower-growing species. The results show that appropriate initial conditions are essential to the successful selection. Calculating the probability of having a certain composition of groups, we provide the criterion of such initial conditions for different target functions.

Keywords:

Artificial group selection, Multilevel selection, Evolutionary dynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A13.08

Heterogeneous vesicle fusion in the auditory hair cells

YOO Jaeyun [1], AHN Kang Hun [*1]
[1]Bio-inspired Artificial Intelligence Lab., Department of Physics, Chungnam National University
ahnkh@cnu.ac.kr

Abstract:

인간의 청각능력을 파악하는데 있어 신경신호가 생성되는 과정을 알아내는 것은 매우 중요하다. 포유류의 청각 유모 세포에서는 소리신호가 신경계로 전달될 때에 시냅스에서 소포가 융합되는 과정을 거친다. 많은 실험에서, 신경 신호는 한번의 정점을 가지는 모양 (monophasic) 과 여러 굴곡이 있는 모양 (multiphasic) 으로 나타나는데, 그 생성 원인을 두고 학계에서 논쟁거리가 되고 있다.
본 연구에서 우리는 각각의 논란 거리를 해소할 수 있는 신호 생성 모델을 제시하며 이는 신경 신호 전달 전체 과정을 나노 도메인 전산 모사를 통해 검증하였다. 기존에 알려진 소포의 크기가 매우 작은 변동계수를 갖는 분포를 갖고 있어서 실험과 일치하는 신경신호의 진폭의 분포를 만들 수 없다. 여기서 우리는 소포의 기공의 개방 속도가 약 25%의 변동계수를 갖는 분포를 갖고 있으면 신경신호의 진폭이 생성되는 것을 확인하였다. 또한 우리의 전산 실험 결과에 따르면 monophasic 의 신호는 크고 작은 한개의 소포가 만들어 내는 것이며 multiphasic 의 신호는 여러 소포가 같이 만들어 내는 것으로 해석하는 것이 가장 합당하다.

Keywords:

Vesicle fusion, EPSC, Inner hair cell

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A18.01

Efficient, stable silicon tandem cells enabled by anion-engineered wide-bandgap perovskites

SHIN Byungha *[1]
[1]Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology
byungha@kaist.ac.kr

Abstract:

Perovskite photovoltaic technology has advanced substantially, with the present record efficiency for single-junction devices reaching > 25%. One of the most promising strategies for commercializing these devices is to apply a perovskite top cell in tandem with a Si bottom cell to reach ultrahigh efficiency beyond the Shockley-Queisser limit for single-junction devices. The ideal band gap for the tandem configuration is ~1.67 to 1.75 eV for the top cell and 1.12 eV for the bottom cell, which, fortuitously, is the Si band gap. The band gap of perovskites can be tuned by (partial) replacement of iodine anions with bromine or chlorine. However, the replacement of I with Br by more than 20%, which is necessary to enlarge the band gap to ~1.7 eV, leads to stability issues under illumination through phase separation that forms I-rich and Br-rich structures. One approach to stabilize the perovskite is to create a two-dimensional (2D) phase in which sheets of $[PbX6]^{-2}$ octahedra are separated by an excess number of long-chain (or aromatic) molecules that act as a passivation agent. Common long-chain or aromatic molecule-based 2D additives include n- butylammonium iodide (n-BAI) and phenethylammonium iodide (PEAI). Most of the recent studies have focused on the cation components of the 2D additives rather than focusing on the anions. We developed a 2D-3D mixed wide band gap (1.68 eV) perovskite using a mixture of thiocyanate (SCN) with the more conventional choice, iodine. Through a careful application of atomic resolution transmission electron microscopy, we demonstrated that electrical and charge transport properties as well as the physical location of 2D passivation layers can be controlled with anion engineering of the 2D additives. Moreover, we can use this approach to extend light stability and to improve device performance. For a perovskite device, we achieved a PCE of 20.7% that retained > 80% of its initial efficiency after 1000 hours of continuous illumination in working conditions. For a monolithic 2T perovskite/Si tandem solar cells, the champion 2T tandem device achieved a PCE of 26.7%.[1]

[1] Shin et al. *Science* 368, p. 155 (2020).

Keywords:

perovskite, tandem solar cells, 2D additives

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A18.02

High-Performance Infrared Photodetectors Based on 2D InSe

JANG Hanbyeol [1], SEOK Yongwook [1], CHOI YiTaek [1], CHO Sang-Hoo [1], WATANABE Kenji [2], TANIGUCHI Takashi [2], LEE Kayoung [*3]
[1]School of Materials Science and Engineering, Gwangju Institute of Science and Technology (GIST)
[2]National Institute for Materials Science, Japan
[3]School of Electrical Engineering, Korea Advanced Institute of Science and Technology (KAIST)
kayoung.lee@kaist.ac.kr

Abstract:

2D InSe is one of the semimetal chalcogenides that has been recently given attention thanks to its excellent electrical properties, such as high mobility near 1000 $cm^2\ V^{-1}\ s^{-1}$ and moderate band gap of ≈1.26 eV suitable for IR detection. In this talk, I will introduce our novel IR photodetectors using surface-doped InSe as a channel and multilayer graphenes as electrodes. IR photodetectors have been receiving increasing attention due to their applications in self-driving cars, networking IoT devices, biosensing, etc. A few top layers of InSe are p-doped using $AuCl_3$, an electron absorbing material. Our surface-doped InSe photodetectors show outstanding performance, achieving a photoresponsivity (*R*) of ≈19,300 A W^{-1} and a detectivity (*D**) of ≈3 × 10^{13} Jones at λ = 470 nm, and *R* of ≈7870 A W^{-1} and *D** of ≈1.5 × 10^{13} Jones at λ = 980 nm, superior to previously reported 2D material based IR photodetectors. A detailed analysis regarding the impact of doping, an electrode type, the structure of graphene electrodes, and the encapsulation using hBN dielectric on the electrical and photoelectrical properties will be presented. I will also briefly talk about our newly demonstrated high-performance self-driven photodetectors as well.

Acknowledgements:
This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (NRF-2018R1C1B3002733, NRF-2020R1A4A1019266).

Keywords:

indium selenide, infrared sensors, photodetectors, self-driven photodetectors

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A18.03

Energy level tuned quantum dot solids for efficient photovoltaics

KIM Taewan [1], CHOI Manmin [1], JEONG Sohee [*1]
[1]Department of Energy Science, Sungkyunkwan University
s.jeong@skku.edu

Abstract:

Colloidal quantum dots are nano-sized semiconductors which exhibit unique size-dependent optoelectronic properties dictated by the quantum confinement effect. The true benefit of such unique quantum size effects depends on the ability to synthesize QDs of a wide range of sizes with a narrow size distribution at high reaction yield. While an adjustable bandgap of colloidal quantum dots promises an efficient harvesting of near-IR solar spectrum when used in photovoltaics, tunability in band edge position of quantum dots draw immense attention very recently as the energy level of semiconductor determine their functionality in various optoelectronic applications including photovoltaics. Here we discuss that the band edge position of lead sulfide colloidal quantum dots can be controlled by careful design of molecules or atoms on nanocrystal surfaces based on atomistic understanding of surface structure thus providing tunability of over 2.0 eV. Further by modulating bandgap and band edge position of quantum dot solids, we demonstrate that the indium arsenide quantum dot solids can serve as a stable n-type layers for quantum dot photovoltaics or electron transport layer for efficient and stable organic photovoltaics.

Keywords:

quantum dot photovoltaics, tuned energy level

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A18.04

Phase Engineering in Transition Metal Dichalcogenides Toward Efficient Electrocatalysis

PARK HYESUNG *[1]
[1]Department of Materials Science and Engineering, UNIST
hspark@unist.ac.kr

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 two different types of heterostructures comprising perovskite oxides and transition metal dichalcogenides as the electrochemical catalyst for overall water electrolysis. First, in a heterostructure comprising $La_{0.5}Sr_{0.5}CoO_{3-\delta}$ (LSC) and 2H-phase molybdenum diselenide ($MoSe_2$), a local phase transition in $MoSe_2$, 2H to 1T phase, was induced owing to the electron transfer from Co to Mo, which significantly enhanced the electrochemical activities of the heterostructure for both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). In the overall water splitting operation, the heterostructure showed excellent stability at a 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. Second, we introduce a facile and scalable synthesis of 1T-phase transition metal dichalcogenides (TMDs) via the molten metal-assisted intercalation (MMI) approach, which exploits the capillary action of molten potassium and the difference between the electron affinity of TMDs and the ionization potential of potassium. A heterostructure comprising LSC and 1T-phase $MoSe_2$ prepared via MMI (LSC&1T-$MoSe_2$ (MMI)) showed much improved HER and OER activities than the LSC and 1T-$MoSe_2$ (MMI). The performance improvement is attributed to decreased charge transfer resistance, improved active surface area, increased hydrogen/oxygen adsorption capability, and improved exchange current density in the heterostructure. We hypothesize that bidirectional electron transfer from LSC to $MoSe_2$ and from potassium to $MoSe_2$ improves 1) HER performance via electron-rich $MoSe_2$ with high electrical conductivity and 2) OER performance by increasing the electrophilicity of LSC. In the overall water electrolysis, the heterostructure (LSC&1T-$MoSe_2$ (MMI) || LSC&1T-$MoSe_2$ (MMI)) showed excellent chronopotentiometric stability over the state-of-the-art Pt/C || IrO_2 couple.

Keywords:

electrocatalyst, molten metal intercalation, overall water electrolysis, phase engineering, transition metal dichalcogenides

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A19.01

Comparison of optical properties AlGaAsSb PIN DA structure and RA structure

KIM Jong Su *[1], HA Jae Du [1], JO Hyun-Jun [1], LEE Sang Jo [1], LEE Seung Hyun [2], KIRISHNA Sanjay [2], LEE Sang Jun [3]
[1]Yeungnam University
[2]Department of Electrical and Computer Engineering, Ohio State University
[3]IoT optical sensor team, KRISS
jongsukim@ynu.ac.kr

Abstract:

본 연구는 AlGaAsSb PIN digital alloy (DA) 구조와 random alloy (RA) 구조를 photoluminescence 와 photo reflectance 를 이용한 광학적 특성을 비교 관찰하였다. 각각의 AlGaAsSb PIN 구조는 분자 선 쌓기(molecular beam epitaxy, MBE) 방법으로 반절연성 InP 기판위에 성장되었다 여기 광원으로 405nm 레이저를 이용하였으며, 여기광 세기 의존성 PL 과 온도 의존성 PL 을 측정하였다. 여기광 세기 의존성 PL 의 결과 중심에너지 DA 1.49 eV ~ 1.51eV, RA 1.51 ~ 1.54 eV 영역대에서 각각의 스펙트럼 변화가 관찰되었다. 여기 광원의 세기가 증가할수록 band filling 효과로 청색 편이가 일어남을 확인하였다. 일정 세기 이상에서의 적색편이는 기원이 다른 다양한 defect 상태의 존재와 포논에 의한 thermal 효과에 의한 적색 편이로 사료된다. 온도의존성 PL 의 결과 RA, DA 온도의 변화에 따른 중심에너지 이동은 DA 가 RA 에 비해 온도의 영향을 많이 받는 것을 확인하였다. PR 에서는 0.731 eV 영역에서 InP 의 신호를 관찰하였으며, RA 와 DA 의 스펙트럼의 shift 를 관찰하였다. 이는 DA 의 격자 불일치의 영향으로 사료된다.

Keywords:

MBE, photoluminescence, photoreflectance, DA, RA

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A19.02

Time-resolved photocurrent measurements in $In_{0.25}Ga_{0.75}As_{0.3}Sb_{0.7}$ nBn infrared detector.

KIM Jong Su *[1], SAEID NAHAEI Sanam [1], JO Hyun-Jun [1], LEE SangJun [2], KWAK Minsoo [1], MORE Vivek Mohan [2]
[1]Yeungnam University
[2]physics, KRISS
jongsukim@ynu.ac.kr

Abstract:

We studied the time-resolved photocurrent in the $In_{0.25}Ga_{0.75}As_{0.3}Sb_{0.7}$ nBn detector at room temperature. The photocurrent measurements have been investigated for different excitation regimes (incident photon wavelength (532 and 1064nm) and power). Generally, nBn detector was operated under bias voltage, therefore for studying the time-resolved photocurrent measurements we applied reversed and forward bias voltage during the measurements. After switching off the light, the persistent photocurrent (PPC) is seen due to the local potential fluctuations arising due to the compositional in-homogeneities causing the photo-generated electron-hole pairs to spatially separate before these recombine. However, after the light is turned off, a negative photocurrent transient is noticed. In addition, current decay can be considered by three-time constants lifetime due to the trapping into defects. The power dependence time-resolved photocurrent is measured for the 1064 and 532 nm pump beam. The results show that for fixed applied voltage the photocurrent peak decreases as a function of the excitation wavelength, which means a reduction in the photo-generated carrier density. In addition, by increasing the pump beam intensity the photocurrent intensity is increased for the 1064 nm laser, but the intensity is not changed under 532 nm illumination.

References:

[1] Ghislotti, G., Pietralunga, S., Ripamonti, L., Sacco, R., Micheletti, S. and Bosisio, F., 2000. Time-resolved photocurrent and electric field measurements in high resistivity CdTe. Journal of Applied Physics, 87(1), pp.322-328.

Keywords:

InGaAsSb nbn infrared detector, time resolved photocurrent

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A19.03

백색조명을 위한 Ca_2YNbO_6 이중 페로브스카이트 형광체 연구

HUA Yongbin [2], YU Jae Su [*1,2]
[1]Department of Electronic Engineering, Kyung Hee University
[2]Department of Electronics and Information Convergence Engineering, Kyung Hee University
jsyu@khu.ac.kr

Abstract:

희토류 (rare-earth) 자원의 비용 관리 및 보호에 대한 인식이 발전함에 따라 4 가 망간 이온은 우수한 특성과 저렴한 가격으로 인해 가장 주목을 받고 있다. 특수한 $3d^3$ 전자 구조와 $^2E_g \rightarrow {}^4A_{2g}$ 전이로 인해 망간 이온 활성화 발광물질은 근적외선 또는 청색광 조사의 여기하에서 강한 적색 발광을 할 수 있다. 본 발표에서는 새로운 망간 이온 활성화된 Ca_2YNbO_6 형광물질이 준비되었는데, 이는 일반식 $A_2BB'O_6$ 을 갖는 이중 페로브스카이트 구조를 갖는 것으로 결정되는 반면 상구조는 P 21/n (14) 공간 그룹과 단사정 구조로 확인되었다. 얻어진 샘플은 강한 deep 발광을 할 수 있었으며, 색순도는 높았다. 또한, 제작된 형과체는 백색발광소자응용에 대해 테스트되었다. 따라서, 백색발광소자는 희토류족 없는 적색 발광 형광체의 일종으로 색순도가 우수한 형광체를 제안할 수 있음을 알 수 있다.

Keywords:

이중 페로브스카이트, 형광체, 백색조명

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A19.04

Fabrication of III-nitride semiconductor based microtube cavity and its optical properties

CHO Yong Hoon *[1], CHOI Doyoung [1], WOO Kie Young [1]
[1]KAIST
yhc@kaist.ac.kr

Abstract:

Semiconductor-based microtubes are micro-level sized tubular structures formed by the strain relaxation generated in heterojunction layers which have different lattice constants [1]. It can be used as an optical resonator because it can form an optical resonance modes (whispering gallery modes) through the total internal reflection along the sidewall of the microtube. Optical resonance modes can be applied as a refractive index sensor or as a strain-based temperature sensor in response to a little variation of surroundings [2,3].

In this study, III-nitride semiconductor-based microtubes were fabricated and its optical properties were analyzed. To this end, AlGaN/GaN/InGaN layer was sequentially grown on a sapphire substrate through the metalorganic chemical vapor deposition growth, and the microtube structure was completely fabricated using a photoelectrochemical etching method. For analysis, the structure of the III-nitride based microtubes were observed through the scanning electron microscope and the spectral shift of the GaN emission was observed due to the strain relaxation. A whispering gallery modes were obtained from the micro-photoluminescence experiments. III-nitride semiconductor-based microtube is expected to serve as a new type of optical resonator in optoelectronics, and is expected to be a special platform in the field of bio/chemical sensors because of its own properties of very thin thickness and hollow structure.

[1] V. Ya. Prinz et al., Physica E, **6**, 828-831 (2000).
[2] T. Kipp et al., Physical Review Letters, **96**, 007403 (2006).
[3] P. Song et al., Nanotechnology, **29**, 415501 (2018).

Keywords:

microtube, optical resonator, III-nitride semiconductor, photoelectrochemical etching

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A19.05

InAs/AlSb 초격자 구조의 photoluminescence 및 photoreflectance 연구

KIM Jong Su *[1], KIM Sung Yeop [1], LEE SeungHyun [2], KRISHNA Sanjay [2]
[1]Yeungnam University
[2]Department of Electrical and Computer Engineering, The Ohio State University
jongsukim@ynu.ac.kr

Abstract:

본연구에서는 p-i-n InAs/AlSb 초격자 구조의 광학적 특성을 연구하기 위해 GaSb 기판 위에 InAs 7 ML 과 AlSb 7 ML 을 1 주기로 사용하여 InAs/AlSb 초격자를 p-i-n 구조로 성장시켰다. 여기광원으로 405 와 808 nm laser 를 사용하여 온도 및 여기광세기 의존성 photoluminescence (PL)과 photoreflectance (PR)의 실험을 진행하였다. 20 K 에서 측정한 PL 에서 0.79 eV 영역에서 InAs/AlSb 초격자 구조에 관련된 신호를 관측 하였다. 808 nm 의 경우 여기광세기 의존성 PL 의 경우 796 mW/cm^2 이하에서는 여기광세기가 증가함에 따라 PL 발광 중심이 높은 에너지로 이동하였으며 일반적으로 band filling 효과에 의한 것으로 사료된다. 796 mW/cm^2 이상의 여기광세기에서는 낮은 에너지 대로 이동함을 확인하였으며 광여기운반자의 밀도 증가로 열운반자 현상에 기인한 phonon 발생의 영향으로 사료 된다. 405 nm laser 를 온도 의존성 PL 실험을 한 결과 S-shape 형태의 PL peak 의 변화를 관측 하였으며 이는 potential fluctuations 의 효과로 판단된다. InAs/AlSb 초격자의 전이 에너지 이상에서 Franz-Keldysh oscillations 가 확인 되었다.

Keywords:

InAs/AlSb superlattices, photoluminescence, photoreflectance

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A21.01

Modern Lock-in Detection at Typical optical/photonics experiment (Squeeze more out of your measurement with modern Lock-in amplifier technology)

RIEK Claudius *1
[1]Zurich Instruments AG
claudius.riek@zhinst.com

Abstract:

Measurement time is precious, so it is critical to capture as much information as possible in one experimental run. In this talk, we will present how to achieve this independently of whether you need to record one parameter or multiple variables simultaneously. We will start by summarizing how to implement lock-in detection to obtain maximum SNR. We will then discuss the advantages of direct AM/FM demodulation, as opposed to tandem demodulation, to recover more information from a measurement.

To conclude, we will illustrate how a boxcar averager can capture even more information from a periodic non-sinusoidal signal within a given measurement time window. The goal of this talk is to provide you with insights into how modern lock-in amplifier technology can help you to make the most out of each experiment you perform.

Keywords:

Lock-in detection, SNR, Optical Experiment, Laser, Photonics, spectroscopy, Pump Probe, AM/FM demodulation, Boxcar averager

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A21.02

DFRT method and feedback optimization at SPM/Ferroelectric measurement

STOMP Romain *[1]
[1]Zurich Instruments AG
romain.stomp@zhinst.com

Abstract:

Resonance enhancement technique such as Dual Frequency Resonance Tracking (DFRT) is particularly relevant for thin-film characterization of ferroelectric and multiferroic materials. This allows measurement of weak signals even with low polarization voltages to avoid film breakdown. While lock-in measurements at a fixed low frequency is the norm for bulk materials, the nano-mechanical response to a mechanical or an electric excitation can be greatly enhanced by turning to a contact resonance technique.
In this process, we also describe how to systematically optimize any linear feedback response to be used in the broader context of Scanning Probe Microscopy and beyond.

Keywords:

AFM, SPM, DFRT(Dual Frequency Resonance Tracking), Ferroelectric, resonance, PLL(phase-locked loop)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A21.03

Sensor characterization and control

ESAT Kivanc *[1]
[1]Zurich Instruments AG
kivanc.esat@zhinst.com

Abstract:

Kıvanç looks at the best ways to use time- and frequency-domain tools to characterize sensing devices. In particular, he shows how to set up feedback loops for sensor control without the need for time-consuming and expensive application-specific integrated circuitry (ASIC) development. A detailed blog post accompanies this webinar.

Keywords:

Sensor, Frequency response, parametric sweep, Impedance, PID

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

A21.04

What makes a good Quantum Computing Control System?

THIELE Tobias *[1], KUNG Bruno [1]
[1]Zurich Instruments AG
tobias.thiele@zhinst.com

Abstract:

When building a quantum computer, the classical control system can make the difference between success and failure. In this workshop, we will present several case studies involving researchers at the forefront of quantum technology and discuss the criteria that we consider crucial for the design of control systems matching experimental requirements. For example, with the ever-increasing number and quality of available qubits, control electronics need to be more specialized and less costly. At the same time, features such as digital oscillators and pre-compensation must simplify the workflow while enabling better gate fidelities. We will also look into why system architecture and software adaptation are increasingly important.

Keywords:

Quantum, qubit, Superconducting, Scalable quantum computing, 100-qubit control, readout, and feedback

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B1.01

Theoretical Prospects of Run III at the LHC

TAIT Tim *[1]
[1]UC Urvine, USA
ukyang@snu.ac.kr

Abstract:

I will review some of the interesting progress and outstanding issues in flavour physics, Higgs and electroweak physics and the search for physics beyond the Standard Model at the LHC. I will discuss prospects for future Run III of the LHC.

Keywords:

Run III, LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B1.02

Experimental Prospects of Run III at CMS

CHOI Suyong *[1]
[1]Department of Physics, Korea University
suyong@korea.ac.kr

Abstract:

Abstract: The Run III period at the LHC will start in 2022. During this period, CMS is expected to collect about twice more data. Also, the detector will operate partially with detector components in preparation for the High-Lumi LHC era. We review some of the prospects for the Run III period in the standard model physics and searches for beyond the standard model phenomena, and the Korea CMS team contributions.

Keywords:

LHC, CMS, Run III

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B1.03

Precision Higgs at CMS

DASU Sridhard *[1]
[1]Univ. of Wisconsin at Madison, USA
ukyang@snu.ac.kr

Abstract:

Since the discovery of the Higgs particle in 2021, the large data sample collected during the LHC Run 2 period. This allows precision tests on the production and decays of Higgs bosons, as well as properties of Higgs boson. The results play a crucial role in constraining the SM and provide a new window to discover new physics. I will review the status of Higgs boson measurements and present prospects of the Run III at CMS.

Keywords:

Higgs, CMS, Run III, LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B1.04

Exploiting anomaly detection for new physics identification at the LHC

PIERINI Maurizio *[1]
[1]CERN, Swiss
ukyang@snu.ac.kr

Abstract:

Anomaly detection techniques have been proposed as a way to mitigate the impact of model-specific assumptions when searching for new physics at the LHC, e.g., at event selection or at trigger. We will discuss how these techniques could be utilized in the data processing workflow and the impact they could have on how we search for new physics.

Keywords:

LHC, Run III

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.01

Bubble configuration and shape coexistence in the ground state of 72 ≤ Z ≤ 80 even-even isotopes

LEE Chang Hwan [*3], KIM Youngman [2], CHOI Yong-Beom [3]
[1]Pusan National University
[2]Rare Isotope Science Project, Institute for Basic Science
[3]Department of Physics, Pusan National University
clee@pusan.ac.kr

Abstract:

A nucleus, one of the quantum many-body system, could have degenerate ground states with different shapes, which is called shape coexistence.
The bubble nuclei show low central proton density.
We investigate the shape coexistence and bubble structure in the ground state of 72 ≤ Z ≤ 80 even-even isotopes using deformed relativistic Hartree-Bogoliubov theory in continuum.

Keywords:

shape coexistence, bubble nuclei

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.02

Coulomb Breakup Reaction of Loosely Bound 17F with dynamic polarization potentials

HEO Kyoungsu [1], CHEOUN Myung Ki *[1]
[1]Department of Physics, Soongsil University
cheoun@ssu.ac.kr

Abstract:

We investigate the breakup reaction of the system 17F + 208Pb in the optical potential approach by including the dynamical polarization potential (DPP). In particular, we focus on the breakup reactions, whose data has not been explained by the CDCC. By exploiting two different potentials composed of a surface-type Woods-Saxon and a Love-type optical potential, the breakup reactions data is explained with other elastic and quasielastic scattering data which were obtained by a fitting anlysis

Keywords:

optical model, near the Coulomb barrier, halo nuclei, elastic scattering, break-up reaction

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.03

Study of proton-unbound states in the vicinity of ^{66}Se

KIM SUNJI *[1]
[1]Center for Exotic Nuclear Studies, IBS
sunjikim@ibs.re.kr

Abstract:

The waiting-point nucleus ^{64}Ge is anticipated to undergo the sequential two-proton capture in the X-ray burst and become ^{66}Se. Here, the $^{65}As(p,\gamma)^{66}Se$ reaction has been found as one of the most influential reactions in several models including variation of burst duration, peak temperatures, and initial metalicities. This reaction can critically change final chemical abundances, which is mainly due to its bridging effect on the ^{64}Ge. It brings the importance of the study of excited states above the proton separation threshold, proton-unbound states, in ^{66}Se. However, only one proton-unbound state in ^{66}Se has been observed up to now. Therefore, the experiment to search proton-unbound states in the vicinity of ^{66}Se was performed using the SAMURAI spectrometer at RIBF, RIKEN in 2019. In the presentation, the status of the data analysis will be shown.

Keywords:

proton-unbound state, 66Se, SAMURAI spectrometer, waiting point

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.04

Exploring the proton dripline in the ^{100}Sn region

PARK Joochun *[1]
[1]Center for Exotic Nuclear Studies, IBS
jcpark@ibs.re.kr

Abstract:

The limit of stability at the extreme ratios of protons to neutrons in the nuclear landscape is an important testing ground for the most modern theories. Investigation of the nucleon dripline and nucleon emission from ground states and isomers of the rarest isotopes covers several important topics in nuclear structure: nucleon binding energies, shell evolution, deformation, and correlations between emitted particles.

The doubly magic ^{100}Sn is bound against proton emission by a few MeV, but several nuclei which possess similar numbers of neutrons and protons have been shown to be unbound. Comparisons of current experimental findings to mass predictions of proton-rich nuclei with A ~ 100 will be presented, as well as possible research topics in the near future with the current production rates at accelerator facilities.

Keywords:

nuclear structure, nuclear masses, proton dripline, decay spectroscopy, shell evolution

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.05

Tensor force effects on the ground and excited states of N=Z nuclei

CHEOUN Myung Ki *[1], HA Eunja [2]
[1]Department of Physics, Soongsil University
[2]Department of General Education, Hoseo University
cheoun@ssu.ac.kr

Abstract:

We investigate the tensor force (TF) effect on the ground states and the Gamow-Teller (GT) transition strength distributions in deformed nuclei, 42Ca and 46Ti, which has a neutron number N = Z +2. The TF is introduced in the pairing interaction added to the mean field described by a deformed Woods Saxon potential. The BCS type pairing comprising isoscalar and isovector parts is treated by the Brueckner G-matrix based on the CD bonn potential which was used to incorporate the residual interaction. By switching on and off the TF and varying the deformation parameter in the ground state of the nuclei we deduce meaningful correlations between the TF and the deformation on the GT strength distributions. It is found that the TF effect shifting the main GT peak becomes the larger with the smaller deformation, but it is compensated with the larger deformation. It infers that the deformation stems mostly from the non-central TF effect in the GT transition of the nuclei.

Keywords:

Tensor force

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.06

Proton-neutron pairing nature in ^{138}I through beta decay

MOON Byul *[1]
[1]Center for Exotic Nuclear Studies, IBS
mb0316@ibs.re.kr

Abstract:

In this talk, the beta-decay scheme of ^{138}Te with the following internal structure of ^{138}I will be introduced. The experiment was performed at the Radioactive Isotope Beam Factory of RIKEN. Secondary ions were produced by the in-flight fragmentation of ^{238}U primary beams with the energy of 345 MeV/nucleon. From the beta decay of ^{138}Te, the non-band levels could be assigned, such as the low-lying negative-parity states and a positive-parity 1^+ state. Several spin values of low-lying levels are proposed to be changed on the basis of the selection rule, governed by the first-forbidden transitions. The observed levels will be broadly described in terms of the proton-neutron pairing nature with the theoretical context of the large-scale shell-model calculations.

Keywords:

Nuclear structure, Gamma-ray spectroscopy, Decay spectroscopy, Beta decay, Nuclear shell model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.07

A study on the boundary condition of the R-matrix theory

PARK Tae-Sun *[1]
[1]CENS, IBS
tspark@ibs.re.kr

Abstract:

We present a new formalism of the R-matrix theory where the formal parameters for the resonance energies and widths are identical to the observed values. To achieve this aim, the boundary condition parameters are allowed to be level-dependent, which makes the basis states for the function space in the internal region non-orthogonal to each other. The procedure of how a consistent R-matrix theory can be formulated with such basis states and the boundary condition parameters is described.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B3.08

Gamow-Teller Giant Resonance in ^{11}Li neutron drip-line nucleus

STUHL Laszlo *1
[1]Center for Exotic Nuclear Studies, IBS
stuhl@ibs.re.kr

Abstract:

We started a program [1] at the RIKEN Radioactive Isotope Beam Factory (RIBF) aiming to measure the spin-isospin responses of light nuclei along the neutron drip line. There is no available data on spin-isospin collectivity for nuclei with large isospin asymmetry factors, where (N−Z)/A>0.25 [2]. We investigated this unexplored region up to (N−Z)/A=0.5.
The spin-isospin responses of ^{11}Li and ^{14}Be drip-line nuclei were measured in charge-exchange (p,n) reactions at around 180 MeV/nucleon beam energies. These reactions in inverse kinematics, at intermediate beam energies (E/A>100 MeV) and small scattering angles can excite Gamow-Teller (GT) states up to high excitation energies in the final nucleus, without Q-value limitation [3,4].
The combined setup [5] of our new, digital-readout-based low-energy neutron spectrometer, PANDORA (Particle Analyzer Neutron Detector Of Real-time Acquisition) [6] and the SAMURAI large-acceptance magnetic spectrometer [7] together with a thick liquid hydrogen target allowed us to perform the SAMURAI30 experiment with high luminosity and low background. In this setup, PANDORA was used for the detection of the recoil neutrons with kinetic energy of 0.1–5 MeV, while the SAMURAI was used for tagging the decay channel of the reaction residues. It was proven, in our first (p,n) experiment on ^{132}Sn [8], that using such setup we can take data on unstable nuclei with quality comparable to those on stable nuclei.
In this talk, details of experimental setup as well as the intelligent digital-pulse processing for neutron-gamma discrimination with PANDORA will be presented. We successfully identified 14 different decay channels of the ^{11}Be reaction product. Preliminary result of the reconstructed excitation-energy spectrum up to about 40 MeV, including the Gamow-Teller (GT) Giant Resonance region in ^{11}Li, will be reported. Our observation, that GT peak occurs below the Isobaric Analog State in ^{11}Li, will be discussed in connection with the variation of residual spin-isospin interaction in exotic nuclei.
This work is performed in the frame of SAMURAI30 experimental collaboration.

Keywords:

Spin-isospin physics, Nuclear collectivity, Gamow-Teller giant resonance, halo nucleus, neutron-gamma discrimination

B3.09

Elastic alpha-carbon-12 scattering for d-wave channel at low energies in effective Lagrangian approach

ANDO Shung-Ichi *[1]
[1]Department of Information Display, Sun Moon University
shungichi.ando@gmail.com

Abstract:

We study elastic alpha-carbon-12 scattering for d-wave channel at low energies in effective Lagrangian approach explicitly including d-wave sub-threshold and two resonant states of oxygen-16. We fit parameters appearing in the elastic scattering amplitudes, which are derived from the Lagragian, to the experimental data and calculate an asymmptotic normalization coefficient (ANC) for the d-wave sub-threshold state of oxygen-16. We discuss our result of the ANC comparing with those reported in previous studies.

Keywords:

elastic alpha-12C scattreing, d-wave channel, effectve Lagrangian approach

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B5.01

Nanoscale Au-Si eutectic mixtures formed by dewetting of a Au-Ni film on Si_3N_4: A Coherent X-ray Diffractive Imaging Study

KIM Yoonhee [1,2], KIM Chan [*1], AHN Kangwoo [2], LEE Su Yong [3], KIM Jin Woo [2,3], KANG Hyon Chol [4], NOH Do Young [*2]
[1]European X-ray Free-Electron Laser Facility
[2]Department of Physics and Photon Science and School of Materials Science and Engineering, Gwangju Institute of Science and Technology
[3]Pohang Accelerator Laboratory
[4]Department of Materials Science and Engineering, Chosun University
chan.kim@xfel.eu,

Abstract:

Solid-state dewetting and agglomeration processes are widely used methods for the fabrication of nanoparticles. For specific substrate materials, it can participate in the reaction and thus affect products. In this presentation, we will show the forming process of a eutectic AuSi compound during dewetting and agglomeration of Ni/Au bilayer films on a Si_3N_4 substrate by using X-ray diffraction, scanning electron microscopy, and coherent X-ray diffraction imaging. During thermal annealing, bilayer film first dewets into islands that are composed of Au-rich and Ni-rich phases. Then, Si and Ni are dissociated and form NiSi, NiN, and AuSi. As the annealing time increases, N is gradually evaporated as a form of N_2. In addition, the eutectic phenomenon of AuSi triggers a movement of Au and forms Au_5Si_2 which has a composition close to the eutectic point. Based on our results, we summarize the mechanism occurred on metal-substrate interface under high temperature, and shows the hidden interface morphology and AuSi eutectic phenomenon, using the nondestructive 3D visualization methodology.

Keywords:

Coherent X-ray Diffractive Imaging, Thin film alloy, X-ray Free electron Laser

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B5.02

Ultrafast Phase Transformation by X-ray Free Light-induced Electron Laser

KIM Hyunjung *[1]
[1]Department of Physics, Sogang University
hkim@sogang.ac.kr

Abstract:

A significant challenge in understanding the phase transformation of materials is whether one can identify and characterize the fine details of the complex ultrafast dynamics of molecules and materials. Many existing techniques only measure the initial and final states of the material transformations. The recent advance of X-ray free electron laser makes it possible to obtain critical information on the intermediate states or pathways during the phase transformation. In this talk, we show the recent results of a transition from a topological insulator to a standard insulator in Bi_2Se_3 followed by carrier-induced contraction and vibration modes and the crystalline-amorphous phase transformation of a phase change material as examples.
This research was supported by the National Research Foundation of Korea (NRF-2015R1A5A1009962 and 2019R1A6B2A02100883) and Samsung Electronics and Samsung Display.

Keywords:

phase transformation, ultrafast, X-ray free electron laser, time-resolved

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B5.03

Observing ultrafast kinetics at quantum space-time domain with femtosecond X-rays

SONG Changyong *[1]
[1]POSTECH
cysong@postech.ac.kr

Abstract:

Materials interacting with intense femtosecond laser pulses have undergone ultrafast phase transitions via exotic kinetic reactions unexplored in thermal equilibrium. This has invoked strong research interest in uncovering the process leading to such phase changes, but femtosecond dynamics of ions has long been veiled with challenges in resolving accompanied irreversible reactions at relevant space-time resolution. By newly establishing a multiplexing experimental technique combining both single-pulse imaging and crystal diffraction using X-ray free electron lasers, we overcome this to directly observe the solid-liquid transition of metallic Au at femtosecond and atomic scale. Real-time images of single specimens undergoing femtosecond irreversible phase transitions are obtained with atomic scale details, which enables *ab initio*understanding on the phase transition processes in nonequilibrium states. We establish a comprehensive femtosecond and atomic scale picture to describe ultrafast photo-induced phase changes.

Keywords:

Femtosecond dynamics, XFEL, Nonequilibrium

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B5.04

In-situ observation of metal-halide perovskite crystal formation using synchrotron x-ray scattering

KIM Hyo Jung *[1,2], HONG Seong Yeon [2], LEE Sunghun [2], CHO In Hwa [3]
[1]Organic Material Science and Engineering, Pusan National University
[2]School of Chemical Engineering, Pusan National University
[3]Department of Physics and Photon Science, GIST
hj07.kim@gmail.com

Abstract:

We investigated the real time formation of metal-halide perovskite crystals using x-rays at PLSII. Using GIWAXS measurement, we distinguished the x-ray signals from the surface region to the bulk region by adopting the various x-ray incident angles. From the real time in-situ measurement, we investigated the effect of the crystal cross-linker Oleylamine during the perovskite crystal formation. Generally, it has been believed that crystal cross-linker induced preferential ordering of the perovskite crystals through the whole film. However, we found that the cross-linker only induced preferential ordering in the surface region in the intermediate state before full conversion to perovskite structure. Due the result of the cross-linker acting at the surface region, we expected the homojunction formation in the perovskite layer.

Keywords:

in-situ, perovskite PV, synchrotron x-ray

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B6.01

Controlling phases in oxygen sponge $SrFe_{1-x}Co_xO_{3-\delta}$

JEEN Hyoung Jeen *1
[1]Department of Physics, Pusan National University
hjeen@pusan.ac.kr

Abstract:

Complex oxides have gotten lots of attentions due to diverse electronic/magnetic phases and their tunability by external stimuli such as strain, magnetic fields, electric fields, etc. In addition, mixed ionic and electronic conducting behaviors in complex oxides have been applied for many energy devices such as solid oxide fuel cells and electrochemical sensors, where redox reactions and catalytic activity at the interfaces of gas-solid and solid-liquid play critical roles for the performance. The primary purpose of this presentation is to address ion-exchange behaviors that can be used for controlling phase in epitaxial complex oxides. As a model system, we chose oxygen sponge $SrFe_{1-x}Co_xO_{3-\delta}$ (x = 0.2 and 0.5 in this work) grown by pulsed laser deposition. Example 1 is to show oxygen tug-of-war at the oxide interfaces. By capping different oxides such as a hole-doped manganite and a titanate on $SrFe_{0.5}Co_{0.5}O_{2.5}$, we observed either oxygen absorption or desorption in $SrFe_{0.5}Co_{0.5}O_{2.5}$. In case of the absorption, we confirmed ferromagnetism, which is not from the capping materials. Example 2 is about selective reduction in $SrFe_{0.5}Co_{0.5}O_{2.5}$. We observed drastic change in optical conductivity spectra and stabilization of unique divalent cobalt ions. We will also address the role of iron ions.

Keywords:

oxygen sponge, epitaxial oxides, ferromagnetism

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B6.02

Direct Observation and Control of Atomic-Scale Defects in Energy Materials

CHUNG Sung-Yoon *[1]
[1]KAIST
sychung@kaist.ac.kr

Abstract:

The importance of direct physical imaging and chemical probing has been widely noted, as both can provide crucial and unexpectedly invaluable information in a variety of scientific fields, including not only materials science and condensed-matter physics but also brain science, photonics, biology, astronomy, and even research for historic materials. In particular, recent advances in spherical aberration correction in scanning transmission electron microscopy (STEM) have enabled the observation of a crystal lattice at a real atomic scale, making it possible to visualize the atomic columns of even light elements in angstrom resolution. In this talk, we summarize our work on olivine phosphates over the last decade for energy storage, including HAADF-STEM images of $LiFePO_4$ reported for the first time in Li-intercalation oxides. By exemplifying oxide-based energy-conversion materials for electrocatalytic activities and for nonlinear I-V and dielectric properties, the beauty of combination of atomic-scale imaging based on STEM and theoretical calculations will be covered to provide a better insight into the correlation between physics, chemistry, and atomic-level imaging.

Keywords:

defects, energy conversion, oxides, scanning transmission electron microscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B6.03

단결정성 박막 내에서의 양이온 이동에 기반한 뉴로모픽 소자

PARK Bae Ho *[1], YOON Chansoo [1], LEE Mi Jung [1], LEE Ji Hye [2], LEE Sangik [1], JEON JI Hoon [1], KIM Dae Hwan [3], JANG Jun Tae [3], KIM Young Heon [4], AHN Jae-Pyoung [5], KIM Sung-Hoon [5], PARK Je-Geun [2], LEE Sungmin [2], HONG Suklyun [6], MIN Kyung-Ah [6], CHOI Hyunsoo [6]
[1]Department of Physics, Konkuk University
[2]Department of Physics, Seoul National University
[3]School of Electrical Engineering, Kookmin University
[4]Graduate School of Analytical Science and Technology, Chungnam National University
[5]Advanced Analysis Center, Korea Institute of Science and Technology
[6]Department of Physics, Sejong University
baehpark@konkuk.ac.kr

Abstract:

인지, 판단, 예측 기능을 가지는 컴퓨팅 시스템에 대한 수요가 급증하면서 인간의 뇌를 모방하는 뉴로모픽 시스템 개발이 활발히 진행되고 있다. 지금까지 인간 뇌의 하드웨어보다는 기능을 모방하는 뉴로모픽 시스템이 성공적으로 개발되고 다양한 분야에서 적용되고 있으나, 에너지 소모가 비효율적이고 지나치게 많은 소자를 필요로 하는 단점으로 인해 많은 한계를 노출하고 있다. 따라서, 인간 뇌의 하드웨어인 시냅스와 뉴런을 모사하는 초저에너지 초고집적 소자 기반의 뉴로모픽 시스템 개발이 필요하다. 뉴런은 연결된 뉴런으로부터 전달된 신호를 모아 특정 값 이상일 때 발화함으로써 인지, 판단의 역할을 담당한다. 시냅스는 인접한 두 뉴런 사이의 시냅스 가소성을 조절함으로써 뉴로모픽 컴퓨팅 시스템에서 기억의 역할을 담당한다. 단결정성 박막에서 양이온의 이동은 낮은 에너지로 유도할 수 있으며, 단결정성 박막과 양이온의 종류에 따라 양이온의 이동 속도를 조절할 수 있어 다양한 특성을 가지는 뉴로모픽 소자 개발에 활용될 수 있다. 본 발표에서는 강유전체 물질인 $Pb(Zr,Ti)O_3$와 새로운 2 차원 소재인 $CrPS_4$ 단결정성 박막에서의 양이온 이동에 의한 저항 변화 현상을 소개하고 이를 기반으로 하는 뉴로모픽 소자의 특성을 논의하고자 한다. 특히, $Pb(Zr,Ti)O_3$와 단결정 박막에서는 강유전 분극의 방향/크기와 외부 전기장의 크기에 따라 양이온 이동이 조절되며 초저에너지로 시냅스 가소성이 가능함을 보이고자 한다. 또한, $CrPS_4$ 단결정성 박막 내에서 전도성 필라멘트의 변화를 투과전자현미경으로 직접 관찰한 결과와 이를 설명하는 시뮬레이션 결과를 통해 양이온 이동에 의한 저항 변화 메커니즘을 설명하고자 한다.

Keywords:

단결정성 박막, 양이온 이동, 뉴로모픽 소자, Pb(Zr,Ti)O3, CrPS4

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B6.04

The role of defects for tunneling phototransistors and electronic spectroscopy based on 2D materials

YANG Heejun *[1]
[1]Department of Physics, KAIST
h.yang@kaist.ac.kr

Abstract:

Each atomic layer in van der Waals (vdW) heterostructures possesses a distinct electronic band structure that can be manipulated for unique device operations. In the precise device architecture, the role of inevitable charged defects for the subtle but critical band coupling between the atomic layers, varied by the momentum of electrons and external electric fields in device operation, has not yet been presented or applied to designing original devices with the full potential of van der Waals heterostructures.

In this talk, I will introduce interlayer coupling spectroscopy at the device-scale based on the negligible quantum capacitance of two-dimensional semiconductors in lattice-orientation-tuned, resonant tunneling transistors. The effective band structures of the mono-, bi-, and quadrilayer of MoS_2 and WSe_2, modulated by the orientation- and external electric field-dependent interlayer coupling in device operations, could be demonstrated by the new conceptual spectroscopy overcoming the limitations of the former optical, photoemission, and tunneling spectroscopy[1]. Based on the vertical heterojunction and unique role of defects, novel orbital-gating based phototransistors could be developed.

References [1] Adv. Mater, 32, 1906942 (2020)

Keywords:

Defects, Screening, Stark effect, Tunneling, Photogating

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.01

Validation of the People-Bean model in estimating the critical thickness of perovskite oxide thin films via data analytics.

CHOI Woo Seok *[1], SHIN Dongwon [2], OH Jin Young [1]
[1]Physics, Sungkyunkwan University
[2]Materials Science and Technology , Oak Ridge National Laboratory
choiws@skku.edu

Abstract:

The understanding of epitaxial strain and its relaxation mechanism can provide us meaningful insight since epitaxial strain is one of the most effective tuning parameters in a thin film fabrication. Epitaxial strain is derived from the lattice mismatch, which is defined as the relative difference of the in-plane lattice parameter between the thin film and the substrate. In an epitaxially strained state, the in-plane lattice parameter of the thin film turn into that of the substrate, up to a certain thickness of the thin film. When the thickness exceeds the critical thickness, however, the epitaxial strain becomes relaxed and the in-plane lattice parameter of the thin film gets back to the bulk value. Because the emergent physical phenomena in condensed matter are significantly affected by its lattice structure, the understanding of the microscopic mechanism of the strain relaxation and prediction of the critical thickness is highly important. Due to its significance, there has been continuous attempts to predict critical thickness and related mechanism. However, the understanding still lacks in spite of many approaches including phenomenological model called People-Bean model. Machine learning is a rapidly emerging tool in materials science owing to its effectiveness and versatility. In condensed matter physics, physical properties including optical band gap, thermodynamic stability, and the formation of perovskite oxides have been estimated through machine learning. Therefore, we can expect to discover new trend in critical thickness via only data dependent machine learning approach. In our case, machine learning approach provided correlation between the critical thickness and physical parameters of the thin film systems so that we can find out that we are able to extract physically relevant parameters from the People-Bean model. We collected critical thickness data of the perovskite oxide thin films grown by pulsed laser deposition as subsets for effective estimation and used them to train the model. Model training process was conducted for the data and feature sets which led to consistent results with physically reasonable condition. The model's estimation accuracy was assessed by checking the R^2 value. As a result, we obtained final model with R^2~0.9. Based on the model, we predicted the critical thickness of the $SrTiO_3$ (STO) thin film grown on $(LaAlO_3)_{0.3}(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT) (001) substrate to be 120 nm, and experimentally verified the value.

Keywords:

Data analytics, Machine learning, epitaxial strain, People-Bean model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.02

Semiconductor–Metal transition in $LaVO_3$ and $La_{1-x}Sr_xVO_3$ ($0 \leq x \leq 1$) thin films grown on LSAT substrates

OH Ye Jin [1], JUNG Dae Ho [1], PARK Woo Sung [1], LEE Jae Jun [1], LEE Ho Sun [*1]
[1]Applied Physics, Kyung Hee University
hlee@khu.ac.kr

Abstract:

We investigated the optical and electrical properties of $LaVO_3$ and $La_{1-x}Sr_xVO_3$ ($0 \leq x \leq 1$) grown on LSAT substrates using RF sputtering deposition. We observed that the resistivities of $La_{1-x}Sr_xVO_3$ showed semiconductor–metal transition near x = 0.2. This can be due to structural phase transition as well as electronic phase transition. Using standard X-ray diffraction measurements, grazing incidence X-ray diffraction measurements, and transmission electron microscopy, we found that the $La_{1-x}Sr_xVO_3$ grown on LSAT substrate had high crystallinity. We measured the dielectric functions and Hall parameters. The change of optical properties of $La_{1-x}Sr_xVO_3$ films as a function of Sr composition was discussed in comparison to the change in electronic structures. Using 2^{nd} derivative of dielectric functions of $LaVO_3$ and $La_{1-x}Sr_xVO_3$ films, several interband transitions are identified. The composition dependence of the electronic transitions in $La_{1-x}Sr_xVO_3$ films are also discussed.

Keywords:

LaVO3, La1-xSrxVO3, semiconductor-metal transition, dielectric function, interband transition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.03

The effect of thermal annealing on Ga_2O_3 X-ray photodetector and observation of X-ray photo-oxidation in non-stoichiometric Ga_2O_{3-x} Thin Films

KANG Hyon Chol *[1], CHOI Sukjune [2], KANG Sae Hyun [2], OH Ho Jun [2], HA Sung Soo [3], LEE Su Yong [4], HAM Daseul [4], NOH Do Young [2]
[1]Department of Materials Science and Engineering, Chosun University
[2]Department of Physics and Photon Science, GIST
[3]School of Materials Science and Engineering, GIST
[4]Pohang Accelerator Laboratory, POSTECH
kanghc@chosun.ac.kr

Abstract:

Ga_2O_3 has been investigated for applications in high-power electronics and solar blind photodetectors due to its outstanding properties such as its high breakdown filed of 8 MV/cm and wide bandgap of 4.9 eV. It has been reported that the performance of β-Ga_2O_3 as a solar-blind photodetector is increased through thermal annealing. In this study, we report on the thermal annealing effects of Ga_2O_3/sapphire(0001) thin films as an x-ray photodetector. The thin films synthesized by RF powder sputtering. The experiments were performed using the synchrotron X-ray micro-beam. Non-stoichiometric Ga_2O_{3-x} thin films epitaxially grown on sapphire(0001) substrates were examined as X-ray photo-detectors. When X-rays irradiated on samples, the changes in electrical conductance were monitored via a four-point probe. The annealing was performed the under the vacuum atmosphere at 900°C. The conductance was measured for the thermal annealed sample in an oxygen environment while x-ray irradiating, and measurements were performed in the same manner for samples that were not thermal annealed. Surprisingly, the results showed that the conductance of the sample worsened as the x-ray irradiation proceeded. When the measurement was repeated on the sample without thermal annealing, it was confirmed again that the conductance was increased by x-ray photocurrent generation as known. From the above results, we concluded that oxygen vacancy generated in Ga2O3 thin films by thermal annealing causes enhancement of conductance, and it was concluded that photo-oxidation occurred by x-ray and the conductance was reduced. Detailed analysis including TEM data supporting this will be presented.

Keywords:

Ga2O3 thin films, X-ray photo-oxidation, X-ray photocurrent

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.04

Symmetry-driven spin wave gap modulation in atomically-designed $SrRuO_3$ heterostructures

JEONG Seung Gyo [1], KIM Hyeonbeom [2,3], HONG Sung Ju [2,3], SUH Dongseok [2,3], CHOI Woo Seok [*1]
[1]Physics, Sungkyunkwan University
[2]Center for Integrated Nanostructure Physics, Institute for Basic Science
[3]Energy Sciences, Sungkyunkwan University
choiws@skku.edu

Abstract:

A strong correlation between spin interaction and topological symmetries manifests unconventional spin-wave dynamics. As a prominent example, Weyl fermions reveal the topologically protected spin-momentum locking, which is closely associated with the spin-wave gap formation in magnetic crystals. Ferromagnetic $SrRuO_3$, a candidate of Weyl semimetal, inherently possesses a nonzero spin-wave gap stemming from its strong magnetic anisotropy. Here, we propose a strategy to adjust the spin-wave dynamics via the artificial crystalline symmetry customization of $SrRuO_3$. We used atomically controlled $SrRuO_3$/$SrTiO_3$ heterostructures to validate the octahedral tilt propagation engineering and resultant crystalline symmetry customization.[1-6] Atomically thin $SrRuO_3$ layers within the superlattices undergoes a phase transition in crystalline symmetry from orthorhombic to tetragonal by changing the thickness of adjacent $SrTiO_3$ layers. In particular, the magneto-transport measurements demonstrated that the magnon gap of $SrRuO_3$ could be substantially enhanced by ~42% from an orthorhombic to a tetragonal structure. Our atomic-scale approach shows the crucial correlation between the tunable lattice degrees of freedom and spin dynamics in topologically nontrivial magnetic materials.[6]

[1] H. Jeong, S. G. Jeong *et al.*, *Appl. Phys. Lett.* **115**, 092905 (2019).
[2] S. G. Jeong *et al.*, *Phys. Rev. Lett.* **124**, 026401 (2020).
[3] S. G. Jeong *et al.*, *Nanoscale.* **12**, 13926 (2020).
[4] S. G. Jeong *et al.*, *Adv. Sci.* **7**, 2001643 (2020).
[5] H. I. Seo, S. Woo, J. Kim, S. G. Jeong *et al.*, *Phys. Rev. B* **103**, 045104 (2021).
[6] S. G. Jeong *et al.*, *ACS Appl. Nano Mater.* **4**, 2160 (2021).

Keywords:

SrRuO3, anomalous Hall effect, Weyl semimetal, spin-wave gap, crystalline-symmetry control

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.05

Temperature dependent ARPES measurement of VS2

KIM Hyuk Jin [1], CHOI Byoung Ki [1], LEE In Hak [2], JOZWIAK Chris [3], BOSTWICK Aaron [3], ROTENBERG Eli [3], LEE Sunghun [4], CHANG Young Jun *[1,5]
[1]Department of Physics, University of Seoul
[2]Center for Spintronics, Korea Institute of Science and Technology
[3]Advanced Light Source (ALS), E. O. Lawrence Berkeley National Laboratory
[4]Department of Physics, Sejong University
[5]Department of Smart cities, University of Seoul
yjunchang@gmail.com

Abstract:

Vanadium disulfide (VS_2) has recently attracted much attention due to their intriguing properties, such as charge density wave (CDW), ferromagnetism, and surface catalytic behavior. However, VS_2 has received relatively little experimental research compared to other vanadium chalcogenides (VSe_2, VTe_2), so physical properties of VS_2 such as an origin of CDW, and ferromagnetism are experimentally unsettled. Here, we present temperature dependent electronic properties of VS_2 by using systematic angle-resolved photoemission spectroscopy (ARPES) measurements and discuss CDW transition in VS_2. The temperature dependent APRES shows the opening of a small energy gap (~15 meV) at 20K that is attributed to the CDW phase, and its transition temperature is estimated about 300K.

Keywords:

VS2, ARPES, Electronic structure

B7.06

Observation of a metallic electronic structure in a single-atomic-layer perovskite oxide

KIM Jeong Rae [1], SOHN Byungmin [1], KIM Changyoung [1], NOH Tae Won [*1]
[1]Department of Physics and Astronomy, Seoul National University
twnoh@snu.ac.kr

Abstract:

Correlated electrons in transition metal oxides (TMOs) exhibit a variety of emergent phases. When TMOs are confined to a single-atomic-layer thickness, experiments so far have shown that they usually loose the diverse properties and become insulators. In an attempt to extend the range of electronic phases of the single-atomic-layer oxide, we search for a metallic phase in a monolayer-thick epitaxial SrRuO3 film. Combining atomic-scale epitaxy and angle-resolved photoemission measurements, we show that the monolayer SrRuO3 is a strongly correlated metal. Systematic investigation reveals that interplay between dimensionality and electronic correlation makes the monolayer SrRuO3 an incoherent metal with orbital-selective correlation. Furthermore, the unique electronic phase of the monolayer SrRuO3 is found to have high tunability. We experimentally demonstrate a crossover from the incoherent metal to a Fermi liquid. Our work emphasizes the potentially rich phases of single-atomic-layer oxides and provides a guide to manipulation of their two-dimensional correlated electron systems.

Keywords:

Correlated electron system, SrRuO3, thin film

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B7.07

Single magnon scattering and possible topological phase of $Y_2Ir_2O_7$ in Raman spectroscopy

NGUYEN Thi Huyen[1,2], SON Jaeseok [1,2], KIM Soyeun [1,2], CHO Hwanbum [1,2], KIM Choong H.[1,2], WANG Yiping [3], BURCH Kenneth S.[3], YANG In-Sang [4], JEONG Jaehong [1,2], PARK Je-Geun [1,2], MOON SoonJae [5], NOH Tae Won [*1,2]
[1]Center for Correlated Electron Systems, Institute for Basic Science
[2]Department of Physics and Astronomy, Seoul National University
[3]Physics Department, Boston College
[4]Department of Physics, Ewha Womans University
[5]Department of Physics, Hanyang University
twnoh@snu.ac.kr

Abstract:

Using Raman spectroscopy, we investigated the magnetic excitations in $Y_2Ir_2O_7$. We observed single-magnon excitations at 28.6 meV and 34.4 meV on Raman spectra of Y227 for the first time. Combining with the tight-binding calculations for the spin-phonon coupling, we obtained spin Hamiltonian parameters, Heisenberg and Dzyaloshinskii-Moriya interactions (J and D). Based on these parameters, we can provide the possible magnon topology phase diagram for *R*227 (*R*=Y, Eu, Sm), in which, *R*227 expects to perform a rich phase of nontrivial magnon topology.

Keywords:

pyrochlore iridate, Raman spectroscopy, magnon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.01

Topological acoustic triple point

PARK Sungjoon [1,2], HWANG Yoonseok [1,2], CHOI Hong Chul [2], YANG Bohm Jung *[1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]IBS CCES, CCES (IBS)
bjyang@snu.ac.kr

Abstract:

Acoustic phonons in an elastic medium is a well known example of elementary excitations with triplet degeneracy in the band structure. Because the triple point of acoustic phonons is protected by the gapless nature of phonons, its topological nature has hitherto been neglected. In this work, we report that in most cases, the triple degeneracy of acoustic phonons carries a topological charge. In particular, the phonons of an isotropic medium is always topological, and it can be characterized by a topological charge $₩mf{q}$ that is a property of a three-band system. The charge $₩mf{q}$ can equivalently be characterized by the skyrmion number of the longitudinal mode, or by the Euler number of the transverse modes. For this reason, we call the triple point with nontrivial $₩mf{q}$ the topological acoustic triple point. Because the phonons in a monatomic lattice is a three-band system, it is a system in which $₩mf{q}$ can be defined in the strict sense. However, continuum approximation allows us to extend this theory to multiband systems, which include electronic bands. We find that the continuum theory constrained by the O_h and the T_h groups can exhibit the topological acoustic triple point.

Keywords:

Triple point, Topology, Acoustic phonon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.02

Mapping current profiles of point-contacted graphene devices using scanning diamond nitrogen-vacancy center magnetometer

LEE Myeongwon [1], JANG Seong [2], JUNG Woochan [2], LEE Yuhan [1], TANIGUCHI Takashi [3], WATANABE Kenji [4], KIM Ha-Reem [1], PARK Hong-Gyu [1,5], LEE Gil-Ho [2], LEE Donghun *[1]
[1]Physics, Korea University
[2]Physics, POSTECH
[3]International Center for Materials Nanoarchitectonics, National Institute for Materials Science
[4]Research Center for Functional Materials, National Institute for Materials Science
[5]KU-KIST Graduate School of Converging Science and Technology, Korea University
donghun@korea.ac.kr

Abstract:

Studying carrier dynamics has become of importance for studying graphene transport. The spatially resolved imaging technique can provide platform to visualize current distribution and complement a
conventional transport measurement. Nitrogen-Vacancy (NV) center in diamond can be used to magnetometer to study not only magnetic materials but also current devices with combining scanning
prob microscope. We demonstrate two-dimensional mapping of current flow in graphene devices by using a single-spin scanning magnetometer based on a diamond NV center. We first image the stray magnetic field generated by the current and then reconstruct the current density map from the field data. We focus on the visualization of current flow around a small sized current source of ~ 500 nm diameter, which works as an effective point contact. We used two types of point-contacted graphene devices and find that the overall current profiles agree with the expected behavior of electron flow in the diffusive transport regime. This work could offer a route to explore interesting carrier dynamics of graphene including ballistic and hydrodynamic transport regimes. In this talk, We will introduce point-contacted graphene devices and current distribution on them. We will discuss how to reconstruct current map from magnetic field map imaged by scanning NV center microscope and its working principles.

Reference

Myeongwon Lee, Seong Jang, Woochan Jung, Yuhan Lee, Takashi Taniguchi, Kenji Watanabe, Ha-
Reem Kim, Hong-Gyu Park, Gil-Ho Lee, and Donghun Lee, Mapping Current Profiles of Point-
Contacted Graphene Devices Using Single-Spin Scanning Magnetometer, Appl. Phys. Lett. 118,
033101 (2021).

Keywords:

Graphene, diamond NV center

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.03

Electrical control of the valley magnetic domain and concomitant anomalous current in bilayer MoS_2

JEON Jiwon [1], KIM Youngjae [1], LEE JaeDong [*1]
[1]Department of Emerging Materials Science, DGIST
jdlee@dgist.ac.kr

Abstract:

In contrast to the valley-selective Berry curvatures of the conduction band of the monolayer (1L-) MoS_2, the bilayer (2L-) MoS_2 (i.e., in 2H-phase) has vanishing Berry curvatures at both K and K' valleys due to the inversion symmetry. When a vertical electric field is applied to 2L-MoS_2, however, conduction bands are split due to a potential difference and become to restore the valley-selective Berry curvatures. Especially, for an electron-doped 2L-MoS_2, an application of the vertical electric field together with the in-plane bias electric field enables to induce the valley magnetization from the valley magnetoelectric effect (VME) and further bring about its real-space distribution, i.e., the valley magnetic domain (VMD), through a competition with the valley Hall effect (VHE). In particular, the uniaxial strain induces a transfer of electrons from the Q valleys and increases radii of the electron pockets at the K and K' valleys. In the context, therefore, at fixed values of the bias field and the strain strengths, the VMD moving and the consequent modulation of the anomalous transverse current perpendicular to the bias field is found to be achieved in an electrical method, that is, by controlling the vertical electric field.

Keywords:

Magnetic Domains, Valleytronics, Topological Hall effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.04

Steady Floquet-Andreev States Probed by Tunneling Spectroscopy

PARK Sein [1], LEE Wonjun [1], JANG Seong [1], CHO Gil Young [1,2,3], LEE Gil-Ho *[1,2]
[1]Department of Physics, POSTECH
[2]., APCTP
[3]Center for Artificial Low Dimensional Electronic Systems, IBS
lghman@postech.ac.kr

Abstract:

Engineering quantum states through light-matter interaction has opened a new paradigm in condensed matter physics. A representative example is Floquet-Bloch (F-B) states that are generated by time-periodically driving the Bloch wavefunctions in crystals. Previous experiments have been limited by the transient nature of the F-B states produced by optical pulses, which masks the universal properties of non-equilibrium physics. Here, we report the generation of steady F-B states in a graphene Josephson junction by applying a continuous microwave and the direct measurement on their spectrum via a superconducting tunnelling spectroscopy. We have analysed the Andreev bound states (ABSs) and F-B states with varying the phase difference of superconductors, temperature, microwave frequency, and power. The oscillations of F-B states with phase difference agree with our theoretical calculations. Moreover, we confirmed the stationary nature of the F-B states by establishing a sum rule of tunnelling conductance. Our study paves the way for understanding and engineering of non-equilibrium quantum states in nano-devices.

Keywords:

Floquet-Anreev states, Graphene Josephson junction, Superconducting tunnelling spectroscopy, Non-equilibrium physics, Anreev Bound states

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.05

Features of Shapiro steps in the presence of 4π-periodic Josephson current

PARK Jinho [1], CHOI Yong-Bin [1], LEE Gil-Ho [1], LEE Hu-Jong [*1]
[1]Physics Department, POSTECH
hjlee@postech.ac.kr

Abstract:

Majorana bound state (MBS) residing at the boundary of a topological superconductor has drawn a great deal of interest recently, because it provides a platform to explore fundamental physics such as non-Abelian statistics as well as to realize fault-tolerant quantum computation. Doubled Shapiro steps in a Josephson junction (JJ) under microwave irradiation has been regarded as a strong evidence for the emergence of the MBS at the junction edges. Up to date, however, it has not been fully understood how the Shapiro steps responds to the presence of 4π-periodic Josephson current. In this study, we investigated the characteristic features of Shapiro steps depending on the ratio (α) of 4π-periodic current to the trivial 2π-periodic one as well as the microwave frequency (Ω) and the McCumber parameter (β) of a junction. Our analysis reproduces the Shapiro steps similar to those experimentally observed with respect to the parameters α, β and $\beta \geq 1.0$. We also revealed that the first lobe of n=1 step can survive as long as a junction is not purely 2π-periodic. Therefore, the full suppression of the first lobe of n=1 step at least guarantees the presence of 4π-periodic Josephson current. In addition, we determined the observation conditions for the full suppression of the first lobe of n=1 step even for small $\alpha \leq 0.1$: sufficiently small Ω and the hysteresis in the junction behavior. To that end, a junction should have a large I_cR_N product and sufficiently large capacitance to resolve the caused by the even-odd behavior of Shapiro steps.

Keywords:

Majorana fermion, Josephson junction, Shapiro step

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B8.06

Nanomechanical bolometry by using a semiconducting nanowires at millikelvin temperatures

KIM Jihwan [1], CHA Jinwoong [2], RYU Younghun [1], PARK Suk In [3], SONG JinDong [3], SUH Junho [*2]
[1]Department of Physics, KAIST
[2]Quantum Technology Institute, KRISS
[3]Center for Opto-Electronics Materials and Devices Research, KIST
junho.suh@kriss.re.kr

Abstract:

The cavity electromechanical system with a semiconducting nanowire enables bolometric microwave power measurement due to the microwave loss at the resistive nanowire. The device consists of an InAs nanowire mechanical resonator and a superconducting microwave resonator. The suspended InAs nanowire is capacitively coupled to the microwave resonator via vacuum gap and its mechanical motion generates the sideband signal of the microwave resonator. The resistive component of the InAs nanowire provides the microwave dissipation, resulting the temperature increasement at the nanowire. This increasing temperature consequently shifts mechanical resonant frequency. We utilize this frequency shift to measure the microwave power by measuring the mechanical sideband signal. The circuit model analysis provides the optimal resistance for the nanomehcanical microwave bolometry. Our technique could be useful to measure the microwave power in the ranges of few pico-watts to nano-watts and this range is suitable for the quantum electornics applications requiring strong microwave power pump.

Keywords:

Bolometer, Nanowire, Cavity Electromechanics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B9.02

Study on interlayer interactions in $WSe_2/MoSe_2$ heterostructures

LIM Soo Yeon [1], CHEONG Hyeonsik *[1]
[1]Department of Physics, Sogang University
hcheong@sogang.ac.kr

Abstract:

Heterostructures based on 2-dimensional-hexagonal transition metal dichalcogenides (TMDs) have recently emerged because of their distinct physical properties. For example, the electrons and holes residing in different layers can be bound and form the interlayer excitons. The interlayer excitons have orders of magnitudes longer lifetime than the intralayer excitons in single materials. Moiré patterns originated from two periodic hexagonal structures of each layer also lead to periodic potential wells. Although much research on TMD-based heterostructures have been intensively performed so far, the interlayer interaction is not fully understood yet.

We fabricated heterostructures of monolayer WSe_2 and $MoSe_2$ on SiO_2/Si substrates using the dry transfer method. We performed Raman spectroscopy on the heterostructure samples with the twist angle in the range of 0°~30°. We classified the 2H- and 3R-types of samples with ~ 0 ° of the twist angle using shear-like and breathing-like interlayer vibrational modes and some activated intralayer vibrational modes. Additionally, zone-folded phonon due to the Moiré potential were observed depending on the twist angle. Photoluminescence (PL) signals from the interlayer excitons were observed both at room temperature or at 9 K. We performed photoluminescence excitation (PLE) and reflectance spectroscopy on the heterostructures using a collimated broadband light combined with a wavelength selector as the excitation source. The feature of the A exciton and B exciton states of each monolayer were observed in the PLE spectra.

Keywords:

WSe2, MoSe2, heterostructure, Interlayer exciton, Moiré phonon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B9.03

Structural and electronic band modulations in MoS_2/WSe_2 heterostructure due to interlayer interaction

KIM Jungcheol [1], JO Jaeyeon [2], KIM Miyoung [2], YOO Hyobin [1], CHEONG Hyeonsik [*1]
[1]Department of Physics, Sogang University
[2]Department of Materials Science and Engineering and Research Institute of Advanced Materials, Seoul National University
hcheong@sogang.ac.kr

Abstract:

Recently, heterostructures of transition metal dichalcogenides (TMDs) have attracted much interest owing to their unique physical properties. One of the most interesting characteristics is the large exciton energy of TMDs [1]. Besides, the variations in the bandgaps of TMDs allow band engineering of heterojunctions for various applications. As the electronic band structures of TMDs are highly dependent on the number of layers [2], the interlayer interaction between constituent layers in the heterostructure also affects the band structure [3]. However, in most heterostructure studies, the band structure of the heterostructure is assumed to be a simple sum of the band structures of each of the two materials, ignoring the change in the band structure due to the interlayer interaction. Therefore, understanding the changes in the band structure of the TMD heterostructure is important for their applications. Here, we fabricated MoS_2/WSe_2 heterostructures with various twist-angles to the systematic study of the electronic band structure change in heterostructure. The structural changes resulting from interlayer interactions between the heterostructure interfaces were investigated using polarized Raman and STEM measurements. We also investigated the change of exciton energies as a function of the twist-angle and studied the effect of the interlayer interaction on the band structure of heterostructure.

[1] A. Chernikov *et al.*, Phys. Rev. Lett. **113**, 1 (2014).
[2] A. Splendiani *et al.*, Nano Lett. **10**, 1271 (2010).
[3] E. M. Alexeev *et al.*, Nature **567**, 81 (2019).

Keywords:

2D Materials, transitio metal dichalcogenides, heterostructure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B9.04

Spatially selective surface charge transfer doping for enhancing electrical characteristics of MoS_2 field-effect transistors

JEONG Inho [1,2], KIM Jaeyoung [3], SHIN Jiwon [3], SONG Minwoo [3], KIM Gyu-Tae [2], LEE Takhee [3], CHUNG Seungjun [*1]
[1]Soft Hybrid Materials Research Center, KIST
[2]Dept. of Electrical Engineering, Korea University
[3]Dept. of Physics and Astronomy, Seoul National University
seungjun@kist.re.kr

Abstract:

Two-dimensional transition metal dichalcogenides (TMDs), have gained great attention due to its high carrier mobility, chemical and thermal stability, absence of dangling bond, and tunable electronic energy band depending on a number of layers.[1] Especially, compared to TMDs produced by top-down methods, such as mechanical exfoliation, chemical vapor deposition (CVD)-synthesized molybdenum disulfide (MoS_2) films exhibit atomically thin, uniform, and large-area semiconducting properties with a direct band gap energy of 1.9 eV with high-yield, and thus offer promising opportunities in the realization of emerging field-effect transistors (FETs) and optoelectronic devices.

One of the key technical issues is the modulation of their electrical characteristics including carrier density, threshold voltage and on/off ratio that are critical to be utilized in a wide range of applications with substituting conventional silicon-based semiconductor devices. Therefore, many research groups have address them by employing a variety types of doping processes.[2] Among promising candidates, surface charge transfer doping with the charge transfer mechanism between deposited dopants and host materials have been widely investigated. Specifically, the electronic structure of the host materials remains unaltered during the doping process, therefore, this attractive advantages provides the ability to control the carrier sheet density reversibly.[3]

To date, surface charge transfer doping is typically conducted *via* a solution-immersion or vapor-phase doping methods to deposit organic dopants onto the TMDs surface. However, because the modulation of their electrical characteristics are only determined by immersion time and the dopant concentration, the effective amount of dopants which critically affects the characteristics of host MoS_2 cannot be precisely controlled. Furthermore, it is of fundamental importance to enable spatially selective doping on demand that allows us to implement integrated circuit applications beyond laboratory-scaled single device.

In this presentation, we will report surface charge transfer doping by using drop-on-demand selective inkjet printing with the use of air-stable surface charge transfer donor, benzyl viologen (BV). The BV ink was carefully optimized considering the dopant concentration and fluid characteristics including viscosity, surface tension, density, and inertia force which allows the creation of a well-defined ink droplet in flight after ejection from the nozzle. With these efforts, we can enhance the electrical

performance of MoS_2-FETs via surface charge transfer doping using inkjet printing spatially on demand.

[1] Z. Yu, Z-Y. Ong, S. Li, J-B. Xu, G. Zhang, Y-W. Zhang, Y. Shi, X. Wang, Adv. Funct. Mater. 27, 1604093 (2017).
[2] M.W. Iqbal, E. Elahi, A. Amin, G. Hussain, S. Aftab, Superlattice. Microst. 137, 106350 (2020).
[3] D. Kiriya, M. Tosun, P. Zhao, JS. Kang, A. Javey, J. Am. Chem. Soc. 136, 7853 (2014).

Keywords:

TMDs, Surface charge transfer doping, Inkjet printing, Field-effect transistor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B9.05

Light-induced carrier behaviors in single-layer MoS2 flakes investigated with Kelvin probe force microscopy

PARK Ji-Yong *[1], YIM Woongbin [1], NGUYEN Van Tu [1]
[1]Ajou University
jiyong@ajou.ac.kr

Abstract:

이황화 몰리브덴 (MoS2)은 대표적인 이차원 반도체 물질로 고유한 광전특성으로 인해 많은 연구가 되고 있다. 본 연구에서는 켈빈 프로브 힘 현미경 (KPFM)으로 표면 광전압 변화를 측정함으로써, 빛의 입사에 따른 단일층 MoS2 에서의 전하거동을 관찰하였다. KPFM 측정을 통해 MoS2 에서 빛의 입사에 의한 전하 캐리어 생성, 확산 및 재결합 과정을 시각화하였고, 이는 생성된 전하의 수직방향 재배치를 보여주는 결과이다. 또한 입사하는 빛의 세기에 따른 전하거동 양상의 변화와 표면 처리에 따른 특성변화 관찰결과는 화학기상증착법으로 성장된 MoS2 의 광반응 특성의 공간적 양상과 불균일성을 보여주고 있다.

Keywords:

KPFM, MoS2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B9.06

Deep learning based TEM image analysis for identification of point defects and polymorphs in TMDCs

CHOI Soyeon [1], JUNG Joowon [1], LEE Kihyun [1], PARK Jinsup [1], LEE Sol [1], LEE Yangjin [1], KIM Kwanpyo [*1]

[1]Physics, Yonsei University
kpkim@yonsei.ac.kr

Abstract:

Identifying structural features in scanning transmission electron microscope (STEM) images of crystalline materials is important in studying structure-property correlations, but traditional methods for identification are often time-consuming and require expertise. Recent advances in deep learning for computer vision, in particular the use of convolutional neural networks (CNNs), holds promise for efficient high-throughput STEM image analysis. Here we investigate the generalizability of CNNs in identifying point defects and polymorphs in STEM images of transition metal dichalcogenides (TMDCs) in the presence of different levels of noise and aberrations. We focus on the application of ResUNet, a type of fully convolutional neural network, in identifying sulfur vacancies and different polymorphs of molybdenum disulfide (MoS_2). Based on these results, we hope to provide a guideline on best practices to train a deep learning model to identify structural features of interest in STEM images.

Keywords:

Deep learning, Convolutional neural networks (CNNs), Scanning transmission electron microscopy (STEM), Transition metal dichalcogenides (TMDCs)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B10.01

Magnetic Skyrmions Studied by Full-Field Soft X-ray Microscopy

IM Mi-Young *[1], JE Soong-Geun [2], SOUMYANARAYANAN Anjan [3], BROCK Jeffrey A.[4], WANG Zidong [5], JIANG Wanjun [5]
[1]Center for X-ray Optics, Lawrence Berkeley National Laboratory
[2]Department of Physics, Chonnam National University
[3]Institute of Materials Research and Engineering, Agency for Science, Technology and Research
[4]Center for Memory and Recording Research, University of California San Diego
[5]State Key Laboratory of Low-Dimensional Quantum Physics and Department of Physics, Tsinghua University
mim@lbl.gov

Abstract:

Magnetic skyrmions are topologically stable particle-like spin textures, which have attracted massive interests not only due to their fascinating features for understanding the fundamental physics of nanospin behavior but also their potentials in a wealth of technological applications for high efficient storage/memory and computing devices [1]. Magnetic skyrmions can store and transfer information and therefore, are promising building blocks for future spintronic devices. In the research of skyrmions, direct observation of skyrmions and their static and dynamic behaviors has been strongly encouraged since it provides a powerful insight into the underlying physics of nanospin phenomena and essential information for their applications. We have tackled scientific and technologically relevant questions for skyrmions based on direct imaging them utilizing a full-field soft X-ray transmission microscope at Advanced Light Source (XM-1, BL6.1.2). In this talk, I will discuss some critical issues on magnetic skyrmions addressed in our research: effective creating room temperature skyrmions [2, 3], selective creating and deleting of skyrmions [4].
[1] A. Fert, N. Reyren, V. Cros, Nature Rev. Mat. 2, 17031 (2017).
[2] J.A. Brock et al., Phys. Rev. Materials 4 (10), 104409 (2020).
[3] Zidong Wang et al., Nat. Electron 3, 672 (2020).
[4] Soong-Geun Je et al., Nano Letters, 21, 3, 1253 (2021).

Keywords:

Magnetic skyrmions, Topological spin texture, X-ray microscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B10.02

Thermal effects on the skyrmion dynamics

JIANG Wanjun *[1]
[1]State Key Laboratory of Low-Dimensional Quantum Physics and Department of Physics, Tsinghua University
jiang_lab@tsinghua.edu.cn

Abstract:

Skyrmions are particle-like topological spin textures stabilized by the Dzyaloshinskii-Moriya interaction, which have recently stimulated great interests in spintronics community. The dynamics of which have been frequently studied via using magnetic fields and current-induced spin torques. On the other hand, a comprehensive understanding of thermal effects, including random thermal fluctuation and directional thermal currents, on the dynamics of skyrmions are not fully established yet.
In this talk, I will first discuss our recent experimental observation of the thermal fluctuation-induced random walk of a single isolated Néel-type magnetic skyrmion in an interfacially asymmetric Ta/CoFeB/TaO_x multilayer. In particular, an intriguing topology dependent Brownian gyromotion behavior of skyrmions has been identified. The onset of Brownian gyromotion of a single skyrmion induced by the thermal effects, including a nonlinear temperature-dependent diffusion coefficient and topology-dependent gyromotion are further formulated based on the stochastic Thiele equation.
Subsequently, I will discuss the thermal generation, manipulation and detection of nanoscale skyrmions, which were made in microstructured devices made of different multilayers – $[Ta/CoFeB/MgO]_{15}$, $[Pt/CoFeB/MgO/Ta]_{15}$ and $[Pt/Co/Ta]_{15}$ integrated with on-chip heaters, by using a full-field soft X-ray microscopy. In particular, the thermal generation of densely packed skyrmions at the device edge, together with the unidirectional diffusion of skyrmions from the hot region towards the cold region were experimentally observed. These thermally generated skyrmions can be further electrically detected by measuring the accompanied anomalous Nernst voltages. These results could open another exciting avenue for enabling skyrmionics, and promote interdisciplinary studies among spin caloritronics, magnonics and skyrmionics.

Keywords:

Magnetism, Spintronics, Skyrmions, Thermal effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B10.03

Creating and Manipulating Magnetic Skyrmions

SOUMYANARAYANAN Anjan *[1,2]
[1]Physics Department, National University of Singapore
[2]Institute of Materials Research & Engineering, Agency for Science, Technology & Research (A*STAR)
anjan@nus.edu.sg

Abstract:

Magnetic skyrmions are topological spin structures emerging from the interplay of atomic-scale magnetic interactions. Their room temperature stability and tunability in multilayer films has spawned a fascinating research field witnessing rapid progress in fundamental science and device applications. Practical technologies require skyrmions stable in the absence of external fields, together with the ability to electrically write, move, and read them within device configurations.
Here we describe our efforts to investigate skyrmion creation and manipulation in multilayer films and devices. First, we present our finding of a distinct macroscopic marker associated with zero field (ZF) skyrmion stability in conventional multilayers. Using this technique, we show that, counterintuitively, skyrmion stability is enhanced at higher temperatures. Next, we examine synthetic antiferromagnetic films – which present a facile means to stabilize compact ZF skyrmions. We conclude with efforts to electrically write, delete, and move skyrmions in nanowire devices.

Keywords:

Magnetism, Spintronics, Skyrmions, Thin Films, Microscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B11.01

OPERANDO ANALYSES OF THE ORGANIC DEVICES BY SUM-FREQUENCY GENERATION SPECTROSCOPY

MIYAMAE Takayuki *1,2
[1]Graduate School of Engineering, Chiba University
[2]Molecular Chirality Research Center, Chiba University
t-miyamae@chiba-u.jp

Abstract:

The organic field-effect transistors (OFETs) with the flexibility and low-cost processability have widely attracted much attention as the key component of “plastic” electronics devices, such as flexible displays, radio-frequency identification tags and sensor devices. Recently, the OFET performance was remarkably improved owing to the development of air-stable thienoacene-based semiconductors with various substituents and the optimization of the crystal structure of organic semiconductors and the device fabrication techniques.[1,2)] Although the current field-effect mobility in OFETs reaches comparable to that of amorphous silicon transistors, a further improvement in the mobility of OFETs is required to enable practical use of innovative organic electronics devices.

Second-order nonlinear optical spectroscopies such as second harmonic generation and sum frequency generation are powerful techniques for investigating the charging behavior at the specific interfaces of OFETs. The electric field induced sum-frequency generation (EFI-SFG) can probe the behavior of charge accumulation of the various organic devices at the molecular level. When the static electric field E_0 is applied to the system, the SFG signal intensity (I_{SFG}) is given by

$$I_{SFG} \propto |P|^2 = \left|\chi^{(2)} + \chi^{(3)} E_0\right|^2 I_{VIS}(\omega) I_{IR}(\omega)$$

where P is the nonlinear polarization, $I_{VIS}(\omega)$ and $I_{IR}(\omega)$ are the intensities of the visible (VIS) and infrared (IR) light source, respectively. $\chi^{(2)}$ and $\chi^{(3)}$ are the second- and third-order nonlinear susceptibilities, and E_0 is the magnitude of the DC electric field. Since the effective nonlinear susceptibility contains the electric field terms, and the effective SFG field amplitude is proportional to E_0. Therefore, the SFG intensity can be used to investigate the electric field distribution under the operation of the organic devices.

In this report, we present direct observation and visualization of the electric field due to charge transportation and accumulation under the operation of OFETs with 2,7-diphenyl[1]benzothieno[3,2-b][1]benzothiophene (DPh-BTBT) by using sum-frequency generation imaging microscopy coupled with compressive sensing technique (CS-SFG).[3)] SFG imaging microscopy is an exciting novel micro-spectroscopic technique for measuring both dimensional and spatial position information on molecules existing at the surface and interfaces with high spatial and spectral resolutions.[4,5)] This hyperspectral chemical imaging technique is expected to bring new perspectives for the characterization of the organic field-effect transistors.

1) K. Takimiya, S. Shinamura, I. Osaka and E. Miyazaki, *Adv. Mater.*, 2011, **23**, 4347–4370.
2) K. Takimiya, H. Ebata, K. Sakamoto, T. Izawa, T. Otsubo and Y. Kunugi, *J. Am. Chem. Soc*, 2006, **128**, 12604–12605.
3) C. Katagiri, T. Miyamae, H. Li, F. Yang, and S. Baldelli, *Phys. Chem. Chem. Phys.*, 2021, DOI: 10.1039/D0CP06407F.
4) D. Zheng, L. Lu, Y. Li, K. F. Kelly and S. Baldelli, *J. Phys. Chem. Lett.*, 2016, **7**, 1781–1787.
5) Z. Sun, D. Zheng and S. Baldelli, *J. Phys. Chem. C,* 2018, **122**, 26543–26553.

Keywords:

Organic field-effect transistors, interface, operando analysis

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B11.02

Aesthetic and Colorful: Dichroic Polymer Solar Cells Using High-Performance Fabry-Pérot Etalon Electrodes with a Unique Sb_2O_3 Cavity

YEOM Hye Rim [1], SONG Seyeong [1], WOO Han Young [*2], KIM Jin Young [*1]
[1]Department of Energy Engineering, Ulsan National Institute of Science and Technology (UNIST)
[2]Department of Chemistry, Korea University
hywoo@korea.ac.kr, jykim@unist.ac.kr

Abstract:

Semitransparent organic solar cells (STOSCs) are a technology that combines the benefits of visible light transparency and light-to-electrical energy conversion. One of the greatest opportunities for STOSCs is their integration into windows and skylights in energy-sustainable buildings. For this application, the aesthetic aspects of solar cells may be as important as their electrical performance. Here, our strategy enables to achieve high-quality and colorful STOSCs using Fabry-Pérot etalon-type electrodes. These electrodes are composed of an antimony oxide (Sb_2O_3) cavity layer and two thin Ag mirrors. These dichroic tri-layer structures perform two functions as top conducting electrodes and color filters. These dual-function electrodes were applied to photovoltaic devices and displayed vivid colors, natural transparency, and good performance as compared to devices that use conventional metal electrodes. Furthermore, to achieve saturated colors and low photocurrent losses, active layer materials were selected such that their transmittance peaks matched the transmittance maxima of the electrodes. These strategies for colorful STOSCs result in power conversion efficiencies (PCEs) of up to 13.3% and maximum transmittances (T_{MAX}) of 24.6% in blue devices, PCEs of up to 9.71% and T_{MAX} of 35.4% in green devices, and PCEs of up to 7.63% and T_{MAX} of 34.7% in red devices.

Keywords:

Sb2O3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B11.03

EFFICIENT ELECTRON INJECTION INTO ORGANIC SEMICONDUCTORS UTILIZING BASES

FUKAGAWA Hirohiko [*1]
[1]NHK Science & Technology Research Laboratories
fukagawa.h-fe@nhk.or.jp

Abstract:

Barrier-free contact from electrodes to organic semiconductors has been critical to the development of organic devices such as organic light-emitting diodes (OLEDs), organic solar cells and organic thin-film transistors. Since the work function (WF) of stable electrodes such as indium tin oxide electrodes is generally over 4.5 eV, it has been relatively easy to inject/extract holes from such electrodes since there are many organic semiconductors with an ionization potential of about 5 eV. On the other hand, since the electron affinity of organic semiconductors suitable for optoelectronic devices is generally less than 3 eV, it has been difficult to inject/extract electrons from such electrodes. Thus, alkali metals capable of donating electrons to the unoccupied states of organic semiconductors because of their low WF have been widely used as the electron injection layer (EIL) in OLEDs, light-emitting organic thin-film transistors and organic semiconductor laser diodes. However, the applicability of alkali metals has been proven to be limited by their high reactivity and diffusivity. An electron injection method without using alkali metals will contribute to expanding the possibilities of organic devices, such as facilitating their fabrication on flexible plastic substrates, where strict encapsulation is difficult to achieve. Here, we show novel strategies for efficient electron injection into organic semiconductors, which is realized by utilizing the weak chemical interaction with stable bases. The effect of bases on the electron injection efficiency was investigated by using them as the EIL in OLEDs. It was demonstrated that the efficient electron injection using bases arises from the formation of hydrogen bonds between the electron-transporting material and the bases, and the injection efficiency is mainly determined by the basicity of the bases. In another study, we found that the coordination reaction between bases and electrodes is useful for producing a stable electrode with a low WF, and the change in the WF is mainly dominated by the amount of electron transfer associated with the coordination reaction. Since both the air stability and the operational stability of these EILs were demonstrated to be high, our findings pave the way for electronic systems that do not require air-sensitive materials.

Keywords:

organic semiconductors

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B11.04

Charge carrier dynamics at organic interface by 2-photon photoemission

KIM Jeong Won *[1]
[1]KRISS
jeongwonk@kriss.re.kr

Abstract:

Among fundamental issues in photophysics and photochemistry, charge generation and separation/recombination at material interfaces are important issues to be studied for high efficiency in optoelectronic devices. Organic/inorganic or organic/organic heterojunctions are fundamental building block of the future generation photovoltaics where the charge separation takes place near the heterointerface. Firstly, to unveil physical behavior of hybrid “Frenkel-Wannier exciton” at the organic/inorganic hybrid interface, I focus on a typical semiconducting material combination, gallium arsenide (GaAs) as inorganic absorber and copper phthalocyanine (CuPc) as organic counterpart. Ultrafast charge transport and separation dynamics are studied by using time-resolved two-photon photoemission spectroscopy (TR-2PPE). CuPc/p-GaAs shows hole injection behavior depending on light intensity [1]. In addition, the photo-generated carriers within GaAs exhibit a few different pathways of relaxation and transfer on picosecond time scale time. At the CuPc/p-GaAs interface, a “hybrid charge transfer exciton (HCTE) state” [2] evolves right after the hole injection from GaAs to CuPc. The initial HCTE state splits into relaxed HCTE states and triplet state (T1) in CuPc. The formation of T1 may be applied to a low power LED if the relaxation to HCTE states is blocked [3].
As second case for organic/organic heterointerface, we compare electron dynamics of ZnPc/C_{60} and CuPc/C_{60} interfaces. Control of CuPc molecular plane by templating effect into lying-down orientation enhances charge separation and interface charge transfer exciton formation. This effect corresponds especially to the increase of open circuit voltage in actual solar cell performance. The face-on orientation of the donor/acceptor interface facilitates interface charge transfer exciton formation competing non-radiative recombination by better molecular orbital overlap.

References

[1] H. Park, et al, “Optical Probe of Charge Separation at Organic/Inorganic Semiconductor Interfaces” J. Phys. Chem. C, 117, 10974 (2013).
[2] C. K. Renshaw and S. R. Forrest, “Excited state and charge dynamics of hybrid organic/inorganic heterojunctions. I. Theory” Phys. Rev. B, 90, 045302 (2014).
[3] H. Lim, at al, “Delayed Triplet-State Formation through Hybrid Charge Transfer Exciton at Copper Phthalocyanine/GaAs Heterojunction”, J. Phys. Chem. Lett. 8, 4763 (2017).
[4] H. Lim, et al, “Influence of the metal phthalocyanine molecular orientation on charge separation at the organic donor/acceptor interface”, J. Mater. Chem. C 9, 2156 (2021).

Keywords:

Charge carrier dynamics, Metal Phthalocyanine, Molecular orientation, 2-photon photoemission

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B12.01

Time-dependent DFT study for photon-dressed spin states, second-order Hall effect of insulators, and resonant amplification of hydrogen production

PARK Noejung *1
[1]Department of Physics, UNIST
noejung@unist.ac.kr

Abstract:

We explored materials state coupled with a strong or weak light field by implementing the light field as a vector potential in the kinetic part of the Kohn-Sham Hamiltonian. In this talk, a few examples that we have worked on are presented, and the effectiveness of this computation method in the description of light-matter interaction is presented. As a response to a weak static uniform electric field, we calculated the intrinsic conductivity that can enumerate the topological numbers of quantum Hall or quantum spin Hall insulators [1]. In response to a strong field, we present that insulators exhibit a transverse oscillation of current in their second-order spectra, proportional to the Berry curvature dipole[2,3]. In a sense, this second-order Hall effect is analogous to the nonlinear Hall effect of noncentrosymmetric metals and the circular photogalvanic effect of insulators. We also investigate the strong-coupling limit of the molecular vibrations and spin dynamics driven by a strong external field [4]. We found that a well-selected combination of the resonance and off-resonance frequency of the light amplify the molecular vibrations very efficiently. We discuss this selective activation of the particular molecular bond in view of the hydrogen generation from hydrocarbons or waters.

[1] Shin et al., PNAS 4135, 116 (2019)
[2] Sodemann et al., Phys. Rev. Lett. 115, 21(2015)
[3] Ma et al., Nature 565, 337 (2019)
[4] Okyay et al. Phy. Rev. B (2020)

Keywords:

Time-dependent density functional theory, photon-dressed spin state, hydrogen production

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B12.02

Carrier Multiplication in Nanosystems

BANG Junhyeok *[1], KANG Joongoo [2]
[1]Department of Physics, Chungbuk National University
[2]Department of Emerging Materials Science, DGIST
jbang@cbnu.ac.kr

Abstract:

Carrier multiplication (CM) is a fundamental process of an excited carrier that generates multi-electron-hole pairs from a single exciton, and thus it can enhance optoelectronic device efficiency. However, CM is rather inefficient in conventional semiconductors because of strong restrictions imposed by the energy and momentum conservation. Here, using real-time time-dependent density functional theory, we show that CM occurs in carbon-based nanosystems due to the existence of subbands. The CM mechanism is different from the ones suggested for quantum dots and graphene. Furthermore, the band gap of the carbon-based nanosystem is significantly modulated depending on system size, and thus it provides the way to control the carrier dynamics and carrier multiplication.

Keywords:

Carrier Multiplication, Excited state dynamics, real-time time-dependent density functional theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B12.03

First-principles study of extended defects in halide perovskites

PARK Ji-Sang *1
[1]Physics, Kyungpook National University
jisangparkphys@gmail.com

Abstract:

Halide perovskite solar cells have received much attention. Similar to other thin-film solar cells, halide perovskite solar cells usually have a polycrystalline absorber material, and thus by definition, many grain boundaries are formed in them. Grain boundaries are likely to have more defects than grain interior, therefore the solar conversion efficiency is expected to decreases with decreasing of the grain size due to faster charge recombination. However, there have been long discussions about whether grain boundaries in halide perovskites can be utilized in beneficial ways or not [1]. Furthermore, early density functional theory studies reported that the grain boundaries have no deep levels. In this talk, we discuss how grain boundaries in halide perovskites become active non-radiative recombination centers through defect segregation [2]. The formation of polytypes and stacking faults in halide perovskites will be also discussed in terms of stability and the electronic structure [3].

[1] Ji-Sang Park and Aron Walsh, Annual Review of Condensed Matter Physics (2021).
[2] Ji-Sang Park, et al., ACS Energy Letters 4, 1321 (2019).
[3] Ji-Sang Park, et al., ACS Energy Letters 5, 2231 (2020).

Keywords:

grain boundary, perovskite, polytype, DFT

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B12.04

Benchmarking CO_2 Adsorption Energies and Geometries in Diamine-Functionalized Metal-Organic Frameworks with Density Functional Theory

LEE Jung-Hoon *1
[1]Computational Science Research Center, Korea Institute of Science and Technology (KIST)
jhlee84@kist.re.kr

Abstract:

Diamine-functionalized M_2(dobpdc) (M = Mg, Mn, Fe, Co, Zn) metal-organic frameworks (MOFs) are currently being intensively investigated because they provide excellent CO_2 capture performance, exhibiting a step-shaped isotherm. To understand their CO_2 adsorption properties and mechanisms, quantum mechanical calculations with near-chemical accuracy (~6 kJ/mol, an averaged experimental error) are required. We present density functional theory (DFT) calculations of CO_2 adsorption in m-2-m–Zn_2(dobpdc) with different exchange-correlation functionals, including semilocal exchange-correlation functionals (PBE and two revised PBE functionals), semiempirical pairwise corrections (D3 and TS), nonlocal van der Waals correlation functionals (vdW-optB88, vdW-DF1, vdW-DF2, revised vdW-DF2, vdW-DF-CX, and revised VV10), and a meta-GGA (SCAN). Overall, we find that revPBE+D3 and rPBE+D3 show the best performance for both the lattice parameters and the CO_2 binding enthalpy of m-2-m–Zn_2(dobpdc). revPBE+D3 and rPBE+D3 predict the lattice parameters of m-2-m–Zn_2(dobpdc) within 1.4 % error. The CO_2 binding enthalpies (~–68 kJ/mol) computed by revPBE+D3 and rPBE+D3 are in good agreement with experiment (~–57 kJ/mol). Although PBE (–57.7 kJ/mol), vdW-DF1 (–49.6 kJ/mol), and vdW-DF2 (–44.3 kJ/mol) also well predict the CO_2 binding enthalpy, they relatively overestimate lattice parameters and bond lengths. The other functionals predict the lattice parameters with the same accuracy as revPBE+D3 and rPBE+D3. However, they overbind by around 30-50 kJ/mol. According to our benchmark calculations, the good performance of revPBE+D3 and rPBE+D3 is because they best predict the formation enthalpy and the lattice parameters of ammonium carbamate, a primary product of the cooperative CO_2 insertion in diamine-functionalized M_2(dobpdc) MOFs. Based on this, we examine the performance of rPBE+D3 for the structural parameters and CO_2 binding enthalpies of thirteen diamine-functionalized Mg_2(dobpdc) MOFs. Our calculations show that rPBE+D3 can successfully reproduce the experimental CO_2 binding enthalpies, and reveal a logarithmic relationship between the step pressure and the CO_2 binding enthalpy of thirteen diamine-functionalized Mg_2(dobpdc) MOFs. Overall, we recommend revPBE+D3 and rPBE+D3 for evaluating and understanding the structure and binding properties of diamine-functionalized M_2(dobpdc) MOFs. The results of our benchmarking study can help guide the development of versatile vdW-corrected DFT methods.

Keywords:

Density Functional Theory (DFT)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.01

Statistical physics of data

JO Junghyo *[1]
[1]Department of Physics Education, Seoul National University
jojunghyo@snu.ac.kr

Abstract:

Inferring systems from data is an intriguing problem. The basic concepts of statistical mechanics play fundamental roles for the system identification. I will introduce our recent works on the reconstruction of causal networks from noisy time series. In particular, we consider the existence of hidden variables and the possibility of missing data. As a specific demonstration, we recover a neural network and dynamics from neuronal activity data.

Keywords:

Kinetic Ising model, Causal inference, Linear regression

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.02

Effectiveness of the vaccination and quarantine policy to suppress the spreading of COVID-19 (코로나-19 백신접종과 격리정책의 효율성)

JANG Gyeong-Hwan [1], LEE Mi Jin [1], SON Seung-Woo [*1]
[1]Department of Applied Physics, Hanyang University
sonswoo@hanyang.ac.kr

Abstract:

오늘날 전세계는 코로나-19 로 인하여 사회적 경제적 피해를 받고 있다. 코로나-19 로 인한 피해를 줄이기 위해 많은 나라들이 사회적 거리두기와 격리 같은 사회정책을 이용하여 감염자와의 접촉을 줄이도록 하고 있다. 다른 방법으로는 백신 접종으로 전염율을 낮추려 하고 있다. 최근의 연구들에서 전염병 전파모델을 이용하여 사회정책과 백신 접종의 효율성에 대해서 증명하였다. 본 연구에서는 사회정책과 백신의 효율성을 동시에 모두 고려하는 SVEIQR 모델을 제안한다. 먼저 서울시의 코로나-19 실시간 감염자 현황을 이용한 베이즈 추론으로 기초재생산지수를 구하고, 이를 이용한 시뮬레이션이 실제 감염자 현황을 잘 예측하는것을 확인하였다. 기초재생산지수와 임상학적으로 얻은 각 백신들의 전염병 예방율을 SVEIQR 모델에 적용하였을때, 각 백신에 따른 감염자 감소 추세를 확인하였다. 더나아가 각 백신의 접종률에 따른 감염자 수 감소 경향과, 사회정책에 의한 감염자수 감소 경향을 비교하여 어느 요소가 더 유효한지 살펴보았다. 본 연구는 백신 접종과 사회정책의 효율적인 적용을 위한 정책수립에 방향을 제시할 수 있을 것이다.

Keywords:

Epidemic, Compartment model, COVID-19, Vaccine, Quarantine

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.03

Effective epidemic control model on multilayer networks

KIM Minsuk [1], YOOK Soon Hyung *[1]
[1]Department of Physics, Kyung Hee University
syook@khu.ac.kr

Abstract:

대한민국 질병관리청(Korea Disease Control and Prevention Agency, KDCA)의 국소적 격리 전략은 사회 및 경제 체계의 극심한 붕괴 없이 코로나바이러스감염증-19 의 확산을 효과적으로 억제하고 있다고 평가받고 있다. 본 연구에서는 이러한 국소적 격리 전략을 반영한 SIRQ(Susceptible-Infected-Recovered-Quarantined) 모형을 제시한다. 두 층으로 이루어진 다층 네트워크를 구성하여 한 층에 대해서만 국소적 격리 전략을 적용하도록 모형을 고안했다. 전산 시뮬레이션을 통하여 국소적 격리 전략이 얼마나 효과적으로 감염병 확산을 억제할 수 있는지 살펴보았다. 특히 감염 상태의 노드가 줄어들었다가 다시 증가하는 감염병 재확산(epidemic resurgence)이 나타나는 것을 발견하였다. 이를 토대로 다층 네트워크 구조에서의 효과적인 감염병 억제의 방법을 논한다.

Keywords:

Epidemic spreading, complex network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.04

Urban traffic analysis through the percolation of road networks

KWON Yongsung [2], SON Seung-Woo *[1,2], LEE Mi Jin [1]
[1]Department of Applied Physics, Hanyang University
[2]Department of Applied Artificial Intelligence, Hanyang University
sonswoo@hanyang.ac.kr

Abstract:

도로 교통 네트워크는 사람들의 삶에 밀접한 관련이 있다. 특히 대도시같이 인구가 밀집된 지역은 교통이 집중되기 때문에 교통체증이 자주 발생한다. 또한 한 도로에서 교통 체증이 발생할 때 주변 도로의 교통에도 영향을 준다. 최근 연구에서 실제 도로 네트워크에 퍼콜레이션을 적용한 사례가 늘고 있다. 그러나 교통량이 입력된 도로 네트워크에 일반 퍼콜레이션의 보편성(universality)에 적용하는 것은 위험하다. 도로 네트워크는 인접한 도로 사이에 교통량 간의 상관관계가 존재하기 때문에 일반 퍼콜레이션과는 다르게 봐야한다. 이러한 차이를 알아보기 위해 도로 네트워크에 퍼콜레이션 이론을 적용하여 임계지수를 분석했다. 실제 교통량이 입력된 서울시 도로 네트워크를 이용해 상관관계를 고려한 도로 네트워크와 고려하지 않은 도로 네트워크의 퍼콜레이션 임계지수가 다른 것을 확인했다. 상관관계가 존재하는 네트워크에 새롭게 정의된 보편성에 적용해야 하는 것을 밝혔고, 상관관계가 존재하는 네트워크의 발전은 도로 네트워크뿐 아니라 많은 분야에 도움이 될 것이다.

Keywords:

network traffic percolation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.05

Polarized social mobilization for pandemic control

HONG Inho *[1], RUTHERFORD Alex [1], CEBRIAN Manuel [1]
[1]Center for Humans and Machines, Max Planck Institute for Human Development
hong@mpib-berlin.mpg.de

Abstract:

Political polarization has become a substantial threat that hinders coordinated action for non-pharmaceutical interventions (NPIs) over the COVID-19 pandemic. Yet, it is not fully explained to what extent polarization can affect voluntary social mobilization aimed at mitigating the pandemic. In this study, we model polarized social mobilization to describe the differential responses to COVID-19 in the US political landscape. Using the time-critical social mobilization models and a novel dataset of the Facebook friendship network and 2016 Presidential Election records, we show that political polarization not only impedes overall mobilization, but also creates a significant heterogeneity across states. Our simulation on hypothetical compliance campaigns for mitigating the COVID-19 spread anticipates success of voluntary mobilization before actual lockdowns in identically polarized states with more than three times of success rate than oppositely polarized states. Lastly, we show the emerging correlation between the growth of COVID-19 infections and social mobilization leading to unrest. These findings highlight social mobilization as both a collective precaution and a potential risk to government measures, together with warning that the growing polarization can be a significant hurdle of NPIs relying on coordinated action.

Keywords:

social mobilization, political polarization, social network, COVID-19

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.06

Relative entropy of the degree distributions under node removal

LEE Mi Jin [1], SON Seung-Woo [*1], LEE Deok-Sun [*2]
[1]Department of Applied Physics, Hanyang University ERICA
[2]School of Computational Sciences, KIAS
sonswoo@hanyang.ac.kr, deoksun.lee@gmail.com

Abstract:

A network represents the structure of interaction among constituents. The effect of an external perturbation such as a blackout in a power-grid system is represented by the loss of a part of a network and the following changes of the network properties are interesting. Recently, it was claimed that the degree distribution converges towards the Poisson distribution under a random or a preferential node removal. The relative entropy of the two distributions is measured, which decreases as more nodes are removed independently of the form of the original degree distribution. This may appear inconsistent with other studies claiming that sampling does not in general change the form of the degree distributions. Here we extend these previous studies by considering a generalized node-removal process and using two reference degree distributions, one Poissonian and the other power-law, to better characterize the evolution of the degree distribution under a generalized node removal. We find different evolution of the relative entropy depending on the original network when small-degree nodes are preferentially removed. Using the results, we discuss how the degree distribution evolves in general node removal processes.

Keywords:

complex network, node removal, percolation, scale-free network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.07

Evolution of irreversible somatic differentiation

GAO Yuanxiao [2], PARK Hye Jin [*1], TRAULSEN Arne [2], PICHUGIN Yuriy [2]
[1]APCTP
[2]Department of Evolutionary Theory, Max Planck Institute for Evolutionary Biology
phj.hyejin@gmail.com

Abstract:

A key innovation emerging in complex animals is irreversible somatic differentiation: daughters of a vegetative cell perform a vegetative function as well, thus, forming a somatic lineage that can no longer be directly involved in reproduction. Primitive species use a different strategy: cells can do both vegetative and reproductive tasks. Starting from such a strategy, how is it possible to evolve life forms which use some of their cells exclusively for vegetative functions? Here, we developed an evolutionary model of a simple multicellular organism and found that three components are necessary for the evolution of irreversible somatic differentiation: (i) costly cell differentiation, (ii) vegetative cells that significantly improve the organism's performance even if present in small numbers, and (iii) large enough organism size.

Keywords:

irreversible somatic differentiation, evolution, multicellular organism

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B13.08

Finite-size effects on the convergence time in continuous-opinion dynamics

JO Hang-Hyun *[1], MASUDA Naoki [2]
[1]Department of Physics, The Catholic University of Korea
[2]Department of Mathematics, State University of New York at Buffalo
h2jo23@gmail.com

Abstract:

We study finite-size effects on the convergence time in a continuous-opinion dynamics model. In the model, each individual's opinion is represented by a real number on a finite interval, e.g., $[0,1]$, and a uniformly randomly chosen individual updates its opinion by partially mimicking the opinion of a uniformly randomly chosen neighbor. We numerically find that the characteristic time to the convergence increases as the system size increases according to a particular functional form in the case of lattice networks. In contrast, unless the individuals perfectly copy the opinion of their neighbors in each opinion updating, the convergence time is approximately independent of the system size in the case of regular random graphs, uncorrelated scale-free networks, and complete graphs. We also provide a mean-field analysis of the model to understand the case of the complete graph.

Keywords:

opinion dynamics, convergence time, finite-size effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B15.01

Plasma performance without ELMs in DIII-D: RMP and other methods

PAZ-SOLDAN Carlos *[1]
[1]Columbia University
paz-soldan@fusion.gat.com

Abstract:

A comprehensive database of stationary DIII-D plasmas without ELMs compares all no-ELM regimes types found in DIII-D: RMP-ELM suppression, QH-mode (incl. wide-ped), I-mode, EDA H-mode, regular L-mode, and negative triangularity L-mode (neg-D). Absolute plasma performance measured by Lawson product ($< P > \tau_E$), increases in all regimes with IaB and injected power. These abscissa are often limited by the ELM, not hardware. Normalizing $< P > \tau_E$ to IaB, comparable performance is found for QH and RMP plasmas though the pedestal pressure ($P_{ped} \equiv 2P_{e,ped}$) is very different. P_{ped} in RMP plasmas is roughly constant, with the best performance found with a high core $< P >$ fraction alongside high core rotation, suggestive of an ExB shear turbulence suppression mechanism. P_{ped} of QH plasmas is significantly higher than RMP, and QH performance does not correlate with core rotation. However, the best QH P_{ped} are found with high carbon fraction. Performance of neg-D is below RMP $\&$QH, owing to lower achieved elongation, IaB, and resultant confinement. The QH, EDA, L, and neg-D scenarios have approached divertor-friendly high density conditions, though neg-D does so with highest core performance owing to its compatibility with both high power and density.

Keywords:

tokamak, ELM, confinement, fusion, H-mode

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B15.02

Regulating 3D Neoclassical Transport in Tokamak for Plasma Rotation Control

YANG S.M. *[1], PARK J.-K. [1], NA Y.-S. [2], WANG Z. R. [1], KO W.H. [3], IN Y. [4], LEE J. H. [3], LOGAN N. [1,5], HU Q. [1], JEON Y. M. [3], PARK G.Y. [3], KIM S. K. [1,6]
[1]Princeton Plasma Physics Laboratory
[2]Seoul National University
[3]Korea Institute of Fusion Energy
[4]Ulsan National Institute of Science and Technology
[5]Lawrence Livermore National Laboratory
[6]Princeton University
syang@pppl.gov

Abstract:

Control of the plasma rotation is important in tokamak due to its significant impact on plasma confinement and stability. The use of a small non-axisymmetric (3D) magnetic field is one promising way to control plasma rotation, but it typically leads to plasma rotation damping over the entire plasma and limits its controllability. Here, we propose a strategy to accelerate plasma rotation based on the physics of 3D neoclassical transport. The plasma rotation can be globally accelerated due to radially drifting electrons and constrained to the electron root if the radial transport is enhanced by an amplified 3D response. This mechanism is verified by a kinetically self-consistent magnetohydrodynamic modeling for both response and transport, which offers quantitative explanations on the internal n=1 structure detected by electron-cyclotron-emission imaging and the co-current plasma spinning observed in the KSTAR experiments. Another alternative is minimizing non-ambipolar transport by restoring a quasi-symmetry in perturbed particle orbits as much as possible. This 3D optimization is also validated through the KSTAR experiment demonstrating no performance degradation despite the large overall amplitude of non-axisymmetric fields.

Keywords:

Tokamak, Plasma rotation, 3D magnetic field, Transport

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B15.03

Optimizing tokamak pedestal confinement via adaptive ELM control using 3D field

KIM S. K. *[1], SHOUSHA R. [1], HAHN S. H. [2], NELSON A. O. [1], WAI J. [1], YANG S. M. [3], PARK J.-K. [3], IN Y. [4], NA Y.-S. [5], LEE J. H. [2], KIM J. [2], KOLEMEN E. [1,3]
[1]Princeton University
[2]Korea Institute of Fusion Energy
[3]Princeton Plasma Physics Laboratory
[4]Ulsan National Institute of Science Technology
[5]Department of Nuclear Engineering, Seoul National University
sk42@princeton.edu

Abstract:

H-mode is a promising plasma operation scenario for future fusion power plants. It is characterized by a narrow edge transport barrier concomitant with the formation of an edge pedestal with a steep pressure gradient. The pedestal significantly improves global plasma confinement, but it can also lead to the growth of dangerous edge instabilities called edge localized mode (ELMs). Therefore, achieving a large pedestal and avoiding ELMs are key to realizing fusion plasma. Unfortunately, improving the pedestal or ELM stability weakens the other, and it is challenging to enhance both at the same time.

We report the first adaptive approach for optimizing both edge stability and confinement through a resonant 3D field and salient hysteresis [1]. Despite the bifurcating characteristics of hysteresis, which lead to oscillations of the system and control difficulties, this approach successfully achieves the optimal ELM-free state using RMPs. This is due to a self-consistent plasma response that removes the unfavorable discontinuity of the system via intrinsic turbulence [2] and support from adaptive control. Here, the edge turbulence eases the control difficulties by modifying the ion pedestal, allowing the controller to find the optimal solution. Consequently, the adaptive approach reaches its desired state, proposing a novel strategy to achieve high confinement and ELM-free state in future fusion devices.
This work was supported by US DOE Contract DE-SC0020372.

References:
[1] F. M. Laggner et al., NF 60 (2020), 076004
[2] J. Lee et al., PRL 17 (2016), 075001

Keywords:

Tokamak, Pedestal, 3D field, ELM suppression, Adaptive control, Edge turbulence

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B16.01

초저전력 나노와트 프로그래머블 포토닉스

HAN Sangyoon *[1]
[1]Robotics Engineering, DGIST
s.han@dgist.ac.kr

Abstract:

광-집적회로는 광소자들을 고밀도로 모놀리식하게 통합할 수 있어 고성능 광학 시스템을 위한 강력한 플랫폼을 제공한다. 광-집적회로는 전자회로의 제작 방식을 차용하기 때문에 과거 전자회로가 따랐던 스케일링 경로를 따를 것으로 예상된다. 그러나 대부분의 광자-집적회로 설계는 종종 단일 애플리케이션 전용이므로 다른 용도로 효율적으로 재사용 할 수 없다. 전자 분야의 FPGA (Field-Programmable Gate Array)에 대응되는 개념인 PPC (Programmable Photonic Circuit)의 개념은 최근 몇 년 동안 상당한 관심을 끌고 있다. PPC 는 프로토 타이핑 시간과 비용을 크게 줄이고 범용 포토 닉 회로 역할을 할 수 있다. 그러나 기존에 시연된 PPC 의 규모는 전자 FPGA 에 비해 상대적으로 훨씬 작다. 특히, 일반적인 선형 변환과 RF 신호 처리를 수행 할 수 있는 Recirculating-PPC (R-PPC)에 관해서는 단위 셀의 수가 여전히 매우 적다 (예 : 칩당 10 개 미만). 이는 단위 셀의 큰 크기와 (~ 1mm / 에지)와 이들이 소비하는 높은전력 (~ 10mW / 셀) 때문이다.

본 발표에서는 MEMS 로 조절되는 도파로를 기반으로 하는 확장 가능한 R-PPC 를 보고한다. 단위 셀 크기는 0.04mm^2 로 다른 그룹에서 발표된 R-PPC 에 비해 10 배 이상 작다. 또한 우리의 R-PPC 는 정전기적 튜닝 방법의 특성으로 인해 정적 전력을 기존의 R-PPC 에 비해 천만배 (100 mW --> 10 nW) 이하로 줄였다. 셀 간의 커플링을 조절하기 위해 2x2 MZI (Mach-Zehnder interferometer) 대신 MEMS 기반의 움직이는 도파로를 사용하였다. 2 개의 커플러와 긴 위상 조정용 도파로가 있는 MZI 와 달리 우리의 방식은 하나의 방향성 커플러 만 필요로 하므로 훨씬 더 작게 구현 가능하다. 또한 MEMS 액추에이터의 높은 공진 주파수 (~ 200kHz)는 몇 마이크로 초 내의 짧은 반응시간을 가능하게 한다. 이 발표에서 우리는 16 개의 셀을 가진 R-PPC 를 구현하고 그것을 사용하여 다양한 광소자(단일 링 필터, 다차 링 필터, 애드드롭 필터 등)를 실시간으로 구현하는 것을 보여주겠다.

Keywords:

Programmable Photonic Circuit, MEMS 로 조절되는 도파로, 초처전력

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B16.02

Material Engineering for Heterogeneous Opto-electronic Integrated Devices

HAN Jae-Hoon *[1]
[1]Center of Opto-electronic devices and materials, KIST
hanjh@kist.re.kr

Abstract:

An efficient active device is indispensable for high-performance integrated opto-electronic devices. To achieve high-performance active devices, material engineering toward state-of-art semiconductor and oxide is important. In this presentation, I will introduce the recent progress on semiconductor and oxide engineering for opto-electronic active devices. To realize the efficient phase modulation, a semiconductor-insulator-semiconductor (SIS) capacitor can achieve very efficient phase modulation efficiency thanks to its strong carrier accumulation at a SIS capacitor compared to other structures such as a pn junction. However, due to the large capacitance of the SIS structure, there is a fundamental trade-off relationship between the modulation efficiency and the modulation bandwidth of a SIS optical phase modulator. To overcome this trade-off relationship, recently, an efficient optical phase shifter using a III-V/Si hybrid semiconductor-insulator-semiconductor (SIS) capacitor are demonstrated [1]. Owing to the large electron-induced effects in III-V semiconductors, we can achieve the highest modulation efficiency among only-semiconductor-based optical phase shifters and overcome the trade-off relationship of a SIS optical phase modulator. I have also proposed the insulator engineering of SIS capacitor using ferroelectric materials for functional insulators [2]. I have also suggested the new applications of a SIS optical phase modulator for an efficient mid-IR photonics platform [3].

Keywords:

Si photonics, III-V, hybrid integration

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B16.03

Universal scaling behavior of Anderson localization of electromagnetic waves incident on a randomly-stratified dielectric medium

KIM Seulong [1], KIM Kihong *[1]
[1]Department of Physics, Ajou University
khkim@ajou.ac.kr

Abstract:

We study theoretically Anderson localization of electromagnetic waves incident on a randomly-stratified dielectric medium. We consider a model where the dielectric permittivity varies randomly along one direction with finite correlation length l_c. We find that the normalized localization length $k\xi$ for *s* waves of wavenumber k incident at the critical angle θ_c is precisely proportional to $g^{-1/3}$, where g is the effective disorder parameter proportional to k, over the entire range of g. This implies that the localization length is strictly proportional to $\lambda^{4/3}$ for all values of the wavelength λ. We find that this scaling behavior is universal in the sense that it is independent of the disorder correlation length. The same scaling behavior is observed also for *p* waves except in the narrow parameter region where resonant phenomena unique to *p* waves are important. In the strong disorder limit, *s* and *p* waves incident at any incident angle converge to the same scaling behavior. We explain this by deriving the analytical expression of the localization length and by precise numerical calculations using the invariant imbedding method. We discuss the dependencies of the localization length on wave polarization, disorder strength, and disorder correlation length in detail and provide their physical interpretations. In the following figure, we illustrate the dependence of the normalized localization length on the effective disorder parameter for various incident angles in short-range correlated random dielectric media.

Keywords:

Anderson localization, Inhomogeneous dielectric media, Localization length, Universal scaling behavior

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B16.04

Synergistic Interplay of Dielectric Metamaterials and Molecular Engineering for Optical Chiral Detection

CHEON Junyeob [1], LEE Seungwoo *[1,2,3,4]
[1]Graduate School of Converging Sci & Tech & Dept. of Integrative Energy Engineering, Korea University
[2]Department of Biomicrosystem Technology, Korea University
[3]Department of Integrative Energy Engineering, Korea University
[4]KU Photonics Center, Korea University, Korea University
seungwoo@korea.ac.kr

Abstract:

A molecule, which is not super-imposable with its mirror counterpart, is called chiral. Because directly observing the chirality of a molecule is technically difficult, optical detection is considered as a commonplace for seeing the chirality of a molecule. However, the optical chiral detection suffers from its intrinsically weak signal which leaves amplifying the weak chiral signal as one of major challenges in optical chiral detection.
In this talk, we present the method combining the top-down and bottom-up approach to address the challenge of amplifying weak signals in chiro-optic detection. In the top-down perspective, we design a lithographically defined dielectric metamaterial which enables the efficient chiral light-molecule coupling. By judiciously optimizing the size parameters of a dielectric metamaterial, enhanced chiral light-molecule interaction can occur at wavelength of interest. While, in the bottom-up perspective, we use self-assembled DNA nanostructures, DNA origami. The usage of DNA origami leads to the molecular engineering of analyte and the deterministic placement of the molecule.

Keywords:

Optical chirality, DNA origami, Dielectric Metamaterials

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B17.01

Polarization entangled photon pair source at warm ^{85}Rb atoms

BAE Jinhyuk [1], PARK Jiho [1], MOON Han Seb *[1]
[1]Pusan National University
hsmoon@pusan.ac.kr

Abstract:

본 연구에서는 ^{85}Rb 원자 증기 셀을 이용하여 강하게 고전성을 위배하는 편광 양자얽힘 광원을 생성하였다. 원자와 광자의 비선형 상호작용을 통해 얻은 광자쌍 큐비트는 양자통신, 양자컴퓨터, 양자반복기 등 다양한 분야에 사용된다 [1-2]. 이러한 분야에 사용되는 큐비트는 양자 얽힘 특성을 가져야만 한다. 높은 상관관계를 가진 광자쌍과 편광 빔 분할기, 위상지연판, 편광자를 이용하면 편광얽힘 큐비트를 만들 수 있다. 편광얽힘 양자광원이 얼마나 고전적인 성질을 위배하는 지 확인하기 위해 편광에 따른 양자기저를 변환시키며 벨 간섭무늬의 가시도가 70.7%를 넘는 것을 확인하고 CHSH 부등식을 위배를 확인하고, 양자상태 단층촬영을 통해 생성된 양자얽힘 상태를 확인하였다. 추후 GHZ 상태에 대해서도 양자얽힘 광원을 얻을 수 있을 것으로 기대한다.

Reference :
[1] J. Park, H. Kim, and H. S. Moon, “Polarization-entangled photons from a warm atomic ensemble using a Sagnac interferometer,” Phys. Rev. Lett. 122, 143601 (2019).
[2] J. Park, H. Kim, and H. S. Moon, “Entanglement Sweeping with Polarization-Entangled Photon-Pairs from Warm Atomic Ensemble,” Optics Letters 45(8), 2403-2406 (2020).

Keywords:

자발사광파조합(SFWM, Spontaneous four-wave mixing), 편광 양자얽힘, 원자결맞음, 양자광원

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B17.02

The origin of quantum advantage of randomness for catalytic implementation of quantum channels

LIE Seok Hyung [1], JEONG Hyun Seok [*1]
[1]Seoul National University
jeongh@snu.ac.kr

Abstract:

In this talk, we introduce a new no-go result we call `the no-secret theorem' which states that it is impossible to secret-share even partial information of quantum system without leaking some information. This result yields that any information non-leaking implementation of quantum channel is catalytic: it does not alter the form of randomness source through the implementation. This result can be generalized to dimension-increasing quantum maps in the sense that every information non-leaking implementation is at most 2-step catalytic. We also identify the origin of the recent results that quantum randomness sources have efficiency advantage compared to classical counterparts by showing that only uniform randomness can have quantum advantage.

Keywords:

quantum information

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B17.03

원자 앙상블에서 생성된 열광원을 이용한 다중경로 간섭

MOON Han Seb *[1], PARK Jiho [1], KIM Heonoh [1]
[1]Pusan National University
hsmoon@pusan.ac.kr

Abstract:

본 연구에서는 도플러 선폭 확대된 ^{87}Rb 원자 앙상블에서 생성된 열광원을 이용하여 다중경로 상관관계를 이용한 간섭실험을 수행하였다. 열광원은 ^{87}Rb 원자의 $5S_{1/2}$ – $5P_{2/3}$ – $5D_{5/2}$ 전이선에서 이-광자 결맞음 효과로 인해 생성된 776 nm 파장의 광자를 이용하였다. 원자 앙상블에서 생성된 광자는 50:50 빔스플리터에서 두 경로로 나뉘어 Franson 간섭계 형태의 독립적인 두개의 불균형한 마이켈슨 간섭계를 지난다. 우리는 이 실험을 통하여 간섭계의 경로차이가 열광원의 결맞음길이를 벗어난 영역에서 간섭무늬가 나타나는 것을 확인하였으며 Franson 간섭실험과는 달리 간섭무늬가 두 간섭계에서 발생하는 각각의 위상성분의 차이로 나타나는 것을 확인하였다. 또한 시간 도메인에서 2 차 상관관계 함수($G^{(2)}$)를 측정하여 간섭에 기여하는 다중경로 성분을 확인하였다. 우리는 이 결과가 열광원 광자의 결맞음과 간섭현상에 대한 이해에 도움을 줄 것으로 기대하고있다.

Keywords:

이-광자 간섭, 원자 앙상블, 열광원

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B17.04

파장 측정기를 이용한 여러 레이저 주파수의 동시 안정화

KIM Junwoo *[1], LEE Dowon [1], LEE Moonjoo [1]
[1]Electrical Engineering, Electrical Engineering, POSTECH
joonu1214@postech.ac.kr

Abstract:

본 발표에서는 분해능 10 MHz 를 가지는 상용 파장 측정기를 이용한 780 nm 다이오드 레이저의 주파수 안정화에 대해서 보고한다. 우선 파장 측정기의 최대 측정 속도를 단채널, 다채널 방식의 경우에 정량화 하였다. 이후 10 시간 넘게 안정화된 레이저 주파수의 Allan 분산을 구하였으며, 적분 시간 1000 초에서 안정화되지 않은 경우보다 10000 배 가량 주파수 흔들림이 개선됨을 관측하였다. 또한 동시에 안정화된 두 레이저 사이의 헤테로다인 실험 결과는 각 레이저가 약 1.5 MHz 의 선폭을 가지는 것을 말해 준다. 주파수 안정화된 레이저를 이용하여 진행 중인 루비듐 원자 기반의 공진기 양자전기역학(Cavity QED) 실험의 진행 상황에 대해 논의한다.

Keywords:

Laser Lock, Wavelength meter, Allan deviation, Cavity QED

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B17.05

Photon pair generation at 1.5 μm-wavelength from warm Rb atomic ensemble

JEONG Hansol [1], MOON Han Seb *[1]
[1]Pusan National University
hsmoon@pusan.ac.kr

Abstract:

본 연구에서는 루비듐 원자의 $5S_{1/2}$-$5P_{3/2}$-$4D_{5/2}$ 전이선에서 자발적 사광파 혼합(Spontaneous Four-wave Mixing)을 통해 780nm, 1592nm 의 광자쌍을 생성하여 양자 광원으로써 적합한 성질을 갖는가에 대하여 조사하였다. 780nm 의 파장을 갖는 광자는 루비듐을 이용한 양자메모리에 적합한 파장을 가지고 있을 뿐만 아니라, 1529nm 의 광자는 광섬유를 통한 장거리 양자통신을 위해서 적합한 파장이다. 이러한 특성을 이용하여 장거리 양자통신 및 양자네트워크에 필수적인 양자 리피터 구현을 위한 연구로 발전시키고자 한다. 이번 연구에서는 생성된 광자쌍의 상관관계 및 Stimulated Emission Beating Method 를 이용하여 광원의 특성을 파악하였다.

Reference
[1] Guo, J., Feng, X., Yang, P. *et al.* High-performance Raman quantum memory with optimal control in room temperature atoms. *Nat Commun* **10**, 148 (2019)
[2] Taek Jeong and Han Seb Moon, "Joint spectral intensity of entangled photon pairs from a warm atomic ensemble via stimulated emission beat interferometry," Opt. Lett. 45, 2668-2671 (2020)

Keywords:

Spontaneous Four-wave Mixing, Joint Spectral Intensity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B18.01

Atomic-scale observation of epitaxial growth through two-dimensional materials

김성규*[1]
[1] 세종대학교 나노신소재공학과
sungkyu@sejong.ac.kr

Abstract:

Based on the conventional epitaxy mechanism, various single-crystalline materials can be directly grown on single-crystalline substrates with acceptable lattice mismatched system. The conventional heteroepitaxy with the relatively huge lattice mismatch generates dislocations to release the accumulated strain energy. These epitaxial growths are theoretically based on atomic interaction and repetitive stacking and can be easily confirmed through experimental results. The recently reported new concept of remote epitaxy method allows the growth of single-crystalline materials onto two-dimensional materials due to strong ionic bond from substrates. Although remote epitaxy materials such as GaN[1], GaAs[2], and various oxide[3] have been successfully demonstrated, atomic arrangement based on ionic interaction across two-dimensional graphene is still not fully understood.

Herein, we demonstrate the role of a graphene layer that allows the formation of ionic bonding between substrate and epitaxy film. In order to directly observe atomic arrangement, the remotely grown single-crystalline film was characterized by cross-sectional STEM analysis. The physically transferred monolayer graphene on Ga-terminated (100) GaAs substrate is effective not only to protect the atoms supplied from the outside during growth process, but also to observe the growth mechanism by ionic fields. Although some areas under the graphene were damaged, it was clearly confirmed that arsenic atoms are located above gallium-terminated substrate through the graphene with the physical distance of 0.60 nm. In addition, heteroepitaxy system between GaAs substrate and GaP film represents the origin of remote epitaxy including the spontaneous relaxation of dislocations through graphene. These findings provide crucial evidence to explain remote epitaxy phenomena, which could eventually broaden epitaxy technologies.

[1] Kim, Y. et al. Remote epitaxy through graphene enables two-dimensional material-based layer transfer. Nature 544, 340-343 (2017)
[2] Bae, S.-H. et al. Graphene-assisted spontaneous relaxation towards dislocation-free heteroepitaxy. Nature Nanotechnology 15, 272-276 (2020)
[3] Kum, H. S. et al. Heterogeneous integration of single-crystalline complex-oxide membranes. Nature 578, 75-81 (2020)

Keywords:

Remote epitaxy, epitaxial growth, graphene, atomic interaction

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B18.02

Semiconductor Nanostructures Grown on Graphene Films

YI Gyu-Chul *[1]
[1]Department of Physics and Astronomy, Seoul National University
gcyi@snu.ac.kr

Abstract:

Here we propose that hybrid heterostructures, composed of inorganic nanostructures grown directly on 2-dimentional (2-D) layered materials such as graphene, are the most promising material system for flexible device applications. In particular, the hybrid heterostructures composed of high-quality GaN thin films or nanostructures grown directly on graphene offer a novel material system for transferable and/or flexible optoelectronics. The inorganic nanostructures in the hybrid nanomaterials exhibit excellent electrical and optical characteristics, including high carrier mobility, radiative recombination rate, and long-term stability. Meanwhile, for the flexible devices based on the hybrid structures, the graphene layers, which have excellent electrical and thermal conductivity, high mechanical strength and elasticity, and/or optical transparency, act as a novel substrate offering new functionalities such as transferability or flexibility. Here I will introduce controlled growths of ZnO nanostructures using catalyst-free metal-organic vapor phase epitaxy and describe the methods to fabricate flexible LEDs based on GaN microdisk array and nitride coated ZnO nanostructures grown on graphene, which exhibit strong light emission after the transfer onto foreign substrates, such as metal, glass, and plastic. We believe that our unique technology to make hybrid nanomaterials will make paradigm shift from rigid to flexible and planar to three-dimensional inorganic semiconductor structures and devices.

Keywords:

semiconductor nanorod, ZnO, graphene, flexible device, LEDs

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B18.03

Transferable GaN layers grown on two dimensional layered materials

CHUNG Kunook *[1]
[1]Department of Physics, Ulsan National University of Science and Technology (UNIST)
kunookc@unist.ac.kr

Abstract:

In this presentation, a method to grow high-quality GaN layers on two-dimensional (2D) layered materials of graphene and hexagonal boron nitride films will be introduced. Single crystalline GaN layers were grown on these 2D layered materials using metal-organic chemical vapor deposition showing high structural and optical characteristics. Moreover, selective-area epitaxial lateral overgrowths on graphene microdots were employed to fabricate high-density, large-size scalable GaN microstructures arrays with an improved and homogeneous GaN crystallinity. Meanwhile, the layered structure of graphene films not only enabled us to fabricate GaN light-emitting diodes (LEDs) directly on various substrates, such as amorphous fused silica and metal electrodes but also makes the LEDs detachable from the original substrates to be utilized for flexible devices. Taking advantage of the heterogeneous material platform comprising of semiconductor microstructures grown on the 2D layered materials, transferable and flexible inorganic semiconductor optoelectronics are further proposed.

Keywords:

GaN, light-emitting diode, graphene, hexagonal boron nitride, heteroepitaxy, transferable, flexible

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B18.04

Stackable 2D and 3D materials for mixed dimensional heterostructures

BAE Sang-Hoon *1
[1]Mechanical Engineering, Research Laboratory of Electronics, and Materials Science and Engineering, Massachusetts Institute of Technology (MIT)
bae0112@mit.edu

Abstract:

In this talk, I will discuss how we can produce freestanding 2D materials and 3D materials which are free from substrates. Our team recently developed a novel approach to grow single crystal materials on graphene-coated substrates. As graphene has a lattice transparency, potential fluctuation through graphene plays an important role in obtaining seeding on the graphene-coated substrates. In addition, it has weak van der Waals bonding at the interface between grown materials and substrates, which enables producing freestanding single crystalline materials. For freestanding 2D materials at large scale, we conceived a unique approach by playing an interfacial toughness contrast, called layer-resolved split. Because it is versatile and universal to all of 2D materials, various kinds of 2D materials were harvested with such method. Thereby, the freestanding 2D and 3D materials allow us to discover new physical coupling phenomenon as well as develop new functional heterostructures, named mixed dimensional heterostructures.

Reference

[1] Sang-Hoon Bae, et al *Nature Nanotechnology*, 15, 272-276 (2020)
[2] Sang-Hoon Bae, et al *Nature Materials*, 18, 550-560, (2019)
[3] Jaewoo Shim, Sang-Hoon Bae et al *Science*, 362, 6415, 665-670, (2018)

Keywords:

epitaxy, monolayer 2D, mixed-dimensional heterostructures

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B19.01

Formation of low density InAs quantum dots by modified SK-growth mode and GaAs quantum dots/rings and drilled inverted grown InAs QDs by droplet epitaxy method for single photon sources

SONG J. D. *1
[1]Center for Opto-Electronic Convergence Systems, Korea Institute of Science and Technology
jdsong@kist.re.kr

Abstract:

Low density quantum dots (QDs) have attracted attention as a single-photon source for the application to quantum cryptography. This application requires the number of quantum dots less than 10 quantum dots on 1 um x 1um.
The most representative compound semiconductor QDs are In(Ga)As QDs grown on (Al)GaAs substrate by Stranski-Krastanow (SK) method. This system has a merit in the point that material and growth method are well-known and widely used. However, these QDs formed by SK method have two crucial problems in an application of single photon source requiring ultra low density. First of all, SK method is not effective for growing uniform, reproducible low density quantum dots because this growth method comes from lattice mismatch system subtly depending on substrate temperature and growth rate. Also, it has a drawback that it is not easy to grow low density quantum dots on a large area substrate. The second problem is photoluminescence peak wavelength of In(Ga)As quantum dots. In general, the emission line of In(Ga)As QDs at a low temperature is about 0.9~1.0 um. Meanwhile, wavelength shorter than 0.8 um is preferred for efficient and cost-effective silicon array based systems to measure a single photon source or longer than 1.3um is necessary for optical communication.
In this research, low density GaAs QDs/Quantum rings (QR) were grown on Al33GaAs/GaAs substrate by using droplet epitaxy, which consists of perfectly separated introduction of group III metals and group V, instead of simultaneous introduction (SK method). Thus, we could get a low density GaAs quantum dots/rings without defect due to strain. In this experiment, the effect of Ga coverage, Ga flux ratio and substrate temperature on the structural properties of GaAs QD/QR s such as size, density and distribution. Here we achieved low density QDs of 0.75um wavelength with droplet epitaxy and >1.55um QDs with modified SK growth method on GaAs wafers.
Finally, the formation of InAs QDs in the drilled hole will be introduced for strain balanced QDs.

Keywords:

양자 소재, 양자 응용

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B19.02

양자응용을 위한 다이아몬드 단결정 반도체 소재기술

남옥현*[1]
[1] 한국산업기술대학교 나노반도체공학과
ohnam@kpu.ac.kr

Abstract:

지금까지 다이아몬드 결정은 절삭용공구, 내마모공구, 광학윈도우 및 히트싱크 등에 널리 사용되어 왔으나, 미래의 반도체 및 양자 소재로서 매우 탁월한 물성을 갖고 있기 때문에 다양한 소재와 소자에 대한 연구가 활발히 진행되어 오고 있다. 단결정 다이아몬드는 녹는점 3550deg C, 열전도율 2200W/(mK), 전자이동도 4,500cm^2/Vs, 절연파괴전계강도 10MV/cm, 전자포화속도 2.7×10^{7}cm/s 등 과 같은 미래의 반도체 및 양자기술용 소재로서 뛰어난 물성을 가지고 있다. 이러한 우수한 물성으로 인해서 미래의 고전력/고주파 반도체소자로의 연구 (BFOM: 50,000, JFOM:1,340)가 활발히 수행되고 있으며, 최근에는 미래의 양자기술응용을 위한 양자소재로서 다이아몬드의 NV 센터를 이용한 양자응용 연구가 매우 활발히 수행되고 있다.

현재 미국, 일본, 유럽 및 중국은 차세대 반도체 응용 및 양자기술 응용을 위한 가장 중요한 소재로서 다이아몬드 단결정 반도체 소재기술을 연구하기 위한 정부지원의 대형프로젝트들이 수행되어 오고있으며 주요한 연구성과들이 발표되고 있는 반면에, 아직까지 국내의 경우는 단결정 다이아몬드에 대한 정부의 연구지원이 이루어지지 못하였으며, 다이아몬드 단결정 소재를 응용한 양자기술과 반도체소자 연구를 위해서는 해외에서 소재를 구입 해야하는 상황으로 이에 대한 국내의 연구개발 지원과 연구가 절실히 필요한 상황이다.

본 발표에서는 미래의 양자기술응용과 반도체소자를 위한 다이아몬드 단결정 반도체 소재기술 현황과 전망에 대해서 소개할 예정이다.

REFERENCES

1. M. Kasu, Progress in Crystal Growth and Characterization of Materials 62 (2016) 317-328
2. Hideo Aida and Seongwoo Kim, Fabrication of freestanding heteroepitaxial diamond substrate via micropatterns and microneedles, Appl. Phys. Express9, 035504 (2016)
3. Taemyung Kwak and Okhyun Nam et al., “Boron-Doped Single-Crystal Diamond Growth on Heteroepitaxial Diamond Substrate Using MPCVD”, Phys. Status Solidi A 2020, 1900973.
4. Taemyung Kwak and Okhyun Nam et al., “Diamond Schottky barrier diodes fabricated on sapphire-based freestanding heteroepitaxial diamond substrate”, Diamond & Related Materials 114 (2021) 108335.
5. Jonggeon Lee and Okhyun Nam et al., “Overgrowth of Single Crystal Diamond Using Defect-Selective Etching and Epitaxy Technique in Chemical Vapor Deposition”, J. Nanosci. Nanotechnol. 21, 1-6, 2021.

Keywords:

양자응용

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B19.03

Room temperature quantum emission from atomic defects in wide-bandgap semiconductor

JEONG Kwang-yong *[1]
[1]Depart. of Physics, Korea University
kyjeong83@gmail.com

Abstract:

Non-classical light sources, such as atoms and atom-like emitters are the basic building blocks of photon-based quantum information processing. Solid-state quantum emitters are attracting a lot of attention due to their excellent optical properties and convenience of scalability. In this talk, I will discuss the room temperature single photon emission from defects in wide-bandgap semiconductor. GaN and AlN is an important wide-bandgap material widely used in an optoelectronics, high-power electronics and photonics. GaN quantum dots have been typically demonstrated as short wavelength (>4eV) quantum light sources at cryogenic temperatures. Theoretical studies of defects in GaN and AlN have been reported, but single defect emission of GaN and AlN has not been reported. Here we report on room temperature, photostable and single photon emission from defect in GaN and AlN with photoluminescence in the visible spectral range. The single photon emitters are studied at room-temperature and cryogenic temperature using a home-built confocal microscope setup. We integrated quantum emitters directly into an aluminum nitride-based photonic integrated circuit platform. This single photon emitter in GaN and AlN is a promising candidate for on-chip quantum information processing.

Keywords:

single photon emitter, GaN, AlN, Quantum defect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B19.04

$LiNbO_3$ photonic platform for on-chip quantum key distribution

HEO Hyungjun [1], KWON Kiwon [2], HWANG Hyeon [3], SEO Min-Kyo [3], LEE Hansuek [3], HAN Sang-wook [1], JUNG Hojoong [*1]
[1]KIST
[2]POSTECH
[3]KAIST
hojoong.jung@kist.re.kr

Abstract:

Lithium niobate(LN) is a promising material platform in nanophotonics for enabling quantum photonics applications, owing to the high refractive index, a wide transparent window and especially the strong nonlinearity. Recently, the development of nanofabrication technology of Lithium niobate on insulator(LNOI) has realized the on-chip integrated optical devices with remarkable performance, including the low propagation loss, high-speed modulation, and efficient power consumption. Consequently, these integrated optical devices based on LNOI provide the basic structural building blocks for the on-chip quantum key distribution(QKD) system, which is one of the quantum encryption method for unconditional security communication. The integration of the QKD system has huge advantages of compactness, low cost, synchronization, stability of operation, and eventually commercializing through mass production.

In this talk, we briefly introduce the outstanding material properties of LN and aspects of current LN nanofabrication technology. Some of the individual basic optical devices based on LNOI such as waveguides, interferometers, ring resonators, and modulators are experimentally demonstrated. Also, we will discuss the architecture and basic building blocks for integration of basic QKD protocol.

Keywords:

QKD, LiNbO3, photonics, quantum, integration

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B19.05

Growth of Topological Insulator using Molecular Beam Epitaxy

박한범 [1], 정광식 [2], 김종훈 [1], 홍석보 [1], 노승원 [1], 조만호*[1]
[1] 연세대학교 물리학과
[2] 동국대학교 물리반도체과학부
mh.cho@yonsei.ac.kr

Abstract:

In this study, various topological insulators were synthesized using ultra-high vacuum molecular beam epitaxy. Moreover, we investigated the change in the spin-orbit coupling caused by the relationship of the substrate and the crystalline characteristics according to various growth variables during the growth process, including temperature and doping. In particular, we reported on the growth characteristics of $Bi2Se_3$, Sb_2Te_3 and Bi_xSb_{1-x} thin films and various characteristics at the interface related to the proximity effect. It also provides the information on how changes in the relationship between Dirac surface states and phase coherence length change according to crystallinity.

Keywords:

Topological insulator, thin film growth, Dirac Surface state, Spin-orbit coupling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B21.01

New Determination of the Hubble Constant with Gaia EDR3, Further Evidence of Excess Expansion

RIESS Adam *1
[1]Johns Hopkins University
ariess@stsci.edu

Abstract:

The Hubble constant remains one of the most important parameters in the cosmological model, setting the size and age scales of the Universe. Present uncertainties in the cosmological model including the nature of dark energy, the properties of neutrinos and the scale of departures from flat geometry can be constrained by measurements of the Hubble constant made to higher precision than was possible with the first generations of Hubble Telescope instruments. A streamlined distance ladder constructed from infrared observations of Cepheids and type Ia supernovae with ruthless attention paid to systematics now provide <2% precision and offer the means to do much better. By steadily improving the precision and accuracy of the Hubble constant, we now see evidence for significant deviations from the standard model, referred to as Λ CDM, and thus the exciting chance, if true, of discovering new fundamental physics such as exotic dark energy, a new relativistic particle, or a small curvature to name a few possibilities. I will review recent and expected progress, most recently based on measurements from Gaia EDR3 released in December, 2020.

Keywords:

Hubble Constant

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

B21.02

Cosmic Discord: Implications for and of Cosmological Theory

KNOX Lloyd *[1]
[1]UC Davis
lknox@ucdavis.edu

Abstract:

The most precise of the direct measurements of the current rate of cosmic expansion (the Hubble constant) is inconsistent with the even more precise, but indirect, model-dependent inferences. In particular the Riess et al. (2019) measurement is more than four standard deviations higher than the inference based on the standard cosmological model with its free parameters constrained by Planck satellite observations of the cosmic microwave background. In this talk I will explain the beautifully simple physics that allows for a prediction of the Hubble constant from observations of temperature and polarization patterns in the sky at millimeter wavelengths and I will entertain the exciting possibility that the origin of this discrepancy is a deficiency of the standard cosmological model. Finally I will address the prospects for future observations of the cosmic microwave background to point us from discord to concord.

Keywords:

Hubble Constant

Inclusive B -> Xu l+ nu and updated measurement of |V_{ub}| at Belle

KWON Youngjoon *1
[1]Physics, Yonsei University
yjkwon63@yonsei.ac.kr

Abstract:

We present the recent analysis of inclusive B -> X_u l+ nu process at Belle. This study is motivated by the well-known 'Inclusive vs. Exclusive tension' of V_cb and V_ub, which has been a puzzling issue in the heavy flavor physics and CKM unitarity. With the improved modeling of signal process as well as the dominant B -> X_c l+ nu background, the Belle collaboration came up with a comprehensive new analysis and obtained results on the partial branching fractions and magnitude of V_ub. The resulting value of V_ub is now within 1.3 sigma of the exclusive measurement.

Keywords:

Belle, CKM, heavy-flavor, B meson, e+ e-

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.02

Status of readout DAQ system R&D of a dual-readout calorimeter for future e+e- collider

RYU Min Sang *[1], KIM Bobae [1], LEE Junghyun [1], LEE Sehwook [1], KO Sanghyun [4], KIM Doyeong [3], LEE Jason [3], LEE Yunjae [3], WATSON Ian [3], CHO Guk [2], EO Yun [2], HA Seungkyu [2], HWANG Kyuyeong [2], KIM Dongwoon [2], KIM Jaeyoung [2], KIM Kyungho [2], KIM Minsoo [2], KIM Sungwon [2], KIM Tongil [2], PARK Junewoo [2], YOO Hwidong [2]

[1]The Center for High Energy Physics, Kyungpook National University
[2]/Dept. of Physics, Yonsei University
[3]/Dept. of Physics, University of Seoul
[4]/Dept. of Physics, Seoul National University
mryu194@knu.ac.kr

Abstract:

To explore the origin of mass and its correlation with Higgs particles, High-Energy Physics (HEP) experiments with future e+e- colliders, such as FCC-ee and CEPC, are proposed, and particle detectors have been designed. Dual-Readout Calorimeter (DRC), which uses two types of optical fibers, plays an essential role in measuring the energy and momentum of both neutral and charged particles in future lepton collider experiments. KFC-DREAM (Korea Future Collider Dual-REAdout Method calorimeter) collaboration has requested a beam test period to measure the nuclear interaction length and the performance of two copper-fiber DRC modules with electrons, pions, and protons at the North area in CERN in November 2021. The copper-fiber DRC modules consist of 2.5 m optical fibers (scintillation and Cerenkov), absorber (Cu), photodetectors (MCP-PMTs, PMTs, and SiPM's), and a data acquisition (DAQ) system. The DAQ system has two operational modes, fast DAQ and waveform modes, with bin event mode, and to obtain an excellent position and time resolution (<50 ps), DRS (Domino Ring Sampler) chip has been used. We will present the status of the preparation of the DAQ system for the Test Beam 2021 campaign.

Keywords:

Dual-readout, Calorimeter, Test Beam, Future collider, Readout DAQ System

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.03

Search for Dark Matter using Nuclear Emulsion

YOON Chun Sil *[1], KIM Sung Hyun [2], KO Jae-Woo [2], LEE Kang Young [2], PARK Byung Do [2], SOHN Jong Yoon [2], LEE Kyong Sei [3], KIM Yeong Gyun [4], CHOI Ki-Young [5], WOO Jong-Kwan [6]
[1]Research Institute of Natural Science, Gyeongsang National University
[2]Physics Education Department & RINS , Gyeongsang National University
[3]KODEL, Korea University
[4]Department of Science Education, Gwangju National University of Education
[5]Department of Physics, Sungkyunkwan University
[6]Department of Physics, Jeju National University
chunsil.yoon@ymail.com

Abstract:

Even though Nuclear emulsion is a very old detector, it is still being used in the various fields of nuclear and particle physics especially due to its best spatial resolution less than 1 μm. Moreover, it can play roles of 3D image detector, high-precision tracker, calorimeter and particle-identification detector. Recently, thanks to hybrid technique with electronic detectors, the Nuclear emulsion can be applied to Neutrino, Hypernucleus, Muon radiography, Gamma-ray telescope, and Dark matter search experiments. In this talk, we will introduce the emulsion technology for Dark matter search in SHiP, SND@LHC and NEWSdm experiments.

Keywords:

Nuclear emulsion, Dark matter, SHiP, SND@LHC, NEWSdm

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.04

Status of 3D printing based module R&D for a dual-readout calorimeter

YOO Hwidong *[1], KIM Bobae [2], LEE Junghyun [2], LEE Sehwook [2], RYU Min Sang [2], KO Sanghyun [3], KIM Doyeong [4], LEE Jason [4], LEE Yunjae [4], WATSON Ian [4], CHO Kuk [1], EO Yun [1], HA Seungkyu [1], HWANG Kyeyeong [1], KIM Dongwoon [1], KIM Jaeyoung [1], KIM Kyungho [1], KIM Minsoo [1], KIM Sungwon [1], KIM Tongil [1], PARK Junewoo [1]

[1]Department of Physics, Yonsei University
[2]Department of Physics, Kyungpook National University
[3]Department of Physics & Astronomy, Seoul National University
[4]Department of Physics, University of Seoul
hdyoo@yonsei.ac.kr

Abstract:

Innovative 3D printing technology is being widely used in various fields for both basic science and high technology. The next generation methodolgy of the novel calorimeter, dual-readout calorimeter, is one of candidates to achieve very high energy resolutions for both EM and hadronic particles in future e+e- colliders. Tranditionally the module of the dual-readout calorimeter has been built by cutting the copper plates and stacking them. In this presentation, we propose to build the module of the dual-readout calorimeter using the innovative metal 3D printing technology to achive very fine and precise projective structure required for the future e+e- colliders and show the status of the R&D.

Keywords:

dual-readout calorimeter, future e+e- collider, 3D-printing, higgs

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.05

Machine Learning application on particle identification for dual-readout calorimeter

LEE YunJae [1], PARK Inkyu [*1], LEE Jason [1], YOO Hwidong [2], KO Sanghyun [3], LEE Sehwook [4], KIM Bobae [3], LEE Junghyun [3], RYU Min Sang [3], KIM Doyeong [1], WATSON Ian [1], CHO Guk [2], EO Yun [2], HA Seungkyu [2], HWANG Kyuyeong [2], KIM Dongwoon [2], KIM Jaeyoung [2], KIM Kyungho [2], KIM Minsoo [2], KIM Sungwon [2], KIM Tongil [2], PARK Junewoo [2]

[1]University of Seoul
[2]Department of Physics, Yonsei University
[3]Department of Physics, Kyungpook National University
[4]Department of Physics, Seoul National University
icpark@uos.ac.kr

Abstract:

The dual-readout calorimeter consists of scintillating and Cerenkov fibers readout together. This design allows to measure both electromagnetic and hadronic showers with high precision in a single component, and neural network based machine learning (deep learning) implementations can maximise the physics potential for future colliders. Since classification using deep learning has been studied widely, it can be applied to Identifying incident particles of shower to improve event trigger and jet analysis. We present demonstrations of particle discrimination for the dual-readout calorimeter performed with energy deposit of simulated showers in the calorimeter. Image based deep learning model analyzes pixelated energy deposits with convolutional neural networks. and raw energy deposits can be applied to a point cloud based deep learning method.

Keywords:

Dual-readout calorimeter, Deep learning, Particle identification

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.06

Status of preparation for first test beam with dual-readout calorimeter R&D for future e+e- collider

HA Seungkyu *[1], KIM Bobae [2], LEE Junghyun [2], LEE Sehwook [2], RYU Min Sang[2], KO Sanghyun [3], KIM Doyeong [4], LEE Jason [4], LEE Yunjae [4], WATSON Ian [4], CHO Guk [1], EO Yun [1], HWANG Kyuyeong [1], KIM Dongwoon [1], KIM Jaeyoung [1], KIM Kyungho [1], KIM Minsoo [1], KIM Sungwon [1], KIM Tongil [1], PARK Junewoo [1], YOO Hwidong [1]

[1]Department of Physics, Yonsei University
[2]Department of Physics, Kyungpook National University
[3]Department of Physics, Seoul National University
[4]Department of Physics, University of Seoul
seungkyu.ha@cern.ch

Abstract:

Future lepton collider experiments (FCC-ee and CEPC) are proposed for the Higgs factory to understand the origin of mass and its relation to the Higgs mechanism. High-quality energy measurements for these experiments are essential to study couplings between Higgs and all decay products. The dual-readout calorimeter is considered an attractive option to satisfy this requirement. The KFC-DREAM (Korea Future Collider Dual-REAdout Method calorimeter) collaboration plans to have a beam test with two copper-fiber calorimeters at CERN at the end of 2021. The main programs measure the nuclear interaction lengths for pion and proton and study the performance of the copper-fiber calorimeters. In this talk, we will present our status of the 2021 test beam preparation.

Keywords:

Dual-readout (DR) calorimeter, Fcc-ee, CEPC, Future lepton collider experiments, Test Beam

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.07

입자가속기충돌실험에서의 원격제어실 구축 및 활용연구

CHO Kihyeon *[1], PARK Kihong [1]
[1]UST, KISTI
cho@kisti.re.kr

Abstract:

KISTI 에서는 고에너지물리 e-Science 를 구축하여 데이터 생산, 데이터 처리, 데이터 분석 전반에 걸쳐 가속기연구소에 가지 않고 언제 어디서나 연구할 수 있는 환경을 구축하여 연구하고 있다. 이의 일환으로, 2008 년 미국 페르미연구소 CDF 실험의 원격제어실을 구축하여 실험이 종료될 때 까지 성공적으로 활용 연구한 바 있다. 현재, 코로나 19 상황으로 가속기연구소를 방문하기 힘들므로, 이러한 e-Science 패러다임은 더욱 더 절실히 요청되고 있다, 이에, 현재 가속기실험데이터를 받고 있는 일본 KEK Belle II 실험의 원격제어실을 KISTI 에 구축하여, 온라인(On-line) 데이터획득 원격제어와 MC 데이터를 생산하는 오프라인(Off-line) 원격제어에 활용하고 있다. 이에 관한 구축 내용과 활용연구를 소개한다.

Keywords:

입자가속기충돌실험, 원격제어실, 온라인 데이터획득, 오프라인 원격제어

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C1.08

Update of calibration and energy resolution study with 4pi dual-readout calorimeter

YOO Hwidong [*1], KIM Bobae [2], LEE Junghyun [2], LEE Sehwook [2], RYU Min Sang [2], KO Sanghyun [4], KIM Doyeong [3], LEE Jason [3], LEE Yunjae [3], WATSON Ian [3], CHO Guk [1], EO Yun [1], HA Seungkyu [1], HWANG Kyuyeong [1], KIM Dongwoon [1], KIM Jaeyoung [1], KIM Kyungho [1], KIM Minsoo [1], KIM Sungwon [1], KIM Tongil [1], PARK Junewoo [1]

[1]Department of Physics, Yonsei University
[2]Department of Physics, Kyungpook National University
[3]Department of Physics, University of Seoul
[4]Department of Physics and Astronomy, Seoul National University
hdyoo@yonsei.ac.kr

Abstract:

Unveiling physics associated with Higgs is a major subject for high energy physics with future e^+e^- colliders such as FCC-ee and CEPC. In the conceptual design reports published in 2018, the dual-readout calorimeter is proposed for the calorimeter of these experiments. Dual-Readout Calorimeter (DRC), embedded with two types of optical fibers, Cerenkov and scintillating fiber, can measure the energy and momentum of electromagnetic and hadronic particles simultaneously. Cerenkov fibers are sensitive to light produced by relativistic shower particles, whereas scintillating fibers read the light signals produced by all charged shower particles. With these two types of signals, DRC accomplishes high precision energy measurement for hadrons and jets by measuring the fluctuation of the electromagnetic shower fraction in hadron showers and correcting their energy event-by-event. This presentation will show the results of calibration and the predictions for the energy resolution of the electromagnetic particles, hadrons, and jets of the dual-readout calorimeter based on the simulation carried out in GEANT4.

Keywords:

calorimeter, resolution, future collider, calibration, Geant4

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.01

Exploring properties of long-lived particles in inelastic dark matter models at Belle II

KANG Dong Woo *1
[1]KIAS
kdwgod54@gmail.com

Abstract:

The inelastic dark matter model is one kind of popular models for the light dark matter (DM) below O(1) GeV. If the mass splitting between DM excited and ground states is small enough, the co-annihilation becomes the dominant channel for thermal relic density and the DM excited state can be long-lived at the collider scale. We study scalar and fermion inelastic dark matter models for O(1) GeV DM at Belle II with $U(1)_D$ dark gauge symmetry broken into its Z_2 subgroup. We focus on dilepton displaced vertex signatures from decays of the DM excited state. With the help of precise displaced vertex detection ability at Belle II, we can explore the DM spin, mass and mass splitting between DM excited and ground states. Especially, we show scalar and fermion DM candidates can be discriminated and the mass and mass splitting of DM sector can be determined within the percentage of deviation for some benchmark points. Furthermore, the allowed parameter space to explain the excess of muon $(g-2)_\mu$ is also studied and it can be covered in our displaced vertex analysis during the early stage of Belle II experiment.

Keywords:

Dark matter, Belle II, Long-lived particle

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.02

XENON1T excess in local Z_2 DM models with light dark sector

BAEK Seungwon [2], KIM Jongkuk *[1], KO Pyungwon [1]
[1]School of Physics, KIAS
[2]Department of Physics, Korea University
jongkuk.kim927@gmail.com

Abstract:

Recently XENON1T Collaboration announced that they observed some excess in the electron recoil energy around a 2–3 keV. We show that this excess can be interpreted as exothermic scattering of excited dark matter on atomic electron through dark photon exchange. We consider DM models with local dark U(1) gauge symmetry that is spontaneously broken into its Z2 subgroup by Krauss-Wilczek mechanism.
In order to explain the XENON1T excess with the correct DM thermal relic density within freeze-out scenario, all the particles in the dark sector should be light enough, namely ~ O(100) MeV for scalar DM and ~ O(1 –10) MeV for fermion DM cases. And even lighter dark Higgs ϕ plays an important role in the DM relic density calculation: $XX^\dagger \to Z'\phi$ for scalar DM (X) and $\chi\chi \to \phi\phi$ for fermion DM (χ) assuming $m_{Z'} > m_\chi$. Both of them are in the p-wave annihilation, and one can easily evade stringent bounds from Planck data on CMB on the s-wave annihilations, assuming other dangerous s-wave annihilations are kinematically forbidden.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.03

The phenomenology of nuclear scattering for a WIMP of arbitrary spin

SCOPEL Stefano *[1], GONDOLO Paolo [2], KANG Sunghyun [1], JEONG Injun [1], TOMAR Gaurav [3]
[1]Physics, Sogang University
[2]Physics, University of Utah
[3]Physics, Munich Tech. University
scopel@sogang.ac.kr

Abstract:

We discuss for the first time the phenomenology of the non-relativistic effective Hamiltonian describing the nuclear scattering process for a Weakly Interacting Massive Particle (WIMP) of arbitrary spin. To this aim we obtain constraints from a representative sample of present direct detection experiments assuming the WIMP-nucleus scattering process to be driven by each one of the 44 effective couplings that arise for spin J up to 2. We find that a high value of the multipolarity s=0,1,...,2J of the coupling, related to the power of the momentum transfer appearing in the scattering amplitude, leads to a suppression of the expected rates and pushes the expected differential spectra to large recoil energies. For operators with large s the expected differential spectra can be pushed to recoil energies in the MeV range, with the largest part of the signal concentrated at above 100 keV and a peculiar structure of peaks and minima arising when both the nuclear target and the WIMP are heavy. As a consequence the present bounds on the effective operators can be significantly improved by extending the recoil energy intervals to higher recoil energies. Our analysis assumes effective interaction operators that are irreducible under the rotation group. Such operators drive the interactions of high-multipole dark matter candidates, i.e. states that possess only the highest multipole allowed by their spin. As a consequence our analysis represents also the first phenomenological study of the direct detection of quadrupolar, octupolar, and hexadecapolar dark matter.

Keywords:

Weakly Interacting Massive Particles, Dark Matter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.04

Self-interacting dark matter with multiple resonances

LEE Hyun Min *[1], KANG Yoo-Jin [1], KIM Seong Sik [1]
[1]Department of Physics, Chung-Ang University
hminlee@cau.ac.kr

Abstract:

We consider a scalar or fermionic particle with Z3 gauged symmetry as self-interacting dark matter. There are multiple mediators such as dark Higgs and gauge bosons for dark matter in this model. We compare between the single mediator and double mediator cases for the self interaction cross-section. In the case of a single mediator, we obtain the self-scattering cross section by the numerical method and the Hulthen approximation. We discuss the effects of double mediators on the non-perturbative enhancement of dark matter scattering.

Keywords:

dark matter, Z3 symmetry, multiple mediator

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.05

Four-form flux mediated dark matter

LEE Hyun Min [*1], SONG Ji Seon [1], KANG Yoo Jin [1], MENKARA Adriana Guerrero[1]
[1]Department of Physics, Chung-Ang University
hminlee@cau.ac.kr

Abstract:

We introduce a pseudo-scalar mediator for fermion dark matter and propose a new mechanism to communicate with the SM particles via the four-form flux couplings. In this scenario, the relaxation of Higgs mass and cosmological constant as well as the dark matter production are achieved simultaneously due to the four-form couplings. We impose the current bounds from direct and indirect detection experiments. We also discuss the possibility of utilizing the dark matter annihilation to explain the observed gamma ray or anti-proton exceses.

Keywords:

Four-form flux, dark matter production, relaxation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.06

Conformally invariant linear sigma models and Higgs inflation.

LEE Hyun Min *[1], GUERRERO MENKARA Adriana [1]
[1]Department of Physics, Chung-Ang University
hminlee@cau.ac.kr

Abstract:

The Standard Model Higgs boson makes a compelling candidate for the inflaton. However, despite its simplicity, Higgs inflation presents unitarity issues for low cutoff scales. We can rewrite Higgs inflation as a non linear sigma model. It is worth noticing that Starobinksky inflation can be regarded as the same non-linear sigma model.

We consider general linear sigma models in which we extend Higgs inflation by adding R^2 and higher curvature terms to the Lagrangian. The case for R^2 recovers slow roll inflation, while the higher curvature terms provide suitable UV completions for Higgs inflation. We also study the inflationary implications of these general sigma models.

Keywords:

Higgs inflation, sigma models, Inflation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C2.07

Aligned Natural Inflation from String Geometry

CHOI Kang Sin *[1,2], ANGUS Stephen [2,3]
[1]Scranton Honors Program, Ewha Womans University
[2]Institute of Mathematical Sciences, Ewha Womans University
[3]APCTP, APCTP
kangsin@ewha.ac.kr

Abstract:

We obtain aligned natural inflation from string theory. In natural inflation, an axion plays the role of inflaton and the alignment of two axions can explan effectively large decay constant requied by observations. The alignment naturally comes from geometry. We present a not-so-Large Volume Scenario stabilizing the moduli and giving the consistent observables with the Planck data, such as the spectral index and the tensor-to-scalar ratio.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C3.01

Experimental Study of Proton-Induced Energy-Dissipation Reactions on ^{93}Zr at 27MeV/u: Future Perspectives

HWANG Jongwon *[1], DOZONO Masanori [2], IMAI Nobuaki [2], MICHIMASA Shin'ichiro [2], SHIMOURA Susumu [2]
[1]Center for Exotic Nuclear Studies, IBS
[2]Center for Nuclear Study, The University of Tokyo
hjw8707@gmail.com

Abstract:

Nuclear reactions induced at a few tens of MeV/u are generally governed by the compound and pre-equilibrium processes. During these processes the kinetic energy of a projectile is *dissipated* into other nucleons in a target via *energy-dissipation reactions*. The present experiment studied the $^{93}Zr+p$ reaction at 27 MeV/u under inverse kinematics, where large production cross sections of a few hundred mb were measured, notably producing isotopes of $^{91,92}Nb$ important in nuclear transmutation. The global reaction code TALYS reproduced the measured results and confirmed the primary reaction mechanisms were the compound and pre-equilibrium processes. These proton-induced energy-dissipation reactions are expected to be a useful tool to produce proton-rich nuclei like ^{80}Zr and ^{100}Sn. By combining such reactions with spectroscopic methods (e.g. in-beam γ-ray spectroscopy), the structure information of exotic nuclei can be investigated. In this talk we will report the results of the recent experiment on $^{93}Zr+p$, present the future potential of proton-induced energy-dissipation reactions, and suggest possible plans using similar reactions for studying exotic nuclei.

Keywords:

Energy-dissipation reaction, TALYS, production cross section

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C3.02

Alpha-cluster structure study of ^{19}Ne using alpha resonance scattering experiment

KIM Dahee *[1], HAHN Insik Kevin [1]
[1]Center for Exotic Nuclear Studies, IBS
dahee@ibs.re.kr

Abstract:

The alpha-cluster structures in proton-rich nuclei recently have been studied based on a simple potential model. A few alpha-cluster states including positive and negative cluster states were suggested by the theoretical calculation. Two negative alpha-cluster states were measured but the positive alpha cluster states were not observed in the previous experiment. To measure the positive alpha-cluster states of ^{19}Ne, an alpha elastic scattering experiment with a radioactive ^{15}O beam was performed via the CNS RI Beam separator(CRIB) at RIKEN. The excitation function of ^{19}Ne was obtained over a wide energy range using the Thick Target Inverse Kinematics(TTIK) method. The resonance parameters were extracted by using the R-matrix code, SAMMY8. In this experiment, the positive alpha-cluster states were observed, which were not found in the previous experiment.

Keywords:

alpha-cluster, alpha elastic scattering, Thick Target Inverse Kinematics, R-matrix

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.01

Deflection of light by a Born-Infeld type electric charge

KIM Jin Young *[1]
[1]Department of Physics, Kunsan National University
jykim@kunsan.ac.kr

Abstract:

We study the bending of a light ray passing the electric field of a Born-Infeld type electric charge. We compute the deflection angle by taking a proper limit of the geodesic equation for the Einstein-Born-Infeld gravity and compare it with the result from the trajectory equation based on geometric optics.

Keywords:

deflection of light, Born-Infeld electrodynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.02

Dark energy from cosmological entanglement

LEE Jae-Weon *[1]
[1]Department of Electrical and Electronic Engineering, Jungwon University
scikid@gmail.com

Abstract:

We calculate the entanglement of cosmic matter across a cosmic horizon and suggest that entanglement energy associated with the entanglement entropy of the universe is the origin of dark energy. We also discuss the relation between our entanglement dark energy model and the Hubble tension.

Keywords:

dark energy, entanglement, Hubble tension

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.03

The Third Law of Thermodynamics in Rotating Black Holes

GWAK Bogeun *[1]
[1]Physics and Semiconductor Science-Physics, Dongguk University
rasenis@dgu.ac.kr

Abstract:

Black holes can be regarded as thermodynamic systems and are known to obey the laws of thermodynamics. This is true to the first and second laws, but the third law is subtle. Here, we introduce our investigations about the third law in some rotating black holes in four and three dimensions.

Keywords:

Black Holes, Thermodynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.04

BH Phase transition in Generalized JT gravity

KIM Kyung Kiu *[1]
[1]Department of Physics and Astronomy, Sejong University
kimkyungkiu@sejong.ac.kr

Abstract:

We review some of recent progress on two dimensional gravity. In addition we introduce BH-BH phase transition in JT gravity which is generalized by an arbitrary dilaton-potential. Also, we discuss a relation between this gravity model and a conformal field theory with TTbar deformation.

Keywords:

2D gravity, T-T bat deformation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.05

Boson stars as instantons

YEOM Dong-han *[1]
[1]Physics Education, Pusan National University
innocent.yeom@gmail.com

Abstract:

We investigate boson stars as a candidate of dynamical instantons. There might be obstacles to describe dynamical instantons, but one may overcome them with reasonable assumptions or several specific techniques. We further discuss on possible physical applications.

Keywords:

Boson star, Instanton

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.06

Observation of gravitational waves by electromagnetic waves beyond geometrical optics.

PARK Chan *[1]
[1]Division of Basic Researches for Industrial Mathematics, NIMS
iamparkchan@gmail.com

Abstract:

Electromagnetic waves are the most promising means of gravitational wave observation. Most of the existing analyzes are based on the assumption of geometrical optics that the frequency of electromagnetic waves is much larger than that of gravitational waves. We remove this premise and analyze the perturbation of electromagnetic waves by gravitational waves in more general situations. We discuss how to apply this in pulsar timing to expand the frequency range of observable gravitational waves.

Keywords:

gravitational wave, pulsar timing

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C4.07

Small-scale shear: peeling off diffuse subhalos with gravitational waves

CHOI Han-Gil *[1], PARK Chanung [1], JUNG Sunghoon [1]
[1]Department of Physics&Astronomy, Seoul National University
alivespace@snu.ac.kr

Abstract:

Dark matter (DM) substructures at subgalactic scales ($M \lesssim 10^7 M_\odot$ or $k \gtrsim 10^3\,\mathrm{Mpc}^{-1}$) are pristine testbeds for DM nature. However, they remain unexplored yet, being typically too diffuse and dark to induce visible signals. We first show that such NFW subhalos can be detected individually with single-imaged diffractive lensing of chirping gravitational waves (GWs). Detection rates are expected to be $\mathcal{O}(10)$ per year at BBO and less at LISA, limited by small merger rates of heavy black-hole binaries and large required SNR $\gtrsim 1/\gamma(r_0) \sim 10^3$. Remarkably, by developing a general formalism for weak diffractive lensing, we find that the frequency dependence, what is actually the measurable effect, *is the shear* γ *at the Fresnel length* r_F. It not only provides useful insights but also offers a new way to measure mass profiles; the chirping $r_F \propto f^{-1/2}$ probes a successively smaller length scale. Further, by completeing the formalism with strong diffractive lensing, we readily generalize estimations for power-law profiles and make the idea of measuring mass profiles more concrete.

Keywords:

Gravitational Lensing, Gravitational wave, Dark matter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C5.01

Structure and chemistry simultaneously studied by X-ray scattering and photoemission

NEMšáK Slavomír *1
1Advanced Light Source, Lawrence Berkeley National Laboratory
nemsak@gmail.com

Abstract:

Ambient pressure X-ray photoemission spectroscopy (APXPS) is a powerful technique for understanding surface chemistry under operating conditions. Although it is successfully closing so-called "pressure gap", materials in operating devices often undergo structural transformations, which are connected to another – "complexity gap". Even for model systems, such as single-crystals, atomically flat surfaces can become structured and rough, exposing new active sites (e.g. boundaries and step edges) and facilitating reaction pathways unavailable on the pristine surfaces.
One successful strategy to tackle this problem is to supplement chemical probe (APXPS) with *ex-situ* structural measurements (high pressure STM, operando XRD, etc) [1,2]. Our solution to the problem goes one step further and provides simultaneous *in-situ/operando* chemical and structural information by coupling APXPS with ambient pressure grazing incidence X-ray scattering (AP-GIXS). The concept and the design of the newly built instrument at the beamline 11.0.2 of the Advanced Light Source will be presented. First experimental results and some of the future concepts will be also discussed.

[1] D.R. Butcher et al., *Chem. Comm.* **61** (2013).
[2] L. Lukashuk et al., *ACS Catalysis* **8** (2018).

Keywords:

Operando analysis, Ambient Pressure XPS, Ambient Pressure Grazing Incident X-ray Scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C5.02

Dynamics in Spin Structures

KIM Changsoo [1], MOON Kyoung-Woong [1], HWANG Chanyong *[1]
[1]Quantum spin team, Koreas Research Institute of Standards and Science
cyhwang@kriss.re.kr

Abstract:

In this talk, we will introduce XFMR (X-ray Ferromagnetic Resonance) and recent researches about heterogeneous thin films studied by XFMR which combines ferromagnetic resonance and XMCD (X-ray Magnetic Circular Dichroism). X-ray generated from a circular accelerator is a form of pulse train (~ten ps pulse width, ~hundred MHz period) that allows us to observe ~ns dynamics if we synchronize the X-ray pulse with a stimulation on a physical system. XMCD measures direction of electron's spin of a specific element, which allows us to observe precession of electron's spin for each element when ferromagnetic resonance occurs. [1, 2] We will introduce recent results about magnetic interactions (spin current and exchange field) between ferromagnet layers in spin valve system (ferromagnet/normal metal/ferromagnet) and discuss our results obtained from 2A-MS beamline of PAL-II. [3] Moreover, it is known that antiferromagnetically ordered Co_xGd_{1-x} has a left-handed circular polarization between two compensation temperatures while normal ferromagnet should be right handed [4]. We expect to measure these precessional directions by using XFMR, directly.

[1] 김재영, X-선 자기 원형 이색성, Journal of the Korean Magnetics Society, **20**, 201 (2010).
[2] C. Klewe *et al*, Element- and Time-Resolved Measurements of Spin Dynamics Using X-ray Detected Ferromagnetic Resonance, Synchrotron radiation new, **33**, 12 (2020).
[3] Q. Li *et al*, Coherent ac spin current transmission across an antiferromagnetic CoO insulator, Nature Communications, **10**, 5265 (2019)
[4] C. Kim *et al*, Distinct handedness of spin wave across the compensation temperatures of ferrimagnets, Nature Materials, **19**, 980 (2020)

Keywords:

XFMR, BLS, spin wave

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C5.03

Ultrafast structural and carrier dynamics studied by optical pump-probe techniques

CHOI In Hyuk [1], LEE Seung Wook [1], KIM Min Seop [1], KANG Chul [2], NAKAMURA Masao [3], TOKURA Yoshinori [3], LEE Jong Seok [*1]

[1]Department of Physics and Photon Science, GIST

[2]Advanced Photonics Research Institute, GIST

[3]Center for Emergent Matter Science, RIKEN

jsl@gist.ac.kr

Abstract:

Optical pump-probe techniques have been proven to be a very powerful tool to investigate ultrafast motions of charge, spin, and lattice in condensed matters. Here, we present a few of our recent accomplishments about the photo-induced charge and structural dynamics. First, we present ultrafast photo-carrier dynamics near the surface of polar semiconductors and discuss an energy relaxation or cooling process of hot photo-carriers. Second, we discuss coherent phonon dynamics in oxide thin films which are closely coupled to electric and structural phase transitions.

Keywords:

ultrafast dynamics, pump-probe technique

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.01

Defect Engineering in Complex Oxide Thin Films

CHOI Woo Seok *[1]
[1]Physics, Sungkyunkwan University
choiws@skku.edu

Abstract:

Defect engineering in crystals opens new possibilities for discovering novel physical phenomena and tailoring the functionalities. Oxygen vacancies are arguably the most important defect, and hence, have been extensively studied in manipulating the physical properties of transition metal oxides. The relative facile control of the oxygen vacancies in transition metal oxides also led to the studies to be flourished. However, we are learning that cation vacancies are also playing an important role for the emergent phenomena in transition metal oxides. More importantly, novel method to systematically engineer the cation vacancies are being developed using Pulsed Laser Epitaxy (PLE) technique.

In this presentation, we report efficient and systematic defect engineering in epitaxial complex oxide thin films. We start from the defect engineering of prototypical perovskite oxide $SrTiO_3$ homoepitaxial thin film. We report a selective formation of the different types of elemental vacancies and their individual roles in determining the structural and electronic properties of $SrTiO_3$ homotepitaxial thin films. Among various parameters of PLE, we found that laser energy, oxygen partial pressure ($P(O_2)$), and oxygen flow rate play distinct roles in influencing both oxygen and cation stoichiometry. In particular, laser energy was mainly responsible for changing the cation stoichiometry, while oxygen flow rate selectively tuned the oxygen vacancy concentration in $SrTiO_3$ thin films. Moreover, it was found that oxygen vacancy was mainly responsible for the electronic insulator-to-metal transition, but on the contrary to the common belief, did not influence the Sr vacancy induced cubic-to-tetragonal structural transition.

We then move to other perovskites by changing either *A*- (Eu for Sr, $EuTiO_3$) or *B*- (Ru for Ti, $SrRuO_3$), or both *A*- and *B*-site (Ca for Sr and Ru for Ti, $CaRuO_3$) elements within the ABO_3 framework, and try to come up with a unified understanding of the defect engineering in complex oxide epitaxial thin films. The control of multiple phase transitions in complex oxides exploiting selective vacancy engineering provided by PLE opens an unprecedented opportunity for tailoring and understanding the materials properties.

[1] H. N. Lee *et al.*, *Sci. Rep.* **6**, 19941 (2016).
[2] S. A Lee *et al.*, *Sci. Rep.* **6**, 23649 (2016).
[3] S. A Lee *et al.*, *Energy Environ. Sci.* **10**, 924 (2017).
[4] S. A Lee *et al.*, *Sci. Rep.* **7**, 11583 (2017).
[5] S. A Lee *et al.*, *Sustain. Energ. Fuels* **3**, 2867 (2019).
[6] J. Lee *et al.*, *Appl. Phys. Lett.* **117**, 163906 (2020).
[7] D. Shin *et al.*, submitted (2021).

Keywords:

Transition metal oxide, Defect engineering, Epitaxial thin film

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.02

Lattice- and impurity-type Kondo effect in graphene studied using ARPES

HWANG Choongyu *[1]
[1]Physics, Pusan National University
choonkyu.hwang@gmail.com

Abstract:

The interaction between magnetic impurities and metallic background provides a key to understand many-body interactions and their effect on the magnetic properties of a material. Such an interaction leads to the formation of a resonant type many-body ground state, so-called Kondo resonance. Here I address the emergence of Kondo resonance in graphene by investigating the electron band structure using angle-resolved photoemission spectroscopy (ARPES). The presence of a magnetic impurity, Ce, and the formation of an interface with a Kondo insulator, SmB_6, provide impurity-type and lattice-type magnetic moments, respectively, that are screened by the spins of Dirac fermions from graphene. By examining the Kondo resonance in graphene, the Kondo effect is observed to be different from those of conventional three-dimensional Kondo insulators. In addition to the well-known temperature dependence of the Kondo effect, I present a direct evidence of the Kondo effect tuned by charge carrier density of graphene, indicating that the many-body physics in graphene can be properly tuned to give rise to the strongly correlated electron phases.

Keywords:

Graphene, Kondo effect, ARPES

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.03

Topological solitons in one-dimensional charge-density waves

KIM Tae-Hwan *[1]
[1]Physics, POSTECH
taehwan@postech.ac.kr

Abstract:

A topological soliton is a topological edge state bridging two degenerate but topologically distinct phases, which has been an important conceptual tool in many branches of science. For example, in electronic systems, solitons are responsible for the high electric conductivity in conjugated polymers such as polyacetylene. The 1D charge density wave (CDW) system of indium atomic wires self-assembled on a silicon surface was known to have topological solitons with unexpectedchirality. The indium wire is described by a coupled double Peierls-dimerized atomic chain with four degenerate ground phases. The interchain coupling induces dynamical breaking of the sublattice symmetry and results in three types of topological solitons—right-chiral, left-chiral, and achiral solitons—each having distinct soliton states.
Chirality or handedness manifests in various forms in nature and plays a significant role in all branches of the natural sciences including chemistry, biology, mathematics, and physics. For example, in spin-ordered states, chirality manifests magnetic chiral solitons in chiral magnets, vortexes or skyrmions in thin magnetic layers, and topological monopoles in Weyl semimetals. Such topological particle-like excitations can be used as next-generation information carriers in non-volatile memory and logic devices on the basis of their topological robustness. Chiral solitons including a ground state (null state) can carry quaternary-digit information in terms of topological charges. Furthermore, due to their unique four-fold degeneracy (or the Z_4 symmetry), Z_4 algebraic operations would be possible in principle among these solitons and a null state. Thus, these topological chiral solitons can be utilized not only for multi-digit memories in electronic systems, but also for logic devices using topological excitations. In contrast to the other logic operation schemes, the chiral soliton operation does not need sophisticated engineering since it is intrinsic to the system's Z_4 symmetry.
In this talk, I will show various local phase defects of In atomic wires on Si(111) in their quasi-1D CDW states. I will discuss the solitonic characteristics including their chirality, electronic states, and mobility. Then, I will demonstrate that two solitons with different chirality can merge into another chiral soliton. This work will open a door towards logic devices using chiral topological excitations. Chiral solitons could be a platform for storage and operation of robust topological multi-digit information.

Key papers:

[1] T.-H. Kim *et al.*, Phys. Rev. Lett. **109**, 246802 (2012).
[2] S. Cheon *et al.*, Science **350**, 182 (2015).

[3] T.-H. Kim *et al.*, Nat. Phys. **13**, 444 (2017).
[4] S.-H. Han *et al.*, Phys. Rev. B **102**, 235411 (2020).
[5] S.-W. Kim *et al.*, Phys. Rev. B **102**, 121408 (2020).
[6] C. Oh *et al.*, Scientific Reports **11**, 1013 (2021).

Keywords:

soliton, charge density wave, topological defect, chirality, topological soliton

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.04

Raman imaging of ferroelastically-designed Jahn-Teller domains in $LaMnO_3$ thin films

KIM Yong-Jin [1,2], PARK Heung-Sik [1,2], YANG Chan-Ho *[1,2]
[1]Physics, KAIST
[2]Center for Lattice Defectronics, KAIST
chyang@kaist.ac.kr

Abstract:

Perovskite $LaMnO_3$ (LMO) displays a wide range of physical properties due to strong coupling among the lattice, charge, spin, and orbital degrees of freedom wherein four electrons occupy Mn^{3+} *d*-orbitals with high spin configuration ($t_{2g}^3 e_g^1$) [1]. Due to single-electron occupation in e_g level, LMO exemplifies the orbital-ordered system harmonized with the cooperative Jahn-Teller (JT) distortion [2] and high electrochemical activity [3]. Here, we introduce the real-space observation of JT phonon/orbiton domains in $LaMnO_3$ thin film using confocal Raman spectromicroscopy. The characteristic symmetries of JT-originated Raman modes allow us to detect and visualize the local population and orientation of JT planes. Based on a crystal structural analysis, we find that the formation of ferroelastic domains with W or W' walls provides the basic framework for JT domain textures. Furthermore, we demonstrate the application of local external stress can manipulate JT domains. Our findings provide a useful pathway for mechanically-tunable orbitronic applications.

[1] Y. Tokura *et al., Science* **288**, 462 (2000).
[2] Y.-J Kim, *et al.*, *EPL* **116**, 27003 (2016).
[3] Y.-J Kim and C.-H Yang, *NPG Asia Mater.* **12**, 1 (2020).

Keywords:

Jahn-Teller distortion, Raman, LaMnO3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.05

Oxygen Vacancy-Induced Topological Nanodomains in Ultrathin Ferroelectric Films

PENG Wei [1,2], MUN Junsik [3], KIM Miyoung [3], NOH Tae Won [*1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]CCES, CCES (IBS)
[3]Department of Materials Science and Engineering , Seoul National University
twnoh@snu.ac.kr

Abstract:

Oxygen vacancy in oxide ferroelectrics can be strongly coupled to the polar order via local strain and electric fields, thus holding the capability of producing and stabilizing exotic polarization patterns. However, despite intense theoretical studies, an explicit microscopic picture to correlate the polarization pattern and the distribution of oxygen vacancies remains absent in experiments. Here we show that in a high-quality, uniaxial ferroelectric system, i.e. compressively strained $BaTiO_3$ ultrathin films (below 10 nm), nanoscale polarization structures can be created by intentionally introducing oxygen vacancies in the film while maintaining structure integrity (namely no extended lattice defects). Using scanning transmission electron microscopy, we reveal that the nanodomain is composed of swirling electric dipoles in the vicinity of clustered oxygen vacancies. This finding opens a new path towards the creation and understanding of the long-sought topological polar objects such as vortices and skyrmions.

Keywords:

ferroelectrics, topological nanodomains, oxygen vacancies

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C6.06

Enhancing functionalities of Ruddlesden-Popper thin films by suppressing of out-of-phase boundaries

KIM Jinkwon [1,2], KIM Youngdo [1,2], MUN Junsik [3], KIM Jeong Rae [1,2], HAHN Sungsoo [1,2], KIM Miyoung [3], KIM Changyoung [1,2], NOH Tae Won *[1,2]
[1]Center for Correlated Electron Systems, Institute for Basic Science
[2]Department of Physics and Astronomy, Seoul National University
[3]Department of Materials Science and Engineering and Research Institute of Advanced Materials, Seoul National University
twnoh@snu.ac.kr

Abstract:

Over the past decades, Ruddlesden-Popper (RP) phase oxides ($A_{n+1}B_nO_{3n+1}$, n = 1, 2, ...) have been spotlighted with advantageous physical properties such as high-temperature superconductivity, giant magnetoresistance, and novel J_{eff} = 1/2 Mott states. [1-3] These emergent phenomena provide a platform for novel oxide-based electronic device applications. However, high-quality RP thin film growth has been disturbed by extended structural defects, so-called out-of-phase boundaries (OPBs), arising from the structural difference with substrates. [4] Since OPB formation hampers the physical properties of RP thin films, the suppression of the structural defects is highly required to carry out the high-performance RP-based functional devices. [4-6]

In this study, we engineered the OPB suppression in RP oxide thin films by using single-terminated $LaSrAlO_4$ substrate (n = 1 RP phase, a = b= 3.756 Å and c =12.636 Å). As a model system, the high-T_c cuprates superconductor $La_{2-x}Sr_xCuO_4$ thin film (n = 1 RP phase, a = b= 3.777 Å and c =13.226 Å) was employed. Despite the structural similarities between films and substrates, the $La_{2-x}Sr_xCuO_4$ films exhibited huge OPB formations when deposited on mixed-terminated $LaSrAlO_4$ substrate. In contrast, when the $La_{2-x}Sr_xCuO_4$ films were deposited on single-terminated $LaSrAlO_4$ substrates, the OPBs were almost suppressed in the film structure. Notably, these OPB-free $La_{2-x}Sr_xCuO_4$ films exhibited highly enhanced superconductivity (T_c^{zero} ~ 30 K) than the film with huge OPB formation (T_c^{zero} ~ 5 K) under the same thickness (~ 6 nm). Our study suggests a comprehensive method to suppress OPB formation in RP thin films, offering fruitful opportunities to utilize genuine physical properties of RP oxides.

[1] J. G. Bednorz *et al.*, *Science* **236**, 73 (1987).
[2] Y. Moritomo *et al.*, *Nature* **380**, 141 (1996).
[3] B. J. Kim *et al.*, *Phys. Rev. Lett.* **101**, 076402 (2008).
[4] M. A. Zurbuchen *et al.*, *Appl. Phys. Lett.* **78**, 2351 (2001).
[5] A. Tsurumaki-Fukuchi *et al.*, *ACS Appl. Mater. Interfaces* **12**, 28368 (2020).
[6] Y. Krockenberger *et al.*, *Appl. Phys. Lett.* **97**, 082502 (2010).

Keywords:

Ruddlesden-Popper phase, Out-of-phase boundaries, Oxide thin films, Superconductivity, Interfaces

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.01

Why the Fermi Liquid can appear in strongly correlated system

OH Eunseok [1], YUK Taewon [1], SIN Sang Jin *[1]
[1]physics department, Hanyang University
sangjin.sin@gmail.com

Abstract:

By considering the effect of the scalar condensation on the fermion spectrum near the quantum critical point in the dual gravity setup,
we find that the spectrum is gapped or gapless depending on the sign of the scalar so that there is a metal to insulator transition. We show that there is a topologically protected fermion zero mode, which provides a stable particle. We suggest that this can be the origin of the Fermi liquid appearing in very strongly correlated system.
We also show that the strange metal phase with T-linear resistivity emerges at high enough temperature if the gravity has a horizon.
The phase boundaries are calculated according to the density of states to understand the structure of the phase diagram near the quantum critical point.
Our work provides an exactly solvable model for quantum phase transition.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.02

Many-body localisation in fine-tuned flatband systems

DANIELI Carlo [2], ANDREANOV Alexei *[1,3], FLACH Sergej [1,3]
[1]Center for Theoretical Physics of Complex Systems, IBS
[2]Condensed Matter, Max-Plank Institute for Physics of Complex Systems
[3]Basic Science Program, UST
aalexei@ibs.re.kr

Abstract:

We present families of translationally invariant systems exhibiting signatures of many-body localization transition from single particle lattices hosting a mix of flat and dispersive bands equipped with fine-tuned two-body interactions. We show how fine-tuning the interaction result in an extensive set of local conserved quantities highlighting irreducible sectors in the Hilbert space. In each sector, the conserved quantities induce an effective disorder in the Hamiltonian resulting in a transition between ergodic and localized phases upon varying the interaction strength and the filling factors. We present computational evidence for the such transition for fermionic systems in two and three band systems. Nevertheless, this fine-tuning result in a generator of lattice Hamiltonians for arbitrary lattice dimensions available both interacting bosons and fermions.

Keywords:

flatbands, fine-tuning, many-body localisation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.03

Strange metal solution of the 2d Hubbard model

KIM Aaram J.*[1,2], WERNER Philipp [1], KOZIK Evgeny [2]
[1]Department of Physics, University of Fribourg
[2]Department of Physics, King's College London
a.romeo85@gmail.com

Abstract:

The bold-line diagrammatic solution of the 2d Hubbard model in the strong coupling regime is of an SYK non-Fermi-liquid (nFL) type, obtained in a controlled way by the numerically exact diagrammatic Monte Carlo method. In the atomic (zero-hopping) limit, the solution is due to the unphysical branch of the Luttinger-Ward functional, for which the SYK model is the exact solution at the second order. The Green's function retains the SYK-type scaling behavior even at higher orders. The solution for the doped 2d Hubbard model also features a SYK-type nFL regime in a wide intermediate temperature range enclosed by the low-temperature metallic phase and the high-temperature atomic limit. The potential SYK physics in the Hubbard model is discussed.

Keywords:

Strange metal, Hubbard model, SYK model, Bold-line diagrammatic series

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.04

A Subsystem Ginzburg-Landau and SPT Orders Co-existing on a Graph

KIM Jintae *[1], LEE Hyun-Yong [2,3], HAN Jung Hoon [1]
[1]Department of Physics, Sungkyunkwan University
[2]Department of Applied Physics, Korea University, Sejong
[3]Division of Display and Semiconductor Physics, Korea University, Sejong
jint1054@gmail.com

Abstract:

We introduce a model demonstrating the co-existence of subsystem symmetry breaking (SSB) and symmetry-protected topological (SPT) order, or subsystem LSPT order for short. Its mathematical origin is the existence of both a subsystem and a local operator, both of which commute with the Hamiltonian but anti-commute between themselves. The reason for the exponential growth of the ground state degeneracy which depends on the first Betti number is attributed to the existence of subsystem symmetries, which allows one to define both the Landau order parameter and the SPT-like order for each independent loop. The model on an open graph demonstrates symmetry fractionalization as an indication of SPT order.

Keywords:

subsystem symmetry breaking, SPT order, topological degeneracy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.05

Causal smoothing spline approach for analytic continuation of imaginary frequency Green’s function

HAN Mancheon [1], CHOI Hyoung Joon [*1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Most of practical many-body simulations are performed in imaginary-time because imaginary-time calculation is much more stable and reliable than real-time one in many cases. However, the analytic continuation which obtains real-time dynamics from the imaginary-time data is a very ill-posed problem. To conduct the analytic continuation, many approaches have been developed and among them the maximum entropy method is most popular. In our present work, we propose a causal smoothing spline approach for the analytic continuation. In our causal smoothing spline approach, the analytic continuation problem is regularized through the roughness penalty using second derivatives of the spectral function. Then, the regularization parameter λ is determined by the L-curve approach. Thus, our approach performs the analytic continuation without relying on any artificial parameter. Moreover, our method can be applied straightforwardly to matrix-valued Green’s functions as well. We demonstrate that our approach is a robust and precise method by applying it to systems of known spectral functions and practical dynamical mean-field calculations. This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335).

Keywords:

Analytic continuation, DMFT, Green's function, Self energy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.06

Determine the spatial locality of self-energy of LiFeAs

KIM Minjae [*1,7], MIAO Hu [2], CHOI Sangkook [3], ZINGL Manuel [4], GEORGES Antoine [4,5,6,8], KOTLIAR Gabriel [3,7]
[1]Department of Chemistry, POSTECH
[2]Material Science and Technology Division, Oak Ridge National Laboratory
[3]Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory
[4]Center for Computational Quantum Physics, Flatiron Institute
[5]Institut de Physique, College de France
[6]CPHT, Ecole Polytechnique
[7]Department of Physics and Astronomy, Rutgers University
[8]Department of Quantum Matter Physics, University of Geneva
garix@postech.ac.kr

Abstract:

Understanding the nature of the electronic correlations is vital for explanations of the electronic properties, magnetism, and superconductivity of the iron-based superconductors (FeSCs). An important question is the degree of spatial non-locality of the electronic correlations. Spatially local electronic correlation in the correlated orbital is the starting point of dynamical mean-field theory (DMFT), which has been proved to be powerful in understanding spectroscopic properties of the FeSCs [1,2]. However, recent theoretical and experimental reports on one of the FeSCs, LiFeAs, suggested the importance of spatially non-local correlations for descriptions of the quasiparticle of the material. [3,4] In this presentation, we extract spatially resolved and orbital dependent electronic self-energy of LiFeAs from angle-resolved photoemission spectroscopy. It is shown that in the reference frame of the linearized quasiparticle self-consistent GW (LQSGW), the extracted electronic self-energy is dominantly local in space.[5] These results imply that an LQSGW reference Hamiltonian augmented by a dynamical local self-energy is a good starting point for describing the electronic structure from which superconductivity emerges at lower temperatures. Hence, correlation effects for this class of materials can be separated into static non-local contributions well described by LQSGW and local dynamical contributions.

[1] H. Miao et al., PRB 98, 020502 (2018)
[2] H. Miao et al., PRB 94, 201109 (2016)
[3] K. Zantout et al., PRL 123, 256401 (2019)
[4] J. Fink et al., PRB 99, 245156 (2019)
[5] M. Kim et al., arXiv:2009.10577 (2020)

Keywords:

Dynamical mean field theory, Iron-based superconductor, GW, electronic correlations, angle resolved photoemission

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.07

Many-body Order Parameters for Two Dimensional Insulators

LEE Wonjun [1], KANG Byungmin [2], CHO Gil Young *[1,3,4]
[1]Department of Physics, POSTECH
[2]Department of Physics, KIAS
[3]Department of Physics, APCTP
[4]Center for Artificial Low Dimensional Electronic Systems, IBS
gilyoungcho@gmail.com

Abstract:

We construct new many-body invariants for quadrupole, 2D Chern, 3D chiral hinge, boundary polarization, and many 2D higher-order insulators [1,2]. Our many-body invariants are written in terms of expectation values of unitary operators with respect to many-body ground states on some manifolds with twisted boundary conditions, which depends on the topology that we want to diagnose. We will show that, when applied to the 2D corner states, the many-body measures satisfy the so-called charge sum rule for multipoles in crystalline systems [2]. This can be viewed as the "many-body generalization" of the previous charge sum rules, which had focused only on the free-electron limits.
[1] B. Kang, W. Lee, and G. Y. Cho, "Many-Body Invariants for Chern and Chiral Hinge Insulators," *Phys. Rev. Lett.*, vol. 126, no. 1, p. 16402, 2021, doi: 10.1103/PhysRevLett.126.016402.
[2] W. Lee, G. Y. Cho, and B Kang, in preparation.

Keywords:

Topological Invariants, Many-body order parameter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.08

Terahertz Time-Domain Spectroscopy of Ferromagnetic van der Waals CrI_3

KIM Jonghyeon [1], KIM Jangwon [1], SON Suhan [2,3], KIM Junghyun [2,3], PARK Je-Geun [2,3], KIM Jae Hoon [*1]

[1]Department of Physics, Yonsei University
[2]Department of Physics and Astronomy, Seoul National University
[3]Center for Quantum Materials, Seoul National University
super@yonsei.ac.kr

Abstract:

CrI_3 is a two-dimensional van der Waals material with Ising-type ferromagnetism below T_c=61 K. We conducted terahertz time-domain spectroscopy of CrI_3 single crystal in the frequency range of 4-125 cm^{-1} under an external magnetic field 0-7 T. The ferromagnetic resonance was detected at around 9 cm^{-1} under 7 T at 1.5 K, and linearly shifted to lower energy as the magnetic field decreased. Also, a phonon splitting was found at the structural phase transition temperature (T_S = 210 K).

Keywords:

van der Waals, ferromagnetism, ferromagnetic resonance, CrI3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C7.09

Metrology of topological band indices via resonant inelastic x-ray scattering

LEE SANGJIN *[1], KANG Byungmin [2], CHO Gil Young [3,4], KIM Bumjoon [1,3,4]
[1]Department of Physics, APCTP
[2]Department of Physics, KIAS
[3]Department of Physics, POSTECH
[4]Center for Artificial Low Dimensional Electronic Systems, IBS
sangjin5190@gmail.com

Abstract:

Topology is a central notion in the classification of band insulators and characterization of entangled many-body quantum states. In some cases, it manifests as quantized observables such as quantum Hall conductance. However, being inherently a global property depending on the entirety of the system, its measurement has remained elusive to local experimental probes. Here, we demonstrate that some topological band indices can be measured by resonant inelastic x-ray scattering. Using the paradigmatic Su-Schrieer-Heeger model and its higher-order variants, we show analytically that non-trivial band topology leads to distinct and pronounced scattering intensity at particular momentum and energy. Our theory is tested by numerical simulations and the result is shown to be robust under the effects of disorders inevitable in real specimens. Our result establishes an incisive bulk probe for the measurement of topological band structures.

Keywords:

RIXS, Topological band indicies, Su-Schrieer-Heeger model, Quadrupolar insulator

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C8.01

Simple physics of triboelectricity

KIM Yong-Hyun *[1]
[1]Department of Physics, KAIST
yong.hyun.kim@kaist.ac.kr

Abstract:

Electricity has a history of more than 2600 years, back to the ages of Thales and Plato in ancient Greece, and triboelectricity is the first notion that humans recognized about electricity. Almost a century ago, Peter Shaw claimed in *Nature* regarding triboelectricity that "*This class of research is simple-seeming. But those who have spent time on the subject will allow that it is very baffling; those who have not done so will at least remember that despite great efforts by physicists the subject has not yet passed the pioneer stage*". Since then, nothing has improved, despite of the birth of modern quantum mechanics and state-of-the-art nanotechnology. The only way to characterize triboelectricity has been to display triboelectric materials in a series called a triboelectric series. Yet, no triboelectric series is commonly accepted, simply because it is not reproducible. No single theory can provide any quantification of a triboelectric series. Triboelectricity remains as a big question mysteriously unsolved in human history.

Here, we for the first time provide a way to quantify triboelectricity and triboelectric series. Based on simple *thermoelectric* physics between two rubbing materials, we formulate a theory of triboelectricity that leads us to profound understanding and new discoveries on this fundamental phenomenon. We are able even to quantify the triboelectric surface charge density at 3-4 micro-C/m^2 and its unique time dependency, which are very consistent with experimental observations. Because of its generality, the theory can be applied even to the triboelectricity in lightning clouds and to the field of triboelectric nanogenerators (TENG), which is fast evolving in energy harvesting technology.

Keywords:

triboelectricity, static electrification, thermoelectricity, energy harvesting, triboelectric series

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C8.02

Quantum coherence and ballistic transport in graphene nanostructures

KI DongKeun *[1]
[1]Department of Physics, The University of Hong Kong
dkki@hku.hk

Abstract:

The ultimate 2D nature of electron transport and the absence of an energy gap separating conduction and valence bands make graphene layers a unique platform to investigate and engineer various quantum transport phenomena. Examples include, but not limited to, ballistic non-local transport, weak (anti-)localization effects, Aharonov-Bohm effects, and Fabry-Perot interference effects in local gated p-n junctions. In this talk, I will review our past and on-going efforts to investigate such diverse quantum coherence and ballistic transport phenomena in graphene nanostructures and understand the microscopic mechanisms that limit the charge transport in the system. I will first show that by studying weak localization effects in graphene-hexagonal boron nitride heterostructures, we can prove that it is random strain fluctuations that limit the charge transport in the system. Furthermore, using ultraclean suspended devices in a multi-terminal geometry, I will show that negative non-local resistance can appear in a specific range of charge density determined by sample temperature. This behavior was later attributed to electron-hole collisions at charge neutrality point in graphene. Finally, I will talk about progresses in building new local-gate architectures to enhance energy and/or length scale of the Fabry-Perot interference in graphene p-n junctions. This may help us to realize room-temperature quantum coherence devices.

Keywords:

Quantum coherence, Ballistic transport, Graphene nanostructure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C8.03

Probing the topological Anderson transition with quantum walks

KIM Kun Woo *[1]
[1]Physics, Chung-Ang University
kunx@cau.ac.kr

Abstract:

We consider one-dimensional quantum walks in optical linear networks with synthetically introduced disorder and tunable system parameters allowing for the engineered realization of distinct topological phases. The option to directly monitor the walker's probability distribution makes this optical platform ideally suited for the experimental observation of the unique signatures of the one-dimensional topological Anderson transition. We analytically calculate the probability distribution describing the quantum critical walk in terms of a (time staggered) spin polarization signal and propose a concrete experimental protocol for its measurement. Numerical simulations back the realizability of our blueprint with current date experimental hardware.

Keywords:

quantum walk, Floquet topological insulator, critical phase, optical linear network, Anderson transition,

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.01

Direct tuning of graphene work function via chemical vapor deposition control

YOON TaeGeun [1], WU Qinke [1], YUN Dong-Jin [4], KIM Seong Heon [2], SONG Young Jae [*3]
[1]SKKU Advanced Institute of Nano Technology (SAINT), Sungkyunkwan University
[2]Department of Physics, Myongji University
[3]Depart. of Nano Engineering and Depart. of Physics, Sungkyunkwan University
[4]Analytical Engineering Group, Samsung Advanced Institute of Technology
yjsong@skku.edu

Abstract:

Besides its unprecedented physical and chemical characteristics, graphene is also well known for its formidable potential of being a next-generation device material. In fabricating graphene-based electronic devices, work function (WF) of graphene plays a crucial role as it is explicitly related to energy band alignment and, eventually, to operation of the devices. Previous works on manipulating work function of graphene were predominantly focused on chemical alternation of the surface, relatively disregarding adjustment of chemical vapor deposition (CVD) condition in spite of its simplicity. Here we report a successful WF tuning method for graphene grown on a Cu foil with a novel CVD growth recipe, in which the CH_4/H_2 gas ratio is changed. Kelvin probe force microscopy (KPFM) verifies that the WF-tuned regions, where the WF differs by approximately ~250 meV, coexist with the regions of intrinsic WF within a single domain. By combining KPFM with lateral force microscopy (LFM), it is demonstrated that the WF-tuned area can be restored or even manipulated, by pressing it with an atomic force microscopy (AFM) tip. A highly plausible mechanism for the WF tuning is suggested, in which the increased graphene-substrate distance by excess H_2 gases may cause the WF increase within a single graphene flake. This novel WF tuning method via a simple CVD growth control provides a new direction to manipulate the WF of various 2-dimensional nanosheets as well as graphene. Further detailed studies on WF-tuned graphene growth will be addressed in the presentation.

Keywords:

graphene, KPFM, LFM, CVD, manipulating work function

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.02

Hydrodynamic Charge Scattering Behavior in Graphene

LEE Jea Jung [1], LEE Heeyeon [1], KIM Hakseong [2], SEO Dongjea [3,4], GONG Yoon Ji [6], KIM Young Dong [1], YOO Keon Ho [1], CHOI Heon-Jin [3], HAN Il Ki [5,6], NAM Youngwoo [7], KIM Young Duck [*1,6,8]
[1]Physics, Kyung Hee University
[2]Korea Research Institute of Standards and Science, KRISS
[3]Materials Science and Engineering, Yonsei University
[4]Electrical and Computer Engineering, University of Minnesota
[5]KHU-KIST Department of Converging Science and Technology, Kyung Hee University
[6]Nanophotonics Research Center, KIST
[7]Physics, Gyeongsang National University
[8]Information Display, Kyung Hee University
ydk@khu.ac.kr

Abstract:

Collective charge movement in the solid can be described by hydrodynamic transport such as Fermi liquid or Dirac fluid. In this system, the charged particles such as electron and hole's interaction get dominant scattering source in the transport. Recently, many experimental results about the hydrodynamic phenomenon in graphene were reported by various studies. [1~6] In graphene, through the reduced screening effect near the charge neutrality point, the electron flows like a liquid by significantly enhanced electron-electron scattering. [7] Although many studies reveal various aspects of the liquid-like charge flow, the on-set conditions according to scattering length relations and influence in charge flow by geometry are still elusive. Here we studied the inter-charge scattering (momentum are conserved) and charge-phonon (momentum are not conserved) scattering inside of the mono- and bilayer graphene in terms of scattering length and their cross-over points through temperature and charge density. We revealed that the scattering length cross-over temperature in monolayer graphene is converged with the increase of charge carrier density. On the other side, the relation in bilayer graphene is far different from the case of the monolayer, increasing linearly as larger carrier density. We confirmed our suggestion is matched well with previous studies of hydrodynamic transport in graphene. Additionally, in this study, we claim the possibilities that the non-reciprocal current flow in the graphene.

Keywords:

Graphene, Hydrodynamic Transport, Charge Scattering, Fermi Liquid, Dirac Fluid

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.03

Semiconductor-less field emission barristor with I_{ON}/I_{OFF} of 10^6

LEE Jun-Ho [1], JEONG Nae Bong [1], CHOI Inchul [1], KIM Min Jeong [1], CHUNG Hyun-Jong [*1]
[1]Department of Physics, Konkuk University
hjchung@konkuk.ac.kr

Abstract:

Semiconductors have long been perceived as a prerequisite for solid-state transistors. Although new switching principles for nanometer-scale devices have emerged based on the deployment of two-dimensional (2D) van der Waals heterostructures, tunneling and ballistic currents through short channels are difficult to control, and semiconducting channel materials remain indispensable for practical switching. In this study, we report a semiconductor-less solid-state electronic device that exhibits an industry-applicable switching of the ballistic current. This device modulates the field emission barrier height across the graphene-hexagonal boron nitride interface with I_{ON}/I_{OFF} of 10^6 obtained from the transfer curves and exhibits unprecedented current stability in temperature range of 15-400 K. The semiconductor-less switching resolves the long-standing issue of temperature-dependent device performance, thereby extending the potential of 2D van der Waals devices to applications in extreme environments.

Keywords:

Graphene, hBN, Barristor, Fowler-Nordheim Tunneling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.04

Gate-Tunable Photodetector and Ambipolar Transistor

OH Gwang Taek [1], AHN Yeong Hwan [2], PARK Bae Ho [*1]
[1]Konkuk University
[2]Department of Physics and Department of Energy Systems Research, Ajou University
baehpark@konkuk.ac.kr

Abstract:

Next-generation electronic and optoelectronic devices require a high-quality channel layer. Graphene is a good candidate owing to its high carrier mobility and unique ambipolar transport characteristics. However, the on/off ratio and photoresponsivity of graphene are typically low. Transition metal dichalcogenides (e.g. $MoSe_2$) are semiconductors with high photoresponsivity but lower mobility than graphene. Here we propose a graphene/MoSe2 barristor with a high-k ion-gel gate dielectric. It shows the highest carrier mobility (~247 cm2/V·s) among reported MoSe2 devices, high on/off ratio (3.3×10^4), and ambipolar behavior that is controlled by an external bias. The barristor exhibits very high external quantum efficiency (EQE, 66.3%) and photoresponsivity (285.0 mA/W). We demonstrate that an electric field applied to the gate electrode can significantly modulate the photocurrent of the barristor resulting in high gate tuning ratio (1.50 μA/V). Therefore, this barristor shows potential for use as an ambipolar transistor with high mobility and on/off ratio and a gate-tunable photodetector with high EQE and responsivity.

Keywords:

graphene, barristor, photo detector, transistor, ion-gel

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.05

Mechanical properties of graphene resonators in various structures

JE Yugyeong [1], SHIN Dong Hoon [2], LEE Sang-Wook [*1]
[1]Department of Physics, Ewha Womans University
[2]Kavli Institute of Nanoscience, Delft University of Technology
nicesw@gmail.com

Abstract:

In this work, the mechanical properties of NEMS(Nano-Electro-Mechanical-Systems) based graphene resonator with various structures were introduced. The devices were basically composed of structures in which graphenes were suspended on silicon oxide/silicon substrates with trenches. In the device processing, we fabricated various graphene resonators by changing the shape and size of the trenches, the number of layers of graphene, etc. In order to analyze the mechanical properties of the device, the resonance frequency of the graphene resonators was measured by an optical measurement method using a laser interferometer. In addition, we modified the optical measurement system for high-sensitivity measurements. As a result, the physical properties of various graphene resonators and their applicability to various fields were confirmed.

Keywords:

NEMS, Nano-Electro-Mechanical-Systems, Graphene, Resonator, Graphene resonator

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.06

Utilization of Deep Learning Networks for Data Analysis of NEMS-Based Mass detector in Noisy Environment

LEE Sang-Wook *[1], SEO Miri [1], YANG Eun Seo [2]
[1]Department of Physics, Ewha Womans University
[2]Department of Computer Science and Engineering, Ewha Womans University
nicesw@gmail.com

Abstract:

A study on NEMS-based mass sensors is being conducted using the advantage of NEMS, which enables precise measurement by compatible electrical and mechanical forces through electrical and mechanical degrees of freedom coupling. When analyzing the properties of a material using data measured by a mass sensor, the problem of included noise in the data affects the accuracy of the properties of the material. A method previously studied in this regard is a method of subtracting the magnitude of noise occurring in the interval without measured values from the total data. However, this method may differ from the expected result because it is subtracted by the same noise value in all sections of the data even if the noise value measured in the data is not uniform. In this study, we trained the data so that the data can be accurately classified to the corresponding mass in a noisy environment using several deep learning models and verified the accuracy of each classification. LSTM, 1D-CNN, and 2D-CNN were used as deep learning models, and each model was classified with an accuracy of 99%, 93%, and 85% at a mass frequency unit that was 9 times lower than the noise frequency. We were able to determine the unit of mass measurement of the NEMS mass sensor through this accuracy value.

Keywords:

noise, artificial intelligence, deep learning, mass detector, NEMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C9.07

Unconventional visible light emission in graphene nanogap.

CHO Minhyun [1], SEO Dongjea [2,6], GONG Younji [3], CHOI Heon-Jin [2], KIM Young Dong [1], YOO Keon Ho [1], HAN Il Ki [3,5], KANG Seokwon [4], KIM Young Duck [*1,3,4]

[1]Physics, Kyung Hee University
[2]Material Science and Engineering, Yonsei University
[3]KHU-KIST Converging Science and Technology, Kyung Hee University
[4]Information Display, Kyung Hee University
[5]Nanophotonics Research Center, KIST
[6]Electrical and Computer Engineering, University of Minnesota
ydk@khu.ac.kr

Abstract:

Graphene, one of the representatives in 2D materials, has been noted as a next-generation optoelectronic device. Especially, graphene under the high electric field shows bright thermal radiation up to 3,000K in the visible range with non-equilibrium phonon modes. Various 2D semiconductor materials such as MoS2 and WSe2 have also emerged as nanoscale light-emitting devices in the near-IR and visible range. But they have a relatively small intrinsic bandgap so still hard to emit visible light emission over 2.1eV. Here, we demonstrate the green light emissions (2.4eV) from graphene nanogap, which formed after a breakdown under the high electric field and thermal radiation. We also observed the switching behavior as a function of the applied electric field and memory characteristic from the graphene nanogap. The properties of unconventional green emission and memristive characteristic in the graphene nanogap paves the way towards graphene-based on-chip light sources and neuromorphic architectures.

Keywords:

Graphene, Nanogap

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C10.01

Orbital for efficient spin manipulation

KIM Junyeon *[1], GO Dongwook [2], TSAI Hanshen [3], JO Daegeun [4], KONDOU Kouta [1], LEE Hyun-Woo [4], OTANI YoshiChika [1,3]
[1]RIKEN-CEMS
[2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA and Johannes Gutenberg University Mainz
[3]The University of Tokyo
[4]Pohang University of Science and Technology
junyeon.kim@riken.jp

Abstract:

Nowadays utilization of the spin degree of freedom for the electronics opens a new opportunity. To find an optimal mechanism for the efficient electrical spin manipulation is the most important issue to realize spin-based electronics. In this talk, we present a non-trivial spin manipulation mechanism in ferromagnet/Cu/Al_2O_3 trilayers. The efficiency for the spin manipulation is ten- or hundred- fold larger than present mechanisms. This exotic result is attributed to a role of imbalanced orbital degree of freedom generated at the Cu/Al_2O_3 interface. Further information will be introduced during the talk.

Keywords:

Orbital, Spin, Interface

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C10.02

Self-generated spin torque in spin-orbit coupled ferromagnets

KIM Kyoung-Whan *[1]
[1]Center for Spintronics, KIST
kwk@kist.re.kr

Abstract:

Electrical manipulation of magnetization is a central topic in spintronics. So far, spin torque induced by an externally injected spin current has been mainly considered. For instance, spin-transfer torque utilizes a spin-polarized current from another magnetic layer and spin-orbit torque utilizes the spin Hall current generated by an adjacent layer or an interface. However, a recent report of an intrinsic spin current generated in a ferromagnet opens another possibility. In the presence of spin-orbit coupling in a ferromagnet, an external current generates a spin component that is transverse to magnetization whose leaving out from the ferromagnet may result in an additional spin torque, which we call a self-generated spin torque.

In this talk, we present a theoretical formalism describing the self-generated spin torque and its Onsager reciprocity. In the previous spin drift-diffusion formalism, any spin component that is perpendicular to the magnetization direction has been neglected by assuming an infinitely fast dephasing rate. However, describing the self-generated spin torque requires a generalization of the spin diffusion formalism which allows for a nonzero transverse component whose transport is not yet explored. We thus generalize the drift-diffusion formalism for spin-orbit coupled ferromagnets and explicitly demonstrate that the intrinsic spin current can be extracted from the ferromagnetic layer and its backaction to the magnetic layer can generate a spin torque. The Onsager reciprocity of the self-generated spin torque describes a self-generated spin pumping. The self-generated spin-orbit torque and spin pumping depend on the thickness of the ferromagnet and thus experimentally distinguishable from the conventional spin-orbit torque. Our work not only generalizes the traditional theory used for a few decades but also changes the paradigm of spin torque.

Keywords:

spin torque, spin-orbit coupling, spin transport, diffusion formalism

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C10.03

Orbital torque in Cr-based heterostructures: A theoretical perspective

GO Dongwook *[1], JO Daegeun [2], LEE Soogil [3], KANG Min-Gu [3], KIM Kyoung-Whan [4], PARK Byong-Guk [3], BLüGEL Stefan [1], LEE Hyun-Woo [2], MOKROUSOV Yuriy [1]
[1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum JülichInstitute of Physics, Johannes Gutenberg University Mainz
[2]Department of Physics, Pohang University of Science and Technology
[3]Department of Physics, KAIST
[4]Center for Spintronics, Korea Institute of Science and Technology
d.go@fz-juelich.de

Abstract:

While it has long been thought that the spin current or density is responsible for current-induced spin-orbit torques, a recent theory has shown that the orbital current can exert torque on the magnetization of a ferromagnet (FM), which is now called orbital torque [1]. Up to date, however, not so much is known about material systems for experimental observation of the orbital torque, except for a few examples such as surface-oxidized Cu/FM [2,3] and W(110)/FM heterostructures [4]. Thus, close inspection and re-examination of real material systems are highly encouraged, which are essential for orbitronic device applications in the near future. A recent spin-orbit torque experiment on Cr-based heterostructures has revealed that bulk Cr is responsible for the torque, but the sign of the torque is opposite to the sign predicted by the spin Hall effect of Cr [5]. The result is instead consistent with the orbital Hall effect of Cr, whose sign is opposite to the spin Hall effect, and the resulting orbital torque [5,6].
In this talk, we aim to provide a theoretical perspective on the orbital torque in Cr-based heterostructures [7]. We show recent first-principles calculations in these systems. In order to simulate large-scale magnetic heterostructures, we have developed an efficient way to construct the Hamiltonian of a full system like LEGO® blocks, by combining hopping parameters of each materials which are extracted by density functional theory calculations. This enables simulation of large heterostructures whose thickness is more than 10 nm. We have investigated Cr/CoFe, Cr/Ni, and Cr/Pt/CoFe in bcc(001) stacking and found that the orbital torque is dominant in all of these systems, which implies that the orbital torque is more prevalent than what has been thought so far. Notwithstanding common features, there are clear differences among these systems. For example, the spin-transfer mechanism is less pronounced in Ni compared to CoFe due to small magnetic moment of Ni, which gives larger room for the orbital torque to be dominant. In Cr/Pt/CoFe, the orbital-to-spin conversion occurs dominantly within the ultrathin Pt layer and the converted spin current exerts spin-transfer torque to CoFe. These results are in accord with the experiment [5]. It confirms that Cr-based heterostructures are attractive systems for investigating the orbital current and its interaction with the spin degree of freedom.

References

[1] D. Go and H.-W. Lee, Phys. Rev. Res. **2**, 013177 (2020).
[2] J. Kim, D. Go *et al.* Phys. Rev. B **103**, L020407 (2021).
[3] D. Go *et al.* arXiv:2011.08601.
[4] D. Go *et al.* Phys. Rev. Res. **2**, 033401 (2020).
[5] S. Lee, M. Park, D. Go *et al.* in preparation.
[6] D. Jo, D. Go, and H.-W. Lee, Phys. Rev. B **98**, 214405 (2018).
[7] D. Go, D. Jo, S. Lee *et al.* in preparation.

Keywords:

orbital Hall effect, orbital torque, spin-orbit torque, spin-orbit coupling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C10.04

Orbital Hall effect induced spin-orbit torque through efficient conversion from orbital Hall current to spin current

LEE Soogil [*1], KANG Min-Gu [1], GO Dongwook [2,3], KIM Dohyoung [1], KANG Jun-Ho [4], LEE Taekhyeon [4], LEE Geun-Hee [4], LEE Nyun Jong [5], KIM Sanghoon [5], KIM Kab-Jin [4], LEE Kyung-Jin [4], PARK Byong-Guk [1]

[1]Department of Materials Science and Engineering, KAIST
[2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich
[3]Institute of Physics, Johannes Gutenberg University Mainz
[4]Department of Physics, KAIST
[5]Department of Physics, University of Ulsan
lee.soogil.83@kaist.ac.kr

Abstract:

Current-induced magnetization switching by spin-orbit torque (SOT) is regarded as an essential key to facilitate a low power operation for spintronic devices. In order to efficient control of magnetization, it has been desired that searching for nonmagnetic materials with the large SOT efficiency. Therefore, there were many efforts to increase the SOT efficiency with 5*d* transition metals because spin-orbit coupling (SOC) of a nonmagnet (NM) was believed a crucial ingredient to create the large spin current via spin Hall effect (SHE). However, further enhancement of the SOT is still required to realize the low power control of magnetization. Recent theories revealed that the SOT can be exerted even with weakly spin-orbit-coupled NMs by the orbital current, as a result of the orbital Hall effect, and subsequent orbital-to-spin conversion through SOC [1-5]. In this presentation, we demonstrate that this orbital torque can be efficiently tailored by orbital-to-spin currents conversion engineering. Here, we discuss the effect of different ferromagnets (FMs) or ultrathin insertion layers at the NM/FM interface on the orbital torque. Our study on the orbital torques enlightens that the further enhnacement of the SOT will be possible with less investigated systems due to their weak SOC.

[1] Dongwook Go and Hyun-Woo Lee, *Phys. Rev. Research* 2 (2020) 013177.
[2] T. Tananka *et al.*, *Phys. Rev. B* 77 (2008) 165117.
[3] H. Kontani, *et al.*, *Phys. Rev. Lett.* 102 (2009) 016601.
[4] Dongwook Go, *et al.*, *Phys. Rev. Lett.* 121 (2018) 086602.
[5] Daegeun Jo, *et al.*, *Phys. Rev. B* 98 (2018) 214405.

Keywords:

spintronics, spin-orbit torque, spin Hall effect, orbital Hall effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C11.01

CHARGE TRANSPORT SIMULATIONS OF ORGANIC SEMICONDUCTORS FOR MATERIALS DEVELOPMENT

ISHII Hiroyuki *[1]
[1]Department of Applied Physics, Faculty of Pure and Applied Sciences, University of Tsukuba
ishii@bk.tsukuba.ac.jp

Abstract:

Prediction of material properties of newly designed molecules is a long-term goal in the field of organic electronics. We have been developed a large-scale transport calculation methodology called “time-dependent wave-packet diffusion (TD-WPD) method”. The method enables us to evaluate mobilities of charge carriers coupled with molecular vibrations using quantum dynamics based on first-principles calculations. We succeeded quantitative evaluation of mobility of organic semiconductors[1]. Furthermore, we proposed a new molecular design strategy to increase the mobility[2]. However, these studies are required experimentally observed single-crystal structural data. When we have no information about the crystal structure, prediction of mobility is a difficult problem. Here, we report a practical method to predict the mobility from structural formula of newly designed molecule, without use of experimental single-crystal data[3]. In our method, the crystal structure is computationally obtained by searching possible packing structures. We increase accuracy in identifying the actual crystal structure from suggested ones by using not only crystal energy but also similarity between calculated and experimental powder X-ray diffraction patterns. The mobility can be obtained by the TD-WPD method using the identified crystal structure. The proposed methodology can be a theoretical design technique for efficiently developing new high-performance organic semiconductors, since it can estimate the charge transport properties at early stage in the process of material development. [1] H. Ishii, *et al.*, Phys. Rev. B **98**, 235422 (2018). [2] A. Yamamoto, *et al.*, Adv. Sci., **5**, 1700317 (2018). [3] H. Ishii, *et al.*, Scientific Reports **10**, 2524 (2020).

Keywords:

organic semiconductors

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C11.02

Efficient Perovskite Solar Cells via Improved Carrier Management and Their Potential Applications

SEO Jangwon *1
[1]Energy Materials Research Center, KRICT
jwseo@krict.re.kr

Abstract:

Power conversion efficiencies (PCE) of perovskite solar cells (PSCs) has rising from the initial 3.8% to the state-of-the-art 25.5% within the past few years. Current PSCs intended for commercialization in the near future require both high efficiency and good long-term stability. Most highly efficient PSCs utilize an n-type layer of mesoporous titanium dioxide or tin oxide in an n-i-p device configuration, in which organic conductors are widely used to transport holes into an adjoined metal. Thus far, a variety of efforts have been devoted to achieve a defect-less perovskite film with high-quality morphologies for realizing reduced loss-in-potential outcomes and enhanced efficiency levels. In this talk, we will discuss several challenges that need to be addressed in improving the photovoltaic performance via improved carrier management, i.e. (1) development of an electron transport layer with an ideal film coverage, thickness and composition by tuning the chemical bath deposition of tin dioxide (SnO_2), (2) preparation of high crystalline film of $(FAPbI_3)_{1-x}(MAPbBr_3)_x$ with controlled carrier mobility and light harvesting, and (3) interfacial passivation between the perovskite and the hole transporting layer for reducing the surface defect and preventing the interfacial recombination. As a result, the best cell exhibited a certified PCE of 25.2%. Furthermore, in forward bias, our devices exhibit an external electroluminescence efficiency of up to 17.2%. Our holistic approach as presented in this work will offer new directions for those involved in the fabrication of highly efficient PSCs.

Keywords:

perovskite solar cell, high efficiency, carrier management

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C11.03

Conformable imager for biometric data measurement

YOKOTA Tomoyuki *1
[1]Dept. of Electrical Engineering and Information Systems, The University of Tokyo
yokota@ntech.t.u-tokyo.ac.jp

Abstract:

With the rapid aging of Japanese society, how to increase the quality of life (QoL) while controlling rising medical expenses has become an urgent issue. To solve this difficult issue, the acquisition and utilization of biological information using new technologies such as wearable devices is more expected. In particular, self-care and home medical care, in which patients and their families are responsible for their own health, are considered as one of the ways to solve the issues of a super-aging society. Indeed, wearable sensors that can constantly monitor health conditions and home-use blood pressure monitors with communication functions are being introduced to the market one after another to prepare for the advent of a self-care era. On the other hand, when designing a new insurance system or incentive system using biometric information from wearable sensors, it is important issue how to confirm whether data measured at home are patients own. Furthermore, the risk of patient mix-ups must be reduced as more wearable devices come to be used in hospitals and welfare facilities in the future. Therefore, measuring vital signs simultaneously with biometric authentication of the user is an urgent issue.
We have developed a sheet-type image sensor that enables high-resolution and high-speed reading. This sheet-type image sensor can take a high-resolution image of fingerprints and veins used for biometric authentication. In addition, the same sheet-type imager can measure the pulse wave that is one of the vital signs, and its distribution. The developed sheet-type image sensor is fabricated by densely integrating a high-efficiency readout circuit using an active matrix of a low-temperature polysilicon thin film transistor and a photodetector that uses a highly efficient organic semiconductor as a photosensitive layer. The resolution of the image sensor achieves 508 dots per inch (dpi) required for fingerprint authentication, and the organic photodetector consists of bulk heterostructure organic layer, which has high photosensitivity to near infrared light with a wavelength of 850 nanometers (external quantum efficiency of 50% or more). It is easy to integrate the sheet-type image sensor into equipment and attach it to curved surfaces due to the thickness of the polymer base material is 10 micrometers, and the total thickness of the sheet-type image sensor is 15 micrometers. By developing a process technology that integrates photodetectors and thin-film transistors without damage to each other, it has become possible to realize a sheet-type image sensor that achieves both high-resolution imaging and high-speed reading.

Keywords:

quality of life (QoL)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C11.04

Molecular doping routes for organic electronics

KANG Keehoon *[1], KIM Youngrok [2], WATANABE Shun [3], SIRRINGHAUS Henning [4], LEE Takhee [2]
[1]Materials Science and Engineering, Yonsei University
[2]Department of Physics and Astronomy, Seoul National University
[3]Department of Advanced Materials Science, University of Tokyo
[4]Cavendish Laboratory, University of Cambridge
keehoon.kang@yonsei.ac.kr

Abstract:

Doping has been a key topic in organic electronics since the demonstration of a metallic conductivity in doped p-conjugated polymers. However, it has been difficult to prevent dopant-induced structural and energetic disorder, while maintaining a high conductivity. We have developed an efficient doping method based on solid-state diffusion of 2,3,5,6-tetrafluoro- 7,7,8,8-tetracyanoquinodimethane (F_4-TCNQ) which introduced a minimal structural disorder in various conjugated polymers including poly(2,5-bis(3- hexadecylthiophen-2-yl)thieno[3,2-b]thiophene) (PBTTT). The doping enabled a consistent observation of both a nearly-ideal Hall effect and a two-dimensional weak-localisation phenomenon in the doped PBTTT, for the first time for conducting polymers, to the best of our knowledge [1]. The emergence of the coherent charge transport at high doping levels can be understood from a non-trivial strong energy dependence of the carrier mobility which was reflected from the thermoelectric response over a wide range of doping levels [2]. The coherent charge transport properties of the doped PBTTT can also be correlated to a recently observed long-range spin transport via an enhanced exchange-coupling-mediated spin diffusion [3]. Furthermore, we have recently employed this doping method to enhance charge injection properties in organic field-effect transistors (FETs) [4, 5]. A selective contact doping of bottom-gated PBTTT FETs by solid-state diffusion of F_4-TCNQ achieved a significantly lower contact resistance. Our developed post-doping treatment was shown to be effective for resolving dopant diffusion problem, which is essential for designing stable and low-power organic electronic devices by utilizing doping of conjugated polymers.

[1] K. Kang†, S. Watanabe† et al. Nature Materials 15, 896 (2016)
[2] K. Kang et al. Materials Today Physics 8, 112-122 (2019)
[3] S. Wang et al. Nature Electronics 2, 98-107 (2019)
[4] Y. Kim et al. Advanced Materials 31, 1806697 (2019)
[5] Y. Kim et al. Advanced Functional Materials 30, 2000058 (2020).

Keywords:

Doping, Conducting polymer, Organic electronics, Charge transport, Contact doping

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C11.05

A Biomass Derived Nano Porous Graphene Memory Cell

SATTARI-ESFAHLAN Mehdi [1,2], KIM Chang-Hyun *[1]
[1]Department of Electronic Engineering, Gachon University
[2]Material Science and Engineering, Seoul National University
chang-hyun.kim@gachon.ac.kr

Abstract:

Despite the great electrical conductivity of graphene, an electronic device using it cannot be easily switched off due to the missing of electrical band gap. Therefore, the lack of band gap is a principle obstacle which hinders the practical application of graphene-based devices. Numerous approaches have been implemented to give a birth to band gap in graphene. One category of these methods is structural engineering, which gives promise for the design of next-generation graphene nanoelectronics, especially switching devices such as transistors and memories. In order to create semiconducting energy gap, facile and large scale fabrication of graphene have been main drawbacks in development of graphene electronic. Graphene nanopore (GNP) is defective semiconducting structure provides emerging category of switching media for the emerging memory technology. Pore size edge-to-edge distance between two neighboring nanopores in GNP structure can modify its electronic features and atomic-scale disorders has substantial effect on energy gap which offers new approach to use GNP in electronic technology. Here, in order to synthesis the semiconducting GNP, a resistive switching memory (RSM) device based on GNP suggested. Device exhibited excellent performance with significant ON/OFF current ratio of 10^6 which rises from highly porous and defective form of GNP. The semiconducting properties of the presented GNP structure can find key application in deploying of next-generation of graphene-based memories.

Keywords:

memory, graphene

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C12.01

Designing Descriptor for Computational Screening of Argyrodite-based Solid State Superionic Conductors

JUN Byeongsun [2], KIM Ji Hoon [2], LEE Sang Uck *[1,2]
[1]Department of Chemical and Molecular Engineering, Hanyang University ERICA
[2]Department of Applied Chemistry, Hanyang University ERICA
sulee@hanyang.ac.kr

Abstract:

All-solid-state rechargeable lithium-ion batteries are attractive power sources for electrochemical applications due to their potential to improve safety and stability compared to conventional batteries with liquid electrolytes. Finding a solid electrolyte with high ionic conductivity and compatibility with other battery components is a key factor in increasing the performance of any solid LIB. Several structural and chemical families of solid LIB conductors such as LGPS, LISICON and Argyrodites have been shown to exhibit ionic conductivity spanning over 10mS/cm at room temperature (RT). And Lithium argyrodites make up a promising family of solid state electrolytes, characterized by the general composition of $Li_{7-y-x}[(A_{1-y}/B_y)C_4]C_{1-x}X_{1+x}$ (A, B, C and X denote elements of group IV, V, VI and VII, respectively) Here, we present systematic exploration of descriptors for computational screening of the argyrodite-based solid state superionic conductors. Argyrodite consist of polyanions and single anions surrounded by cage-like Li ion diffusion network. We found that the ionic conductivity has strong correlation with the disorderedness of single anions and the size of the Li-ion cage formed around the single anions. Especially, when the Li-ion cages are of uniform size, the inter-cage diffusion for higher ionic conductivity is accelerated. Therefore, we proposed the uniformity of Li-ion cage size as a screening descriptor for argyrodite-based solid state superionic conductors. The proposed our results will provide insights into the development of new compositions of argyrodite.

Keywords:

Solid state electrolyte, ab initio molecular dynamics, Density functional therory, Argyrodite, Ionic conductivity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C12.02

Flexoelectric effect in corrugated two-dimensional materials

JIN Yeongrok [1], LEE Jaekwang [*1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

The flexoelectricity, electrical polarization induced by a strain gradient, is one of the very exotic physical phenomena because it can induce the huge piezoelectricity even in centrosymmetric materials. Here, combining density functional theory calculations and mathematical analysis, we find that the corrugation generates the great out-of-plane polarization mediated by the flexoelectric effect even in centrosymmetric two-dimensional (2D) materials. The correlation between flexelectricity and out of plane polarization in 2D materials will be discussed, and associated underlying mechanism will be introduced in detail

Keywords:

flexoelectricity, out-of-plane polarization, corrugation, density functional theory calculation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C12.03

Computational catalyst design at electrified solid-liquid interfaces

RINGE Stefan *[1]
[1]Energy Science & Engineering, DGIST
stefan.ringe.tum@gmail.com

Abstract:

Electrochemistry is at the heart of a future sustainable energy landscape, driving the green conversion and storage of energy. To date, however, almost all electrochemical processes suffer from a high overpotential or low product selectivity which greatly reduces their industrial competitiveness. In the search for more active and selective electrocatalysts, quantum chemical simulations based on Density Functional Theory have become a state-of-the-art means. In order to computationally facilitate the involved complex calculations, the electrochemical interface is commonly highly simplified by ignoring physical characteristics such as the accumulation of surface charge leading to the creation of the double layer, solvation stabilization of reaction intermediates or mass transport effects. In this talk, we first present continuum solvation methods as a way to to beyond these approximations and then use them to revisit such effects with a particular focus on electrochemical CO2 reduction. In contrast to previous believes, we find the interfacial electric field to be significant and even determine the product selectivity and conversion rate on Gold and Copper catalysts. We show how this observation leads to specific design principles for the electrolyte and catalyst for which we perform a descriptor-based screening study and identify promising catalysts. The idea is extended to other electrochemical systems, for which we find solvation effects to be a further critical factor. Finally, by introducing a multi-scale computational design approach, we show that also mass transport is critically influenced by the electrified interface and plays a crucial role in understanding electrochemical processes.

Keywords:

co2 reduction, electrochemistry, catalyst design, double layer, density functional theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C12.04

“Atomic Semiconductor” via flat phonon bands

LEE Jun Hee *[1]
[1]School of Energy & Chem. Eng., UNIST
junhee@unist.ac.kr

Abstract:

We discovered that the elastic interaction between atoms in a solid completely disappears only when voltage is applied when flat bands in polar phonon exist. Strikingly then each atom can be individually manipulated by voltage for information storage [1]. This discovery will lead us to the design of ultimate-density memories [2]. Just as Einstein's theory of relativity ($E=mc^2$) enabled us to make bombs out of atoms, not out of matter, with our "Atomic Semiconductor" theory, we will open the era of making memories in an atomic scale rather than in materials scale. This theory is surprisingly applicable to the commercial gate compound HfO_2 and thus can be realized in all electronic devices. Our paradigm shift will open the era of storing big data in the palm of your hand as the memory density will increase up to ~100 TB in the future according to the prediction of our theory.

[1] Lee et al., Science 369, 1343 (2020)
[2] Noheda et al., Science 369, 1300 (2020)

Keywords:

Flat band, Ferroelectric, HfO2, Atomic Semiconductor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.01

Analysis of Couped Dynamic Model for Malaria Spreading between Human being and Mosquito with Infected Immigrants

LEE Jae Woo *[1], MAFWELE Biseko Juma[1]
[1]Inha University
jaewlee@inha.ac.kr

Abstract:

In this study, we assume that the recovered human population does not generate permanent immunity. Therefore, they become susceptible class after losing their immunity. In this model, we use mathematical modelling techniques and non-linear dynamic system to analyze the SIRS model for human population and SI model for mosquito population. We compute the disease-free equilibrium and derive the basic reproduction number (R_0) by using the next generation matrix. Moreover, the local stability of the model is computed by using the Jacobian Matrix. The result shows that the per capita rate of loss of immunity in humans contributes to the stability of the model. The infected migration rate for human also contributes to both the stability of the model and the basic production number (R_0).

Keywords:

SIRS model, SI model, Basic reproduction number

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.02

The compartment learning model and the core vocabulary in Korean Language

LEE Hae Seong *[1], KIM Beom Jun [1]
[1]Department of Physics, Sungkyunkwan University
haesung0125@gmail.com

Abstract:

When a second language learner tries to study the definition of words using a dictionary, performance of learning is strongly affected by the learner's prior knowledge of the vocabulary. Finding a word meaning in a dictionary often requires recursive searches for words presented in words' definitions. If the learner's prior knowledge is limited, the learner will often encounter an outbreak of search. The outbreak can be stopped at the early stage as one's knowledge of the vocabulary expands.

The process of recursive search can be understood as an epidemic spreading on a lexical network. We consider three states of words: "Unknown", "Found", and "Known" states which correspond to Susceptible, Infective, and Removed states in the SIR model of epidemic spreading. A word that the learner is not aware of its meaning is in the "Unknown" state. As the learner looks for the definition of the word, the word goes to the "Found" state. A word in the "Found" state infects other words in the "Unknown" states in its definition recursively. Finally, words in the "Known" state can be considered as pre-immunized words that the learner knows their meaning in advance and thus do not go to the "Found" state. As we aim to study the size of the search outbreak only, we do not consider the transition from the "Found" state to the "Known" state.

We define the core vocabulary as the minimal group of pre-immunized words preventing the search outbreak efficiently. We apply vaccination strategies to the Korean lexical network based on the Korean Standard Dictionary. In a detailed manner, we test vaccination strategies pre-immunizing a given fraction of words with the highest in/out-degree, betweenness centrality, and the random vaccination strategy. We report that pre-immunization of words with high betweenness centrality leads to the most efficient core vocabulary among various strategies.

Keywords:

korean language, core vocabulary, network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.03

Political polarization in the United States House of Representatives

KIM Jonghoon [1], BAEK Seung Ki *[1]
[1]Department of Physics, Pukyong National University
seungki@pknu.ac.kr

Abstract:

Although political polarization is inherent in democracy, it becomes a growing concern in the United States as the distance between parties gets wider than at any time in history. To check the level of elite polarization, we apply the principal-component analysis to co-sponsorship data in the United States House of Representatives. The resulting one-dimensional projection indeed shows an unprecedented degree of polarization from 2018 to date. At the same time, the one-dimensional representation explains a small part of the total variance, in contrast with our previous study on the National Assembly of Republic of Korea. In addition, the second principal axis shows that party polarization has already been under way since the late 1970s. We discuss dynamics of party politics by comparing Korea and the United States.

Keywords:

Political polarization, Principal-component analysis, United States House of Representatives

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.04

Stability of cooperation in a continuous model of indirect reciprocity

LEE Sanghun [1], MURASE Yohsuke [2], BAEK Seung Ki *[1]
[1]Department of Physics, Pukyong National University
[2]Center for Computational Science, RIKEN
seungki@pknu.ac.kr

Abstract:

Reputation is a powerful mechanism to enforce cooperation among unrelated individuals through indirect reciprocity, but it suffers from disagreement originating from private assessment, noise, and incomplete information. In this work, we investigate stability of cooperation in the donation game by regarding each player's reputation and behavior as continuous variables. Through perturbative calculation, we derive a condition that a social norm should satisfy to give penalties to its close variants, provided that everyone initially cooperates with a good reputation, and this result is supported by numerical simulation. A crucial factor of the condition is whether a well-reputed player's donation to an ill-reputed co-player is appreciated by other members of the society, and the condition can be reduced to a threshold for the benefit-cost ratio of cooperation which depends on the reputational sensitivity to a donor's behavior as well as on the behavioral sensitivity to a recipient's reputation. Our continuum formulation suggests how indirect reciprocity can work beyond the dichotomy between good and bad even in the presence of inhomogeneity, noise, and incomplete information.

Keywords:

Indirect reciprocity, Evolution of cooperation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.05

The feasibility and stability of plant-pollinator networks under mutualism and competition

LEE Hyunwoo [1], LEE Jaewoo [1], LEE Deok-Sun [*2]
[1]Department of Physics, Inha University
[2]School of Computational Sciences, KIAS
deoksun.lee@gmail.com

Abstract:

Many studies investigating the stability of ecological networks often assume that the inherent network structure is random. In empirical studies for a mutualistic network, however, there is a heterogeneous connectivity pattern between species. In this study, we present an simple model that provides an analytic solution to how the network structure relates to stability and feasibility. Considering the all-to-all connected competition among the same type of species and mutualism between selected plant and pollinator species, we derive the exact abundance of species from the inverse of the interaction matrix. This solution shows how interaction strengths -both competition and mutualism- and the degree heterogeneity determine both feasibility and stability. We show a relation between a minimum abundance of species and the largest eigenvalue of the community matrix determining the stability. Since there are still intense debates that whether mutualism stabilizes or destabilizes the ecosystem, we claim that the role of mutualism is different for the conditions describing in this paper. We demonstrate the analytic results with the empirical data of real-world mutualistic networks.

Keywords:

Mutualistic network, Stability, Feasibility

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.06

Network Analysis of International Trade based on Community Inconsistency

CHO Wonguk *[1], LEE Daekyung [1], KIM Beom Jun [1]
[1]Department of Physics, Sungkyunkwan University
wonguk.cho@gmail.com

Abstract:

The application of community detection methods to the studies of real-world complex networks is often susceptible to the inconsistency problem. That is, the resulting structures of community detection often show considerable variation, which is typically considered as evidence that the community detection methods are unreliable. Besides, the community structures also vary depending on the choice of the resolution parameter, which makes it more difficult to detect the single optimal community structure. In real-world networks, however, the inconsistency in community structures and the resolution problem may be a natural consequence caused by the structural properties of the networks and the intrinsic ambiguity of certain nodes. Hence, we argue that in the international trade network, the inconsistency of a node (country) in community detection will reveal some information about its geopolitical characteristics and its diplomatic strategies towards its partner countries.

For the analysis, we study the community structure of the international trade network over the 2001-2019 period. We compare the structures over different values of the resolution parameter and time by means of the Membership Inconsistency (MeI) and the Edge Consistency Index (ECI) that we devised in order to quantify the relative inconsistency that each node and edge possesses. As a result, we find the set of countries which are more inconsistent than others because of the structural characteristics they share. Furthermore, we also obtain the set of countries that remain consistent irrespective of the resolution parameter, which can be considered as the building blocks of the international trade network. These findings allow us to produce a hierarchical decomposition of the international trade network that displays the fundamental structures of the trade relations among countries.

Keywords:

community detection, mesoscale structure, complex networks, international trade

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.07

Modified inference algorithm for gravity model

LEE Daekyung [*1], KIM Gunn [2], JEONG Hyeong-Chai [2], KIM Beom Jun [1]
[1]Department of Physics, Sungkyunkwan University
[2]Department of Physics and Astronomy, Sejong University
exaparsec@gmail.com

Abstract:

The gravity model is a useful theoretical framework to handle macroscopic patterns of spatially correlated networks. In the general scheme of gravity model, an interaction strength between a node pair is proportional to the mass of each node and decreases with respect to their distance. Even if the approach reveals many interesting features in various networks, the present procedure to deduce each attribute possesses a crucial logical defect. Although the mass of each node is usually treated as equal to its total flow, we find that those quantities cannot be equivalent because of the difference between their spatial information range. In the present work, we propose a numerical algorithm which can find masses and a spatial dependence function of the gravity model with a self-consistent way. assigns exact masses and a spatial dependence function of the target network. With empirical simulations on the Seoul subway system and synthetic model networks, we confirm that our methodology successfully finds concrete attributes of the networks which are consistent with the original context of gravity model.

Keywords:

Complex system, Transport network, Network analysis, Numerical inference

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.08

Discovering conservation laws from trajectories via machine learning

HA Seungwoong [1], JEONG Hawoong *[1,2]
[1]Physics Department, KAIST
[2]Center for Complex System, KAIST
hjeong@kaist.ac.kr

Abstract:

Invariants and conservation laws convey critical information about the underlying dynamics of a system, yet it is generally infeasible to find them from large-scale data without any prior knowledge or human insight. We propose ConservNet to achieve this goal, a neural network that spontaneously discovers a conserved quantity from grouped data where the members of each group share invariants, similar to a general experimental setting where trajectories from different trials are observed. As a neural network trained with a novel and intuitive loss function called noise-variance loss, ConservNet learns the hidden invariants in each group of multi-dimensional observables in a data-driven, end-to-end manner. Our model successfully discovers underlying invariants from the simulated systems having invariants as well as a real-world double pendulum trajectory. Since the model is robust to various noises and data conditions compared to baseline, our approach is directly applicable to experimental data for discovering hidden conservation laws and further, general relationships between variables.

Keywords:

Invariants, Machine learning, Neural network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C13.09

Mesoscale properties of mutualistic networks in ecosystems

LEE Sang Hoon *[1]
[1]Department of Liberal Arts, Gyeongsang National University
lshlj82@gntech.ac.kr

Abstract:

Uncovering structural properties of ecological networks is a crucial starting point of studying the system's stability in response to various types of perturbations. We analyze pollination and seed disposal networks, which are representative examples of mutualistic networks in ecosystems, in various scales. In particular, we examine mesoscale properties such as the nested structure, the core-periphery structure, and the community structure by statistically investigating their interrelationships with real network data. As a result of community detection in different scales, we find the absence of meaningful hierarchy between networks, and the negative correlation between the modularity and the two other structures (nestedness and core-periphery-ness), which themselves are highly positively correlated. In addition, no characteristic scale of communities is perceivable from the community-inconsistency analysis. Therefore, the community structures, which are most widely studied mesoscale structures of networks, are not in fact adequate to characterize the mutualistic networks of this scale in ecosystems.

Keywords:

ecological networks, mutualistic networks, community structure, core-periphery structure, nested structure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C15.01

Nonlinear energy flows from low frequency electromagnetic fluctuations to broadband turbulence during ELMs

GHIM Young-chul *[1], KIM Jaewook [2], CHOI M.J. [2], NAM Y.U. [2], JHANG Hogun [2], BAK J.G. [2], HAHN S.H. [2], SUNG C. [1], CHOE W. [1]
[1]Department of Nuclear and Quantum Engineering, KAIST
[2]Korea Institute of Fusion Energy
ycghim@kaist.ac.kr

Abstract:

We report experimental observations of nonlinear three-wave couplings and energy flows from low frequency ion-scale density fluctuations containing electromagnetic components to broadband turbulence during ELM crashes in KSTAR [1]. The results are based on conditional ensemble averages over 2,660 ELMs obtained during three different long ELMy H-mode KSTAR discharges; where the density fluctuations are measured by the 2D beam emission spectroscopy and magnetic fluctuations from a Mirnov coil. Our observations suggest that increased level of density fluctuations during ELMs are not only caused by well-known linear stability criteria and stochastic magnetic fields, but also nonlinear couplings between the low frequency electromagnetic components and higher frequency broadband turbulence.

[1] Jaewook Kim, M.J. Choi, Y.U. Nam, Hogun Jhang, J.G. Bak, S.H. Hahn, C. Sung, W. Choe and Y.-c. Ghim, Nuclear Fusion 60, 124002 (2020)

Keywords:

ELMs

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C15.02

Impact of 3D magnetic field on confinement and energetic particle transport in KSTAR

KIM Kimin *[1], KIM Hyunseok [1], KANG Jisung [1], YOO Jeongwon [1], CHOI Minjun [1], KIM Junghee [1], KO Won-Ha [1], LEE Myungwon [1], KWON Jaemin [1]
[1]KFE
kiminkim@kfe.re.kr

Abstract:

It has been widely demonstrated that externally applied non-axisymmetric (3D) magnetic field alters toroidal plasma rotation and can be a powerful tool for control of toroidal rotation profile and potentially transport and confinement of fusion plasmas. In this presentation, we discuss the impact of 3D magnetic field on the confinement and fast ion transport in tokamaks. As one example, we report improved confinement observed in the magnetic braking experiment in KSTAR. The improved confinement is achieved with reduced toroidal plasma rotation by 3D magnetic field induced toroidal rotation braking. Total stored energy is increased by up to 20% along with improved fast ion confinement in spite of 3D field driven density pump-out. The increase of stored energy is found to be synchronized to the minimum toroidal rotation and the maximum rotational shear, which are suggested as the main ingredients for the confinement improvement. We present another example of 3D field effects on the fast ion transport observed in the magnetic braking discharge on KSTAR. The toroidicity-induced Alfven eigenmodes (TAEs) are found to be destabilized by toroidal plasma rotation reduced down to the minimum with near-zero rotational shear by magnetic braking. We show the stability of TAEs is strongly correlated to modification of the Alfven continuum due to modification of rotation profile and the TAE frequency predicted by stability calculation with the reduced rotation agrees with the measurement. We suggest the impact of 3D magnetic field and rotation on the global tokamak confinement and fast ion transport should be considered for the operation of magnetic confinement fusion devices.

Keywords:

Tokamak, KSTAR, 3D magnetic field

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C15.03

3D imaging diagnostics of tokamak plasmas

YUN Gunsu *[1]
[1]POSTECH
gunsu@postech.ac.kr

Abstract:

Tokamak in its ideal state is an axisymmetric magnetic field configuration formed by external fields and plasma-generated fields. To a large degree, the good plasma confinement of the tokamak originates from the axisymmetry. Conventional diagnostics, simulations, and theories for tokamak plasmas rely on the assumption of axisymmetry to reduce the dimensionality and make more manageable the data or equations. Minor degradation of the axisymmetry is unavoidable due to naturally occurring fluid instabilities, toroidally non-uniform external heating, and inaccuracies in machine construction. In the recent decade, it was also found that nonnormal fluid instabilities exist and cause substantial degradation of the axisymmetry. This talk provides the progress of 3D imaging diagnostics to understand the 3D effects in fluid instabilities and transport events in tokamak plasmas. *Work supported by the National Research Foundation under grant No. 2019M1A7A1A03088456 and BK21+ program.

Keywords:

tokamak, non-axisymmetry, imaging diagnostics, nonnormal fluid instability

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C16.01

In-situ THz spectroscopies for investigating advanced functional materials

AHN Yeong Hwan *[1]
[1]Ajou University
ahny@ajou.ac.kr

Abstract:

High speed THz spectroscopic tools allow us to interrogate the optoelectronic characteristics of functional materials, which can be engineered in-situ by the post-process such as chemical treatment, thermal annealing, molecular adsorption, and light illuminations. For instance, we were able to unravel the crystallization kinetics of lead halide perovskites from the dynamical change in the THz phonon modes during the thermal annealing process; this helps us to optimize the device efficiency and find new quantum states when they are incorporated into subwavelength structures. In addition, we developed a unique epsilon-near-zero platform operating in the THz frequency range, made possible by the in-situ dielectric engineering of low-dimensional carbon materials. Finally, recent progress in the development of 3D imaging tools will be discussed based on the time-of-flight analysis of THz signals with a scanning speed of more than 100 Hz per pixel. This tool turned out to be a very useful for the nondestructive inspection of semiconducting chips and the quality assessment of conductive films.

Keywords:

THz spectroscopy, Metamaterials, Perovskite, ENZ

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C16.02

Non-Hermitian metasurfaces based active devices and sensitive sensors

KIM Teun-Teun *1, BEAK Soojeong 2, PARK Sang Hyun 3, HA Taewoo 4, MIN Bumki 2
[1]Department of Physics, University of Ulsan
[2]Department of Mechanical Engineering, KAIST
[3]Department of Mechanical Engineering, University of Minnesota
[4]Center for Integrated Nanostructure Physics, IBS
ttkim@ulsan.ac.kr

Abstract:

Recently, non-Hermitian (NH) degeneracies, also known as exceptional points, have been extensively studied in many physical systems [1]. Particularly in optics, gain and loss can be integrated and controlled with structures, realizing an ideal playground for non-Hermitian physics. In this talk, I will present that exceptional points and phase singularities can be observed in a non-Hermitian metasurface [2]. 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 at an exceptional point in the transmission through an anisotropic metasurface.

By combining with single-layer graphene, we further demonstrated that the EP is also observable by varying the gate voltage leading to an electrical tuning of the optical conductivity of graphene. 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. we also applied the polarization phase singularity to the very sensitive bio sensor for amyloid beta protein which represents a pathological hallmark of Alzheimer's disease. The proposed approach provides a femtomolar-level limit of detection.

Reference

1. Özdemir, Ş. K., Rotter, S., Nori, F. & Yang, L. Parity–time symmetry and exceptional points in photonics. *Nature Materials* **490**, 472–16 (2019).
2. Park, S. H. *et al.* Observation of an exceptional point in a non-Hermitian metasurface. *Nanophotonics* **9**, 1031–1039 (2020).

Keywords:

THz devices, Non-Hermitian metasurfaces, Graphene metasurfaces, Exceptional point

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C16.03

Applications of THz nanoslot antennas for ultrafast dynamics on photo-excited semiconductors

CHOI Geunchang *[1]
[1]Chung-Ang University
nightsky@cau.ac.kr

Abstract:

Terahertz nanoslot antennas have been studied for various applications, such as sensing and nonlinear effect, due to the advantage of background free, field enhancement, and field confinement. Recently, we have conducted carrier dynamics of semiconductor materials using the optical pump-terahertz probe method. Combined with semiconductor materials, terahertz nanoslot antenna enables various semiconductor materials to have unique properties as an ultrafast terahertz device. In this talk, we will discuss the nanoslot antennas with different widths, fabricated onto the bulk Ⅲ-Ⅴ semiconductor materials (InP and GaAs), and the measurement of ultrafast surface carrier dynamics in picosecond time scale. Using metallic nanoslot antenna accompanying strong THz field confinement, we observed the carrier lifetimes of InP and GaAs dramatically decrease as the gap size decreases down to nanoscale and their original bulk dynamics values once the nanoslot antenna patterns are removed. After then, we will discuss high on/off ratio and ultrafast terahertz modulation using graphene/metal nanoslot antennas. By the strongly localized fields near the nanoslot antenna, we achieved a distinctive modulation of graphene from off- to on-resonance.

Keywords:

Terahertz, Metal nanoantenna, Carrier dynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C16.04

광소자 기반 테라헤르츠 부품 개발 및 그 응용

LEE Eui Su *[1], KIM Mugeon [1], SHIN Jun-Hwan [1], PARK Dong Woo [1], LEE Ilmin [1], PARK Kyung Hyun [1]
[1]Terahertz Research Section, ETRI
euisu@etri.re.kr

Abstract:

밀리미터 및 테라헤르츠 전자기파 대역의 소자 개발과 관련하여 두가지 접근 방법인 전자소자 기반 솔루션과 포토닉스 기반 솔루션이 있다. 접근 방법에 따라 파워, 크기, 밴드폭, 가격 등에서 서로 장단점이 존재하며 현재, 상용 제품으로 구매 가능한 소자도 일부 있지만, 아직까지는 실험실 연구 목적으로만 이용되고 있는 실정이다.
본 연구 그룹은 포토닉스 기반 테라헤르츠 신호 발생 및 검출과 관련하여 III-V 화합물 반도체 기반의 비팅광원 이중모드레이저, 포토다이오드 기반의 포토믹서(UTC-PD), 쇼트키 배리어 다이오드(SBD) 검출기, 서브하모닉 믹서 등의 소자들을 개발하고 있다.
전자소자들에 비하여 출력 파워가 부족하지만, 전체적으로 소자들이 소형이고 출력 주파수가 넓은 출력 밴드폭을 가지고 있어 포토믹싱 방법을 이용하여 손쉽게 출력 주파수 가변이 가능하다.
이러한 소자들의 특성을 이용하여 비파괴 시스템을 구현, 산업적 응용(두께 모니터링 및 비파괴 이미징 등)과 테라헤르츠 무선 전송 등의 시연을 성공적으로 진행하였다.
끝으로, 포토닉스 기반의 테라헤르츠 소자들에 대한 앞으로의 연구 동향 및 향후 연구 방향에 대해 논의 할 것이다.

Keywords:

Dual-mode laser, UTC-PD, SBD, Subharmonic Mixer, Photonics-based THz devices

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C17.02

Quantum gas microscope of Bosonic atoms with tunable interaction

HUR Junhyeok [1], KWON Kiryang [1], KIM Kyungtae [1], HUH SeungJung [1], CHOI Jae Yoon [*1]
[1]Physics Department, KAIST
jaeyoon.choi@kaist.ac.kr

Abstract:

Quantum gas microscope is a high-resolution imaging technique that resolves individual atoms in optical lattices with single-site and single-atom resolution. Here, we report the realization of the quantum gas microscope of Lithium-7 atoms in a square two-dimensional optical lattice. We implement the Raman sideband cooling in the lattice and about 3,000 photons per atom are detected by high numerical aperture (NA=0.65) objective lens during 1 s of imaging time. The point spread function (PSF) of the imaging system is measured to be 600 nm (full width half maximum), small enough to resolve the lattice spacing (752 nm). Moreover, we achieve the unity filling Mott insulator with 1,000 particles using magnetic Feshbach resonance, introducing a new quantum simulator platform with larger system size and wide tuning range of interaction. Finally, we investigate the Gray molasses cooling in the deep lattice potential, where the collisional blockade might suppress the light-assisted atom loss at high filling (n>1).

Keywords:

Quantum Gas Microscope, Optical Lattice, Single-atom Imaging, Feshbach resonance, Gray Molasses

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C17.03

Parametric excitation of star-shaped patterns in Bose-Einstein condensates.

KWON Kiryang [1], HUH SeungJung [1], KIM Kyungtae [1], HUR Junhyeok [1], CHOI Jae Yoon [*1]
[1]Physics Department, KAIST
jaeyoon.choi@kaist.ac.kr

Abstract:

In this talk, we report the observation of two-dimensional star-shape patterns in a Bose-Einstein condensate (BEC). Under a periodic modulation of interparticle interactions, the surface of the BEC is deformed, displaying regular polygons with l-fold rotational symmetry (from l=2 to l=7) after 0.5-1 s of modulation. Superfluid hydrodynamic analysis reveals that the surface boundary can be described by the Mathieu equation, which shows resonance tongues for l-fold symmetry breaking patterns. Studying the resonance spectrum for each mode, we identify the dispersion of the surface mode and observe a blue shift of the resonance frequency at l=7 mode as a result of the finite system size.

Keywords:

Bose-Einstein condensate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C17.04

Quantum computing of maximal independent set problem for non-planar graphs

KIM Kangheun [1], KIM Minhyuk [1], HWANG Jaeyong [1], AHN Jaewook *[1]
[1]Physics, KAIST
jwahn@kaist.ac.kr

Abstract:

We present a Rydberg quantum simulator experiment of solving the Maximal Independent Set (MIS) problem at small scales. The computational complexity of MIS is NP-hard, so this problem at large scales is intractable with non-quantum computers. We first show that the MIS problem of any target graph can be naturally mapped to the ground-state finding problem of an interacting Rydberg-atom arrangement. In general, non-planar graphs require not only three-dimensional atom arrangements [1] but also quantum wires (for coupling of nonadjacent atoms) [2]. For experimental demonstration, we utilize our 3D-qubit Rydberg quantum annealer and, in addition, we propose and implement Ryberg-atom version quantum wires. We have performed programmed quantum annealing to find the ground states of 6-vertex graphs, H, X_{95} (which is H plus one wire), and $2K_3$+e (which is H plus two wires), as well as the essential non-planar graphs K_5 and $K_{3,3}$ [3]. The results exhibit MIS solutions, suggesting the possibility of optimization problems of general graphs to be mapped on interacting Rydberg atoms.

[1] Y. Song, M. Kim, H. Hwang, W. Lee, and J. Ahn, "Quantum annealing of Cayley-tree Ising spins," http://arxiv.org/abs/2011.01653.
[2] X. Qiu, P. Zoller, and X. Li. "Programmable quantum annealing architectures with Ising quantum wires." PRX Quantum 1.2 (2020).
[3] https://www.graphclasses.org/smallgraphs.html

Keywords:

Rydberg atom, quantum simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C17.05

Efficient creation of dipolar Bose-Einstein condensate for quantum simulation

SEO Bojeong [1], CHEN Peng [1], CHEN Ziting [1], HUANG Ming chen [1], PARIT Mithilesh Kumar[1], JO Gyu Boong *[1]
[1]Department of Physics, HKUST
gbjo@ust.hk

Abstract:

Ultracold system is a prominent platform for the study of degenerate quantum many-body physics since it provides us the ability to precisely tune and control experimental parameters, such as the s-wave interaction strength. On top of the benefit from the conventional ultracold system, we add a long-range anisotropic dipole-dipole interaction into the experiment by exploiting erbium atoms which have a large angular momentum and a large magnetic moment (7 Bohr magneton). Such dipolar degenerate quantum gases enable us to explore many intriguing physics, such as supersolidity, quantum droplet, and extended Bose-Hubbard model. Besides the long-range dipole-dipole interaction, the large angular momentum of erbium provides various useful cold-atom toolkits such as Feshbach resonance, a narrow-line optical transition, and a metastable excited state. With Feshbach resonance for instance, we can tune s-wave scattering interaction to zero and induce a non-negligible amount of quantum fluctuation.
In this talk, I present how we efficiently achieve degenerate dipolar quantum gases which consist of more than 10,000 dipolar atoms.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C18.01

Stability of Graphene on GaN for the Realization of III-Nitride Remote Epitaxy

PARK J.-H. [1,2], YANG X. [2], LEE J.-Y. [1], PARK M.-D. [1], LEE D.-S. *[1], BAE S.-Y. [3], AMANO H. *[2]
[1]School of Electrical Engineering and Computer Science (EECS), Gwangju Institute of Science and Technology (GIST)
[2]Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University
[3]Energy Materials Center, Korea Institute of Ceramic Engineering and Technology (KICET)
dslee66@gist.ac.kr,

Abstract:

Last over 10 years, III-nitride growth on graphene has been studied and demonstrated that the grown III-nitride can be exfoliated from the substrate, which opens potential opportunities for III-nitride application to various field. It basically has a sandwiched structure such as III-nitride/2-D material/III-nitride, which can even widen the scope of the III-nitride application. However, there is a main hurdle, graphene-loss on the III-nitride substrate during the growth in the MOCVD. Because of this, still, the realization of III-nitride remote epitaxy is very challenging. In this talk, we show the results on the graphene-loss problem by using various substrates. We found that graphene is stable on substrates containing oxygen atom unlike on III-nitrides. For example, when graphene was on GaN and AlN substrate, it was unstable over the substrate's decomposition temperature. However, the overgrown GaN on graphene/sapphire could be exfoliated rather easily, which indicates graphene can survive on substrates containing oxygen[1-3]. We will discuss more on the possible mechanism which can explain the graphene loss on III-nitrides.

References

1. Influence of Temperature-Dependent Substrate Decomposition on Graphene for Separable GaN growth, *Adv. Mater. Interfaces* **2019**, *6*, 1900821.
2. Multiple epitaxial lateral overgrowth of GaN thin films using a patterned graphene mask by metal organic chemical vapor deposition, *J. Appl. Cryst.* **2020**, *53*, 1052.
3. Stability of Graphene and Boron Nitride for Realization of III-Nitride Remote Epitaxy, Submitted.

Keywords:

GaN, graphene, remote epitaxy, MOCVD

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C18.02

Hybrid van der Waals heterostructures for quantum materials research

YOO Jinkyoung *[1]
[1]Center for Integrated Nanotechnologies, Los Alamos National Laboratory
jyoo@lanl.gov

Abstract:

Quantum materials research are under intensive studies due to strong demands on novel information technologies and exotic phenomena. Emerging nanomaterials such as topological materials and low-dimensional nanomaterials are the main building blocks of the quantum materials research. However, the emerging nanomaterials used to have limitations of lack of scalable synthesis and of quality control. Atomically thin two-dimensional (2D) materials are good examples of novel materials set promising exotic properties and requiring established manufacturing approaches. Heterostructuring is a powerful and general strategy to control physical properties of materials. Moreover, heterostructuring can offer novel characteristics differentiating the heterostructure from individual component in a structure. Recently, 2D/2D heterostructures prepared by stacking are being explored to observe quantum phenomena. However, fabrication of 2D/2D heterostructures has been limited by difficulty in preparation of individual 2D layers in controlled manner. Heterostructuring with 2D and conventional materials in other dimensions (e.g. bulk-like structure for 3D and nanowires for 1D) has shown great potential for multi-dimensional heterostructures.

In this presentation I'll discuss how to prepare multi-dimensional heterostructures composed of 2D and conventional materials. The experimental approach is epitaxial growth Si, Ge, and ZnO on various 2D materials including graphene, hexagonal boron nitride, transition metal dichalcogenides. Absence of surface dangling bonds on a 2D material provides a unique opportunity to overcome materials compatibility issues. Nucleation strategy and novel characteristics of multi-dimensional heterostructures will be discussed in detail.

Keywords:

van der Waals heterostructure, quantum materials, 2D/2D

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C18.03

Challenges and opportunities in remote epitaxy for releasable epilayers on graphene

KIM Jeehwan *1
1MIT
jeehwan@mit.edu

Abstract:

In today's talk, I will introduce a remote epitaxy technique that can produce single-crystalline membranes on graphene readily exfoliatable to form freestanding single-crystalline membranes. My group at MIT recently discovered that "any types" of single-crystalline compound materials, such as III-V, III-N, and complex oxides, can be epitaxially grown on graphene-coated substrates. The graphene is sufficiently thin such that crystalline orientation of substrates can be guided by the substrate beneath graphene. The slippery graphene surface allows the epitaxial films to be released from the substrate while the substrate can be reused. At the same time, remote epitaxial films grown on graphene can substantially reduce the density of dislocations. I will discuss how this advanced technology revolutionizes compound semiconductor technologies.

References

[1] Y. Kim, et al, and J. Kim, "Remote epitaxy through graphene enables two-dimensional material based layer transfer" Nature, Vol. 544, 340 (2017)
[2] W. Kong, et al, and J. Kim, "Polarity govern atomic interaction through two-dimensional materials", Nature Materials, Vol. 17, 999 (2018)
[3] S. Bae et al, and J. Kim, "Graphene-assisted spontaneous relaxation towards dislocation-free heteroepitaxy", Nature Nanotechnology (2020)
[4] S. Bae, et al, and J. Kim, "Integration of bulk materials with two-dimensional materials for physical coupling and applications", Nature Materials (2019)
[5] H. Kum, et al., and J. Kim, "Heterogeneous integration of singlecrystalline complex-oxide membranes, Nature, Vol 578, 75-81 (2020)

Keywords:

releasable epilayer, graphene, remote epitaxy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C18.04

Compound Semiconductor based Thin-Film and Flexible Optoelectronics

LEE Kyusang *[1]
[1]University of Virginia
kyusang@virginia.edu

Abstract:

Compound semiconductors are the basis for many of the highest performance optical and electronic devices in use today such as photodetectors, light emitting diodes, high frequency transistors, lasers and solar cells etc. Their widespread commercial application has, however, been limited due to a prohibitive substrate cost. We address this limitation by fabricating thin film and flexible optoelectronic devices via a new, non-destructive epitaxial lift-off (ND-ELO) process. ND-ELO has the potential to dramatically reduce the device production cost by separating the thin-film from the substrate and by recycling the parent wafer an unlimited number of times without loss of performance. The thin-film and flexible technology can be combined with unique dynamic three-dimensional structure developed through substrate bending and folding based on the arts of origami and kirigami. We apply these techniques to the demonstration of low-cost integrated kirigami-based solar tracking concentrators, and high performance conformal thin-film InGaAs photodiode focal plane arrays (FPAs) on bendable substrates. The unique features of these low cost, flexible and high performance thin-film optoelectronics devices provide a new paradigm for realizing a wide range of heretofore inaccessible electronic and imaging applications.

Keywords:

Compound semiconductor, thin film, flexible optoelectronics, epitaxial lift-off

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C19.01

Low-frequency noise characterization in 2-dimensional semiconductor transistors with large interfacial carrier fluctuations

JI Hyunjin *[1], LEE Gwanmu [2], YI Hojoon [2], LIM Seong Chu [2]
[1]School of Electrical Engineering, University of Ulsan
[2]Department of Energy Science, Sungkyunkwan University
hyunjin@ulsan.ac.kr

Abstract:

Although the device research using layered 2-dimensional(2-D) materials is gaining world-wide attention with the various unique physical properties caused from the weak van der Waals interaction between layers and the wide range of material properties from insulators to semiconductor and even semi-metals, it is still required that the delicate study the influence of surfaces or interfaces on device performance and parameters generated by device structures of enormous surface to volume ratio and the top-down harsh manufacturing processes. Not only the harsh manufacturing processes such as etching the channel region by particle collisions or deposition of metal electrodes with high thermal energy severely suffered the ultra-thin channel materials, but also the resultant large interfacial area between the channel and the effective gate dielectric region promoted the interfacial carrier fluctuations.

It is almost impossible to solve the problem without accurately identifying the cause. One of the good analysis tools that can electrically analyze the interfacial carrier fluctuation in a device is to measure and model the low-frequency noise (LFN) characteristics. Although previous studies on LFN in silicon-based bulk or thin-film device have been well established for a long time, the existing results of LFN in 2-D devices showed the limitations in directly applying models commonly used in silicon devices to 2-D material devices. Through this study, the cause of the limitations of the existing LFN results in 2-D semiconductor transistors is to be identified and the modified method is provided and explained. It was confirmed that the modified model well described the characteristics of carrier fluctuations in 2-D device with the various dielectric environments, and applied studies based on this were introduced as well. As the importance of precise analysis studies is increasing with the miniaturization of devices, the results of this study are expected to contribute to quantifying the characterization of nano devices.

Keywords:

low-frequency noise, 2-dimensional semiconductors, carrier fluctuation, electrical analysis

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C19.02

옴식 영역에서의 전기 전도도 측정을 통한 MoS_2 에서의 도체-부도체 상전이 연구

MOON Byoung Hee *[1]
[1]Department of Physics, Incheon National University
bhmoon@inu.ac.kr

Abstract:

저온에서의 물질 또는 전자계에서의 전기 전도도는, 보통 측정하기 위해 가해지는 전기장의 크기에 따라 달라진다. 즉 대부분의 전기장 영역에서 비옴식 경향성을 가진다. 따라서, 계의 수송특성을 규정할 때 주의가 필요하다. 이번 발표에서는, MoS_2 에서의 옴식 영역에서의 전기 전도도 측정의 예시를 통하여, 복층 MoS_2 에서의 도체-부도체 상전이가 수송자간의 강한 상호작용에 의한 Mott 상전이로써 잘 설명이 됨을 보이고자 한다.

Keywords:

Mott 상전이, 전기 전도도, 도체-부도체 상전이, MoS2, 옴식 측정

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C19.03

테라헤르츠파를 이용한 반도체 및 저차원 소재의 전기적 특성 분석법

SHIN Hee Jun *[1]
[1]fs-THz, Pohang Accelerator Laboratory
shinhj@postech.ac.kr

Abstract:

테라헤르츠파는 주파수 상 0.1 THz ~ 10 THz 영역의 전자기파를 일컬으며 펨토초 펄스 레이저의 출현으로 반도체, 광전도 안테나 및 비선형 결정 등을 이용한 다양한 테라헤르츠파 발생 및 검출 기법이 개발되어 반도체 특성 분석에 활발히 활용되어 왔다. 뿐만 아니라 포토믹서, 양자폭포 레이저, 고출력 펨토초 레이저 및 입자 가속기 기반의 첨단 테라헤르츠파 발생 기법이 개발되어 보다 다양한 방법으로 반도체와 여러 소재의 전기적 특성 분석이 가능해졌다. 본 발표에서는 테라헤르츠파 기반의 시간 축, 시간 분해 분광법 등 테라헤르츠 시스템을 이용하여 반도체, 저차원 소재 등의 전기적 파라미터를 추출하고 모델링을 통해 관측 가능한 전기적 특성 분석법 및 활용에 대해 소개하고자 한다.

Keywords:

Terahertz, Semiconductor, Electrical property

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C19.04

Metal–Insulator Transition and Photocurrent of MoS_2

LIM Seong Chu *[1], SAKONG Won Kil [1]
[1]Department of Energy Science, Sungkyunkwan University
seonglim@skku.edu

Abstract:

The resistance–temperature plot of molybdenum disulfide (MoS_2) displays a change in slope as follows: $dR/dT>0$ for metal and $dR/dT<0$ for semiconductor. Using back-gate bias, the metal and insulator states of MoS_2 are controllable through the carrier concentration n. During the transition, the localized electron transport becomes delocalized when E_F moves above the mobility edge and the correlation among electrons increases. We demonstrate that the electrical metal–insulator transition (MIT) of MoS_2 produces a photocurrent that has a different origin. This enables an optical sensor that can detect from the visible to the mid-infrared range.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C20.01

Mechanical Responses of Breast Cancer Cells to Substrates of Varying Stiffness Revealed by Single-Cell Measurements

PARK Hyokeun *[1]
[1]HKUST
hkpark@ust.hk

Abstract:

Mechanical properties of matrices are known to play an important role in metastasis of cancer cells. However, how cancer cells respond to different mechanical environments during metastasis remain elusive. Here, we have investigated the force transduction in focal adhesions of MDA-MB231 cells (a metastatic human breast cancer cell line) and MCF-10A (a normal human breast cell line) on substrates with varying stiffness. Using an improved FRET-based tension sensor, we measured the tension in focal adhesions of breast cancer cells directly and found that the tension in focal adhesions of breast cancer cells increased when they were grown on stiffer substrates. In contrast, normal breast cells exhibited no obvious trend in the tension in focal adhesions against varying stiffness of substrates. Increased stiffness led to decrease of power-law exponent of breast cancer cells in the viscoelastic measurements with magnetic tweezers whereas normal breast cells had similar power-law exponents against different stiffness of substrates, indicating that breast cancer cells become more elastic on substrate with higher rigidity. The changes in tension in focal adhesions and higher viscoelasticity of breast cancer cells according to the stiffness of substrate contribute to adaptability of breast cancer cells in the mechanical environments of possible metastasis sites and facilitate metastasis of cancer cells to different tissues or organs.

Keywords:

Single-cell measurement, Cancer cells, Mechanical response, Substrates, Stiffness

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C20.02

Shapes, Motions, and Forces in Cells

SHIN Jennifer H.*[1], CHO Youngbin [1]
[1]Department of Mechanical Engineering, KAIST
j_shin@kaist.ac.kr

Abstract:

Forces are ubiquitous in life, and they directly impact the physiological functions of the cells. Cells experience and exert physical forces by responding sensitively to these forces or by generating them for everyday biological processes in our body. For example, certain abnormalities in the physical properties of the tissue microenvironment can provoke pathological conditions such as cancer, and the physical state of the cells can direct the metastatic fate in the tumor mass. To understand the physiological behavior of the cells, it is crucial to develop pathologically relevant cell-based *in vitro* experimental models. In this work, we developed 2D and 3D cell-based models to visualize how stresses between adjacent cells and those between cells and the environment are developed in the clusters and how these stresses dictate the shapes and motions of the constituent cells. For quantitative analyses, we utilized particle image velocimetry (PIV), traction force microscopy (TFM), and monolayer stress microscopy (MSM) along with conventional biochemical assays and other phenotyping tools and identified the active remodeling of stresses during the rearrangement of cell clusters. Using the simple 2D model, we unraveled the correlation among the shapes, motions, and physical stresses of the cells. In the context of cancer metastasis, we first identified the key factors that actively regulated the formation of the cellular aggregates and quantified the physical forces that would suppress the dissemination from the aggregates.

Keywords:

forces, traction force microscopy, monolayer stress microscopy, cancer metastasis, in vitro model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C20.03

Molecular tension authenticates apoptotic cells during efferocytosis

MIN Chanhyuk [1,2], CHO Hyeokjin [1,2], JEON Jaesun [1,2], LEE Gwangrog [1,2], PARK Daeho *[1,2]
[1]School of Life Sciences, Gwangju Institute of Science and Technology
[2]Laboratory for cell mechanobiology, Gwangju Institute of Science and Technology
daehopark@gist.ac.kr

Abstract:

Phagocytosis of apoptotic cells, called efferocytosis, is an event concomitant with massive cytoskeleton and plasma membrane dynamics due to ingestion of apoptotic cells as large as phagocytes. However, current studies in the field have overlooked whether the dynamics causes a signal and, if any, how it is coordinated with known signaling of efferocytosis. Here, using Tension Gauge Tether (TGT) and various approaches, we report that molecular tension between phosphatidylserine (PS) and its receptors generated by the dynamics is converted into a signal verifying apoptotic cells for engulfment. Engulfment of PS-TGT beads occurred in a tension-dependent manner. In addition, decreasing membrane stiffness of apoptotic cells abrogated efferocytosis, but increasing membrane stiffness of live cells exposing PS resulted in phagocytosis of them. The binding of targets, Rac1 activation, or phagosome maturation was unaffected by the tension but phagocytic cup closure was altered. Mechanistically, PI3K was recruited to PS receptors in a tension-dependent manner, which caused Rac1 inactivation required for phagocytic cup closure to ingest apoptotic cells. In sum, molecular tension between PS and PS receptors is used as a gauge for phagocytes to authenticate apoptotic cells to be phagocytosed.

Keywords:

Molecular tension, efferocytosis, apoptotic cells, phagocytes, phosphatidylserine, phosphatidylserine receptor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

C20.04

Single-molecule analysis of integrin tension required for chemotaxis of metastatic cancer cells in confinement.

KIM Young [1], KIM Kyung Ah [1], KIM Byoung Choul *[1]
[1]Major of Nano-Bioengineering, Incheon National University
introbc@gmail.com

Abstract:

Cancer metastasis involves serial steps of adhesion, spreading, and migration of cells. Mechanical interaction, tension applied on a bond between integrin and extracellular matrix (ECM), is a critical determinant of the cancer metastasis, however, quantitative changes in the integrin tension during cancer migration are poorly understood. Here, we characterize integrin tension at the single-molecule level when metastatic cancer cells migrate in response to a chemical stimulus. We developed the single-molecule force probe integrated microchannel systems (10 x 3, 6, and 9 μm) mimicking cancer microenvironment and measured spatio-temporal changes in integrin tension. Our real-time analysis revealed that 1) migration of metastatic cancer cells into microchannels was enhanced significantly in the existence of chemical stimuli, 2) during the onset of cell entering into the microchannels, cells generated peak integrin tension in the range between 54 pN and 100 pN, and 3) during cell migration through the microchannels, integrin tension at the cell front was below 43 pN, whereas integrin tension at the cell rear was above 54 pN. In summary, our experimental results identify dynamic changes in integrin tension required for chemotaxis of metastatic cancer cells in confinement.

Keywords:

Mechanobiology, Single molecule technique, TGT, Microconfinement, Cancer metastasis

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

CC3.01

Current status of the development of the mass measurement system (MRTOF-MS) at RAON

MOON Jun Young *[1], SHIN Teaksu [1], LEE Jinho [1], CHAE Kyungyuk [2], NGUYEN Duy Ngoc[2], NGUYEN Kim Uyen[2]
[1]Rare isotope science project, Institute for basic science
[2]Department of physics, Sungkyunkwan University
jymoon70@gmail.com

Abstract:

After a five-year collaboration with KEK/WNSC (Japan), a multi-reflection time-of-flight mass spectrograph has been assembled and installed on the ISOL (Isotope on-line) at RAON, a new rare-isotope beam factory in Korea. It consists of three main parts, a gas cell, a trap system, and an MRTOF analyzer.
Most of the parts are similar to those manufactured in KEK, but some of them have been revised or if possible, replaced with commercial one for easy maintenance. In this presentation, the current status of its installation and preliminary results of tests performed will be shared.

Keywords:

Mass, MRTOF, Rare isotope

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

CC3.02

Recent experiments and upgrades at the TITAN MR-TOF-MS at TRIUMF

MURBOECK Tobias *[1], DUNLING Eleanor [1,2], JACOBS Andrew [1,3], WALLS Coulter [1,4], KWIATKOWSKI Ania [1,3,5]
[1]TRIUMF
[2]University of York
[3]University of British Columbia
[4]University of Manitoba
[5]University of Victoria
tmurboeck@triumf.ca

Abstract:

High-precision mass spectrometry has grown over the previous years to become a pivotal tool in nuclear physics. Providing direct information on the nuclear binding energy it facilitates the study of nucleosynthesis or of nuclear features such as magic numbers, mid-shell effects, and nuclear deformation. Multiple-Reflection Time-of-Flight Mass Spectrometers (MR-ToF-MS) in particular, with their exquisite sensitivity, short measurement time and non-scanning operation, have allowed to access increasingly exotic species. Here we present recent experiments performed with the MR-ToF-MS at TITAN, TRIUMF's Ion Trap for Atomic and Nuclear Science. In addition we highlight a series of upgrades, which have greatly improved parameters like the mass resolution, the dynamic range, and the temporal stability of the system.

Keywords:

atomic masses, binding energy, exotic nuclei, mass spectrometry, time-of-flight mass spectrometer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.01

FPGA-based firmware implementation of a missing transverse momentum algorithm for the CMS Phase-2 Level-1 trigger

MOON Chang-Seong *[1], HONG Jieun [1]
[1]Department of Physics, Kyungpook National University
csmoon@knu.ac.kr

Abstract:

The high-luminosity upgrade of the CERN Large Hadron Collider (HL-LHC) will enable a factor of ten increase in the total dataset collected by the CMS experiment, maximizing the potential for the discovery of new physics. While the increased instantaneous luminosity will bring this significant advantage, it also requires improved capabilities of the CMS detector performance. The CMS Level-1 trigger will be significantly expanded during the Phase-2 upgrade to allow for more efficient data collection. The Level-1 correlator trigger will become the main engine of the trigger system, performing particle-flow (PF) reconstruction, which reconstructs physics objects by combining signals collected by all subdetectors. These PF objects are passed to a second-stage FPGA for further processing into higher-level objects. This work describes the firmware implementation of a missing transverse momentum algorithm, developed using Xilinx Vivado high-level synthesis. The de-regionizer algorithm is added to the MET algorithm, with modifying the input stream method. The emulation results with the prototype trigger board will be included.

Keywords:

CMS, L1 trigger, firmware

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.02

Physics at SND@LHC

LEE Kang Young *[1], 김성현 [1], 김영균 [2], 박병도 [1], 손종윤 [1], 우종관 [3], 윤천실 [1], 이경세 [4], 최기영 [5]
[1]Gyeongsang National University
[2]Department of Science Education, Gwangju National University of Education
[3]Department of Physics, Jeju National University
[4]Department of Physics, Korea University
[5]Department of Physics, Sungkyunkwan University
kylee.phys@gnu.ac.kr

Abstract:

SND@LHC 는 SHiP 실험의 SND 검출기를 LHC ATLAS 검출기의 충돌점에서 접선 방향으로 충분히 거리를 두고 설치하여, 충돌에서 나오는 중성미자를 연구하고, 상호작용이 매우 작은 숨겨진 입자를 발견하기 위한 실험이다. SND 는 원자핵건판을 이용해서 중성미자와 숨겨진 입자를 검출한다. 여기서는 SND@LHC 실험과, 실험에서 연구하게 될 물리학을 설명한다.

Keywords:

SND, SHiP, LHC, 중성미자, 숨겨진 입자

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.03

Preproduction of improved RPCs for Phase-2 upgrade of the CMS Muon System

LEE Kyong Sei *[1], KANG Minho [1], JO Youngmin [1], CHOUI Suyong [1]
[1]Korea University
kslee0421@korea.ac.kr

Abstract:

The Korea CMS group is in charge of construction of detector electrodes for functionally 'improved' RPCs (iRPCs) for the future CMS experiment in high-luminosity (HL) LHC runs (Phase-2). To demonstrate the technology of the iRPCs for the CMS operated with the HL LHC beams, we plan installation of two iRPC modules each in RE3.1 and RE4.1 regions during a period of year-end technical stop (YETS) 21/22. The construction of the RPC electrodes and the quality control for the demonstration of the iRPCs as a preproduction step of the detector construction have been successfully performed at Korea Detector Laboratory at Korea University. In virtue of the intensive R&D effort of the CMS RPC group, positive statements on the present RPC upscope project were recently reported by the engineering design review (EDR) committee. Now, the full-scale construction of the iRPCs is planned to start on July 2021 with the production of the detector electrodes. Here, we report the construction of detector electrodes for the demonstration iRPCs and the results of the quality control. Finally, we install all planned 72 iRPC modules equipped with final-version front-end and back-end electronics in a technical stop in 2023 and complete installation of the trigger electronics in a dedicated period to be allocated for the RPC system in Long-Stop 3 (LS3).

Keywords:

Compact Muon Solenoid, Resistive Plate Chambers, high-luminosity (HL) LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.04

Status of CMS LGAD Sensor Testing in Korea

YOO Jae Hyeok *[1], PADMANABAN Jayashri [1], HWANG In Seong [1]
[1]Physics, Korea University
jaehyeokyoo@korea.ac.kr

Abstract:

As part of the CMS Phase 2 upgrade, MIP Timing Detector is planned to be installed in order to mitigate the impact of pileup that is expected to reach 200 in HL-LHC. In the endcap region, silicon-based Low Gain Avalanche Detector (LGAD) sensors that allow timing resolution of a few tens of picoseconds are used. The sensor design needs to be optimized considering several factors, including radiation resistance, uniformity of gain, and long-term stability. At Korea University, we have set up the sensor testing facility using a laser and I will discuss the status of and the plan for the sensor testing in Korea.

Keywords:

CMS, MTD, ETL, LGAD, silicon sensor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.05

The CMS Muon High Level Trigger for the High Luminosity LHC

OH Minseok *[1], YOO Hwidong [2]
[1]Department of Physics, Seoul National University
[2]Department of Physics, Yonsei University
khaosmos93@gmail.com

Abstract:

The High Luminosity LHC (HL-LHC) is designed to operate with the maximum peak instantaneous luminosity of 7.5×10^{34} $cm^{-2}s^{-1}$ by increasing the average number of proton-proton collisions per bunch crossing to about 200. In these challenging conditions, the CMS Muon High Level Trigger (Muon HLT) aims to reduce the event rate from the order of tens of kHz, accepted by the Level-1 (L1) muon system, to 1.5 kHz by preferentially selecting muons from decays of the W, Z, and H bosons. In this presentation, upgraded algorithms for the CMS Muon HLT, incorporating new inputs from the L1 muon system and L1 track trigger, are described. Measurements of efficiencies, purity of the selected muons, momentum resolution, and trigger rates are presented. Furthermore, extended developments involving the machine learning technique are presented.

Keywords:

HL-LHC, CMS, Trigger

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.06

Development of boron-cathode based GEM detector for neutron imaging

PARK Inkyu *[1], LEE Jason Sang Hun[1], JUNG Younggun [1], LEE Hyupwoo [1], SONG DongHyun [1]
[1]University of Seoul
icpark@uos.ac.kr

Abstract:

Previously, we have studied the potential of a gas electron multiplier (GEM)-based neutron detector by using a gadolinium plate functioning as both the cathode and neutron converter. It is difficult to specify a location using a gadolinium-cathode GEM detector because gadolinium emits gammas and electrons after neutron capture. Boron, on the other hand, emits alpha after neutron capture, generating a large signal in the local area, making it easier to obtain the position of a neutron. We present the status of our neutron imaging boron-cathode-based GEM detector using a 2D strip readout.

Keywords:

GEM, Detector, Neutron, Gadolinium, Boron

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D1.07

Measurements of LGAD sensors with 120 GeV proton beam for CMS MTD Endcap Timing Layer

MOON Chang-Seong *[1], LEE Hakseong [1]
[1]Department of Physics, Kyungpook National University
csmoon@knu.ac.kr

Abstract:

The simultaneous interaction per bunch crossing (pileup) that gives rise to the rate of false triggers is one of the major challenges during the high luminosity LHC (HL-LHC) running. The development of mitigation techniques based on 4D reconstruction using timing information is expected to significantly reduce the effect of pileup by helping to find the correct primary vertex. The minimum ionizing particle (MIP) Timing Detector (MTD), which is planned to be installed for the CMS Phase-II Upgrade, is designed to provide timing information for the MIP with a 30-40 ps resolution. In order to guarantee this level of timing performance, low gain avalanche detectors (LGAD) silicon sensors are going to be used for endcap timing layer (ETL). We present the measurement of LGAD sensors for timing resolution and radiation hardness with a 120 GeV proton beam at the Fermilab Test Beam Facility.

Keywords:

Timing, MTD, ETL, LGAD

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.01

Status of Muon Veto detector development for AMoRE-II

KIM Go Woon *[1], LEE Jaison [1], NYANDA Pendo [1], YI Eungseok [1]
[1]CUP, IBS
kkw-owo@hanmail.net

Abstract:

The AMoRE experiment is a neutrinoless double-beta decay search of CUP, IBS, using ^{100}Mo, and AMoRE-II, its 2nd phase, will begin soon.
AMoRE experiment is aiming to reach zero-background, and one of the ways is cosmic ray background rejection. Underground is a suitable environment to avoid cosmic muon rays, and AMoRE-II will be carried out in Yemi-Lab, which is a new underground laboratory in Jeongseon, Korea. Furthermore, to reach our goal of the background level, we will install a muon veto detector to reject muon events which can be made an effective signal for the background level. Muon veto detector for AMoRE-II will consist of 2 parts: a Plastic Scintillator part and a Water Cherenkov detector part. In this talk, the status of development for these two muon veto detectors in recent will be presented.

Keywords:

AMoRE, Muon Veto detector, Plastic Scintillator, Water Cherenkov detector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.02

Study of the decay of ^{180m}Ta using the CAGe

KIM Go Woon *[1], KIM Yeongduk [1], HAHN Insik [2], KANG WoonGu [1], KAZALOV Vladimir [3], LEE EunKyung [1], LEONARD Douglas [1], PARK Su-Yeon [1]

[1]CUP, IBS

[2]CENS, IBS

[3]Institute for Nuclear Research of the Russian Academy of Science, Baksan Neutrino Observatory

kkw-owo@hanmail.net

Abstract:

^{180m}Ta, the second excited state of ^{180}Ta, at Ex = 77 keV, is one of the most interesting meta-stable nuclear isomers. This isomer is naturally occurring and very stable. The half-life of the ^{180m}Ta decay is one of the keys to understanding heavy-element nucleosynthesis. However, the decay of ^{180m}Ta has never been observed yet, and its half-life is only known by a lower-limit value.
Y2L, the underground laboratory in Yangyang, has an array of 14 HPGe detectors, named CAGe. We measured ~6.9 kg of natural tantalum using the CAGe to identify the half-life of ^{180m}Ta decay. We will present The experimental setup and measurement result in this talk.

Keywords:

HPGe detector, 180mTa

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.03

Stabilization heaters & drift correction in AMoRE-I

KIM Yong-Hamb *[1,2], KWON Dohyung [1,2]
[1]Center for Underground Physics, IBS
[2]Basic Science, UST
yhk@ibs.re.kr

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. The heater installation process in the amore 1 experiment and the result of drift correction using the heater signal will be announced.

Keywords:

AMORE, MMC, SQUID

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.04

Background study of monopole experiment (KAEM) using GEANT4 simulation

LEE Junghyun *[1], LEE Sehwook [1], HUH Changgi [1], YE Ryonghae [1]
[1]Department of physics, Kyungpook National University
dakdi93@knu.ac.kr

Abstract:

In 1931, Paul Dirac claimed the existence of a magnetic monopole. Many experiments have been searching for magnetic monopoles since then, but they have not discovered such particles. KoreA Experiment on Magnetic Monopole (KAEM) searches the monopoles with the e+e− annihilation process in the low-mass, low-charge region that has not been unexplored.
KAEM consists of a vacuum chamber and various apparatuses. In the center of the vacuum chamber are an aluminum target and sodium-22, which produces positron source. The LYSO, which acts as an electromagnetic calorimeter trigger-veto, surrounds the positron source, and there are LYSO EM calorimeters to detect annihilated gamma in the target. Two solenoids around the chamber form a magnetic bottle between them and a uniform magnetic field inside them. This magnetic field traps charged particles in the magnetic bottle and plays a role to accelerates magnetic monopoles from the e+e− annihilation.
In this presentation, we present KAEM simulation environments and results of background study performed with GEANT4.

Keywords:

Magnetic monopole, KAEM, GEANT4

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.05

Axion haloscope experiment using 18T high temperature superconducting magnet and Josephson parametric converter at CAPP/IBS in KAIST

LEE Youngjae *[1], BYEONGSU Yang [2], YOON Hojin [1], AHN Moohyun [3], PARK Heejun [2], KIM DongLak [2], YOO Jonghee [1,2]
[1]Physics, KAIST
[2]CAPP, IBS
[3]Physics&Astronomy, Seoul National University
ylee.axion@kaist.ac.kr

Abstract:

About 23% of energy budget of the universe is consisted with dark matter. Axion is one of the strongest candidates of the dark matter. In order to detect the dark matter axions, we design an axion haloscope experiment. The experiment is equipped with 18T high temperature superconducting magnet, high quality factor microwave cavity with frequency tuning-rod, an ultra-low-noise Josephson Parametric converter, and dilution refrigerator. The detector is designed to be sensitive to the axion mass about 5 GHz which is correspond to the axion mass of 20 ueV. In this presentation, we report the performance of the CAPP18T dark matter axion search experiment.

Keywords:

dark matter, axion, superconducting magnet, Josephson parametric converter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.06

Characterization of a NaI(Tl)-SiPM detector at low temperatures

LEE Hye Young *[1]
[1]IBS
hylnate@nate.com

Abstract:

Silicon photomultipliers (SiPMs) are solid-state light detectors that achieve an ultimate sensitivity of single photon detection.The SiPM also has other nice features that take advantage of silicon's material properties. They are expected to eventually replace conventional PMTs (photomultiplier tubes) for many physics applications. In the present work, we report a study of the characterization of a NaI(Tl)-SiPM detector at low temperature. The scintillation light output of a NaI(Tl)-SiPM detector irradiated with 59.54 keV gamma particles was measured for temperatures ranging from 97K to 300K. The intrinsic gain and dark rate characteristics of the SiPM were measured at low temperatures prior to tests with specific detectos. The temperature dependence of the decay time constant of the NaI(Tl) crystal are reported. Also, previous measurements of the temperature dependence of the NaI(Tl) light yield are confirmed.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D2.07

NaI(Tl) neutron and gamma pulse shape discrimination study around -30℃

LEE Seo Hyun *[1,2], LEE Hyun Su [1,2], KIM Kyungwon [2]
[1]Basic Science, UST
[2]Center for Underground Physics, IBS
alicelee3141@gmail.com

Abstract:

NaI(Tl) detectors have been used in various rare event search experiments. Since it is known that the responses of NaI(Tl) are increased at low temperatures around -30℃, we compared performances of the NaI(Tl) crystal detector at -33℃ and 22℃. Temperature dependence on the neutron and gamma pulse shape discrimination power and on neutron quenching of NaI(Tl) will be reported.

Keywords:

NaI(Tl), Low temperatures, Pulse shape discrimination

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D3.01

Status of construction of NDPS facility

HONG Seung Woo *[1], MOON Dalho [1], GIL Ghoong-Sup [2], KIM Do Heon [2], LEE Young-Ouk [2], SONG Tae-Yung [2], YANG Sung-Chul [2], MOON SEOK HO [3], KWAK DONGHYUN [3], JEONG JUNYEONG [3], CHEON YOOLIM [3], CHUNG Moses [3], LEE Sangjin [4], TSHOO Kyoungho [4], HAM Cheolmin [4], SHIGYO Nobuhiro [5], WATANABE Yukinobu [5], NISHIO Katsuhisa [6], YASHIMA Hiroshi [7], CHIBA Satoshi [8]

[1]Department of Physics, Sungkyunkwan University
[2]Nuclear Physics Application Research Division, KAERI
[3]Department of Physics, UNIST
[4]RISP, IBS
[5]Department of Applied Quantum Physics and Nuclear, Kyushu University
[6]Advanced Science Research Center, JAEA
[7]Research Reactor Institute, Kyoto University
[8]Laboratory for Advanced Nuclear Energy, Tokyo Institute of Technology
swhong@skku.ac.kr

Abstract:

Nuclear Data Production System (NDPS) is an experimental system for measuring nuclear data by use of mainly neutron Time-of-Flight detection systems. The RAON provides deuterons and protons up to 98 MeV and 83 MeV, respectively. They are accelerated by a superconducting driver LINAC (SCL3) and are delivered to the neutron production target to produce neutrons. Pulsed beams with intensity up to ~12 μA can be used to do experiments for measuring neutron-induced cross sections. Nuclear data such as (n, fission), (n, xn), and (n,ɣ) cross sections can be measured. The range of the beam repetition rate is to be 1 kHz ~ 1MHz while the RF frequency of the LINAC is 81.25 MHz. The pulse width of the beams is an important factor in determining the accuracy of nuclear data and is aimed to be as small as 1~2 ns. Both white neutrons and monoenergetic neutrons will be produced. White neutrons will be generated by thick C (graphite) targets, while thin Li targets will produce monoenergetic neutrons. Beam lines for charged particles and neutrons together with a neutron collimator and beam dumps are under construction. Experiments for fission (n, f) and (n, xn) reactions can be done with various detectors. The current status of the construction of the NDPS will be presented.

Keywords:

NDPS, Neutron TOF

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D3.02

Fission study using multinucleon transfer reaction

NISHIO Katsuhisa *1
1Advances Science Research Center, Japan Atomic Energy Agency
nishio.katsuhisa@jaea.go.jp

Abstract:

Fission studies using multinucleon transfer (MNT) reaction [1-3] at the tandem facility of Japan Atomic Energy Agency (JAEA) in Tokai will be presented. The MNT reaction allows us to produce neutron-rich actinide nuclei, which cannot be populated by particle capture reactions. Taking advantage of many MNT channels opened in the ^{18}O induced reactions, fission fragment mass distributions (FFMDs) for various actinide nuclei can be obtained in one reaction. Also, evolution of fission properties with excitation energy is obtained. From the data, effects of multichance fission on FFMD was investigated [2,4]. We also show that the MNT reaction is a useful method to derive fission-barrier height [5].

We also discuss possible experiments to be considered in the NDPS facility at RAON.

[1] R. Léguillon *et al.*, Phys. Lett. B, **761**, 125 (2016).
[2] K. Hirose *et al.*, Phys. Rev. Lett. **119**, 222501 (2017).
[3] M.J. Vermeulen *et al.*, Phys. Rev. C **102**, 054610 (2020).
[4] S. Tanaka *et al.*, Phys. Rev. C **100**, 064605 (2019).
[5] K. R. Kean *et al.*, Phys. Rev. C **99**, 051601 (2019).

Keywords:

Multinucleon transfer reaction, Fission-fragment mass distribution, Multichance fission, Fission-barrier height

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D3.03

Overview and status of the LAMPS experiments

KWEON Min Jung *[1]
[1]Inha University
minjung@inha.ac.kr

Abstract:

Large Acceptance Multi-Purpose Spectrometer (LAMPS) is an experimental system for rare isotope collision experiments at RAON, and the detector is designed for studying the equation of state (EoS) and the nuclear symmetry energy of the compressed nuclear matter. Particularly, LAMPS will provide an excellent opportunity to study various physical variables of nuclei and nuclear matter with extraordinary neutron-to-proton ratios. Several detector components for LAMPS, including the Time Projection Chamber (TPC) and the neutron detector array, have been developed, constructed and tested. Furthermore, the prototype detectors of Time-of Flight array encompassing the TPC and in forward, Beam Diagnosis Counters and Start Counter have been developed and tested for the high energy LAMPS experiments. Active target TPC is also under R&D for the low energy experiment. To understand the performance of the prototype detectors, the beam test with the combination of all the prototype detectors was performed using 100 MeV Proton beams at KOMAC in last November. In this talk, the overview of the LAMPS experiment and the current status of the detector developments for LAMPS are presented with some perspectives.

Keywords:

LAMPS, nuclear equation of state, nuclear symmetry energy, beam test

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D4.01

물리가 있는 풍경: 감마선 폭발과 중력파(Gamma ray bursts and gravitational waves)

이현규*[1]
[1] 한양대학교 물리학과
hyunkyu@hanyang.ac.kr

Abstract:

감마선 폭발과 중력파의 관측은 우주에는 태양질량과 맞먹는 에너지를 짧은 시간에 방출하는 우주전체의 밝기보다 훨씬 밝은 현상이 존재한다는 것을 알려주었다. 이 현상들의 중심에 블랙홀이나 중성자 별 등 올찬 별(compact star)에 의해 조성된 풍경과 물리적 과정을 살펴본다. 블랙홀 계에서의 중력결합에너지의 방출과정, 회전 운동에너지가 짧은 시간에 방출될 수 있는 자기제동 과정과 감마선 폭발의 중심을 살펴 볼 수 있는 중력파의 특징을 논의한다. 감마선 폭발과 중력파는 거시적인 풍경 뿐 만 아니라 중성자 별의 내부의 고밀도 극한 환경의 미시적인 풍경에 대한 이해의 가능성을 열어 주고 있다.

Keywords:

gamma ray bursts, gravitational waves

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D4.02

한국-이태리 천체물리 공동 학술회의 성과와 전망

KIM Sung Won *[1]
[1]Science Education, Ewha Womans University
sungwon@ewha.ac.kr

Abstract:

한국물리학회 천체물리학분과에서는 다양한 국제협력활동을 수행해오고 있다. 개인적으로나 소규모 단체활동 등 다양한 활동을 하지만 이 중에서 가장 역사가 오래되고 분과회원이 전체 참여하는 행사는 “한국-이태리 상대론적 천체물리 공동 학술회의”이다. 분과 창립 이전인 1987 년 한양대에서 시작된 본 회의는 2019 년 16 번째 이태리 페스카라에서 진행될 때까지 32 년간 격년제로 한국과 이태리를 왕복하면서 공동연구와 학문의 교류를 활발하게 진행해왔다. 이러한 성과를 기반으로 미래를 위한 천체물리학 분과의 발전과 세계적인 천체물리학의 흐름에 선도적인 역할을 담당할 본 학술대회의 방향성을 제시하고자 한다.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D4.03

The 25th anniversary of the astrophysics division JKPS special issue

KWAK Kyujin *[1]
[1]School of Natural Science, UNIST
kkwak@unist.ac.kr

Abstract:

지난 2020 년은 한국물리학회 천체물리분과가 설립된 지 25 주년이 되는 해였다. 이를 기념하기 위해 한국물리학회지 특별호가 기획 되었고 천체물리분과 임원진을 중심으로 한 편집위원이 구성돼 특별호 발간을 진행하였다.
2021 년 봄 출간 예정인 특별호는 천체물리분과 출범 및 초기 역사에 대한 회고를 포함 천체물리분과 내 다양한 연구 주제에 대한 총설 논문 15 편으로 구성돼 있다. 이번 발표를 통해 특별호 발간 경과와 특별호에 실린 15 편의 논문을 간략히 소개한다.

Keywords:

천체물리분과 설립 25 주년 특별호

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D4.04

Overview of the 2020 Astrophysics Division Roadmap

KIM Chunglee *1
[1]Department of Physics, Ewha Womans University
chunglee.kim@ewha.ac.kr

Abstract:

We present a summary of the 2020 Astrophysics Division Roadmap. This is prepared as a part of the 2020 Korean Physics Society roadmap.

Keywords:

astrophysics, theory, experiment

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D4.05

천체물리학에 관한 우주 프로젝트의 기획 및 실현

PARK IL Hung *[1]
[1]Physics, Sungkyunkwan University
ilpark@skku.edu

Abstract:

물리학 관련한 우주임무 프로젝트의 기획과 실현을 위한 과거의 사례를 열거하고 현재 천체물리학자들이 시도할 수 있는 여러 방법들을 논의하고자 한다. 새로운 물리현상 또는 현안 문제의 해결을 위한 참신한 아이디어을 바탕으로 이를 실현하기 위한 계획과 전략이 중요하다. 이는 우주 프로젝트가 통상 5 년 이상의 시간을 요하는 관계로 장기적 관점에서 단계적 접근을 필요로 하기 때문이다. 또한 국제공동 연구의 추세에 따라 해외 유수기관과의 협력 구축도 중요할 것이다. 본 발표에서는 현재 우리가 처해 있는 상황을 파악하고 앞으로의 방향과 방법에 대하여 과거의 미력한 경험을 공유하고자 한다.

Keywords:

천체물리학, 우주임무 프로젝트

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D5.01

Nematicity in BaFe2As2 studied with strain-dependent ARPES

PFAU Heike *[1]
[1]Physics Department, Stanford University
hpfau@lbl.gov

Abstract:

Nematicity is a phenomenon found in an increasing number of strongly correlated materials in close proximity to other quantum phases such as unconventional superconductivity. It is therefore important to understand its microscopic origin. The phase diagram of most iron-based superconductors contains a nematic phase. It breaks rotational symmetry and involves an in-plane anisotropy of lattice, spin and charge degrees of freedom. A key experimental signature is an anisotropic resistivity. However, it is unclear how changes in the band dispersion, the scattering rate and quasiparticle coherence contribute to this anisotropy. To obtain a microscopic understanding, we combine angel-resolved photoemission spectroscopy (ARPES) with in-situ tuneable uniaxial strain in order to gain access to the orbital contribution of the nematic susceptibility. I will present our results on the strain-induced band splitting and anisotropic quasiparticle coherence in BaFe2As2. I will discuss the connection to the Hund's metal characteristic of iron-based superconductors.

Keywords:

ARPES, uniaxial-strain, iron-based superconductor, nematic phase, Hund's metal

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D5.02

In situ strain tuning of the nematicity and superconductivity in iron-based superconductors

ZHANG Yan *1
[1]International Center for Quantum Materials, School of Physics, Peking University

Abstract:

Iron-based superconductors are in close proximity to a nematic state, where the spontaneous symmetry breaking of the four-fold rotational symmetry occurs. The existence of strong nematic susceptibility makes the iron-based superconductors very sensitive to uniaxial strain. In this talk, I would like to show how we utilize the angle-resolved photoemission spectroscopy and in situ strain tuning techniques to study the nematicity and superconductivity of iron-based superconductors. The strain-induced domain rotation in FeSe, the successive measurement of the momentum dependent nematic susceptibility in FeSe, and the strain-tuning of the superconducting order parameter in $Ba_{1-x}K_xFe_2As_2$ will be discussed.

Keywords:

ARPES, uniaxial strain, iron-based superconductor, nematic phase

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D5.03

Strain control of topological phases in quasi-1D stacked materials visualized by ARPES

KONDO Takeshi *1
[1]The Institute for Solid State Physics, The University of Tokyo
kondo1215@issp.u-tokyo.ac.jp

Abstract:

Since the discovery of topological insulators (TIs), controlling the fascinating properties has been attempted. The most direct way for it is to utilize the phase transition from the topological to normal insulators, which allows an on/off switching of spin current robust against the impurity scattering. The topological phase transition has been realized by elemental substitution in semi-conducting alloys, which can tune the spin-orbit coupling (SOC) and lattice constant, leading to the band inversion or eliminating it. However, such treatment requires elaborate preparation of materials with various compositions, thus it is quite far from a feasible device application, which demands a reversible operation. Another way for controlling the bulk topology is to apply pressure to the crystals, tuning only the lattice constant by strain; it is much simpler, reversible, and thus promising for future application.

The quasi-1D structure is advantageous to modify the band structure effectively by uniaxial pressure, thus compounds built from chains are ideal to realize the strain-induced topological phase transition. In our studies, we used the simplest technique of applying pressure to substances, which just mechanically bends a crystal on a substrate [1], and revealed a systematic variation of the band structure under the strain along the chain direction which is controlled *in-situ*. The samples were mounted on the sample platform of the strain device shown in Fig. 1, by which tensile strain is applied via tightening four screws. We measured the amount of strain at the sample position by commercial strain gauges, and made a diagram relating the turning angle of screws and the resulting strain, which is used for the in-situ strain control. The reliability of this diagram was evaluated by simulating the strain distribution in the device with finite element analysis; a good agreement has been confirmed between the simulation and the strain gauge measurements.

In my talk, I will reveal that $ZrTe_5$ [2] and $TaSe_3$ [3] are weak and strong topological insulators under no strain, respectively, and visualize the topological properties of these two compounds controlled by strain, using angle-resolved photoemission spectroscopy (ARPES).

[1] S. Riccò et al., Nat. Commun. **9**, 1 (2018).
[2] P. Zhang et al., Nat. Commun. **12**, 406 (2021).
[3] C. Lin et al., arXiv:2009.06353 (2020).

Keywords:

ARPES, uniaxial strain, topological phases

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D6.01

Perspective on the optical tools for studies under high magnetic fields

JHO Young Dahl *[1]
[1]School of Electrical and Computer Engineering, GIST
jho@gist.ac.kr

Abstract:

The use of various laser fields to explore light-matter interactions both in cw and n time-resolved fashion has played a major role in our understanding of quantum characteristics in materials. Nevertheless, a variety of spin-correlated optical phenomena under high magnetic fields remain for the most part unexplored in condensed matter systems because they require tuneable lasers to create spin-specific carriers and probe them in combination with high magnetic fields to freeze the motion of carriers or controllably tune their quantum states.Heretofore, the scarcity of spectroscopic capabilities under magnetic field has limited progress in this area. To enable these investigations, a perspective of experimental schmes and tools is briefly surveyed plausibly for the prospective Korean High Field Facility suggestively with the capability of probing over MIR-to-UV wavelengths range in fields up to 18 T (by using superconducting magnets) or up to 30 T (by using resistive or hybrid magnets). As a prelude to investigations of magneto-optics, here we introduce the transition of a magneto-exciton state to a magneto-plasma state in condensed matter systems in classica quantum wells and spin-state mixing in modern monolayered materials. Acknowledgements: This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT ₩& Future Planning(2013R1A2A2A03068982;2018R1A2B6008101).

Keywords:

spin, optics, magnetic field

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D6.02

Magneto-optical spectroscopy on the confined exciton in nanostructures

KYHM Kwangseuk *[1]
[1]Optomechatronics, Pusan National University
kskyhm@pusan.ac.kr

Abstract:

Excitons are a crucial ingredient of optical spectroscopy on nanostructures. When various linear and nonlinear optical spectroscopy are performed under an external magnetic field, the novel quantum nature can be revealed in terms of confinement and quantum coherence. In this work, the unique exciton features of various nanostructures were studied in a framework of center-of-mass confinement, localization, dipole-dipole interaction, and optical Aharonov-Bohm oscillations. First, the weakly confined excitons were considered in a wide (~100 nm) well structure, where the quasi 2 dimensional nature of the center-of-mass exciton confinement states was revealed. We observed a large g-factor and high nonlinearity through ultrafast Kerr-rotation. Secondly, we found the excitons are likely localized in a single droplet quantum dot through time-resolved and magneto-micro-PL spectroscopy. Finally, the fine energy levels and the quantum coherence were studied in a laterally-coupled quantum dot dimer and a quantum ring using micro-magneto spectroscopy, where we found the strongly localized excitons show a novel selection rule, but strong magnetic field can induce an extended state. The novel selection rule was verified through the single photon correlation measurement.

Keywords:

Exciton, magneto-optic, quantum dot, coupled quantum dot, quantum ring

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D6.03

Quantum transport evidence of isolated topological nodal-line fermions

KIM Jun Sung *[1]
[1]Department of Physics, POSTECH
js.kim@postech.ac.kr

Abstract:

Anomalous transport responses, dictated by the nontrivial band topology, are the key for application of topological materials to advanced electronics and spintronics. One promising platform is topological nodal-line semimetals due to their rich topology and exotic physical properties. However, their transport signatures have often been masked by the complexity in band crossings or the coexisting topologically trivial states. Here we show that, in slightly hole-doped $SrAs_3$, the single-loop nodal-line states are well-isolated from the trivial states and entirely determine the transport responses. The characteristic torus-shaped Fermi surface and the associated encircling Berry flux of nodal-line fermions are clearly manifested in quantum oscillations of the magnetotransport properties and drastically enhance the quantum interference effect, leading to the largest weak antilocalization among the topological semimetals. These extraordinary quantum transport signatures make the isolated nodal-line fermions in $SrAs_3$ desirable for novel devices based on their topological charge and spin transport.

Keywords:

topological nodal line semimetal, Quantum oscillations, Weak antilocalization

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D6.04

Zeeman splitting and pressure induced Fermi surface modification in nodal line semimetals

BHOI Dilip *[1,2], SINGHA Ratnadwip [3], SUR Yeahan [2], GOUCHI Jun [1], MIYAKE Atsushi [1], CHATURVEDI Shashank [4,5], PARIDA Prakash [6], GRAF David [7], MURATA Keizo [2], WAGHMARE Umesh V.[4], MANDAL Prabhat [3], TOKUNAGA Masashi [1], KIM Kee Hoon [2], UWATOKO Yoshiya [1]
[1]The Institute for solid state Physics, The University of Tokyo
[2]Department of Physics and Astronomy, CeNSCMR and Institute of Applied Physics, Seoul National University
[3]Saha Institute of Nuclear Physics, HBNI
[4]Chemistry and Physics of Materials Unit, School of Advanced Materials, JNCASR
[5]Theoretical Sciences Unit, JNCASR
[6]Indian Institute of Technology
[7]National High Magnetic Field Lab
dilipkumar.bhoi@gmail.com

Abstract:

Unlike Dirac- and Weyl- semimetals where the bands cross each other to form isolated nodal points in a three-dimensional Brillouin zone, nodal-line semimetals display much richer topological configurations such as nodal ring, nodal chain, nodal link, or even nodal knots [1]. In this talk, I will present our recent investigation of the effect of hydrostatic pressure on the electronic properties of nodal line semimetals, ZrSiS and $NbSb_2$, using Shubnikov-de Haas (SdH) oscillation [2]. By comparing the SdH oscillation frequencies with first-principle band structure calculations, we identify the signature of Zeeman splitting of nodal-line electron pocket in both compounds. Furthermore, the angular dependence of Zeeman splitting highlights the important role of spin orbit coupling. In addition, in both compound we found the evidence of Fermi surface modification with application of modest pressure of 2.3 GPa. With application of pressure nodal line electron pocket of ZrSiS become more two dimensional than at ambient pressure as revealed by the angular dependence of SdH oscillation. On the other hand, a new fermi pocket in $NbSb_2$ emerges above 1.07 GPa, indicating the possibility of a pressure induced Lifshitz transition.

Reference:
1) R. Bi, Z. Yan, L. Lu, Z. Wang, Nodal-knot semimetals. Phys. Rev. B **96**, 201305 (2017).
2) D. Bhoi et al., (Unpublished)

Keywords:

Nodal-line semimetals, Zeeman splitting, Fermi surface modification

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.01

First Principles studies of Strain-Induced Ferroelectricity in (Sr, Ba)$Fe_{12}O_{19}$ hexaferrite

KIM Inhwan [1], LEE Jaekwang *[1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

M-type hexagonal ferrites, (Sr, Ba)$Fe_{12}O_{19}$, have a ferrimagnetic property with 8 spins up and 4 spins down. It is also a quantum paraelectric material because the ferroelectric phase transition is suppressed due to the quantum fluctuation even at a very low temperature. Using first-principles density functional theory (DFT) calculations, we observed that (Sr, Ba)$Fe_{12}O_{19}$ can possess a spontaneous electric polarization in various biaxial compressive strain conditions even though filled 3d orbitals at the iron site. To verify the origin of the ferroelectricity in strain-induced (Sr, Ba)$Fe_{12}O_{19}$, we also simulated Pauli repulsive interaction using the Born and Mayer equation as a function of off-centered displacement at the trigonal bipyramidal iron site. In Born and Mayer equation simulation, only the compressive strain induced cases are predicted as ferroelectric which is consistent with our DFT calculations. Thus, we expect that M-type hexagonal ferrite could have ferrimagnetic and ferroelectric properties with the proper biaxial strain.

Keywords:

DFT, Ferroelectric, Ferrimagnet

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.02

High-harmonic spectroscopy in 3D topological insulators

BAYKUSHEVA Denitsa [3], CHACON Alexis [*1,2,4], LU Jian [3], BAILEY Trevor P.[5], SOBOTA Jonathan A.[6], SOIFER Hadas [6], KIRCHMANN Patrick S.[6], ROTUNDU Costel R.[6], UHER Ctirad [5], HEINZ Tony F.[3], KIM Dong Eon [1,2], REIS David A.[3], GHIMIRE Shambhu [3]

[1]MPC-AS, Max Planck Center for Attosecond Science
[2]Physics Department, POSTECH
[3]Stanford PULSE Institute, SLAC national accelerator Laboratory
[4]Center for Nonlinear Studies and Theoretical Division, Los Alamos National Laboratory
[5]Department of Physics, University of Michigan
[6]Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory
achacon@postech.ac.kr

Abstract:

Probably, the next technological revolution will lie on ultrafast electronic devices and our capability to control the transistor speeds by using quantum materials —which might still follow Moore's law. However, we believe, this is yet an extremely interesting fundamental and technological challenge. Surprising, topological states of matter, recently, promise a novel avenue to the modernization of electronic devices; since the underlying topological conducting surface states and isolating bulk states are topologically protected by the time-reversal symmetry or other —making topological insulators (TIs) robust against dissipation and perturbations, and more importantly attractive to the ultrafast optimization of our daily use of electronic devices. In spite of this promise, the control of topological states of matter remains yet in its infancy not only because of the TI material production, but also because its characterization.

Here, we investigate an alternative technique to explore topological surface states with respect to the bulk bands by means of studying the optical nonlinear responses from Bi2Se3 subjected to strong lasers. We produce high-order harmonic generation (HHG) from Bi2Se3 driven by elliptically polarized lasers. Specially, our experimental results suggest an atypical HHG enhancement while the TI is driven by a circularly polarized laser-beam in comparison to a linearly polarized laser-field.
This experimental observation is fully supported by our theoretical treatment in which we split the bulk contribution from the surface one. Our theory shows that this anomalous enhancement can be attributed to the emission from the topological surface states. We find theoretical evidences to show that the main mechanism behind that atypical/anomalous enhancement lies in the dipole vortex and the spin-orbit coupling (SOC) strength structure, mostly present at the TI surface states rather than at the bulk states. Those SOC in and out of plane at the surface are indispensable pieces in our understanding of the anomalous enhancement of the emitted radiation.

This work opens exciting new opportunities to explore how the charge and spin

currents can be controlled by strong lasers at PHz regimes and also how the optical-laser can assist topological phases and transitions in quantum materials.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.03

The hybrid on-the-fly machine learning algorithm for accelerating Monte Carlo sampling

YOON Hongkee [1], HAN Myung Joon *[1]
[1]Department of Physics, KAIST
mj.han@kaist.ac.kr

Abstract:

We present Monte Carlo (MC) acceleration via improved sampling with the generative model [1-3], which is a powerful machine learning (ML) method. MC is widely used in many problems but simultaneously has the weakness of the so-called ‘curse of dimensionality’ that its usefulness is limited as the sampling space increases. Previous studies tried to increase sampling efficiency by replacing all MC processes with bare ML [4, 5]. In this case, the black box ML model's statistical accuracy mostly depends on training, and the improvement by training is limited. Here, we propose a hybrid ML approach that performs importance sampling through ML and enforces causality by physical relationships. Additionally, our ML-based sampler performs on-the-fly learning from massive data generated by the MC procedure. As a first example, we adopted this method for an analytical continuation problem [6], a long-standing problem in quantum many-body physics. Applying ML-based sampling to the stochastic analytic continuation allows us to achieve improved sampling in this notorious problem. Furthermore, it was expanded to the Markov chain Monte Carlo (MCMC) problem, which expects a higher statistical accuracy level. As a representative example, we applied for the Ising spin model. Even without ad-hoc processing, physical relationships are well satisfied, and the autocorrelation time was reduced by efficient sampling through our on-the-fly hybrid ML part. We anticipate that this approach may generally improve MC performance and expand MC usability in various problems.

[1] I. J. Goodfellow, J. Pouget-Abadie, M. Mirza, B. Xu, D. Warde-Farley, S. Ozair, A. Courville, and Y. Bengio, *Generative Adversarial Networks*, ArXiv:1406.2661 (2014).
[2] D. P. Kingma and M. Welling, *Auto-Encoding Variational Bayes*, ArXiv:1312.6114 (2013).
[3] Arjovsky, M., Chintala, S. & Bottou, L. *Wasserstein GAN*. ArXiv:1701.07875 (2017).
[4] L. Huang and L. Wang, *Accelerated Monte Carlo simulations with restricted Boltzmann machines*, Phys. Rev. B **95**, 035105 (2017).
[5] J. Liu, H. Shen, Y. Qi, Z. Y. Meng, and L. Fu, *Self-learning Monte Carlo method and cumulative update in fermion systems*, Phys. Rev. B **95**, 241104 (2017)

[6] H. Yoon, J.-H. Sim, and M. J. Han, *Analytic Continuation via Domain Knowledge Free Machine Learning*, Phys. Rev. B **98**, 245101 (2018).

Keywords:

Machine learning (ML), Monte Carlo (MC), Generative model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.04

First principal study of the coalescence of large grains on a Cu (111) surface

LEE Hyung-June [1], KWON Young-Kyun *[1]
[1]Department of Physics, Kyung Hee University
ykkwon@khu.ac.kr

Abstract:

A Cu substrate allows the growth of large-area and high-quality graphene layers because of their small lattice mismatch with each other. It is, therefore, important to prepare a single domain and a large area of Cu (111) surface, for which one should remove grain boundaries of small domains to continue to form a bigger domain. Our experimental colleagues found a way to expand the domain size by removing grain boundaries or surface grooves through the cyclic heat treatment (CHT). To understand the fundamental mechanism of the smoothing process of grain boundaries through CHT, we combined the density functional theory with a Monte Carlo method. Firstly, we explore the hopping behavior of an extra Cu atom on a perfect Cu (111) surface by evaluating its diffusion behaviors based on the binding energies of the extra Cu atom on different adsorption sites. Its diffusion barrier was evaluated to be 76 meV. Secondly, we investigated the escaping process of an edge Cu atom attached to a grain boundary or a surface groove. It has to overcome our estimated barrier of 0.96 eV to escape on to the surface. Thirdly, we executed image-processing with optical microscopy image of Cu (111) surface to obtain the distribution of various grooves, from which we can determine the mean free path of a Cu adatom on the Cu (111) surface with large grains. Based on the values of the diffusion and escaping barriers we evaluated together with the distribution of the grooves, we performed Monte Carlo simulations using the hopping and escaping probabilities obtained from the Boltzmann distribution at a given temperature. We consequently evaluated necessary conditions of the surface density of freely-moving Cu adatoms and the linear density of dangling Cu atoms at the grain boundaries corresponding to the experimental result achieved through the CHT.

Keywords:

DFT, Cu (111) surface, Monte Carlo

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.05

First-Principles Study of Electronic Structures and Topological Properties of hexagonal networks of carbon

KIM Woochang [1], CHOI Young Woo [1], CHOI Hyoung Joon [*1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Graphdiyne is a two-dimensional allotrope of carbon whose electronic structure resembles that of graphene. The atomic structure of graphdiyne offers a lot of possibilities for engineering its electronic structure through various kinds of functionalization. In this talk, we study electronic structures and topological properties of heavy-element-decorated α-graphdiyne using first-principles density functional theory calculations. We obtain stable atomic structures with heavy-element adatoms while preserving the hexagonal crystal symmetry of the pristine graphdiyne. We analyze their electronic structures, focusing on changes due to the spin-orbit coupling, and calculate topological invariants and edge states. Our results suggest that heavy-element-decorated graphdiyne can offer an excellent platform for realizing topologically nontrivial phases in two dimensions.

This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335). Y.W.C. acknowledges support from NRF of Korea (Global Ph.D. Fellowship Program NRF-2017H1A2A1042152).

Keywords:

First-priciples calculations, Hall effect, Topological phase of matter, 2-dimensional systems, Honeycomb lattice

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.06

First-principles study of interfacial water structures on electrified gold electrodes

KIM Yong-Hoon *[1], LEE Juho [1]
[1]School of Electrical Engineering, KAIST
y.h.kim@kaist.ac.kr

Abstract:

A crucial step for the development of next-generation electrochemical devices will be the understanding of the atomic and electronic structures of interfacial waters next to biased electrode surfaces. In this presentation, carrying out first-principles non-equilibrium electronic structure and molecular dynamics calculations within the multi-space constrained-search density functional theory formalism we have recently developed [1,2], we report the study of structural and electronic properties of the interfacial water molecules on the gold electrode surface at finite bias. We show the distinct structural changes of the interfacial water molecules with OH groups pointing toward the electrode surface at negative potentials, which are in good agreement with the previous experimental reports [3,4]. To understand the bias-dependent structural change of the interfacial water, we also provide the total enthalpy change of the water molecule on the electrified electrode surface and find that the formation of interlayer hydrogen bonds at the metal–water interface plays a key role to induce the change of the interfacial water structures even at low negative potentials. Our findings shed light on the fundamental understanding of interfacial water properties on electrified metal surfaces.

References

1. J. Lee *et al.* Proc. Natl. Acad. Sci. U.S.A., **117**, 10142 (2020)
2. J. Lee *et al.* Adv. Sci., **7**, 2001038 (2020)
3. J.-J. Velasco-Velez *et al.* Science, **346**, 831 (2014)
4. C.-Y. Li *et al.* Nat. Mater., **18**, 697 (2019)

Keywords:

metal–water interface, non-equilibrium calculation, interfacial water structure, molecualr dynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D7.07

Second harmonic Hall effect in time-reversal-symmetric insulators

OKYAY Mahmut Sait [1], PARK Noejung *[1]
[1]UNIST
noejung@unist.ac.kr

Abstract:

The nonlinear Hall effect in time-reversal-symmetric conditions has attracted significant interest as a new realm of Hall physics, attributable to the intraband Berry curvature dipole on the metallic Fermi surface. Here, we show that similar Hall effects in nonlinear regime can also occur in insulators. Together with perturbation analysis of theoretical model Hamiltonian, we performed real-time time-dependent density functional theory calculations to investigate the first- and second-order optical responses of various insulators. We show that the interband Berry curvature dipole leads to a substantial second-order Hall effect, beyond the circular photo-galvanic effect, when the light frequency exceeds one-half the bandgap. We suggest this nonlinear Hall effect in insulators can be thought of as a new tracer, indicative of Berry curvature distributions of time-reversal symmetric systems.

Keywords:

nonlinear Hall effect, second harmonic generation, Berry curvature dipole

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.01

Electric Quantum Oscillation in Weyl Semimetals

HWANG Kyusung *[1], LEE Woo-Ram [1,2], PARK Kwon [1]
[1]School of Physics, Korea Institute for Advanced Study
[2]Physics Department, Virginia Tech
kyusung0211@gmail.com

Abstract:

Electronic transport in Weyl semimetals is quite extraordinary due to the topological property of the chiral anomaly generating the charge pumping between two distant Weyl nodes with opposite chiralities under parallel electric and magnetic fields. Here, we develop a full nonequilibrium quantum transport theory of the chiral anomaly, based on the fact that the chiral charge pumping is essentially nothing but the Bloch oscillation. Specifically, by using the Keldysh nonequilibrium Green function method, it is shown that there is a rich structure in the chiral anomaly transport, including the negative magnetoresistance, the non-Ohmic behavior, the Esaki-Tsu peak, and finally the resonant oscillation of the DC electric current as a function of electric field, called the electric quantum oscillation. We argue that, going beyond the usual behavior of linear response, the non-Ohmic behavior observed in BiSb alloys can be regarded as a precursor to the occurrence of electric quantum oscillation, which is both topologically and energetically protected in Weyl semimetals.

Keywords:

Weyl semimetal, Chiral anomaly, Electric quantum oscillation, Strong field phenomena, Nonequilibrium quantum transport theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.02

Symmetry correspondence in Su-Schrieffer-Heeger and Jackiw-Rebbi models

OH Chang-geun [1], HAN Sang-Hoon [2], CHEON Sang Mo *[2,1]
[1]Research Institute for Natural Sciences, Hanyang University
[2]Department of Physics, Hanyang University
sangmocheon@gmail.com

Abstract:

The bulk-edge correspondence and symmetry play pivotal roles in understanding topological materials and lead to the general principle that an enhancement of symmetry results in richer physics [1, 2]. The Jackiw-Rebbi (JR) and Su-Schrieffer-Heeger (SSH) models are the simplest 1D models presenting such topological physics [3, 4]. However, the conditions for the emergence of chiral edge states in 1D are not yet discovered. In this work [5], we present the universal conditions for the emergence of chiral and non-chiral edge states in the generalized Jackiw-Rebbi model having tunable physical parameters. We show that the cooperation between T, C, and P symmetries and field rotation symmetry characterizes physical properties of such edge states. Remarkably, chiral edge states can emerge with enhanced rotation symmetry. Moreover, T, C, and P analysis disclose that a pair of chiral edge states form a particle-antiparticle pair while a non-chiral edge state is its own antiparticle. Furthermore, we find symmetry correspondence between global minima and edge states such that T, C, and P symmetries of an edge state inherit from global minima that are connected by the edge state, which provides a novel tool of symmetry analysis for edge states. Our work can be applied to 1D, 2D, and 3D electronic systems having multiply degenerate ground states and boundary states among them.

[1] M. Z. Hasan and C. L. Kane, Rev. Mod. Phys.82, 3045 (2010).
[2] X.-L. Qi and S.-C. Zhang, Rev. Mod. Phys.83, 1057 (2011).
[3] R. Jackiw and C. Rebbi, Phys. Rev. D13, 3398 (1976).
[4] W. P. Su, J. R. Schrieffer, and A. J. Heeger, Phys. Rev. Lett.42,1698 (1979)
[5] C.-g. Oh, S.-H. Han, and S. Cheon, submitted (2021)

Keywords:

Edge states, Chirality, Su-Schrieffer-Heeger model, Jackiw-Rebbi model, Bulk-boundary correspondence

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.03

Time-resolved photoemission study for extreme ultrafast dynamics of topology in Floquet-Bloch Dirac cone

KIM Youngjae [1], LEE JaeDong [*1]
[1]Department of Emerging Materials Science, DGIST
jdlee@dgist.ac.kr

Abstract:

Extreme ultrafast dynamics on the Floquet-Bloch Dirac cone are explored, which accentuates nonequilibrium dynamical nature of the Floquet state beyond the usually considered quasi-static band nature and then gives a missing connection between the two. Phase oscillation of the Fano resonance at the frequency of 2ωpump ω_{pump} on the Floquet-Bloch Dirac cone of graphene is disclosed from the transient absorption spectroscopy (TAS), which is due to the correlation between 2ωpump ω_{pump} -absorption paths. This implies an inevitable link between dynamical and quasi-static nature of the Floquet state and establishes a driving of the petahertz (PHz) quantum oscillation from Dirac materials. On another Floquet-Bloch Dirac cone of the graphene/h-BN (Gr/h-BN) heterostructure, where the inversion symmetry is broken, under the circularly polarized pulse pumping, the fluctuating topological order (FTO) is discovered to prevail between topologically trivial and nontrivial phases from the time-resolved dichroic photoemission spectroscopy (TRdPES). The fluctuating order defines a novel transient topological phase produced by the pulse induced ultrafast dynamical nature of the Floquet state, not predicted by the continuous wave based quasi-static nature.

Keywords:

Time-resolved photoemission, Floquet-Bloch phase, Topological phase transition, Ultrafast dynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.04

Electron-hole asymmetry and band gaps of commensurate double moire patterns in twisted bilayergraphene on hexagonal boron nitride

SHIN Jiseon [1], PARK Youngju [1], CHITTARI Bheema Lingam[2], SUN Jin-Hua [3], JUNG Jeil *[1,4]
[1]Department of Physics, University of Seoul
[2]Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata
[3]Research Institute of Advanced Technologies, Ningbo University
[4]Department of Smart Cities, University of Seoul
jeiljung@uos.ac.kr

Abstract:

Spontaneous orbital magnetism observed in twisted bilayer graphene (tBG) on nearly aligned hexagonal boron nitride (BN) substrate builds on top of the electronic structure resulting from combined G/G and G/BN double moiré interfaces. Here we show that tBG/BN commensurate double moiré patterns can be classified into two types, each favoring the narrowing of either the conduction or valence bands on average, and obtain the evolution of the bands as a function of the interlayer sliding vectors and electric fields. Finite valley Chern numbers ±1 are found in a wide range of parameter space when the moiré bands are isolated through gaps. We illustrate the impact of the BN substrate for a particularly pronounced electron-hole asymmetric band structure by calculating the optical conductivities of twisted bilayer graphene near the magic angle as a function of carrier density. The band structures corresponding to other N-multiple commensurate moire period ratios indicate it is possible to achieve narrow width $W \leq$ 10meV isolated folded band bundles for tBG angles $\theta \leq 1°$.

This work was supported by the Korean National ResearchFoundation (NRF) through Grant NRF-2020R1A2C3009142 for J.S., grant NRF-2020R1A5A1016518 for Y.P., the Basic Science Research Program of the NRF-2018R1A6A1A06024977 for B.L.C., by the Zhejiang Provincial Natural Science Foundation of China (GrantNo. LY19A040003) for J.-H.S., and by the Basic study and Urban convergence R&D research fund of the University of Seoul (2019) for J.J. We acknowledge computational supportfrom KISTI through Grant KSC-2020-CRE-0072.

Keywords:

double moire patterns, twisted bilayer graphene aligned with hexagonal boron nitride, tBG/BN, orbital magnetism, Quantum anomalous Hall effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.05

Topological Flat Bands and Optical Conductivity in Trilayer Graphene Boron Nitride Moire Superlattices

JUNG Jeil *[1,2], APPALAKONDAIAH Samudrla [1], JISEON Shin [1], YOUNGJU Park [1], CHITTARI Bheema Lingam [1,3]
[1]Department of Physics, University of Seoul
[2]Department of Smart Cities, University of Seoul
[3]Department of Physical Sciences, Indian Institute of Science Education and Research-Kolkata
jeiljung@uos.ac.kr

Abstract:

We present the electronic structure of ABC stacked trilayer graphene (TG) aligned with hexagonal boron nitride (BN) using a full bands continuum Hamiltonian that refines the accuracy of earlier approximations based on low energy models. The topological flat bands obtained in TG/BN within our model shows an inherent band gap at charge neutrality not reported previously and it is possible to trigger in some cases gate tunable topological changes in the bands without changing the direction of the applied electric field. The obtained bandwidth phase diagrams show narrowest bandwidths of ~6 meV with an electric field strength of ~50 meV for twist angles of up to ~0.5°. We report optical conductivity calculations as a function of electric field and carrier density doping in TG/BN and resolve the relative strength of the transitions in momentum space.

This work was supported by the Korean National Research Foundation (grant NRF-2020R1A2C3009142) and by KISTI computational resources (grant KSC-2020-CRE-0072) for A. S and J.S., grant NRF-2020R1A5A1016518 for Y.P., the Basic Science Research Program of the NRF-2018R1A6A1A06024977 for B.L.C., and by the Basic study and Urban Convergence R&D research fund of the University of Seoul (2019) for J.J.

Keywords:

Moire superlattices, Trilayer Graphene/h-BN, Topological Properties, Optical Conductivity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.06

Macroscopically degenerate localized zero-energy states of quasicrystalline bilayer systems in strong coupling limit

HA Hyunsoo [1], YANG Bohm Jung [*1]
[1]Department of Physics and Astronomy, Seoul National University
bjyang@snu.ac.kr

Abstract:

When two identical two-dimensional (2D) periodic lattices are stacked in parallel after rotating one layer by a certain angle relative to the other layer, the resulting bilayer system can lose lattice periodicity completely and become a 2D quasicrystal. Twisted bilayer graphene with 30º rotation is a representative example. We show that such quasicrystalline bilayer systems generally develop macroscopically degenerate localized zero-energy states (ZESs) in a strong coupling limit where the interlayer couplings are overwhelmingly larger than the intralayer couplings. The emergent chiral symmetry in strong coupling limit and aperiodicity of bilayer quasicrystals guarantee the existence of the ZESs. The macroscopically degenerate ZESs are analogous to the flat bands of periodic systems, in that both are composed of localized eigenstates, which give a divergent density of states. For monolayers, we consider the triangular, square, and honeycomb lattices, comprised of homogenous tiling of three possible planar regular polygons: the equilateral triangle, square, and regular hexagon. We construct a compact theoretical framework, which we call the quasiband model, that describes the low energy properties of bilayer quasicrystals and counts the number of ZESs using a subset of Bloch states of monolayers. We also propose a simple geometric scheme in real space which can show the spatial localization of ZESs and count their number. Our work clearly demonstrates that bilayer quasicrystals in a strong coupling limit are an ideal playground to study the intriguing interplay of flat band physics and the aperiodicity of quasicrystals.

Keywords:

quasicrystal, flat band, twisted bilayer graphene

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D8.07

Electronic Structures of twisted bilayer of gapped two-dimensional semi-Dirac materials

NAM Taesik [1], KIM Han-gyu [1], CHOI Hyoung Joon [*1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Gapped two-dimensional (2D) semi-Dirac materials, such as few-layer black phosphorus, have pseudospin features even in their semiconducting phase. When the band gap is closed, they have a semi-Dirac point, and when the band gap is inverted, they have anisotropic Dirac cones. Twisted bilayers of gapped 2D semi-Dirac materials may have interesting emergent phenomena due to directional mismatch of in-plane anisotropy of each layer. In our present work, we consider 90-degree twisted bilayer of gapped 2D semi-Dirac materials. Constructing a general 2D model Hamiltonian, we find interesting variation of electronic structures as a function of interlayer interaction and the band gap of each layer. We also construct relevant pseudospin representation, and consider effects of externally applied electric field on the electronic structure. Finally, as a particular example, we perform density functional theory calculations of 90-degree twisted bilayer of few-layer black phosphorus, confirming important results of the general 2D model Hamiltonian. This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335).

Keywords:

2D semi-Dirac materials, DFT calculations, interlayer interaction

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D9.01

Interface between the spin qubit of diamond color center and acoustic phonons using microelectromechanical systems

SOHN Youngik *[1]
[1]School of Electrical Engineering, KAIST
youngik.sohn@kaist.ac.kr

Abstract:

One of the interesting features of diamond color centers is its quantum interface between internal spin and emitted photon. In addition to such a photon – spin interface for remote entanglement, another quantum interface between color center's spin and other local qubits would be beneficial.

One way to build a such interface is to use a phonon, which is a quantized object of mechanical vibration. Due to its nature, phonon has been able to couple to a variety of quantum systems, including superconducting qubits, ultracold atoms and photons.

In this work, we present the interface between electronic spin of a diamond color center and acoustic phonons. Both nitrogen-vacancy (NV) and silicon-vacancy (SiV) color centers are studied using microelectromechanical systems (MEMS). The key figures of merit of the two color centers, strain susceptibilities, are compared and their important qualitative difference is elaborated.

As a concluding remark, outlook for the future application of SiV – surface acoustic phonon interface will be discussed.

Keywords:

quantum transducer, nitrogen-vacancy center, silicon-vacancy center, MEMS, single-crystal diamond

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D9.02

Nanomechanical cat-states generated by dc voltage-driven Cooper pair box qubit

RADIC D. [1], CHOI Sang-Jun [*2,3], PARK H. C. [2], SHEKHTER R. I. [4], GORELIK L. Y. [5]
[1]Department of Physics, Faculty of Science, University of Zagreb
[2]Center for Theoretical Physics of Complex Systems, Institute for Basic Science (IBS)
[3]Institute for Theoretical Physics and Astrophysics, University of Wuerzburg
[4]Department of Physics, University of Gothenburg
[5]Chalmers University of Technology
aiehtle2@gmail.com

Abstract:

Coherent interplay of the superconducting qubits and mechanical vibrations in nanoelectromechanical (NEM) devices has been the modern frontline research of quantum communication and information [1-5]. Such NEM device provides possibility to store quantum information in so-called (Shroedinger) cat-states, i.e., quantum superposition of coherent states of the nanomechanical vibrations. Such states, rather resilient to external perturbation, allow to encode quantum information in such a way that mechanical losses can be detected and corrected, as opposite to single phonon states where such losses irreversibly delete the quantum information.

In this talk, we will focus on possibility to generate quantum entanglement of charge-qubit with the nanomechanical resonator. We consider the NEM device consisting of Cooper pair box qubit performing nanomechanical vibrations between two bulk superconductors. We demonstrate that an electrical voltage bias across the superconductors indeed generates the entangled states of the Cooper pair qubit and quantum cat-states. Tracking the formation and development of such states with the corresponding Wigner function and entropy of entanglement, we propose the experimentally feasible detection of the effect by measuring the average current which attains specific features due to the entanglement.

[1] S. M. Girvin, *Phys. Rev. Lett.* **123**, 250501 (2019).
[2] A. Bienfait, K. J. Satzinger, Y. P. Zhong, H.-S. Chang, M.-H. Chou, C. R. Conner, E. Dumur, J. Grebel, G. A. Peairs, R. G. Povey, and A. N. Cleland, *Science* **364**, Issue 6438, 368 (2019).
[3] Y. Chu, P. Kharel, T. Yoon, L. Frunzio, P. T. Rakich, and R. J. Schoelkopf, *Nature* **563**, 666 (2018).
[4] P. Arrangoiz-Arriola, E. A.Wollack, Z.Wang, M. Pechal, W. Jiang, T. P. McKenna, J. D. Witmer, R. Van Laer, and A. H. Safavi-Naeini, *Nature* **571**, 537 (2019)
[5] K. J. Satzinger, Y. P. Zhong, H.-S. Chang, G. A. Peairs, A. Bienfait, M.-H. Chou, A. Y. Cleland, C. R. Conner, E. Dumur, J. Grebel, I. Gutierrez, B. H. November, R. G. Povey, S. J. Whiteley, D. D. Awschalom, D. I. Schuster, and A. N. Cleland, *Nature* **563**, 661 (2019).

Keywords:

NEM, Josephson junction, cat states, entanglement

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D9.03

Approaches toward nanomechanical quantum transducers

KIM Jihwan [1], CHA Jinwoong [1], SHIM Seung-Bo [1], SUH Junho *[1]
[1]Quantum Technology Institute, KRISS
junho.suh@kriss.re.kr

Abstract:

Mechanical transducers have been employed in a diverse range of electro-mechanical and opto-mechanical applications. As these mechanical devices scale down and low-noise precision mechanical measurements became available, mechanical tranducers reached the quantum regime realizing operations near ground states and coherent coupling to photons and qubits. In this talk, I will discuss our recent progress toward nanomechanical quantum transducers involving superconducting niobium membranes and semiconductor nanowires.

Keywords:

nanomechanical resonator, quantum harmonic oscillator, quantum transducer, quantum electro-mechanical system, nanomechanical sensor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D10.01

Topological transport of deconfined hedgehogs in magnets

TSERKOVNYAK Yaroslav *1
[1]Department of Physics and Astronomy, UCLA

Abstract:

We theoretically investigate the dynamics of magnetic hedgehogs, which are three-dimensional topological spin textures that exist in common magnets, focusing on their transport properties and connections to spintronics. We show that fictitious magnetic monopoles carried by hedgehog textures obey a topological conservation law, based on which a hydrodynamic theory is developed. We propose a nonlocal transport measurement in the disordered phase, where the conservation of the hedgehog flow results in a nonlocal signal decaying inversely proportional to the distance. The bulk-edge correspondence between the hedgehog number and skyrmion number, the fictitious electric charges arising from magnetic dynamics, and the analogy between bound states of hedgehogs in ordered phase and the quark confinement in quantum chromodynamics are also discussed. Our study points to a practical potential in utilizing hedgehog flows for long-range neutral signal propagation or manipulation of skyrmion textures in three-dimensional magnetic materials[1].

[1] J. Zou et al., Phys. Rev. Lett. 125, 267201(2020)

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D10.02

Hidden skyrmion diffusion and device for the Brownian computing

MIKI Soma *[1], SUZUKI Yoshishige *[1,2], TAMURA Eiiti [1], GOTO Minori [1,2], ISHIKAWA Ryo [3], NOZAKI Takayuki [4], TANAKA Yuji [1], ABE Shota [1], NOMURA Hikaru [1,2]
[1]Graduate School of Engineering Science, Osaka University
[2]Center for Spintronics Research Network (CSRN), Osaka University
[3]ULVAC-Osaka University Joint Research Laboratory for Future Technology, Osaka University
[4]Research Center for Emerging Computing Technologies, National Institute of Advanced Industrial Science and Technology(AIST)
,

Abstract:

The magnetic skyrmion system in a magnetic film can be an ideal platform to design stochastic computers [1] and Brownian computers [2], since it may show Brownian motion in all-solid-state devices. The skyrmion is a chiral object and may pose a velocity perpendicular to the direction of the force. Therefore, naïvely thinking, we may suppose that the diffusion constant is no more a scalar but a tensor [3]. However, a flow made by the off-diagonal elements is divergence-less and does not appear in the equation of diffusion. According to this context, we mention the off-diagonal-diffusion constants as “the hidden diffusion constant”.
In this talk, we show evidence of gyro-motion in diffusion and discuss the gyro-diffusion constant, referring to recent observations [4]. Then, we mention recent progress to implement the “Brownian computer” using Skyrmions [5].

Acknowledgments
We thank to Mr. Y. Jibiki of Osaka Univ., Dr. S. Auffret, Dr. C. Baraduc, and Dr. Hélène Béa of Spintec, Dr. M. Oogane of Tohoku Univ.. This research was supported by the ULVAC, Inc., the Ministry of Internal Affairs and Communications, Basic research S (20H05666) of JSPS, and CREST (Non-classical Spin project) of JST.

References

[1] J. Zazvorka et al., Nat. Nanotech. 14, 658 (2019).
[2] F. Peper et al., ACM J. Emerg. Technol. Comput. Syst, 9, 1, Article 3 (2013).
[3] E. Tamura et al. https://arxiv.org/abs/2005.04860.
[4] L. Zhao et al., Phys. Rev. Lett. 125, 027206 (2020).
[5] Y. Jibiki et al., Appl. Phys. Lett. 117, 082402 (2020).

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D10.03

Stabilization, Creation, Deletion and Shifting of Magnetic skyrmion toward Spintronics application

YANG Seungmo *1, MOON Kyoung-Woong 1, JU Tae-Seong 1, KIM Changsoo 1, KIM Hyun-Joong 1, KIM Juran 1, HWANG Chanyong 1

1Quantum Spin Team, Korea Research Institute of Standards and Science

Abstract:

Topological swirling spin textures, magnetic skyrmions, have been intensively studied in spintronics as a prospective information carrier due to distinct topological features [1, 2]. Therefore, stabilization of magnetic skyrmions is the key technology for realizing skyrmion-based spintronic devices. However, to date, skyrmions have only been stabilized in extremely narrow ranges of material parameters. For example, more than 10 repeated numbers of multilayers are required to induce a large dipole field [3], or the thickness control within 0.1 nm is essential for achieving a particular magnetic anisotropy [4, 5]. The other key issue is to intentionally create a magnetic skyrmion. Therefore, experimental demonstrations of skyrmion creation have been achieved using diverse methods, including a pulsed local magnetic field [6] or by a spin-orbit torque (SOT)-based perturbation [7]. However, most of them utilized a randomly created defect site as a source of skyrmion creation, which disturbs the skyrmion motion after the creation. The above mentioned limitations in skyrmion creation are the key challenges in skyrmion research. Here, we present a fine tuning of material parameters for stabilizing magnetic skyrmions and also provide a defect-free skyrmion creation in general PMA films using external magnetic field. In addition, based on the mechanism, we introduce a novel method for creating, deleting and shifting isolated skyrmions by means of electrical signals by utilizing a current injection. As a result, we have obtained not only mass production of skyrmion but also methods of creating and deleting individual skyrmions.

[1] Nagaosa, N. *et al.*, *Nat. Nanotechnol.* 8, 899-911 (2013).
[2] Christian, H. B. *et al.*, *J. Phys. D Appl. phys.* (2020).
[3] Moreau-Luchaire, C. *et al.*, *Nat. Nanotechnol.* 11, 444-448 (2016).
[4] Zázvorka, J. *et al.*, *Nat. Nanotechnol.* 14, 658-661 (2019).
[5] Jiang, W.; Zhang, X. *et al.*, *Nat. Phys.* 13, 162-169 (2017).
[6] Woo, S. *et al.*, *Nat. Mater.* 15, 501-506 (2016).
[7] Büttner, F. *et al.*, *Nat. Nanotechnol.* 12, 1040-1044 (2017).

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D10.04

Propagating spin wave dynamics in synthetic antiferromagnets

SHIOTA Yoichi *1
1Institute for Chemical Research, Kyoto University

Abstract:

Spin waves and their quasiparticles, i.e., magnons, are promising for high-frequency information processing with low power consumption due to the absence of charge flow and very low energy dissipation [1-3]. Because synthetic antiferromagnets (SAFs), which are magnetic multilayers with antiferromagnetically coupled ferromagnets through a nonmagnetic spacer, realize gigahertz resonance frequency due to relatively weak interlayer exchange coupling, they provide an excellent platform for studying antiferromagnetic dynamics in magnonics.
In this study, we investigated the propagating spin wave properties in SAFs consisting of $Fe_{60}Co_{20}B_{20}$/Ru/$Fe_{60}Co_{20}B_{20}$. By applying the magnetic field parallel to the spin wave propagation direction, switchable and highly nonreciprocal frequency shift of spin waves have been demonstrated [4]. We further show that the tunable magnon-magnon coupling between in-phase and out-of-phase branches of resonance mode can be realized by breaking the symmetry with respect to the exchange of magnetizations [5]. These phenomena mainly originate from the dynamic dipolar interaction generated by the magnetization motion of spin waves. Our findings open a new way for highly nonreciprocal and tunable magnonic devices. In the presentation, we also introduce the imaging of the intensity and phase of the propagating spin waves using the optical heterodyne detection, which enable to reconstruct 1D and 2D spin wave dispersion relations [6,7].

Reference
[1] V.V. Kruglyak *et al., J. Phys. D. Appl. Phys.* **43**, 264001 (2010)
[2] A. Khitun *et al., J. Phys. D. Appl. Phys.* **43**, 264005 (2010)
[3] A.V. Chumak *et al., Nat. Phys.* **11**, 453-461 (2015)
[4] M. Ishibashi *et al., Sci. Adv.* **6**, eaaz6931 (2020)
[5] Y. Shiota *et al., Phys. Rev. Lett.* **125**, 017203 (2020)
[6] Y. Shiota *et al., Appl. Phys. Lett.* **116**, 192411 (2020)
[7] Y. Shiota *et al., Phys. Rev. B* **102**, 214440 (2020)

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.01

Organic MVL Technology: From Fundamentals to Applications

KIM Chang-Hyun *1
[1]Department of Electronic Engineering, Gachon University
chang-hyun.kim@gachon.ac.kr

Abstract:

The latest digital revolution was made possible by the binary logic family, which simplifies complex computing and memory functions into only two possible levels of information (“0” and “1”). However, the multi-valued logic (MVL) systems have recently gained a lot of attention, thanks to their higher information density. Previously proposed MVLs were mostly based on the nanoscale tunneling and/or externally connected transistors, lacking a scalability and fabrication simplicity. Recently, an organic p-n heterojunction ternary inverter has been developed, demonstrating the potential for low-power, light-weight, and flexible MVL circuits. In this paper, we present a combined experimental and theoretical investigation into the optimization of the organic field effect transistor-based complementary MVL. The two-dimensional finite-element method (FEM) simulation systematically guided the precise tuning of the materials, interfaces, and geometrical parameters toward well-balanced voltage levels and ideal resistive distributions. As one of the key findings, we proposed a method to efficiently tailor the half-level (“1/2”) voltage, by re-positioning one electrode on the same device footprint. In addition to this, it was found that the minority carrier diffusion, junction lengths, and metal contact barriers are all critical to the performance improvement. Therefore, our results provide a new engineering strategy for future trit-coded data processing and communications, which may find applications in flexible high-resolution display drivers where the same grayscale scheme can be implemented by a smaller number of integrated components

Keywords:

Organic semiconductors, Flexible electronics, Multi-valued logic system

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.02

Electronic tattoo systems based on silk protein and carbon nanotube for diagnosis and man-machine interfaces

GOGURLA Narendar [1,2], KIM Sunghwan *[1,2]
[1]Physics, Ajou University
[2]Energy Systems Research, Ajou University
sunghwankim@ajou.ac.kr

Abstract:

Epidermal electronics or smart electronic tattoo systems that interface the human skin and act as primary interacting devices for human-machine interfaces will constitute important tools in the future of healthcare [1,2]. Such devices require highly deformable and biocompatible materials, imperceptible wearability with long-term comfortableness, and low-cost in-device fabrication. However, the existing epidermal devices, usually comprising complex multilayer structures, have not fully addressed the aforementioned challenging issues. Here, we present the utilization of a natural silk protein with carbon nanotubes (CNTs) to realize an epidermal electronic tattoo (E-tattoo) system for multifunctional applications that address these challenging issues through dispersing highly conductive CNTs onto the biocompatible silk nanofibrous networks to construct skin-adhesive ultrathin electronic patches. The E-tattoo can be imperceptibly tattooed on the skin and removed with water. Because of the micro-to-nano hierarchical pores (with a high surface-to-volume ratio), the E-tattoo can be used as a triboelectric device *via* contact-induced electrification that generates a power density of ~6 mW/m^2 and pressure sensitivity of ~0.069 kPa^{-1}. Individual components that incorporate electrically and optically active heaters, a temperature sensor, a stimulator for drug delivery, and real-time electrophysiological signal detectors are also studied using E-tattoo. This strategy of E-tattoos interfaced onto human skin can open a new path to a next-generation electronic platform for wearable and epidermal applications.

References

1. Xu *et al*. *Science* 2017, 355, 59.
2. Kim, *et al*. *Science* 2011, 333, 838.

Keywords:

Electronic skin, Silk protein, Sensor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.03

Crystallinity-dependent device characteristics of polycrystalline Ruddlesden-Popper perovskite photodetectors

KIM Junwoo [1], LEE Woocheol [1], AHN Heebeom [1], LEE Jonghoon [1], BAEK Kyeong-Yoon [1], KIM Jae-Keun [1], KANG Keehoon [1], LEE Takhee [*1]
[1]Department of Physics and Astronomy, Seoul National University
tlee@snu.ac.kr

Abstract:

Ruddlesden-Popper (RP) perovskites have attracted a lot of attention as the active layer for various optoelectronic devices due to their excellent photophysical properties and environmental stability. Specifically, local structural properties of RP perovskites have shown to act important roles in determining the performance of optoelectronic devices [1]. In this presentation, we report the photodetector performance variation depending on the crystallinity of n=4 two-dimensional (2D) RP perovskite polycrystalline films. By controlling the solvent evaporation rate, phases of 2D RP perovskite films could be tuned between highly- and randomly-orientated phases [2]. We investigated how different factors related to the film crystallinity are reflected in the variation of photodetector performances by considering grain boundary and low energy edge state effects in n=4 RP perovskites [3]. Better understanding the interplay between these factors that govern the photophysical properties of the devices would be beneficial for designing high-performance RP perovskite-based optoelectronic devices.

References:
[1] Chen Y, Sun Y, Peng J, Tang J, Zheng K and Liang Z, *Adv. Mater.* **30**, 1703487 (2018).
[2] Chen A Z, Shiu M, Deng X, Mahmoud M, Zhang D, Foley B J, Lee S-H, Giri G and Choi J J, *Chem. Mater.* **31**, 1336 (2019).
[3] J. Kim et al., *Nanotechnology*, **32**, 185203 (2021)

Keywords:

perovskite, crystallinity, grain boundary, edge state, photodetector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.04

Photo-excited conduction of halide perovskite crystals and its applications to photodetectors

JUNG Hye Ri [1], CHO Yunae [2], JO William *[1,2]
[1]Department of Physics, Ewha Womans University
[2]New and Renewable Energy Research Center, Ewha Womans University
wmjo@ewha.ac.kr

Abstract:

Photo-excited conduction due to the photogenerated charge separation is a key to develop the photonic devices. A great attention is growing up to use halide perovskite $CH_3NH_3PbX_3$ (X= I, Br, and Cl) single crystals for highly effective photodetectors and related functional applications beyond solar cells. Surface photovoltage mapping visualizes quasi-Fermi level shift for ethe specific spectral range at the localized area, which is a clue to figure out majority carriers, charge separation and band bending in the material near the surface. It is possible to trace energy states of the defects which can determine excitement in the perovskites. We also examine the conduction with and without the external light sources. The photocurrent reveals defect densities and carrier concentration through a model of space-charge-limited conduction. Pulsed light illumination into the crystals induces a photocurrent which shows very strong wavelength dependence and temporal variation

Keywords:

Hybrid perovskite, Single crystal, Surface photovoltage, Photodetector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.05

Current Noise Properties of organo-metal halide perovskite unipolar resistive memory devices

AHN Heebeom [1], KANG Keehoon [1,2], LEE Jae Sung [3], LEE Woocheol [1], KIM Jae-Keun [1], KIM Junwoo [1], LEE Jonghoon [1], BAEK Kyeong-Yoon [1], LEE Takhee [*1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Materials Science and Engineering, Yonsei University
[3]School of Physics, KIAS
tlee@snu.ac.kr

Abstract:

Resistive switching memory has emerged as a candidate for next-generation memory devices due to its excellent characteristics such as high scalability, non-volatility, and fast operation speed. Organo-metal halide perovskite, which is solution-processable and has outstanding optical and electrical properties, is also applied to a resistive memory device. The material has the advantage of being able to be operated with a low voltage and large ON/OFF ratio. However, random distributions in operation voltage remain a challenge as in other material-based resistive memory. This stochastic operation characteristic is due to the random formation of conducting filaments that cause resistance changes in the material. Therefore, studies on the structure of the conducting filament are important, but observing a nano-scale structure is difficult. Moreover, there is insufficient research on how the conducting filament is formed in the organo-metal halide perovskite. In this presentation, the geometric shape of the conducting filament formed in the perovskite was explored through a low-frequency current noise analysis. And by observing electrical properties and current noise under different temperature conditions, we investigated how the temperature condition affects the formation of the conductive filament. Through this, an advanced understanding of the operating mechanism of the perovskite resistive memory device was possible.

Reference
[1] K. Kang, H. Ahn et al., *Adv. Mater*. 31, 1804841 (2019).
[2] H. Ahn et al., Manuscript in preparation.

Keywords:

organo-metal halide perovskite, resistive memory, 1/f noise, random telegraph noise

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.06

Molecular photodiode with two-dimensional semiconductor

SHIN Jaeho [1], YANG Seunghoon [1], EO Jung Sun [1], JEON Takkyeong [1], LEE Chul-Ho [1], WANG Gunuk [*1]

[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
gunukwang@korea.ac.kr

Abstract:

Until now, a specifically designed functional molecular species has been recognized as an absolute necessity for realizing the functional behavior in molecular electronic photodiodes.[1-4] Here, we demonstrate a new type of molecular-scale photodiode implemented by molecular heterostructure[5] composed of standard molecules and 2D semiconductor. Two non-functionalized molecular species that have opposite direction in their dipole moment (i.e., 1-octanethiol (denoted as C8) and tridecafluoro-1-octanethiol (F6H2)) were used herein. As a 2D semiconductor, a four-layered (4_L)-WSe_2 was used to form a heterojunction with the SAMs. Depending on the direction of molecular dipole moments, the interfacial band alignment at 4_L-WSe_2/molecules interfaces are differently shifted, resulting in change of the photocurrent direction and rectifying direction. Especially, in the case of the F6H2/4_L-WSe_2 junction, the current response at zero bias under the light illumination (λ = 532 nm, 9 μW) is higher than 4 orders of magnitude as compared with under the dark condition. In addition, the constant value of photocurrent over a chopper frequency of 5-900 Hz was observed, achieving the photo-response time of ~ 100 μs that is faster as compared to other molecular photodiodes. This study suggests a new concept of molecular-scale photodiode where can engineer the photo-current direction depending on the molecular dipole moments.

Keywords:

Molecular electronics, Molecule-2D heterojunction, Molecular photodiode, Photoresponse

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.07

Tailored Design-of-Experiments Approach for Device Performance Prediction and Optimization of Flash-Evaporated Organic-Metal-Halide Perovskite-Based Photodetectors

LEE Jonghoon [1], LEE Woocheol [1], LEE Jeongjae [2], BAEK Kyeong-Yoon [1], SHIN Jiwon [1], KIM Jae-Keun [1], KIM Junwoo [1], AHN Heebeom [1], KANG Keehoon [1], LEE Takhee [*1]
[1]Department of Physics and Astronomy, Seoul National University
[2]School of Earth and Environmental Sciences, Seoul National University
tlee@snu.ac.kr

Abstract:

Organic-inorganic halide perovskites (OHPs) have recently received enormous attention due to their excellent optoelectronic properties for solar cell and light-emitting diode applications. Solution-based deposition techniques of OHPs are widely used in lab-scale device fabrication but it is necessary to develop vacuum-based deposition for large-scale production. One of the widely used vacuum-based deposition techniques is dual-source vapor-deposition of perovskite materials, i.e., co-depositing two (or more) precursors that compose OHPs under vacuum conditions, but it is difficult to optimize various deposition conditions. On the other hand, single-source thermal evaporation has the advantage of fewer input variables and ease of fabrication but there are remaining challenges for coordinating completely different physical and optoelectronic properties depending on the evaporation conditions. In this study, we systematically investigated the relation between three input variables; (1) excess methylammonium iodide (MAI) to $MAPbI_3$ molar ratio in the source materials, (2) heating current and (3) total mass of the source materials ($MAPbI_3$), and the resulting film properties by using design-of-experiment method [1]. The Box-Behnken design method is an efficient statistical analysis tool that was applied to induce the relationship between the input variables and the film properties, expressed in multiple linear regression equations, and to extract the interaction between each variable. Additionally, the relationship between the physical and optoelectronic properties of the deposited films was investigated, which provided guidelines for optimizing the overall film quality through exploring the variable space of the flash-evaporation technique.

[1] J. Lee et al., Adv. Mater. Technol. in press (2021).

Keywords:

flash-evaporation, organic perovskite, Design-of-experiment, photodetector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.08

One-dimensional multi-synapses based on the organic ferroelectric transistor for wearable neuromorphic applications

WANG Gunuk *[1], HAM Seonggil [1], KANG Minji [2], JANG Seonghoon [1], JANG Jingon [1], CHOI Shanghyeon [1], KIM Tae-Wook [2]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]Department of Flexible and Printable Electronics, Jeonbuk National University
gunukwang@korea.ac.kr

Abstract:

A wearable neuromorphic electronic system, that can learn and interpret the non-structural biometric information at extremely low-power, has been brought great attention because of its applicability as the intelligent device that can easily attach onto the human body or any rough surface [1-3]. With this reason, organic-based artificial synaptic devices have been proposed as a potential candidate for wearable neuromorphic applications due to its inherent mechanical flexibility and the material (or device form) variability for the desired functionalities [2,3]. In this study, we designed 1D fiber-shaped multi-synapses comprising ferroelectric organic transistors fabricated on a 100 mm Ag wire and utilized them as multi-synaptic channels in an e-textile neural network for wearable neuromorphic applications. The device mimics diverse synaptic functions, including short- and long-term plasticity with 80 states and spike rate- and timing-dependent plasticity. It exhibited excellent reliability even under 6,000 repeated input stimuli and mechanical bending stress. Various NOR-type textile arrays are formed simply by cross-pointing 1D synapses with Ag wires, where each output from individual synapse can be integrated and propagated without undesired leakage. Notably, the 1D multi-synapses achieved up to ~90% and ~70% recognition accuracy for MNIST and electrocardiogram patterns, respectively, even in a single-layer neural network, and almost maintained regardless the bending conditions.

References

[1] Park, Y.; Park, M.-J.; Lee, J.-S. Adv. Funct. Mater. **2018**, 1804123
[2] van de Burgt, Y.; Lubberman, E.; J. Fuller, E.; T. Keene, S.; C. Faria, G.; Agarwal, S.; J. Marinella, M.; Talin, A. A.; Salleo A. Nat. Mater. **2017**, 16, 414-418
[3] Jang, S.; Jang, S.; Lee, E.-H.; Kang, M.; Wang, G.; Kim, T.-W. ACS Appl. Mater. Interfaces **2019**, 11, 1071-1080
[4] *S. Ham et al. Sci. Adv. **2020**, 6, eaba1178 [Published]

Artificial synapse, Nueromorphicdevice, Wearable device

Keywords:

Artificial synapse, Nueromorphic device, Wearable device, Organic ferroelectric transistor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D11.09

Single crystalline halide perovskites on polymers by a capping method for flexible photonic devices

CHO Yunae [1], JUNG Hye Ri [2], KIM Yeon Soo [1], JO William [*2,1]
[1]New ans Renewable Energy Research Center, Ewha Womans University
[2]Department of Physics, Ewha Womans University
wmjo@ewha.ac.kr

Abstract:

Organic-inorganic hybrid perovskite $CH_3NH_3PbX_3$ (X =Cl, Br, I) single crystals have attracted attention as the promising candidate for the optoelectronic application due to its stable device implementation and reduced the trap density as well as its superior potential properties compared to thin film counterpart. Recently, flexible perovskite single crystals and its application the related devices have been studied for soft wearable electronic systems. Although they have shown the outstanding flexibility and high performance of flexible perovskite optoelectronic devices, the physical interpretation of flexibility for perovskite single crystals on flexible substrates should be necessary as well as the solution of complicated and lengthy fabrication process. Here we present a novel method of growing thin $CH_3NH_3PbBr_3$ single crystals on the flexible substrates based on the modified capping method and inverse temperature crystallization. We compared the crystallinity and optoelectronic performance of perovskite single crystal structures depending flexible substrates. The perovskite single crystals were synthesized on a variety of polymers including polyimide, polytetrafluoroethylene, and polyethylene naphthalate using by a capping method. Structural properties of perovskite single crystals on three substrates were investigated by X-ray diffraction. In particular, the flexibility and initial properties of perovskite single crystals were examined in a bent state. We confirmed the high-performance photonic device characteristics of our flexible perovskite single crystals. Our advanced growth technique and resulting single crystal structures will contribute to demonstrating its potential in flexible optoelectronic applications.

Keywords:

Perovskite single crystal , CH3NH3PbBr3, Flexible device, Polymer substrates, Capping method

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D12.01

Discovery of “Topotactic ReRAM”

JUNG Chang Uk *[1,2], NALLAGATLA Venkata Raveendra [1,2]
[1]Department of Physics, Hankuk University of Foreign Studies
[2]Memory and Catalyst Research Center, Hankuk University of Foreign Studies
cu-jung@hufs.ac.kr

Abstract:

Tens of thousands of papers were published on Resistance Switching Random Access Memory (ReRAM) over more than 30 years and by more than hundreds of groups in Universities and Companies like Samsung and Toshiba etc. So many materials were found to have the switching and the switching phenomena in each material had shown so diverse behavior. But from about 10 years ago, most big groups began to escape this field due to the very low probability of commercial devices. One of the major reasons was due to the random nature of generation/breaking of conducting filament in the device.

To find India, Christopher Columbus tried to sail westward about 500 years ago while the others have tried to find the path in a conventional way, eastward. By adopting three strategies, our group tried to find a ReRAM device with reproducible/stable generation/breaking of conducting filament. As a result, we discovered the “Topotactic ReRAM” for the first time; SrCoOx in 2014 and SrFeOx in 2016. The existence of promising switching behaviors based on peculiar topotatic transition in Sr(Fe,Co)Ox in our papers has reignited the research in ReRAM.

The ReRAM based on SrFeOx has shown excellent resistive switching performance with high endurance (> 10^6 cycles), fast switching speed (10 ns), and high uniformity in key switching parameters. It also showed good synaptic learning behavior. The switching mechanism was revealed using X-ray absorption spectromicroscopy in a sub-micron scale. We also have registered three Patents in Kore and one patent in the USA.

In this talk, I will focus not on details of research but on the importance of raising a new question that can trigger new breakthroughs in the research.

References

[1] Octolia T. Tambunan,,, **Chang Uk Jun**g,,, Miyoung Kim, and Cheol Seong Hwang, Applied Physics Letters 105, 063507 (2014)

[2] S. K. Acharya, **R. V. Nallagatla**, O. Togibasa, B. W. Lee, C. Liu, **C. U. Jung***, B. H. Park, J. Y. Park, Y. Cho, D. W. Kim, J. Jo, D. H. Kwon, M. Kim, C. S. Hwang, S. C. Chae, *ACS Appl. Mater. Interfaces* **2016**, *8*, 7902.

[3] S. Kumar Acharya, J. Jo, **N. Venkata Raveendra**, U. Dash, M. Kim, H. Baik, S. Lee, B. Ho Park, J. Sung Lee, S. Chul Chae, C. Seong Hwang, **C. Uk Jung*, 2017**, DOI 10.1039/c7nr04011c, *Nanoscale,* **2017,** 9, 10502.

[4] **V. R. Nallagatla, T.** Heisig, C. Baeumer, V. Feyer, M. Jugovac, G. Zamborlini, C. M. Schneider, R. Waser, M. Kim, **C. U. Jung***, R. Dittmann, *Adv. Mater.* **2019**, 1903391.

[5] Venkata Raveendra Nallagatla, Jihun Kim, Kyungjun Lee, Seung Chul Chae,

Cheol Seong Hwang and **Chang Uk Jung**, ACS Applied Materials & Interfaces **2020** 12 (37), 41740
[6] **Chang-Uk JUNG**, Susant Kumar Acharya, Venkata Reveendra Nallagatla, Bo What Lee, and Chunli Liu, USA patent (US 10,886,466 B2), registered at **2021**-01-05, applied at 2018-02-20, " Variable resistor, Non-volatile memory element using the same and method of the fabricating the same".

Keywords:

Topotactic ReRAM, SrFeOx, Christopher Columbus, Multi-valence, topotatic transition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D12.02

Directional ionic transport across the oxide interface enables low-temperature epitaxy of rutile TiO_2

SON Junwoo *[1]
[1]Department of Materials Science and Engineering, POSTECH
jwson@postech.ac.kr

Abstract:

Heterogeneous interfaces exhibit the unique phenomena by the redistribution of charged species to equilibrate the chemical potentials between dissimilar materials. Despite a number of recent studies on the electronic charge accumulation across chemically inert interfaces, the systematic research to investigate massive reconfiguration of charged ions has been limited in heterostructures with chemically reacting oxide interfaces so far. Here, we demonstrate that a chemical potential mismatch systematically controls oxygen ionic transport across TiO_2/VO_2 interfaces, and that this directional transport unprecedentedly stabilizes high-quality epitaxial TiO_2 films with rutile phase at the lowest temperature (~ 150 °C) ever reported, at which rutile phase is difficult to be crystallized. A combination of structural and electrical characterizations combined with theoretical calculation reveal that this unconventional low-temperature epitaxy of rutile TiO_2 phase is achieved by lowering the activation barrier by increasing the “effective” oxygen pressure through a facile ionic pathway from $VO_{2-\delta}$ sacrificial templates. This discovery shows a robust control of defect-induced properties at oxide interfaces by the mismatch of thermodynamic driving force, and also suggests a novel strategy to overcome a kinetic barrier to phase stabilization at exceptionally low temperature.

This work was performed in collaboration with Yunkyu Park, Hyeji Sim, Minguk Jo, Dr. Gi-Yeop Kim, Daseob Yoon, Dr. Hyeon Han, Dr. Younghak Kim, Dr. Kyung Song, Prof. Donghwa Lee and Prof. Si-Young Choi

Keywords:

Low-temperature epitaxy, Oxide interface, TiO2, Ionic transport, Oxygen vacancies

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D12.03

Cooperative lattice evolution in oxide heterostructures

MIN Taewon [1], CHOI Wooseon [2], SEO Jinsol [2], HAN Gyeongtak [2], KIM Young-Min [2], OH Sang Ho [2], LEE Jaekwang [*1]
[1]Department of Physics, Pusan National University
[2]Department of Energy Science, Sungkyunkwan University
jaekwangl@pusan.ac.kr

Abstract:

The polarity discontinuity across $LaAlO_3/SrTiO_3$ (LAO/STO) heterostructure induces electronic reconstruction involving the formation of two-dimensional electron gas (2DEG). The heterostructure also exhibits structural distortion in close correlation with the 2DEG formation, which can be characterized by either antiferrodistortive (AFD) rotation, ferroelectric (FE) distortion, or both. Here, by combining scanning transmission electron microscopy and density functional theory (DFT) calculations, we show that the AFD and FE modes are cooperatively coupled in the (111)-oriented LAO/STO heterostructure; they coexist below the critical thickness (t_c) and disappear simultaneously above t_c with the formation of 2DEG). Electron energy loss spectroscopy of the O-K edge and DFT calculations provide direct evidence of oxygen vacancy (V_O) formation at the LAO (111) surface, which acts as the source of 2DEG. Tracing the AFD rotation and FE distortion of LAO from the interface to the surface reveals that their evolution is strongly correlated with the V_O distribution. The present study demonstrates that the AFD and FE modes in an oxide heterostructure emerge as a consequence of the intricate interplay of interface orientation, lattice misfit strain, and internal polar field; it further demonstrates that their combination can drive competitive or cooperative coupling by tuning the relative evolution of the two modes.

Keywords:

antiferrodistortive (AFD) rotation, ferroelectric (FE) distortion, LaAlO3/SrTiO3 (LAO/STO) heterostructure, density functional theory (DFT) calculations

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.01

Geometry-induced rectification for an active object

LEE Jae Sung *[1], PARK Jong-Min [1], NOH Jae Dong [2], PARK Hyunggyu [1]
[1]Korea Institute for Advanced Study
[2]University of Seoul
jslee@kias.re.kr

Abstract:

Study on a rectified current induced by active particles has been received a great attention due to its possible application to a microscopic motor in biological environments. Insertion of an {₩em asymmetric} passive object amid many active particles has been regarded as an essential ingredient for generating such a rectified motion. Here, we report that the reverse situation is also possible, where the motion of an active object can be rectified by its geometric asymmetry amid many passive particles. This may describe an unidirectional motion of polar biological agents with asymmetric shape. We also find that a weak rectified motion with less diffusivity occurs when the asymmetric object is driven by a dissipative force. This “moving by dissipation” mechanism could be used as a design principle for developing more reliable microscopic motors.

Keywords:

thermodynamics, heat engine, active matters

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.02

Limit of periodic signal detection in the presence of thermal noise using neural networks

BOICHENKO Nelli [1], AHN Kang Hun [*1]
[1]Bio-inspired Artificial Intelligence Lab., Department of Physics, Chungnam National University
ahnkh@cnu.ac.kr

Abstract:

The human ear can detect acoustic signals that carry the energy of a small fraction of thermal energies. We propose a simple model that can demonstrate how information whether a seemingly random signal contains a regular, periodical part can be extracted.

We study a particle that is moving in a 1D medium with friction under a thermal noise force with and without an extra sinusoidal force of a varied amplitude. The presence of a periodical force in a system increases a particle's average energy, but not the velocity. To be unbiased towards a choice of system scale, we utilized the dimensionless units in which the relaxation time of the system, as well as the average square of the velocity, would be equal to unity.

The dataset consists of velocity samples of two types: ones that were modeled in the presence of an extra periodical force as well as a thermal noise force, and ones without such. We solved a classification task with a neural network consisting of two fully connected layers. The certainty of a nonequilibrium force detection depends on the force amplitude: if 20% of the particle energy comes from the extra force, the accuracy of the detection would surge over 90%.

Our study shows that even from seemingly random time-series data the network can learn and detect a regular pattern. This may open various questions, interesting for further investigation. For example, can a network of more complex architecture improve the accuracy of non-random detection? Where is the limit any network can detect the difference between those two?

Keywords:

thermal noise, neural network, signal detection

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.03

Mechanochemical coupling in the fuel-consuming active heat engine

BAEK Yongjoo *[1], OH Yongjae [1]
[1]Department of Physics and Astronomy, Seoul National University
y.baek@snu.ac.kr

Abstract:

By utilizing active particles as working substance, colloidal heat engines can apparently surpass the conventional Carnot efficiency bound. In order to clarify the energetic picture of such phenomena, we introduced a thermodynamically consistent model of fuel-consuming active heat engine. The composite efficiency of the engine, which accounts for fuel consumption, preserves the Carnot upper bound but exhibits significantly different behaviors depending on the parity of the self-propulsion force. If the particle swims by position-dependent force, slower engines tend to be more efficient. However, in the case of a velocity-dependent swimmer such as a chemically powered screw, there is a notable drop in the efficiency as the engine operates on a shorter time scale. This phenomenon can be intuitively understood by imagining a particle spatially being stuck to the wall and consequentially being unable to relate its fuel consumption to useful work. We also check the generality of this finding using alternative models of chemically driven self-propulsion inspired by real-world examples of mechanochemical coupling.

Keywords:

active matter, stochastic thermodynamics, heat engine, mechanochemical coupling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.04

Disorder-induced long-ranged correlations in scalar active matter

RO Sunghan *[1], KAFRI Yariv [1], KARDAR Mehran [2], TAILLEUR Julien [3]
[1]Faculty of Physics, Technion
[2]Department of Physics, MIT
[3]laboratoire Matière et Systèmes Complexes, Université de Paris
nsident@gmail.com

Abstract:

Self-propelled particles may aggregate and phase separate even if they do not attract each other. The class of systems featuring this *motility-induced phase separation* is commonly called scalar active matter. This talk will discuss the impact of quenched random potentials and torques on the scalar active matter. By combining numerical and analytic approaches, it will be shown that the phase separation is replaced by a *disordered phase* in the large system size limit for dimensions equal to or less than 4. This result stems from the nonlocal effect of disorder on the density field. For weak disorder, the structure factor of the density field satisfies S(q) ~ 1/q^2 with the wavenumber q, indicating a scale-free structure. In d=2, it is argued that this behavior should cross over to a strong-disorder regime on very large length scales. Lastly, disorder-induced currents, which flow persistently even in the steady-state, will be characterized.

Reference: Sunghan Ro, Yariv Kafri, Mehran Kardar, and Julien Tailleur, Phys. Rev. Lett. **126**, 048003 (2021).

Keywords:

active matter, quenched disorder, long-ranged correlation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.05

Symmetry-breaking transitions and critical phenomena induced by generic negative drag in an active fluid

KIM Ki-Won [1], CHOE Yunsik [1], BAEK Yongjoo [*1]
[1]Department of Physics and Astronomy, Seoul National University
y.baek@snu.ac.kr

Abstract:

A symmetric object immersed in an active fluid may become motile through symmetry breaking. In previous studies [1,2], the phenomenon presupposed the presence of polar or nematic order in the active fluid. In this study, we theoretically show that such symmetry-breaking motility can generally emerge even in dilute and disordered fluid. This is due to a "negative drag" which applies in the direction of the object's velocity. This effect leads to a continuous transition associated with the bifurcation of the steady-state velocity of the object. We numerically show that the critical phenomena associated with the transition belong to the Ising universality class. The generality of our result is not affected by the shape of the symmetric object.

[1] E. Tjhung et al., Proc. Natl. Acad. Sci. **109**, 12381 (2012).
[2] De Magistris et al., Soft Matter **10**, 7826 (2014).

Keywords:

active matter, negative drag, spontaneous symmetry-breaking, critical phenomena

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D13.06

Investigation on the finite-time Otto cycle: When do quantum effects benefit the heat devices?

LEE Sangyun [1], HA Meesoon *[2], JEONG Hawoong *[3]
[1]school of physics, KIAS
[2]Physics Education Department, Chosun University
[3]Physics Department, KAIST
msha@chosun.ac.kr, hjeong@kaist.ac.kr

Abstract:

To figure out how quantum effects change heat devices, we study the quantum Otto cycle and its classical counterpart. We find that the performance of the quantum one is better than the classical one in the respects of efficiency, power, and precision in the finite-time regime due to the special structure of the quantum heat bath. By changing the strength between the system and the bath, we compare the performance of both engines and find interesting results. In both high and low strength limits, the quantum Otto cycle shows higher performance. Furthermore, we test the validity of the conventional thermodynamic uncertainty relation [1] and discuss the condition of the violation of the thermodynamic uncertainty relation [2].

[1] Andre C. Barato and Udo Seifert, Phys. Rev. Lett. 144, 158101 (2015).
[2] Sangyun Lee, Meesoon Ha, and Hawoong Jeong, Phys. Rev. E, 103, 022136 (2021).

Keywords:

quantum thermodynamics, heat engine, nonequilibrium statistical physics, open quantum system, quantum master equation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D15.01

High-Brightness Self-seeded X-ray Free Electron Laser covering from 3.5 keV to 14.6 keV

NAM Inhyuk [*1], MIN Chang-ki [1], KIM Gyujin [1], NA Donghyun [1], YANG Haeryong [1], CHO Myung-Hoon [1], KIM Changbum [1], SHIM Chi Hyun [1], KO Jun Ho [1], HOON Heo [1], KIM Minjae [1], KANG Heung-Sik [1]
[1]PAL-XFEL, Pohang Accelerator Laboratory
ihnam@postech.ac.kr

Abstract:

We produced hard X-ray pulses with an unprecedented peak brightness (3.2×10^{35} photons/(s·mm^2·mrad^2·0.1%BW)) using the forward Bragg-diffraction at Pohang Accelerator Laboratory (PAL) hard-X-ray self-seeded (HXRSS) free-electron lasers. The self-seeded FEL generates hard X-ray pulses with improved spectral purity. The bandwidth of the self-seeded FEL at 9.7 keV is about 1/70 as wide and spectral brightness is 40 times higher than in self-amplified spontaneous emission (SASE) mode. We could reach an outstanding self-seeding performance at a photon energy of 3.5 keV (lowest) and 14.6 keV (highest), increasing the peak brightness to 6.1×10^{33} and 1.3×10^{35}, the highest to date, respectively. We will present experimental results of characteristics of hard X-ray self-seeded FEL at PAL-XFEL.

Keywords:

Free electron laser, Hard X-ray self-seeded free electron laser, hard X-ray

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D15.02

Round beam generation and its issues on the 4th generation storage ring

오봉훈*[1]
[1]PAL,
hope@postech.ac.kr

Abstract:

Coupling study was carried out in Korea-4GSR. In our coupling study, full coupled lattice was made by putting tilt errors in normal quadrupoles. Coupling lattice by locating skew quadrupoles will be designed and study using that lattice will be fulfilled in the future. Firstly, Twiss parameters of full coupling (round) beam were calculated and compared with those of flat beam. Then, injection study was carried out. The beam enters the ring with 7 nm emittance after full acceleration to 4GeV energy in booster ring. After injection, beam emittance goes from 7nm to 38 pm and 100 % injection efficiency was accomplished.

Keywords:

Round beam generation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D15.03

Interplay of space-charge driven fourth order resonance and envelope instability and their mitigation by using beam spinning

CHEON Yoolim [1], CHUNG Moses *[1], MOON Seokho [1], JEON Dong-O [2]
[1]Department of Physics, UNIST
[2]RAON, IBS
mchung@unist.ac.kr

Abstract:

One of the challenging issues in high intensity linear accelerators is to minimize the halo formation and beam losses driven by strong space-charge forces. The main two concepts on the halo formation are parametric instabilities (also called coherent resonances) and particle resonances (also called incoherent resonances).
For initially well-matched Gaussian beams, the fourth order particle resonance is manifested dominantly over the envelope instability along short periods. Furthermore, the fourth order resonance leads to beam mismatch which consequently excites the envelope instability leading to a significant emittance growth within the envelope instability stop band. We have investigated the interplay of the fourth order resonance and the envelope instability under various values of zero-current phase advance and tune depression.
Next, we present a novel method to mitigate the space-charge driven fourth order particle resonance and the subsequent envelope instability by introducing a new concept of spinning beams. The spinning beams have non-zero average canonical angular momentum which is conserved under axisymmetric system.
Motivated by classical mechanics on the stability of spinning flying objects, we had a question on whether charged-particle beams in high intensity linear accelerators can have benefit from the spinning when dealing with the strong space-charge effects.
From the analytical and numerical simulation studies, we have found that the spinning beams have an intrinsic characteristic that can suppress the impact of the nonlinear particle resonance on the emittance growth and the associated envelope instability.
Unlike other approaches based on nonlinear lattice, this new approach does not require complicated focusing elements and shows evidently different characteristics from the cases of initial thermal emittance increase only.

Keywords:

Fourth order particle resonance, Envelope instability, Mitigation of particle resonance, Beam spinning

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D15.04

New non-linear optimization scheme for the 4th generation storage ring

JANG Gyeongsu [1], OH BongHoon [2], KIM Jaehyun [1], SHIN SeungHwan [2], LEE Jaeyu [2], HA Taekyun [2], KIM Dong-Eon [2], YOON Moohyun [*1]
[1]Physics, POSTECH
[2]Pohang Accelerator Laboratory, POSTECH
moohyun@postech.ac.kr

Abstract:

One feature of the fourth generation storage rings (4GSRs) is a small dynamic aperture compared to the third generation storage rings (3GSRs). The reduction of the dynamic aperture comes from strong non-linear effects. This effects can be relieved by the non-linear optimization. Control of the phase advance between the sextupoles compensates the non-linear effects from the sextupoles. Theoretical background is analyzed and the numerical optimization is conducted.

Keywords:

Fourth generation storage ring, Non-linear optimization

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D16.01

Optical modulating terahertz transmittance through metal nanowires on a Si substrate

KEE Chul Sik *[1]
[1]GIST
cskee@gist.ac.kr

Abstract:

This talk presents the optical excitation effect on the transmission of terahertz radiation through aligned silver nanowires on a silicon substrate. Terahertz radiation passes well through both a bare Si substrate and the nanowires on a Si substrate. However, the optically excited Si substrate with the nanowires significantly reduces the transmittance, comparing with the excited bare Si substrate. Metallic arrays on Si substrates could be useful in implementing optically tunable THz modulators.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D16.02

Ultrafast optical-pump THz-probe spectroscopy of 2D systems

SIM Sangwan *[1]
[1]Division of Electrical Engineering, Hanyang University ERICA
swsim@hanyang.ac.kr

Abstract:

Optical-pump Terahertz (THz)-probe (OPTP) spectroscopy is a powerful tool to study photoinduced dynamics in various systems. In OPTP spectroscopy, nonequilibrium dynamics of pump-generated carriers and heat are directly measured by the THz probe. Interestingly, insulating and metallic systems exhibit completely different OPTP signals, from which we can understand the electrical and thermal properties of materials. In this presentation, we discuss OPTP spectroscopy studies on two-dimensional (2D) systems that have recently gained attention.

First, we discuss ultrafast carrier dynamics in a few-layer platinum diselenide. Platinum diselenides have recently gained a great deal of attention owing to their excellent air stability, thickness-dependent electrical phase transition, and intriguing magnetic properties. We here utilized OPTP to observed the three-carrier Auger process of two free carriers and one defect-trapped carrier. We also confirm the semiconducting response of $PtSe_2$ from the sign of OPTP signals.

Second, we study the electrical and thermal properties o ruthenium thin-films using OPTP. Ruthenium thin-films are a promising material for applications in various nanoelectronic devices. We here observe a thickness-dependent electrical phase transition near the thickness of 10 nm. We attribute this to the metal-insulator percolation transition, offering seminal information for optimization of thin-film thickness in device designs. Next, OPTP reveals interfacial thermal dissipation from ruthenium thin-films to various dielectric substrates. We found that morphologies of ruthenium islands significantly affect thermal dissipation.

Keywords:

Optical-pump terahertz-probe, platinum diselenide, ruthenium thin film

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D16.03

Perspective of terahertz technologies for the industrial applications

LEE IL-Min *[1], LEE Eui Su [1], KIM Mugeon [1], PARK Dong Woo [1], SHIN Jun-Hwan [1], CHOI Da-Hye [1], KIM Younghoon [1], PARK Kyung Hyun [1]
[1]Terahertz Research Section, Future & Basic Technology Research Division, Electronics and Telecommunications Research Institute (ETRI)
Ilminlee@etri.re.kr

Abstract:

Developing industrial terahertz technologies seems to have to meet two objectives at the same time. The first is to develop small, light-weight, and less-expensive terahertz technology, and the second is to discover appropriate applications where the developed technology would be competitive. In this sense, we are struggling to develop terahertz devices, their applications, and the systems.
In the presentation, we would like to present our recent efforts to develop terahertz technologies with our efforts to find their specific applications in the fields of terahertz non-destructive tests, terahertz wireless communications, and terahertz security screenings will be presented.

Keywords:

Terahertz, Security check, Passenger screening

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D17.01

Feshbach resonances in collisions of ultracold triplet ground state $^{23}Na^{6}Li$ with ^{23}Na

SON Hyungmok *[1,2]
[1]Department of Physics, Harvard University
[2]Department of Physics, MIT
hson@g.harvard.edu

Abstract:

There have been extensive efforts in understanding molecular collisions in the quantum regime. As colliding bodies get heavier, due to high rovibrational density-of-states of the collision complex, theoretical simulation of collisions becomes significantly complicated. Ultracold NaLi – the lightest bi-alkali molecule – that lives long in the triplet manifold of the electronic spin offers a new platform for the study of atom-molecule collisions, as a promising benchmark system for theoretical quantum scattering calculations. As demonstrated in our recent study, spin-polarization of a NaLi-Na mixture suppresses the molecular loss by more than an order of magnitude compared to the universal model prediction. We report magnetic control of Feshbach resonances in the spin-polarized NaLi-Na mixture in which the reflection of incoming scattering wavefunction at short-range is larger than zero. At the Feshbach resonances, fluxes reflected at short and long ranges interfere and results in the enhancement of loss beyond the universal limit. The observation of atom-molecule Feshbach resonances at ultracold temperature provides information on the short-range physics and the three-body potential energy surface with resolution beyond the current level of calculations and possibly enables the creation of magnetically-associated triatomic molecules.

Keywords:

Cold Molecules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D17.02

Ultracold dipolar molecules: a new platform for quantum simulation and computing

PARK Jee Woo *1
[1]Department of Physics, POSTECH
jeewoopark@postech.ac.kr

Abstract:

In the past few decades, rapid advancement in achieving quantum control of ultracold atoms has enabled their use as a powerful resource to investigate complex quantum phenomena. However, for quantum simulation and computing purposes, a key limitation in these systems is that the underlying interaction between a pair of atoms is a simple contact interaction, which not only limits the many-body Hamiltonians that can be explored but also makes the realization of two-qubit gate operations necessary for quantum information processing very challenging. A quantum gas of dipolar molecules holds exceptional promise in this regard, whose long-range and anisotropic dipole-dipole interaction can allow the realization of exotic states of matter such as topological superfluids and the implementation of entangling gate operations.

In this talk, I will present the creation and coherent control of an ultracold gas of chemically stable fermionic $^{23}Na^{40}K$ molecules with large electric dipole moments. This involves the atom-by-atom assembly of molecules from ultracold gases of sodium and potassium atoms while maintaining the low entropy of the molecular gas. Using optical and microwave fields, we achieve coherent control of the molecular internal states, revealing that the nuclear spin states in particular exhibit exceptional coherence times for their use as robust storage qubits. By further reducing the temperature and by combining state-of-the-art trapping and control techniques, this system can realize a highly scalable and programmable platform for quantum technology applications.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D17.03

Collisions of Ultracold Ground-state NaRb Molecules

WANG Dajun *[1]
[1]Department of Physics, The Chinese University of Hong Kong
djwang@cuhk.edu.hk

Abstract:

Dipolar collisions between ultracold polar molecules are an important topic both by its own right from the fundamental point of view and for the successful exploration of many-body physics with strong and long-range dipolar interactions. However, due to the difficulty in making ultracold sample of ground-state polar molecules, experimental data in this topic is largely absent. Here we report the investigation on dipolar collisions between ultracold ground-state $^{23}Na^{87}Rb$ molecules. In the first part, we induce the electric dipole-dipole interaction between $^{23}Na^{87}Rb$ molecules by external electric fields. In the second part, we investigate resonant dipole collisions between $^{23}Na^{87}Rb$ molecules in different rotational states. Some recent results on understanding the complex mediated loss of the non-chemical reactive ultracold molecules will also be presented.

Keywords:

Cold Molecules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D17.04

Torwards ultracold molecular quantum machine

CHAE Eunmi *[1]
[1]The department of Physics, Korea University
echae@korea.ac.kr

Abstract:

Due to their complex internal structures and strong long-range interactions, diatomic molecules are promising platforms for precision measurements, quantum simulations/computations, and quantum chemistry. Most of these experiments require ultracold temperatures and a general method of cooling is essential to fully exploit the diversity of molecular structures.
One route towards ultracold temperature is to cool the molecules directly, just as atoms, using laser cooling. Despite the additional internal structures present in molecules, there have been great successes in laser cooling of molecules during the last decade. After the realization of a magneto-optical trap (MOT), people can now manipulate ultracold molecules in a magnetic trap, an optical dipole trap, and optical tweezers. This has opened a new era of molecular research for quantum technology. In this talk, two topics using ultracold molecules in optical tweezers will be introduced. I will first start with the CaF experiment at Harvard, where we engineer inelastic collisions between two molecules in optical tweezers by manipulating their quantum states. In the second part of the talk, a scheme to entangle two polar molecules using the electric dipole-dipole interaction will be discussed. At the end of the talk, I will also briefly introduce a new MgF experiment at Korea University.

Keywords:

ultracold molecules, laser cooling, quantum chemistry, quantum simulation/computers

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D18.01

Atomistic Simulations of Perovskite Materials from First-Principles to Machine Learning

PAO Chun-Wei *[1]
[1]Research Center for Applied Sciences, Academia Sinica
cwpao@gate.sinica.edu.tw

Abstract:

Organic-inorganic halide perovskite materials have drawn significant attentions in the past few years with a wide range of applications such as solar cells, light-emitting diodes and lasers. Nevertheless, there are still gaps to fill for the process-structure-property correlations of perovskite materials due to difficulties in extracting atomistic details of perovskite structures subjected to different processing conditions directly from experiments. In this talk, I will present our recent work in revealing atomistic details of perovskite materials using both first-principle calculations and machine-learning-enabled models. We will present our results on the surface structures and equilibrium crystal shapes of 2D perovskite crystals, and lithium ion diffusion in perovskite from the first-principle calculations. Then, we will present our work in investigating phase stability of complex perovskite materials using machine-learning-enabled potential energy models. We will demonstrate that the machine-learning models offers orders of magnitudes of computational speedup relative to the first-principle calculations, thereby allowing exhaustive sampling of complex perovskite materials to reveal microstructures that are difficult to be extracted from both the first-principle calculations and experimental characterizations.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D18.02

Exploration of halide perovskites via a classic solid-state reaction

LEE Sangwook *[1]
[1]School of Materials Science and Engineering, Kyungpook National University
wook2@knu.ac.kr

Abstract:

Halide perovskites attract enormous attention as promising light absorption and emission materials for photovoltaics and optoelectronic applications. Here we report ternary diagrams of the phase, optical bandgap energy (E_g) and photoluminescence intensity of $APbX_3$ (A = methylammonium (MA); *X* = I, Br and Cl) compositions. $MAPbX_3$ perovskites, with three vertices of $MAPbI_3$, $MAPbBr_3$ and $MAPbCl_3$ were synthesized via a facile mechanochemical reaction at room temperature, to ensure the desired stoichiometries of the final products. Through structural study on $MAPbX_3$, the phase diagram comprising a single phase region and two multi-phase regions was obtained. In the single phase region, the a-axis lattice constant increases almost linearly with increasing the average size of the X site ions. Interestingly, optical E_g decreases almost linearly with increasing the average size of the X site ions, giving negligible deviation from Vegard's law. Interestingly, $CsPbX_3$ also exhibits very low bowing parameters of Vegard's law, although it has a complex phase system depending on halide ion and temperature. The low bowing parameters of $APbX_3$ is attributed to symmetry-breaking large lattice relaxation. The ternary diagram of the photoluminescence intensity reveals the effective compositions for red, green and blue light emission. The comprehensive structural and optical information reported in this study is useful for designing halide perovskites for various applications. In addition, our approach for compositional mapping various characteristics using a solid-state reaction is an efficient and robust way to studying halide perovskites.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D18.03

Defect Manipulation for Perovskite Solar Cells and Light-emitting Diodes

HAN Tae-Hee *[1]
[1]Division of Materials Science and Engineering, Hanyang University
taeheehan@hanyang.ac.kr

Abstract:

The metal halide perovskites have shown excellent optoelectronic properties for solar cells and light-emitting diodes (LEDs), reaching a high certified power conversion efficiency (> 25%) and luminous efficiency (> 20%). Metal halide perovskite has high absorption coefficient, long charge carrier diffusion length and defect tolerance. Furthermore, low temperature and solution processability of perovskites is an advantage for low-cost mass production as well. However, the solution-processed perovskite thin films that can be used for SCs and LEDs are polycrystalline in nature and inevitably possess grain boundaries with crystalline defects and traps. The grain boundaries and surface in the polycrystalline thin films have been found to be significant on both optoelectronic performances and operational stability of the perovskite optoelectronic devices. We present the manipulating strategies of grain boundaries and surface in perovskite thin film by adjusting nucleation and growth. The effective strategy for perovskite growth results in improved device efficiency and operational stability of optoelectronic devices with reduced crystal defects and traps.

Keywords:

perovskite, solar cells, light-emitting diodes

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D18.04

Probing the ionic effect in $MAPbBr_3$ perovskite LED

GUO Tzung-Fang *
[1]Department of Photonics, National Cheng-Kung University
[2]Advanced Optoelectronic Technology Center, National Cheng-Kung University
guotf@mail.ncku.edu.tw

Abstract:

The interfacial phenomenon in the case of $MAPbBr_3$ based organic-inorganic hybrid LEDs depends upon the existence of vacant sites that enable electric-field driven ion migration which in turn causes detrimental effect on the device efficiency. A clear deeper knowledge of the fundamental interfacial mechanism in hybrid LEDs that is dependent on the material properties must be essentially brought in focus so as to improve the optoelectronic properties.

In this present study, we have attempted to bring out this interfacial phenomenal occurrences using Admittance Spectroscopy and demonstrate the fundamental mechanism in such perovskite LED and further establish a method to tune the interfacial kinetics by appropriate passivation of perovskite layer by additive engineering. Defect passivation via additive engineering improved the LED device performance incredibly evidenced by the lowering of built-in potential (V_{bi}) indicating faster light turn-on and reduced interface potential revealing better interfacial charge injection behavior. Moreover, the current-voltage (I-V) hysteresis behavior speculated to be arising due to ion migration is suppressed. Carrier dynamics is altered by enhancing the carrier injection due to improved interfacial conduction and noticeable change from inductive behavior to capacitive behavior due to increased carrier density. The DC bias dependences of characteristic times and carrier distribution are analyzed to understand the complex kinetic behavior of hybrid LED as it is composed of both organic and inorganic components. This clear understanding of the interfacial kinetics and carrier dynamics will enable materials scientists to establish strategic design to overcome the existing disadvantages in near future and improve the optoelectronic functionalities and properties.

Keywords:

ion migration, defect passivation, additive engineering, interfacial kinetics, Admittance spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D18.05

Metal halide Perovskite nanocrystals based highly efficient liquid scintillators

IM Hyunsik *1
[1]Department of Physics and Semiconductor Science, Dongguk University
hyunsik7@dongguk.edu

Abstract:

Highly sensitive X-ray detection is becoming increasingly important in uses from everyday life to industry, military, and scientific research. Scintillating materials convert X-ray, ɣ-ray, and particle radiation into visible or ultraviolet (UV) light. Compared with crystalline or plastic scintillators, liquid scintillators generally have better resistance to damage from exposure to intense radiation while providing excellent area/volume scalability; consequently, liquid scintillators are used for various purposes such as β-ray spectroscopy, radioactivity measurements, and particle physics. However, despite the above advantages, liquid scintillators have relatively low density and low radioluminescence quantum yield, both of which are crucial in achieving high resolution and contrast in X-ray imaging.

Here we report the experimental investigations of a highly efficient X-ray scintillation and significantly enhanced quantum yields of liquid scintillators consisting of perovskite metal halide $CsPbA_3$ (A: Cl, Br, I) nanocrystals and organic molecules in the soft and hard X-ray regimes, and demonstrate their use in high-resolution X-ray imaging. We propose a new class of mechanism for substantially enhancing the scintillation quantum yield, which was accomplished by hybridising different scintillation nanomaterials.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D19.01

Role of the A-site cation in optical properties of $APbBr_3$ (A = Cs, CH_3NH_3)

JANG Joon Ik *[1]
[1]Physics, Sogang University
jjcoupling@sogang.ac.kr

Abstract:

$APbBr_3$ (A = Cs, CH_3NH_3) are prototype halide perovskites having bandgaps of 2.30–2.35 eV at room temperature, rendering their apparent color nearly identical (bright orange but opaque). Upon optical excitation, they emit bright photoluminescence (PL) arising from carrier recombination whose spectral features are also similar. At 10 K, however, the apparent color of $CsPbBr_3$ becomes transparent yellow, whereas that of $CH_3NH_3PbBr_3$ does not change significantly due to the presence of an indirect Rashba gap. With increasing the excitation level, evolution of the PL spectra, which are excitonic at 10 K, reveals the emergence of P-band emission arising from inelastic exciton-exciton scattering. Based on the spectral location of the P-band, exciton binding energies are determined to be 21.6 ± 2.0 meV and 38.3 ± 3.0 meV for $CsPbBr_3$ and $CH_3NH_3PbBr_3$, respectively. Intriguingly, upon further increase in the exciton density, electron-hole plasma appears in $CsPbBr_3$ as evidenced by both redshift and broadening of the PL. This phase however does not occur in $CH_3NH_3PbBr_3$ presumably due to polaronic effects. Although the A-site cation is believed not to directly impact optical properties of $APbBr_3$, our results underscore its critical role, which destines different high-density phases and apparent color at low temperatures.

Keywords:

halide perovskites, Rashba effects, polaron effects, photoluminescence, excitons

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D19.02

Phase-dependent excitonic properties of metal halide perovskites

CHO Chang-Hee *[1]
[1]Department of Emerging Materials Science, DGIST
chcho@dgist.ac.kr

Abstract:

금속 할로겐화물 페로브스카이트 물질은 온도가 변화함에 따라 결정 상전이를 보인다. 본 연구에서는 금속 할로겐화물 페로브스카이트 물질 중 하나인 MAPbBr3 의 결정 상전이에 따른 엑시톤 특성 변화에 대한 최근 연구 결과를 소개하고자 한다. MAPbBr3 는 온도가 증가함에 따라 orthorhombic, tetragonal, cubic 상의 순서로 상전이를 일으키게 되는데, 이에 따른 엑시톤 확산 계수 변화를 측정하였다. 결과적으로 tetragonal 상에서 가장 낮은 엑시톤 확산 계수를 보임을 확인하였다. 더 나아가 MAPbBr3 의 결정 상전이에 따른 엑시톤-폴라리톤의 Rabi splitting 변화를 관찰하였다. 흥미롭게도 엑시톤-폴라리톤의 결합 세기의 지표인 Rabi splitting 에 대해서도 tetragonal 상에서 가장 작은 값을 보임을 관찰하였다. 본 발표에서 이와 같은 페로브스카이트 결정 상전이에 따른 엑시톤 물성 변화에 대한 물리적 의미에 대해 논의하고자 한다.

Keywords:

금속 할로겐화물 페로브스카이트, 엑시톤, 폴라리톤, 상전이

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D19.03

Simultaneous Raman and photoluminescence mapping studies of few-layer MoS_2

RHO Heesuk *[1]
[1]Department of Physics, Jeonbuk National University
rho@jbnu.ac.kr

Abstract:

라만 산란 및 발광 분광 기술은 반도체 물질의 물리 특성 연구를 위한 비파괴적인 광 분석 방법이다. 라만 산란의 경우 2 차원 층상 물질의 광학 포논 연구를 통해서 결정성, 변형, 도핑, 층수 등에 대한 정량적인 정보를 얻을 수 있다. 2 차원 층상 물질의 발광 반응은 주로 엑시톤과 트라이온 방출 스펙트럼으로 구성되어 있으며 이들의 특성은 전자 도핑에 영향을 받는다. 따라서 라만 산란 및 발광 실험을 통해 결정성, 형태 변화 및 전자 구조에 대한 포괄적인 이해가 가능하다. 특히, 넓은 영역에 걸친 분광 이미징 기술을 활용하면 에너지 구조에 대한 공간적인 비균질성을 관찰할 수 있다. 이와 관련, 본 발표에서는 공간 분해된 라만 산란 및 발광 실험을 이용해서 2 차원 MoS_2 층상 물질에 대한 변형, 도핑, 적층 구조, 전자-포논 상호작용, 전하 이동 현상 등을 어떻게 연구할 수 있는지 소개한다.
[이 성과는 2019 년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임 (No. 2019R1A2C1003366)]

Keywords:

Raman spectroscopy, Photoluminescence, MoS2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D19.04

인접 금속판을 이용한 2 차원반도체의 양자효율 향상

KIM Jeongyong *[1]
[1]Department of Energy Science, Sungkyunkwan University
j.kim@skku.edu

Abstract:

유전체 환경은 발광 2 차원 (2D) 반도체인 단층 전이금속 칼코게나이드 (1L-TMD)에서 엑시톤의 쿨롱 상호작용에 결정적인 영향을 미친다. 그러나 많은 결정 결함으로 인한 짧은 엑시톤 수명과 TMD 의 강한 엑시톤-엑시톤 상호 작용때문에 엑시톤 방출의 효율이 매우 낮다. 우리는 1L-WS2 의 엑시톤-엑시톤 쌍극자 상호 작용을 hBN/Au 기판을 사용하여 효과적으로 스크리닝 할 수 있다는 결과를 제시하고자 한다. 이러한 기판 구조에서는 쌍극자 엑시톤-엑시톤 상호 작용이 금속 내부에 형성된 이미지 쌍극자 때문에 사중 극자-사중 극자 상호 작용처럼 약해진다. 크게 줄어든 엑시톤-엑시톤 상호 작용은 시간 분해 광학 측정에 의해 확인 된 바와 같이 엑시톤-엑시톤 소멸 (EEA) 속도의 감소를 동반하며 높은 엑시톤 농도에서 양자효율의 향상을 이루었다. 실험에서 관찰된 엑시톤 밀도에 대한 EEA 변화는 Au 기판에서의 거리에 따른 쌍극자-쌍극자 상호 작용의 스크리닝 이론 모델에 의하여 잘 설명되었다. [1]

[1] Y. Lee et al., Boosting quantum yields in 2D semiconductors via proximal metal plates, arXiv:2012.12114

Keywords:

엑시톤, 2 차원반도체, 유전체스크리닝, 양자효율, 쌍극자

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.01

HsMSH2-HsMSH6 and HsMLH1-HsPMS2 function on G/T DNA mismatch

LEE Jong-Bong *[1,2], YANG Inho [1], LONDON James [3], LOPEZ Juana Martin[3], LIU JuaQuan [3], FISHEL Richard [3]
[1]Physics, POSTECH
[2]Interdisciplinary Bioscience and Bioengineering, POSTECH
[3]Department of Cancer Biology and Genetics, The Ohio State University Wexner Medical Center
jblee@postech.ac.kr

Abstract:

Human mismatch repair is activated by HsMSH2-HsMSH6 homologs (MSH) and HsMLH1-HsPMS2 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. Single-molecule images show that MSH provides a platform for MLH to form a stable sliding clamp on mismatched DNA. We use DNA skybridge method to image labeled Cy5-MSH, Cy3-MLH and Alexa488-G/T DNA mismatch. The mechanics of sliding clamp progression solves a significant operational puzzle in MMR

Keywords:

mismatch repair, Lynch syndrome, HNPCC, single molecule, sliding clamp

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.02

Single-Molecule Imaging Reveals Physical Characteristics of Phi29 DNA Polymerase and R-loop Collision during Replication

SHIN Woohee [1], LEE Ja Yil *[1]
[1]School of Life Sciences, UNIST
biojayil@unist.ac.kr

Abstract:

Phi29 DNA polymerase (Phi29 DNAp) is a bacteriophage Phi29 DNA polymerase that not only unwinds DNA duplex but also synthesizes DNA with exceptionally high processivity. Numerous applications have been developed using Phi29 DNAp. Here, we precisely characterize the physical properties of Phi29 DNAp by visualizing the replication by Phi29 DNAp in real time using a high-throughput single-molecule imaging technique, DNA curtain. We image the fluorescence of RPA-eGPFs, which bind to the displaced single-stranded (ss) DNA while Phi29 DNAp synthesize one strand of DNA in the DNA curtain. The speed of Phi29 DNAp is 100 bp/sec, which is consistent with the previous single-molecule result. The processivity is approximately 20 kbp, which is by far less than the previous bulk estimate because DNA curtain gives single turnover measurement whereas multiple turnovers occur in the bulk measurement. Furthermore, we investigate the collision between Phi29 DNAp and R-loop, a triple-strand construct consisting of an RNA-DNA hybrid and the displaced single-stranded DNA. When Phi29 DNAp encounters an R-loop during replication, Phi29 DNAp is stalled at the R-loop for a long time, suggesting that the R-loop blocks the progression of replication by Phi29 DNAp.

Keywords:

Phi29 DNA polymerase, DNA replication, single-molecule imaging, replication collision with R-loop

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.03

DNA hanger: novel surface-free/multiplexed single-molecule blotting platform

SEOL Jincheol [2], KIM Daehyung [1], KIM Byungju [1], PARK Yeonkyoung [3], JEONG Churlhyun [4], KIM Yoon Ki [3], LEE Jong-Bong [*1,2]
[1]Physics, POSTECH
[2]School of Interdisciplinary Bioscience & Bioengineering, POSTECH
[3]Department of Life Science, Korea University
[4]Center for Theragnosis, Biomedical Research Institute, KIST
jblee@postech.ac.kr

Abstract:

All blotting techniques require surface immobilization of target molecules or substrates. Nonspecific binding of fluorescently labeled molecules to the surface remains a hurdle to make hard to image and analyze target molecules. Especially, highly sensitive single-molecule detection requires super clean surfaces. Here, we introduced a new single-molecule blotting platform that is a surface-condition independent and high-throughput single-molecule optical imaging platform. Furthermore, we demonstrate colocalization of the components in a polyribosome complex during translation using this single-molecule platform, which reveals the structure of the translation initiation complex during translation.

Keywords:

translation, fluorescence microscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.04

Study on the binding affinity of Leucosporidium-derived ice-binding protein (LeIBP) using steered MD simulation

PARK Suhyun [1], KIM Hakjun [2], WU Sangwook [*1]
[1]Department of Physics, Pukyong National University
[2]Department of Chemistry, Pukyong National University
sangwoow@pknu.ac.kr

Abstract:

Ice-etching experiment and molecular docking demonstrated that *Leucosporidium*-derived ice-binding protein (LeIBP) from artic yeast, shows suppression of the growth and re-crystallization of ice, leading to a thermal hysteresis (TH). In this study, we investigated the ice-binding pattern of the LeIBP to ice plane using steered molecular dynamics simulation.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.05

Identification of the core subunit connectivity within the 20S complex

KIM Changwon [2], SHON Min Ju [3], YOON Tae-Young [*2]
[1]Seoul National University
[2]School of Biological Sciences, Seoul National University
[3]Department of Physics, POSTECH
tyyoon@snu.ac.kr

Abstract:

Fueled by ATP hydrolysis in *N*-ethylmaleimide sensitive factor (NSF), the 20S complex disassembles rigid SNARE (soluble NSF attachment protein receptor) complexes in single unraveling steps. This global disassembly distinguishes NSF from other molecular motors that make incremental and processive motions, but the molecular underpinnings of its remarkable energy efficiency remain largely unknown. Using multiple single-molecule methods, we found remarkable cooperativity in mechanical connection between NSF and the SNARE complex, which prevents dysfunctional 20S complexes.

Keywords:

N-ethylmaleimide sensitive factor (NSF), Soluble NSF Attachment protein REceptor (SNARE), Cooperativity, single-molecule FRET

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.06

Polymer brush-induced depletion interactions and clustering of membrane proteins

TOM Anvy Moly[1], KIM Won Kyu *[1], HYEON Changbong [1]
[1]School of Computational Sciences, KIAS
wonkyukim@kias.re.kr

Abstract:

We investigate the effect of mobile polymer brushes on proteins embedded in biological membranes by employing both Asakura-Oosawa type of theoretical model and coarse-grained molecular dynamics simulations. The brush polymer-induced depletion attraction between proteins changes non-monotonically with the size of brush. The depletion interaction, which is determined by the ratio of protein size to the grafting distance between brush polymers, increases linearly with brush size as long as the polymer brush height is shorter than the protein size. When the brush height exceeds the protein size, however, the depletion attraction among proteins is slightly reduced. We also explore the possibility of brush polymer-induced assembly of a large protein cluster, which can be related to one of many molecular mechanisms underlying recent experimental observations of integrin nanocluster formation and signaling.

Keywords:

depletion force, protein clustering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.07

The energetic cost of reducing positional error in biological pattern formation

SONG Yonghyun *[1]
[1]Computational Sciences, KIAS
yonghyun@kias.re.kr

Abstract:

Biological patterns originate from the pre-patterning of tissues by signaling molecules, called morphogens. The reproducibility of the spatial domains patterned by morphogens is limited by the precision of the morphogen profile at the domains' boundary positions. In the classical reaction-diffusion model of morphogen profile formation, the morphogens diffusing away from a localized source of synthesis feature an exponentially decaying concentration profile with a characteristic length λ. Intuitively, producing more morphogen at the source would better serve to generate more precise boundaries; however, it would also incur more thermodynamic cost. Our theory indicates that precise morphogen profiles can be shaped with the minimal thermodynamic cost when λ is roughly half the distance to the target boundary position from the source. Remarkably, we find that the well characterized morphogens patterning the fruit fly embryo and wing imaginal disk have nearly optimal λ, which suggests that the thermodynamic cost imposes an important physical constraint in the biological profile formation.

Keywords:

biological pattern formation, non-equilibrium thermodynamics, developmental biology

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D20.08

Prediction of Biological Effect using Monte carlo Simulation

CHO Il Sung *[1], MIN Sun-Hong [1], PARK Chawon [1], KIM Minho [1], MA Sukhwal [1], HONG Bong Hwan [1]
[1]Medical Accelerator Research Team, KIRAMS
ischo@kirams.re.kr

Abstract:

In radiobiology, the relative biological effectiveness (RBE) is the ratio of the radiation dose of X-ray and the radiation dose of the evaluation radiation that gives the same cell killing effect.Therefore, biological models play an important role in particle ray therapy by linking the physical radiation dose with the prescribed dose in consideration of the cell killing effect. Recently, ion beam therapy has been applied to clinical practice, and many studies are being conducted to apply it to other particle radiation therapy. In this presentation, we would like to present the connection between physical variables and biological effects.

Keywords:

RBE, Monte Carlo simulation, Cell survival, Radiobiology, Radiation therapy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

D21.01

기초연구사업 현황 및 향후 계획, 발표자: 김보열 (과학기술정보통신부 기초연구진흥과장)

김보열*[1]
[1] 과학기술정보통신부 기초연구진흥과장
office@kps.or.kr

Abstract:

- 14:00 - 14:05 인사말 (한국물리학회장, 정책위원장)
- 14:05 - 14:30 기초연구사업 현황 및 향후 계획, 김보열 (과학기술정보통신부 기초연구진흥과장)
- 14:30 - 14:45 패널 의견 제시

  송정현 교수 (건국대)
  정문석 교수 (한양대)
  이홍석 교수 (전북대)
  김현정 교수 (서강대, 정책위원장)

- 14:45 - 15:00 질의 및 응답
- 15:00 폐회사

Keywords:

기초연구사업

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E1.01

Multi-boson physics at CMS

CHANG Philip *[1]
[1]U.C. San Diego, USA
ukyang@snu.ac.kr

Abstract:

The Large Hadron Collider (LHC) at CERN provides the highest energy proton proton (pp) collisions. In 2012, CMS and ATLAS made the discovery of a new particle consistent with the last missing piece of the Standard Model (SM), the Higgs boson. Yet unanswered questions still remain in the SM, for example, whether the couplings between, and the self-couplings of, the electroweak bosons and the Higgs boson are all consistent with the SM. To answer these questions, one must study the rare multi-boson processes. This talk will present the searches for and measurements of the rare multi-boson production processes carried out at the LHC. I will highlight some of the recent results. Lastly, I will discuss the future outlook of multi-boson physics at Run III.

Keywords:

CMS, Run III, LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E1.02

EFT exploration with the LHC Run III data

SKOVPEN Kirill *[1]
[1]Ghent University, Belgium
ukyang@snu.ac.kr

Abstract:

The LHC experiments have been delivering a large number of astonishing results that show a remarkable agreement with the Standard Model predictions. In the assumption that new physics phenomena are associated with higher energy scale, not achievable at the LHC, the induced low-energy effects of its presence can be probed within the Effective Field Theory (EFT) approach. The talk summarizes the past and recent developments in the EFT field and illustrates the EFT application to a number of experimental studies with the LHC Run II data. Several approaches that are used in the ongoing EFT experimental studies, as well as future prospects for exploration of Run II data in the context of EFT, will be discussed.

Keywords:

LHC, Run III, Effective Field Theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E1.03

Long Lived Particles and non-conventional BSM at Run III

ALIMENA Juliette *1
[1]CERN, Swiss
ukyang@snu.ac.kr

Abstract:

Particles with large lifetimes are an important possibility in searches for new phenomena, especially in search for the particle nature of dark matter. Conventional searches at the CERN LHC target promptly decaying particles, but standard model (SM) particle lifetimes span a very wide range, and long lifetimes can generically appear in scenarios beyond the standard model (BSM) as well. I will present a few recent searches for long-lived particles with unconventional signatures from the CMS experiment, and then I will show the prospects for these searches in the upcoming Run III of the LHC.

Keywords:

Run III, beyond the standard model (BSM), LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.01

Classifying pole-skipping points

AHN Yongjun [1], JAHNKE Viktor [1], JEONG Hyun-Sik [2], KIM Keun Young [*1], LEE Kyung-Sun [1], NISHIDA Mitsuhiro [1]
[1]Physics, GIST
[2]Physics, Sogang University
fortoe@gist.ac.kr

Abstract:

We clarify general mathematical and physical properties of pole-skipping points. For this purpose, we analyse scalar and vector fields in hyperbolic space. This setup is chosen because it is simple enough to allow us to obtain analytical expressions for the Green's function and check everything explicitly, while it contains all the essential features of pole-skipping points. We classify pole-skipping points in three types (type-I, II, III). Type-I and Type-II are distinguished by the (limiting) behavior of the Green's function near the
pole-skipping points. Type-III can arise at non-integer $i₩omega$ values, which is due to a specific UV condition, contrary to the types I and II, which are related to a non-unique near horizon boundary condition. We also clarify the relation between the pole-skipping structure of the Green's function and the near horizon analysis. We point out that there are subtle cases where the near horizon analysis alone may not be able to capture the existence and properties of the pole-skipping points.

Keywords:

Pole-skipping

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.02

Holographic teleportation in higher dimensions

KIM Keun Young *[1], AHN Byoungjoon [1], AHN Yongjun [1], BAK Sang-Eon [1], JAHNKE Victor [1]
[1]Physics, GIST
fortoe@gist.ac.kr

Abstract:

We study higher-dimensional traversable wormholes in the context of Rindler-AdS/CFT. The hyperbolic slicing of a pure AdS geometry can be thought of as topological black hole that is dual to a conformal field theory in the hyperbolic space. The maximally extended geometry contains two exterior regions (the Rindler wedges of AdS) which are connected by a wormhole. We show that this wormhole can be made traversable by a double trace deformation that violates the average null energy condition (ANEC) in the bulk. We find an analytic formula for the ANEC violation that generalizes Gao-Jafferis- Wall result to higher-dimensional cases, and we show that the same result can be obtained using the eikonal approximation. We discuss how the bound on the information that can be transferred through the wormhole is affected by the dimensionality of the spacetime and the interplay between traversability and scrambling.

Keywords:

Traversable Wormhole, Quantum Teleportation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.03

The exponential growth of OTOC without chaos: an inverted harmonic oscillator

HASHIMOTO Koji [1], HUH Kyoung-Bum [2], KIM Keun Young [*2], WATANABE Ryota [1]
[1]Physics, Osaka University
[2]Physics, GIST
fortoe@gist.ac.kr

Abstract:

We provide a detailed examination of a thermal out-of-time-order correlator (OTOC) growing exponentially in time in systems without chaos. The system is a one-dimensional quantum mechanic with a potential whose part is an inverted harmonic oscillator. We numerically observe the exponential growth of the OTOC when the temperature is higher than a certain threshold. The Lyapunov exponent is found to be of the order of the classical Lyapunov exponent generated at the hilltop, and it remains non-vanishing even at high temperatures. We adopt the various shapes of the potential and find these features universal. The study confirms that the exponential growth of the thermal OTOC does not necessarily mean chaos when the potential includes a local maximum. We also provide a bound for the Lyapunov exponent of the thermal OTOC in generic quantum mechanics in one dimension, which is of the same form as the chaos bound obtained by Maldacena, Shenker, and Stanford.

Keywords:

Gauge-gravity correspondance, Black Holes, Models of Quantum Gravity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.04

Supersymmetric TTbar Deformation and Negative Norm State

YOON Junggi *[1], YI Piljin [1], LEE Kyungsun [2]
[1]Department of Physics, KIAS
[2]Department of Physics, GIST
junggiyoon@gmail.com

Abstract:

We study an irrelevant deformation of 2D QFT — so-called TTbar deformation— generated by composite operator of the energy momentum tensor, which features the universal formula for the deformed spectrum. We demonstrate that the deformed Lagrangian may, in general, depend on the whether we use Noether energy-momentum tensor or covariant one. We present an explicit example in which the deformation by covariant energy-momentum tensor leads to additional degrees of freedom with negative norm. We discuss properties of those negative norm state from a simple quantum mechanical toy model, and show that they can ruin nice physical properties such as unitarity and orthogonality of eigenstates. We investigate the various (SUSY) TTbar deformations of free SUSY model. We find that only one TTbar deformation is independent of negative norm state and we show that this deformed model is equivalent to the Green-Schwarz superstring.

Keywords:

QFT, integrable deformation, TTbar deformation, negative norm state, Green-Schwarz superstring

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.05

Supersymmetric TTbar Deformation and String Theory

YOON Junggi *[1], YI Piljin [1], KIM Keun Young [2], LEE Kyung-Sun [2]
[1]Physics, KIAS
[2]Physics, GIST
junggiyoon@gmail.com

Abstract:

In this talk, we demonstrate the relation between the TTbar deformation and the string theory. The TTbar deformation of 2D free scalar theory is equivalent to the Nambu-Goto theory. This equivalence can be seen in the static gauge and the lightcone gauge. The former gives the deformed Hamitonian density in terms of the undeformed Hamiltonian density while the latter leads to the deformed Hamiltonian in terms of the undeformed Hamiltonian. We can extend the connection between the TTbar deformed theory and the string theory to fermion. Specifically, we study for the TTbar deformation of free SUSY theory. It turns out that it is equivalent to the Green-Schwarz superstring theory with uniform lightcone gauge. We discuss the dictionary between Green-Schwarz superstring and the TTbar deformation.

Keywords:

TTbar deformation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E2.06

5D BPS quiver and KK towers

DUAN Zhihao [1], GHIM Dongwook *[1], YI Piljin [1]
[1]School of Physics, KIAS
sg1841@snu.ac.kr

Abstract:

This talk will present recent progress in computing (refined) Witten index of BPS quiver for 5d gauge theories, compactified on a circle.
With stringy BPS objects in 5d theory being wrapped on the circle, the wall-crossing problem of 4d KK theory can be addressed by N=4 quiver quantum mechanics. However, the fine-tuned superpotential of the latter makes many of the known machinery fail to capture its Witten indices. I will show how the subtlety can be bypassed for a restricted class of BPS quivers.
Specifically, I will construct the entire KK tower of Cartan components in vector multiplets, based on L2 cohomology counting. Then the analysis will be extended to purely electric BPS particles without magnetic or instanton charges in the weak coupling chamber.

Keywords:

supersymmetry, gauge theory, Witten index, Seiberg-Witten theory, BPS state

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E3.01

Effects of symmetry energy on inhomogeneous nuclear matter in core-collapse supernovae

TOGASHI Hajime *1
[1]Tohoku University
togashi@nucl.phys.tohoku.ac.jp

Abstract:

I investigate the effects of nuclear saturation properties on equations of state (EOS) for inhomogeneous nuclear matter at finite temperatures. In order to examine systematically empirical relations between the symmetry energy and properties of hot dense matter, various nuclear EOSs are constructed by using the Thomas-Fermi approximation based on macroscopic uniform EOSs whose saturation parameters differ from each other.
It is found that the mass of heavy nuclei appearing in neutron-rich matter becomes larger as the density derivative coefficient of the symmetry energy decreases. On the other hand, for symmetric nuclear matter, the species of heavy nuclei in non-uniform phase is insensitive to the symmetry energy.
In the presentation, I will report on the systematic properties of the inhomogeneous nuclear matter at finite temperatures and discuss the effects of the symmetry energy on the particle compositions in the low-density supernova matter in more details.

Keywords:

Nuclear matter, Nuclear EOS, symmetry energy, Neutron stars, Supernovae

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E3.02

Study of Nuclear Shapes for Neutron Rich Isotopes

CHOI Seonho *[1,2], HA Jeongsu [1,2], BAE Sunghan [1,2], CHOI Hyunsuk [1,2]
[1]Department of Physics & Astronomy, Seoul National University
[2]Institute for Nuclear & Particle Astrophysics, Seoul National University
leojustin@gmail.com

Abstract:

With the advance of RI accelerators worldwide, it is possible to study unstable nuclei in various ways. One of the main goals of the RI physics is the measurement of the basic properties of these unstable isotopes, such as, mass, lifetime, energy levels, etc. Among these, the study of their shapes gives some interesting features covering both quantum and classical physics. Not just for simple curiosity, the shapes of the neutron rich RI can provide valuable information on the microscopic interaction between the individual nucleons, which is one of the starting points in nuclear physics. There have been developed several experimental ways to observe deformations from spherical shapes and the study is on-going at every RI accelerator in the world. After brief review on the topic, the focus will move to two experiments to which my group has participated and of which the data were analyzed by the students. One experiment involves the study of rotational band structure and the other uses laser ionization spectroscopy of the atomic hyperfine structure of RI atoms. After the description of the experiments and results, a personal view on the future of this topic will be presented.

Keywords:

RI, neutron-rich isotopes, nuclear shape, gamma spectroscopy, laser ionization spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E3.03

Reaching towards N=126 Shell Closure using Multi-Nucleon Transfer Reaction of 136Xe+198Pt

KIM Yung Hee *1
[1]Nuclear and particle physics group, Institut Laue Langevin
cosmic0001@gmail.com

Abstract:

Nuclei far from the valley of stability provide new vistas for searching and understanding the simple and regular patterns in complex nuclei. The extremes of the nuclear landscape not only allow examining specific aspects of the nuclear interaction but also provide in certain cases valuable inputs for understanding astrophysically important processes such as the r-processes responsible for elemental synthesis heavier than iron. The recent discovery of gravitational waves from neutron star merger and measurement of r-process element strontium in the debris has sustainably increased the interest.
Studies of the excited states of nuclei at and near the shell closures provide special benchmarks for our understanding of nuclear structure. The neutron-rich unstable nuclei in the vicinity of neutron magic numbers are relatively well studied far from the stability line up to the magic number N = 82. This region is accessible using conventional production mechanisms such as fission or fragmentation. However, for the more neutron-rich nuclei to the south of 208Pb, there is limited knowledge of the excited states of these nuclei. This arises from the difficulty in producing these nuclei using conventional methods. This results in a so-called "blank spot" in the chart of nuclei, where the experimental data are lacking. Even for nuclei that have been already produced, basic properties such as the first-excited states are not well known.
A new proposal at GANIL has been approved to measure the energies of the unknown low-lying excited states of neutron-rich isotopes with N=126 and other neighboring nuclei, which are difficult to produce. These nuclei will be produced by multi-nucleon transfer reactions of 136Xe beam + 198Pt target at a beam energy of 7 MeV/u. The new experiment is based on the previous measurement at a beam energy of 8 MeV/u in the same system, which demonstrated the feasibility of producing nuclei around N=126 by absolute production cross sections for various residues of the target-like fragments (TLF) deduced from the projectile-like fragments (PLF). In the new experiment, PLF will be detected and isotopically identified by a much improved VAMOS++ spectrometer and the complementary TLF will be detected directly by another set of detectors in the relevant angular range. The discrete prompt and delayed gamma rays in coincidence from the excited states of the nuclei of interest will be measured using the AGATA array having 13 triple clusters placed around the target position and 4 EXOGAM Ge detectors placed around the implantation position of the 2nd arm, respectively.

The motivations and experimental details will be presented with an overview of the possible future developments of the topic.

Keywords:

N=126, multi-nucleon transfer reactions, r-process

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E4.01

Ground-based Gravitational Wave Detections and Their Implications

KANG Gungwon *[1]
[1]CAU High Energy Physics Center, Chung-Ang University
gwkang@cau.ac.kr

Abstract:

A bit of historical review is given for the concept of gravitational waves and detection experiments. In the presence of gravitational waves, it is frequently asked whether the laser light gets stretched and shrunk in the same way as the mirror distances in the interferometer so that gravitational waves cannot be measured. To answer this question, we have reviewed the interaction between light and gravitational waves carefully in both the transverse-traceless (TT) gauge and the proper detector or locally Lorentz frame. In the TT frame, the laser light directly interacts with gravitational waves, its frequency gets modified, but mirrors remain at rest to the linear order of a gravitational wave perturbation. In the detector frame, on the other hand, the frequency of light does not change while "distances" between the beam splitter and the mirrors get modified. Recent results for gravitational wave observations up to the first half of the third observation run in the advanced LIGO and the advanced Virgo are briefly summarized. Tests of general relativity based on gravitational wave data observed during O1 and O2 are described. These tests include residual and inspiral-merger-ringdown signal consistency tests, parameterized deviations in the waveform model, and constraint on the speed of gravitational waves by comparisons with the propagation of the electro-magnetic counterpart observed in the binary neutron star merger event. Some interesting events observed during O3a are also discussed.

Keywords:

Gravitational waves, Ground-based detectors, LIGO, Virgo, KAGRA

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E4.02

Studying Fundamental Physics from Early Universe Cosmology

GONG Jinn-Ouk *[1]
[1]Department of Science Education, Ewha Womans University
jinn.ouk.gong@gmail.com

Abstract:

I discuss the cosmological opportunities for studying fundamental physics yet to be discovered. I discuss the lessons we can gain from novel signatures which may well be potentially observable by planned experiment programs.

Keywords:

Cosmology

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E4.03

Research on dark universe using large scale structure of the universe

SONG Yong Seon *[1]
[1]KASI
ysong@kasi.re.kr

Abstract:

The recent progress in understanding the universe, and the massive astronomical data sets from planned surveys, provide unique opportunities to test fundamental laws of physics on cosmic scales. These lead us to new frontiers exploring the origin and fate of the Universe, the detection of invisible dark matter, and the nature of dark energy or gravity beyond Einstein. The next generation of deep wide-field surveys provide a fertile ground for expanding our knowledge and addressing cosmological questions. We are engaged in several of these major cosmological endeavors, such as the premier spectroscopy wide field survey of the Dark Energy Spectroscopy Instrument, the premier imaging wide field survey of Large Synoptic Survey Telescope, and the unprecedently deep and high resolution Giant Magellan Telescope. Their astronomical data will not only lead to a deeper understanding of our Universe, but deliver new, unexpected discoveries that expand our science framework. We will become central investigators of critical questions about the Universe beyond present knowledge: 1) Initial Seeds - beyond the simplest model of early universe inflation, 2) Dark Matter - beyond the invisibility of dark matter, and 3) Dark Energy - beyond Einstein's gravity and vanishing vacuum energy.

Keywords:

Dark Energy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E4.04

Neutron Star Properties from Astrophysical Observations

KIM Young-Min *[1], KIM Myungkuk [1], KWAK Kyujin [1], LEE Chang-Hwan [2], CHO Hee-Suk [2], CHOI Yong-Beom [2], HYUN Chang Ho [3]
[1]Department of Physics, UNIST
[2]Department of Physics, Pusan National University
[3]Department of Physics Education, Daegu University
ymkim715@gmail.com

Abstract:

A neutron star (NS) is a compact object under the circumstance of the strong gravity in the Universe, and it's related to the origin of high energy astrophysical phenomena such as pulsar, X-ray burst, Gamma-ray burst, etc. Recently, simultaneous measurements of the masses and the radii of neutron stars from X-ray observations by the Neutron Star Interior Composition Explorer (NICER) have been reported. In addition, gravitational wave detections from the mergers of neutron star binaries by LIGO and Virgo allowed us to estimate the tidal deformability of neutron stars. The measured properties of NS is highly dependent on the equation of state (EoS) in the interior of NS. The central density of NS is up to about several nuclear saturation density, and the understanding of the dense matter like the interior of NS is also an important issue in nuclear physics.
In this presentation, we review the implication of the neutron star properties measured by gravitational-wave and x-ray observations. We also discuss the effect of the EoS on the properties of NS including our recent works.

Keywords:

Neutron Star, Low-mass X-ray binary, Gravitational waves, Tidal deformability, Equation of State

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E5.01

Strain-controlled transition from a weak to strong topological insulator phase in a quasi-one-dimensional superconductor

KIM Sunghun *[1]
[1]Department of Physics, KAIST
sunghun.kim@kaist.ac.kr

Abstract:

Topological superconductor has attracted wide interest as it is expected to be a good system which leads Majorana quasiparticles. The superconductivity with a topologically nontrivial phase is believed to be a prerequisite for the topological superconductor that several materials such as heterostructure systems between superconductor and topological insulator, or superconductors which possess topological surface state have been examined as proper candidates to study this unique superconductivity. Transition-metal trichalcogenide $TaSe_3$ is a quasi-one-dimensional (quasi-1D) superconductor predicted to have nontrivial topological property that can be another good system to be a novel superconductor. Interestingly, it locates at the boundary between two different topological insulator phases, a strong and a weak topological insulator, depending on the lattice size. This suggests that its topological phase can be controlled by an external strain, thus, a superconductor coupled with two different topological phases can be realized.

In this talk, I present our recent work of the demonstration of the strain-driven topological phase transition in a qausi-1D superconductor $TaSe_3$. Using angle-resolved photoemission spectroscopy and first-principles calculation, we identified that $TaSe_3$ is in weak topological insulator phase of Z_2 topological invariants (0;101) by observing band inversion gap without any signature of topological surface state on the cleaved (10-1) plane. In addition, we revealed that topological surface state appears on the very surface of (10-1) plane accompanied with Z_2 invariant change to (1;010), by applying an uniaxial tensile strain along the chain direction. This indicates the phase transition from weak to strong topological insulator in the quasi-1D superconductor. These results provide a new platform to study the superconductivity in two different topological insulator phase which can lead further understanding of the topological superconductor.

Keywords:

Strain, ARPES, Topological insulator, Superconductor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E5.02

Strain tuning of the metal insulator transition of Ca_2RuO_4 in angle resolved photoemission experiments

RICCò S. [1], TAMAI A. [1], KIM M. [2,3], PERRY R.S. [4], GEORGES A. [1,2,3,5], BAUMBERGER F. *[1,6]
[1]Department of Quantum Matter Physics, University of Geneva
[2]Centre de Physique Théorique Ecole Polytechnique, CNRS, Universite Paris-Saclay
[3]College de France
[4]London Centre for Nanotechnology and UCL Centre for Materials Discovery, University College London
[5]Center for Computational Quantum Physics, Flatiron Institute
[6]Swiss Light Source, Paul Scherrer Institut
felix.baumberger@unige.ch

Abstract:

We report the evolution of the *k*-space electronic structure of lightly doped Ca_2RuO_4 with quasi-continuous external strain [S. Riccò et al. Nat. Comm. 9, 4535 (2018)]. Using ultrathin plate-like crystals mounted on flexible substrates, we achieve uniaxial strain levels up to −4.1%, sufficient to suppress the Mott phase and access the previously unexplored metallic state at low temperature. Angle-resolved photoemission experiments performed while tuning the uniaxial strain reveal that metallicity emerges from a marked redistribution of charge within the Ru t_{2g} shell, accompanied by a sudden collapse of the spectral weight in the lower Hubbard band and the emergence of a well-defined Fermi surface which is devoid of pseudogaps. Our results highlight the profound roles of lattice energetics and of the multiorbital nature of Ca_2RuO_4 in this archetypal Mott transition and open new perspectives for spectroscopic measurements.

References

[1] S. Riccò et al. Nat. Comm. 9, 4535 (2018)

Keywords:

ARPES, uniaxisal strain, Metal-insulator transition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E5.03

ARPES studies of the uniaxial strain-driven Lifshitz transition in Sr_2RuO_4

SUNKO V. [1,2], MORALES E. Abarca[1,2], MARKOVIć, I. [1,2], BARBER M.E. [2], MILOSAVLJEVIć D. [2], MAZZOLA F. [1], SOKOLOV D. [2], KIKUGAWA N. [3], CACHO C. [4], WATSON M.D. [4], DUDIN P. [4], ROSNER H. [2], HICKS C.W. [2], MACKENZIE A.P. [1,2], KING Phil [*1]
[1]School of Physics and Astronomy, University of St Andrews
[2]Max Planck Institute for Chemical Physics of Solids
[3]National Institute for Materials Science
[4]Diamond Light Source
philip.king@st-andrews.ac.uk

Abstract:

Application of controlled uniaxial pressure has recently been shown to more than double the transition temperature of the unconventional superconductor Sr_2RuO_4, leading to a pronounced peak in T_c versus strain whose origin is still under active debate.[1–3] We have developed a simple and compact method to passively apply large (ca. 1%) uniaxial pressures in restricted sample environments. In this talk, I will describe this strain device, and its application to study the evolution of the electronic structure of Sr_2RuO_4 using angle-resolved photoemission.[4] Through this, we directly visualise how uniaxial stress drives a Lifshitz transition of the ɣ-band Fermi surface, pointing to the key role of strain-tuning its associated van Hove singularity to the Fermi level in mediating the peak in T_c. Our measurements of how the Lifshitz transition is traversed with increasing strain further provide stringent constraints for theoretical models of the electronic structure evolution of Sr_2RuO_4.

[1] Steppke *et al.*, Science 355 (2017) eaaf9398
[2] Barber *et al.*, Phys. Rev. Lett. 120 (2018) 076602
[3] Liu et al., npj Quantum Mater. 2 (2017) 12
[4] Sunko et al. npj Quantum Mater. 4 (2019) 46

Keywords:

ARPES, uniaxial strain, Lifshitz transition, superconductivity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E6.01

Development trend for high magnetic field research magnets using ReBCO tapes

LEE SangGap *[1]
[1]KBSI
sgl757@kbsi.re.kr

Abstract:

The second-generation high-temperature superconducting ReBCO (Rare-earth Barium Copper Oxide) tape has a high critical current density even in a high magnetic field of 25 T or higher. For this reason, the application of ReBCO tapes has recently been active in the development of magnets for use in high magnetic field NMR and physical properties measurement. In this talk, we review the recent development of high magnetic field research magnets using ReBCO tapes. In particular, we introduce detailed results of the recent development of a 400 MHz (9.4 T) all-ReBCO NMR magnet carried out at KBSI and discuss its applicability as a magnet for use in high-resolution NMR.

Keywords:

high-field magnet, high-field research magnet development, ReBCO, ReBCO NMR magnet

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E6.02

Temperature dependent anomalous Hall effect in Temperature dependent anomalous Hall effect in itinerant ferromagnets

JO Youn Jung *[1]
[1]Physics, Kyungpook National University
jophy@knu.ac.kr

Abstract:

Pyrite cubic CoS_2 is an itinerant ferromagnet which can be engineered by chemical doping. We have measured magnetoresistance(MR) and anomalous Hall effect(AHE) of pristine CoS_2 and Ni doped CoS_2 single crystals. CoS_2 shows a large positive MR at low temperature, which is suppressed as soon as the Ni doping level increases. We found that the (Co, Ni)S_2 single crystals exhibit negative coefficients of ordinary Hall effect and positive saturation values of anomalous Hall resistivity at low temperature. Both values change the sign on a pristine sample as the temperature increases. Ni-doped samples have almost temperature-independent ordinary Hall coefficients below ferromagnetic transition temperature, T_c, and a maximum saturation value of anomalous Hall resistivity at slightly lower than T_c. At last, we compare the Hall angle and Hall factor of (Co, Ni)S_2 with previously reported data for other AHE materials.

Keywords:

itinerant ferromagnet, quantum oscillation, anomalous Hall effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E6.03

High magnetic field phase diagram of a quasi-two-dimensional square lattice antiferromagnet with strong single-ion anisotropy.

LEE Minseong *[1], SCHOENEMANN Rico Uwe[1], JAIME Marcelo [1], ZAPF Vivien S.[1]
[1]Los Alamos National Laboratory, Los Alamos National Laboratory
minseong.lee10k@gmail.com

Abstract:

In the first part of this talk, I introduce several types of nondestructive pulsed magnets which can provide the peak fields ranging from 60 to 100 T at the National High Magnetic Laboratory Pulsed Field Facility at Los Alamos National Laboratory. Then I briefly discuss measurement techniques that are performed under the pulsed magnetic fields, including magnetization, polarization, transport, magnetocaloric effect, and magnetostriction measurement utilizing Fiber Bragg Grating (FBG) sensors, and physics associated with those measurement techniques. In the second part of this talk, we combine the high field measurement techniques introduced in the first part of this talk to reveal the properties of a quasi-two-dimensional square lattice antiferromagnet, which comprises square spin – 2 Fe^{2+} lattice layers separated by a nonmagnetic layer. At low temperatures below Neel temperature about 5 K, with an increasing magnetic field, the material undergoes a series of spin-state transitions changing the magnitude and directions of spins due to the abnormally strong single magnetic ion anisotropy. Our results of magnetocaloric effect and FBG measurement indicate the existence of a quantum phase transition to the fully polarized spin state around 50 T. Based on the magnetic phase diagram completed from the various high field measurement technique, we discuss the possible realization of the magnetic superfluid and supersolid phases and the nature of the unconventional multiferroic quantum critical point at the transition to the fully polarized state.

Keywords:

H-T phase diagram, high magnetic field measurements, quasi two dimensional square lattice antiferromagnet

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E6.04

Observation of itinerant quantum criticality in La-diluted $CeIn_3$ under pressure

PARK Tuson *[1], LEE Hanoh [1], KIM Suyoung [1], JANG Haraim [1], LEE Sangyun [2], PARK Chan-Koo [1], SEO Soonbeom [1], GU Dachun [1], KIM Sung-Il [1], KIM In-Ceol [1]
[1]Physics, Sungkyunkwan University
[2]MPA-Quantum, Los Alamos National Laboratory
tp8701@skku.edu

Abstract:

$CeIn_3$ is the representative Kondo lattice system compound which has the antiferromagnetic (AFM) transition at 10 K in ambient pressure. The AFM transition temperature (T_N) is suppressed with increasing pressure and disappears completely at the quantum critical point (QCP) around 2.65 GPa (P_c). When La is substituted for Ce, T_N decreases due to the dilution effect of Ce magnetic moments. In this study, we have measured transport and a.c calorimetry of $CeIn_3$ by simultaneously applying both La-substitution and pressure to explore the nature of the QCP. When 20, 40, and 50% La are substituted for $CeIn_3$, T_N is suppressed to 8, 6, and 4 K, respectively. The corresponding P_c is also reduced to 2.47, 1.98, and 1.31 GPa for 20, 40, and 50% La are substituted samples, respectively. While T_N decreases smoothly with respect to the pressure and La-substitution, the electrical resistivity at T_N changes its shape from a sharp drop to a gap-like hump across a pressure (P_1) which is lower than P_c. Moreover, in the Hall coefficient, a broad maximum appears above P_1 at the temperature (T_m) similar to the one below which itinerant property is observed in NQR measurement of the pure $CeIn_3$ [1]. These behaviors are observed in the samples with all the La concentrations, suggesting an emergence of itinerant state below T_m at $P > P_1$. Besides, T^2 behavior in resistivity is observed above T_N in La-diluted samples even at $P < P_c$ before the AFM is completely suppressed, indicating that Fermi liquid state may be developed while AFM state still exists. Taken together, these results suggest that the nature of the QCP in La-diluted $CeIn_3$ is an itinerant type rather than the Kondo breakdown type.

[1] S. Kawasaki, *et al.* Pressure-induced unconventional superconductivity in the heavy-fermion antiferromagnet $CeIn_3$: An ^{115}In-NQR study under pressure. *Phys Rev B*. **77**(6), 064508 (2008)

Keywords:

Kondo lattice system, Quantum critical point, Anomalous Hall effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.01

Electronic structure and catalytic behavior of layered Pt_3Te_4

PARK Karam [1], JEONG Sukmin [*1]
[1]Department of Physics, Jeonbuk National University
jsm@jbnu.ac.kr

Abstract:

Transition metal dichalcogenides (TMDC) are promising low-dimensional materials with various properties and tunnable band gaps in van der Waals (vdW) heterostructures. Recently, a new TMDC material composed of a vdW stacked structure of $PtTe_2$ and Pt_2Te_2 has been reported in mineralogical magazine with XRD data and atomic structure [1]. In addition, it has been reported that Pt_3Te_4 is a very effective material for hydrogen evolution reaction (HER) [2]. In this study, we calculate the atomic and electronic structures of $PtTe_2$, Pt_2Te_2, Pt_2Te_2–$PtTe_2$ bilayer and bulk Pt_3Te_4 using density functional theory (DFT). Due to the very weak vdW interaction, the charge transfer between layers of Pt3Te4 is very small. $PtTe_2$ and PtTe, which exist almost independently in Pt_3Te_4 bulk, show the characteristics of insulator (topological insulator) and conductor, respectively. As a result, it is also a conductor in complete Pt_3Te_4. It can also partially confirm the presence of electron and hole pocket. The wave functions of bulk Pt_3Te_4 are spatially separated like a double layer system. Additionally, we discuss the possibility of HER through the calculation of the Gibbs free energy at the defects and edges of Pt_3Te_4.

[1] Mineralogical Magazine, 2018, 83(4), 523–530.
[2] ACS Appl. Mater. Interfaces 2021, 13, 2, 2437–2446

Keywords:

DFT, TMDC, Hydrogen evolution reatcion, PtTe2, Pt3Te4

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.02

Non-Hermitian localizations on the kagome lattice

KIM Sangbum [1], KIM Kihong [*1]
[1]Department of Physics, Ajou University
khkim@ajou.ac.kr

Abstract:

We study numerically Anderson localization phenomena of a two-dimensional non-Hermitian Anderson model with a random on-site scalar potential and a constant imaginary vector potential on the kagome lattice. The eigenenergies and eigenfunctions of the non-Hermitian Hamiltonian are computed, together with the inverse participation ratio, for a wide range of parameter values. The kagome lattice contains a flat band as well as dispersive bands. We focus on the differences between the states in the dispersive bands and those in the flat band in the dependence of the localization behavior on the strength of the imaginary vector potential. Most states remain localized when the imaginary vector potential is weak. Delocalization arises at larger values of the imaginary vector potential and the eigenvalues obtain nonzero imaginary parts similarly to the Hatano-Nelson theory. As the strength of the imaginary vector potential increases, the number of localized states reaches a minimum and then increases again to reach a constant value. This suggests a delicate interplay between the states in the flat band and the non-Hermitian field. We explore the dependence of the participation ratio on the magnitude and the direction of the imaginary vector potential in detail and provide their physical explanations.

Keywords:

Non-Hermitian localization, Imaginary vector potential, Kagome lattice, Flat band

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.03

Strain tuned topological properties in type-II Dirac semimetal NiTe2

LEE Jaekwang *[1], NGUYEN PHUONG LIEN [1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

The trigonal-phase transition-metal dichalcogenides (TMDs) have attracted considerable attention as topological semimetals hosting new types of low-energy quasiparticles such as type-I and type-II Dirac and Weyl fermions. The significant feature of this material classification is the strong tilted 3D Dirac cone, where electron/hole-like pockets touch at the Dirac point along a certain momentum direction in the electronic band structure. Here, by performing density functional theory calculations, we systematically study the electronic and topological properties of type-II Dirac semimetal $NiTe_2$ under a biaxial strain. We find that the biaxial strain shifts in energy to the position of the Dirac point and breaks electron-hole symmetry and then modulate electronic and topological properties. In this presentation, strain tuned topological properties in type-II Dirac semimetal $NiTe_2$ will be discussed in detail.

Keywords:

TMDs, Dirac semimetal, NiTe2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.04

Synergistic effect between pyridinic and graphitic nitrogen dopants in graphene for oxygen reduction reaction

NOH Min Jong [1], KIM Yong-Hoon *[1]
[1]School of Electrical Engineering, KAIST
y.h.kim@kaist.ac.kr

Abstract:

Nitrogen (N) dopants on carbon materials play a crucial role in metal-free carbon catalysis, while the role of pyridinic nitrogen (N^{py}) or graphitic nitrogen (N^{gr}) is still on debate. In this work, N-doped graphenes were employed to catalyze the oxygen reduction reaction (ORR). We observed a significant enhancement of ORR activity caused by the incorporation of nitrogen dopants when the N^{gr} is located in nearby the N^{py} region. This synergistic attribute was rationalized by thorough density functional theory calculations and different catalytic functions of N^{gr} and N^{py} in types of graphene (basal/edge or armchair/zigzag) were systematically demonstrated. We also suggest a novel ORR mechanism behind the improvement, which may provide design rules to generate active sites. These theoretical findings are expected to pave a way to the rational design of high-performance metal-free carbon catalysts.

Keywords:

Density functional theory, nitrogen doped graphene, oxygen reduction reaction, synergistic effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.05

Peierls-type metal-insulator transition in NbO_2/MoO_2 superlattices

JUNG Sungyeb [1], JEEN Hyoungjeen [1], LEE Jaekwang *[1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

Using the first-principles density functional theory (DFT) calculations, we have examined the metal-insulator phase transition in $(NbO_2)_x/(MoO_2)_{8-x}$ superlattices with varying thickness of the NbO_2, x = 0–8. Here, we found that novel Peierls-type insulating state in $(NbO_2)/(MoO_2)$ superlattices is driven by the strongly distorted cation-cation dimer chains accompanied by structural phase transition. The degree of Peierls distortion is quantitatively described in terms of the cation-cation dimer ratio. In this presentation, the relationship between structure and electronic properties, and will be presented and discussed along with experimental results.

Keywords:

Peierls distortion, Metal-insulator transition, Density functional theory, rutile

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.06

First principle study of shift current mechanism in organic molecular solids and perovskite solids

KIM Bumseop [1], KIM Jeongwoo [*2], PARK Noejung [*1]
[1]UNIST
[2]Physics, Incheon National University
kjwlou@gmail.com, noejung@unist.ac.kr

Abstract:

Bulk photovoltaic effect characterized by the generation of a steady photocurrent without the aid of an external p-n junction has attracted a lot of attention due to its novel physics and potential for high-performance solar cell devices. We briefly introduce the basic theory of bulk photovoltaic effect and show the electronic origin and photocurrent mechanism in organic molecular solids (TTF-CA) and hybrid halide perovskite ($MAPbI_3$ and $FAPbI_3$). For TTF-CA, we show the electronic origin of the photovoltaic property of TTF-CA at low temperature (< 81 K). In the high-temperature phase, despite a net zero current, a non-vanishing shift current can be generated by the interchain effect. In addition, we find that the ferroelectric polarization of the hybrid halide perovskite is largely dominated by the ionic contribution of the molecular cation. In contrast, the photovoltaic nature is mostly determined by the intrinsic electronic band properties near the Fermi level, originating from iodine to lead atoms (inorganic backbone). Our results provide a fundamental understanding of intriguing bulk photovoltaic materials and pave a way for their practical applications.

Keywords:

DFT, Electronic structure, shift current, Bulk photovoltaic effect, perovskite halide

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E7.07

Topological phases in N-layer rhombohedral graphene boron-nitride moire superlattices

GONZALEZ David Andres Galeano[1,2], CHITTARI Bheema Lingam[1,3], PARK Youngju [1], SUN Jin-Hua [4], JUNG Jeil *[1,5]
[1]Department of Physics, University of Seoul
[2]Instituto de Fisica, Universidad de Antioquia
[3]Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata
[4]The Research Institute of Advanced Technologies, Ningbo University
[5]Department of Smart Cities, University of Seoul
jeiljung@uos.ac.kr

Abstract:

Rhombohedral N=3 trilayer graphene on hexagonal boron nitride (TLG/BN) hosts gate-tunable, valley-contrasting, nearly flat topological bands that can trigger spontaneous quantum Hall phases under appropriate conditions of the valley and spin polarization. Recent experiments have shown signatures of C = 2 valley Chern bands at 1/4 hole filling, in contrast to the predicted value of C = 3. We discuss the low-energy model for rhombohedral N-layer graphene (N = 1, 2, 3) aligned with hexagonal boron nitride (hBN) subject to off-diagonal moire vector potential terms that can alter the valley Chern numbers. Our analysis suggests that topological phase transitions of the flat bands can be triggered by pseudo magnetic vector field potentials associated with moire strain patterns and that a nematic order with broken rotational symmetry can lead to valley Chern numbers that are in agreement with recent Hall conductivity observations.

Keywords:

Topological phase transition, Pseudomagnetic vector field potentials, N-layer ABC graphene on boron nitride moire superlattices

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.01

Development of NEMS-based Thermal Hall Bar for Two-dimensional Quantum Fluids

KIM Ryundon [1], CHOI Hyunjin [1], JEONG Jinhoon [1], KIM Kitak [1], SUH Junho [*2], CHOI Hyoungsoon [*1]
[1]Department of Physics, KAIST
[2]Quantum Technology Institute, KRISS
junho.suh@kriss.re.kr, h.choi@kaist.ac.kr

Abstract:

Transport measurements provide foundational information for our understanding of a material, and along with the fact that electrical conductivity, both ac and dc, has been one of the most accessible properties to measure, electrical transport of materials has been extensively studied. However, the electrical transport properties can only be measured for conductors. One needs to measure an alternative properties for a whole class of materials that are insulating, and thermal conductivity is a good example. Despite its usefulness, thermal conductivity measurements on quantum fluids, especially in two dimensions, have been carried out in limited occasions due to the difficulty of the task. Here we present a thermal Hall bar, a nano-electromechanical system specifically designed for that purpose. A suspended plate serves as a substrate on which two dimensional quantum fluids can be deposited, and four nano-mechanical wires attached to the plate serves as local thermometers based on the vibration wire thermometry. The resonant properties of the individual wires are measured and comparison is made with simulations.

Keywords:

Quantum fluid, Two dimensional, Thermal conductivity, NEMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.02

Thermoelectric origin of triboelectric charging and series

SHIN Eui-Cheol [1], KIM Yong-Hyun *[1,2]
[1]Department of Physics, KAIST
[2]Graduate School of Nanoscience and Technology, KAIST
yong.hyun.kim@kaist.ac.kr

Abstract:

Triboelectricity has been poorly understood for a long time from ancient Greece to today. Here we report a simple thermoelectric physics of triboelectric charging and series, which can be a final answer of the unsolved mystery. We have revealed that the dissipation of frictional energy forms a temperature distribution in material and thus creates an electrostatic potential difference at the interface, which initiates charge transfer. We have found that triboelectricity is governed and quantified by the density, specific heat, thermal conductivity, and Seebeck coefficient of each material. Our findings are expected to contribute to delicate maneuvering in a variety of fields, from the efficient enhancement of triboelectric nanogenerators to safety issues at airplanes and gas stations in daily life.

Keywords:

Thermoelectric, Triboelectricity, Triboelectric Nanogenerator (TENG), Energy Harvesting

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.03

Investigation on surface chemical states of $SrTiO_3$ (001) with Ambient Pressure XPS

SONG Chanyang [1], LIM Hojoon [1], SEO Minsik [1], KIM Dongwoo [1], KIM Geonhwa [2], JUNG Moonjung [1], YU Youngseok [2], KIM Seunghwan [1], KANG Habin [1], KIM Ki-jeong [2], MUN Bongjin Simon [*1]
[1]Department of Physics and Photon Science, GIST
[2]8A2 AP-XPS Beamline, Pohang Accelerator Laboratory
bsmun@gist.ac.kr

Abstract:

In heterostructure device, any slight changes in physical/chemical characteristics of interface, e.g., space charges, band alignment, chemical structure, can contribute significant affects to transport and electronic properties of devices. The formation of 2-dimensional electron gas at the interface of $LaAlO_3$/ $SrTiO_3$ is a good example. Clearly, the design and control of interface has become major interest in the community of devices physics.

As well known, $SrTiO_3$ has been a popular choice for ideal substrate for the growth of ferroelectric materials due to its ideal physical and chemical properties for the growth of ferroelectric overlayer. To identify the roles of $SrTiO_3$ as substrate, we investigated the surface properties of $SrTiO_3$ under device fabrication condition, e.g. elevated oxygen partial pressure, high temperature. Synchrotron-based ambient pressure x-ray photoelectron spectroscopy and low energy electron diffraction measurements were utilized to analyze surface states of $SrTiO_3$ (001) under 0.1 mbar oxygen pressure and UHV condition. Under oxygen annealing condition, the formation of well-ordered SrO_{1+x} surface oxide was observed on Ti-terminated surface with 0.6 eV charge accumulation effect.

Keywords:

SrTiO3, AP-XPS, SrO formation, surface electron structure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.04

Control over the Dirac plasmon with intense terahertz radiation

LEE Bumjoo [1,2], IN Chihun [2], KIM Tae Hoon [2], CHOI Hyunyong [2], NOH Tae Won *[1,2]
[1]Institute of Basic Science, Center for Correlated Electrons Systems
[2]Department of Physics and Astronomy, Seoul National University
twnoh@snu.ac.kr

Abstract:

The materials hosting Dirac fermions, such as graphene or topological insulator, have attracted great interest by their possibility for the photonic functionalities. For example, the linear energy dispersion relation of the Dirac band itself is expected to give rise to a strong nonlinear electromagnetic wave response, especially in a low-energy, terahertz regime. In such a situation where the light-matter interaction acts an important role, tuning a plasmon excitation is an intuitive way to control such functionalities. In our work, we prepared a stripe patterned topological insulator sample, where the periodic pattern provides the momentum to enable a direct photon-plasmon interaction. We excited the sample with an intense terahertz radiation polarized along the pattern, where the terahertz field cannot directly excite the plasmon. Then, we observed an ultrafast blueshift of the plasmon resonance frequency in the terahertz regime on a picosecond timescale. We assume such a shift originates from the enhanced electronic temperature by terahertz pump. The low-energy terahertz pump cannot affect the well-known quantities to change the plasmon resonance frequency, such as the carrier density, or the background dielectric constant. However, with the unique property of the linear band, the enhanced electronic temperature can affect the Drude weight, which, in turn, affect the plasmon frequency.

Keywords:

topological insulator, surface plasmon, terahertz, ultrafast

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.05

Density functional theory study of ferromagnetic phase diagram of magic-angle twisted bilayer graphene

CHO Yosep [1], CHOI Young Woo [1], CHOI Hyoung Joon [*1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Magic-angle twisted bilayer graphene (TBG) has drawn great attention for its superconducting, insulating, and magnetic phases appearing at different doping concentrations. To understand these phases, density functional theory (DFT) calculations of low-energy band dispersions and magnetic instabilities are required as a function of doping. However, the large number of atoms in the moiré supercell makes DFT calculations very expensive. Here, we develop an efficient and accurate method to calculate electronic and magnetic properties of doped TBGs based on DFT results of undoped TBG. With this method, we investigate doping and temperature dependences of electronic and magnetic properties of doped TBGs. We obtain ferromagnetic phase diagram of TBG as a function of doping and temperature. This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335)

Keywords:

twisted bilayer graphene, magnetism, doping, band structure, DFT

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.06

Electrically-induced high-order optical Hall effect in Weyl semimetal

CHOI Young-Gwan [1], DOAN Manh-Ha [1], KIM Youngkuk [2,3], CHOI Gyungmin [*1,3]
[1]Department of Energy Science, Sungkyunkwan University
[2]Department of Physics, Sungkyunkwan University
[3]Center for Integrated Nanostructure Physics, Institute for Basic Science
gmchoi@skku.edu

Abstract:

Nonlinear optical phenomena can be utilized for exploring exotic natures of topological materials. Recently, it has been studied that even if the system has time-reversal symmetry, Hall effects can occur with intrinsic magnetization properties associated with Berry curvatures in terms of nonlinear phenomena[1-3]. Here, we report a current-induced nonlinear optical Hall effect in a Weyl semimetal WTe_2 without an external magnetic field at room temperature. We observe an electrical-bias-induced third-order Kerr rotation in reflection geometry. We quantitatively extract the fourth-order susceptibility tensor components, and it shows strongly anisotropic values according to the crystalline direction of WTe_2 crystal. As a possible origin, we employ the concept of Berry curvature multipoles by conducting symmetry analysis to explain the non-zero intrinsic magnetization resulting in fourth-order optical effects.

[1] Sodemann, I. & Fu, L. Quantum Nonlinear Hall Effect Induced by Berry Curvature Dipole in Time-Reversal Invariant Materials. *Phys. Rev. Lett.* **115**, 216806 (2015).
[2] Ma, Q. *et al.* Observation of the nonlinear Hall effect under time-reversal-symmetric conditions. *Nature* **565**, 337-342 (2019).
[3] Kang, K., Li, T., Sohn, E., Shan, J. & Mak, K. F. Nonlinear anomalous Hall effect in few-layer WTe_2. *Nat. Mater.* **18**, 324-328 (2019).

Keywords:

Nonlinear effect, Kerr effect, Weyl semimetal, Berry curvature

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E8.07

Study of resonant Auger emission in Pt_3Co alloy with resonant photoemission

MUN Bongjin Simon *[1,2], SEO Minsik [1], KANG Habin [1], KIM Geonhwa [3], JUNG Moonjung [1], BOURNEL Fabrice [4,5], GALLET Jean-Jacques [4,5], KIM Kijeong [3]
[1]Department of Physics and Photon Science, GIST
[2]Laboratory for Electron Spectroscopy for Surface/Interface Chemical Analysis, Center for Advanced X-ray Science
[3]8A2 AP-XPS Beamline, Pohang Accelerator Laboratory
[4]TEMPO Beamline, Synchrotron SOLEIL
[5]Laboratoire de Chimie Physique-Matière et Rayonnement, Sorbonne Universités, Université Pierre et Marie Curie Paris
bsmun@gist.ac.kr

Abstract:

Valence band spectra of a polycrystalline Pt_3Co alloy were observed at photon energies near Co L_3 L_3 absorption edge. On the absorption edge, Co $L_3M_{4,5}M_{4,5}$ $L_3M_{4,5}M_{4,5}$ Auger signals simultaneously appear with the valence band spectra. With the photon energy just below the absorption maximum position, the Auger signals appear at constant binding energy position showing the sign of radiationless Raman Auger process, e.g. Ni 6 eV satellite in valence band spectra. [1] When the photon energy is increased to higher than the absorption maximum energy, normal Auger process takes place, showing constant kinetic energy feature in Auger electron.

Furthermore, the transition of Auger process in Pt_3Co is carefully investigated, showing distinct behavior from that in Co metal and other 3*d* transition metals, [2] i.e. higher photon energy is needed for *resonant-to-normal* Auger transition in Pt_3Co compared to 3*d* transition metals. Our analysis of *resonant-to-normal* Auger transition verified the strong delocalization of Co 3*d* band in Pt_3Co alloy. [3]

References

[1] M. Weinelt, A. Nilsson, M. Magnuson, T. Wiell, N. Wassdahl, O. Karis, A. Föhlisch, N. Mårtensson, J. Stöhr, M. Samant, Resonant Photoemission at the 2*p* Edges of Ni: Resonant Raman and Interference Effects, Physical Review Letters, 78 (1997) 967.
[2] S. Hüfner, S.H. Yang, B.S. Mun, C.S. Fadley, J. Schäfer, E. Rotenberg, S.D. Kevan, Observation of the two-hole satellite in Cr and Fe metal by resonant photoemission at the 2*p* absorption energy, Physical Review B, 61 (2000) 12582-12585.
[3] Y.S. Lee, J.Y. Rhee, C.N. Whang, Y.P. Lee, Electronic structure of Co-Pt alloys: X-ray spectroscopy and density-functional calculations, Physical Review B, 68 (2003) 235111.

Keywords:

Resonant photoemission, 6 eV satellite, Radiationless resonant Raman Auger process, Electron delocalization, Final state relaxation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E9.01

Electrical manipulation of quantum light sources in 2D hexagonal boron nitride

LEE Jieun *1
[1]Department of physics and astronomy, Seoul National University
jieuntb@gmail.com

Abstract:

Single photon emitters are fundamental resources of quantum optics and quantum information technologies. Recently, the emergence of single photon emission in atomically thin materials such as transition metal dichalcogenides and hexagonal boron nitride (h-BN) has triggered tremendous interests in 2D material based single photon sources. For full exploitation of 2D single photon emitters for quantum technologies, however, the ability to control each atomic defect individually is critical. In this talk, we introduce methods to generate and manipulate single photon sources in 2D h-BN crystals using local crystalline geometries and electrical controls. First, we show the role of strain for the creation and orientation of the single photon emitters in h-BN. Second, we demonstrate that the photon energy of single photon sources in h-BN can be controlled using an electric field by fabricating 2D van der Waals heterostructures composed of h-BN and graphene layers. A diverse trail of Stark shifts is observed, providing information on crystallographic ground states of defect structures. Lastly, we will discuss the electrical switching of the quantum emitters enabled by the Fermi level tuning of graphene electrodes.

Keywords:

Quantum light source, 2D materials, van der Waals heterostructures

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E9.02

Symmetry Dictated Grain Boundary State in a Two-Dimensional Topological Insulator

KANG Seoung-Hun *[1]
[1]Korea Institute for Advanced Study
physicsksh@kias.re.kr

Abstract:

Grain boundaries (GBs) are ubiquitous in solids and have been of central importance in understanding the nature of polycrystals. In addition to their classical roles, topological insulators (TIs) offer a chance to realize GBs hosting distinct topological states that can be controlled by their crystal symmetries. However, such roles of crystalline symmetry in two-dimensional (2D) TIs have not been definitively measured yet. Here, we present the first direct evidence of a symmetry-enforced metallic state along a GB in 1T′-MoTe2, a prototypical 2D TI. Using scanning tunneling microscopy, we show a metallic state along a GB with nonsymmorphic lattice symmetry and its absence along another boundary with symmorphic symmetry. Our atomistic simulations demonstrate in-gap Weyl semimetallic states for the former, whereas they demonstrate gapped states for the latter, explaining our observation well. The observed metallic state, tightly linked to its crystal symmetry, can be used to create a stable conducting nanowire inside TIs.

Keywords:

Grain boundaries, MoTe2, crystal symmetries, Weyl semimetallic states

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E9.03

Resonance Effects in Two-dimensional Semiconductors

LEE Jae-Ung *[1]
[1]Department of physics, Ajou University
jaeunglee@ajou.ac.kr

Abstract:

Two-dimensional semiconductors have been studied extensively due to their unique properties in contrast to their bulk part. Semiconducting Transition Metal Dichalcogenides (TMDs), the representative of two-dimensional semiconductors, have the optical absorption spectrum that can be related to exciton states due to the strong Coulomb interaction. In this presentation, I will discuss the excitonic resonance effect in light scattering from these crystals, especially in the perspective of Raman spectroscopy. Furthermore, controlled synthesis of such two-dimensional semiconductors and their heterostructures using Metal-Organic Chemical Vapor Deposition (MOCVD) will be discussed. By combining such unique capabilities, I would briefly introduce the plans to utilize the quantum mechanical properties of two-dimensional semiconductors.

Keywords:

Two-dimensional semiconductors, Raman spectroscopy, excitonic resonance

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E10.01

Néel-type multilayer skyrmions stabilized at high temperature

KWON Hee Young [1], SONG Kyung Mee [1], JEONG Juyoung [2,3], LEE Ah-Yeon [4], PARK Seung-Young [4], KIM Jeehoon [3], WON Changyeon [5], MIN Byoung-Chul [1], CHANG Hye Jung [2], CHOI Jun Woo [*1]
[1]Center for Spintronics, KIST
[2]Advanced Analysis Center, KIST
[3]Department of Physics, POSTECH
[4]Division of Scientific Instrumentation & Management, KBSI
[5]Department of Physics, Kyung Hee University
junwoo@kist.re.kr

Abstract:

Recent studies on magnetic skyrmions have been focused on heavy metal/ferromagnetic multilayer systems with strong interfacial Dzyloshinskii-Moriya interaction (DMI). Skyrmions in magnetic multilayers, which possess homochiral Néel domain walls, have two main advantages in application compared to those in other material systems: (i) they are stabilized at room temperature, and (ii) they exhibit current driven unidirectional translation motion.

In this study, using Lorentz transmission electron microscopy (LTEM), we discover a high-density homochiral Néel-type skyrmion phase in a magnetic multilayer system, which is stabilized in a wide temperature range, even at high temperatures above 700 K.[1] Micro-magnetic simulations confirm the experimental observations, showing that a high-density Néel-type skyrmion phase can be stabilized by appropriately tuning the temperature-dependent material parameters (e.g., magnetic anisotropy, magnetization).[1] The existence of a high-density skyrmion phase at high temperature demonstrates the thermal stability of this magnetic domain phase. It also suggests that multilayer Néel-type skyrmions can be utilized in non-volatile spintronic devices that require operation at elevated temperatures. Our findings provide an important technological basis for more extensive employment of skyrmion-based spin memory devices.

References

1. H. Kwon *et al.,* NPG Asia Materials **12**, 86 (2020).

Keywords:

Magnetic skymrions

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E10.02

Dzyaloshinskii–Moriya interaction at single metallic interfaces

YU Ji-Sung [1], LEE Seong-Hyub [1], MOON Joon [1], CHOE Sug-Bong [*1]
[1]Department of Physics and Astronomy, Seoul National University

Abstract:

The magnetic exchange interaction is one of the key ingredients that dominates the basic properties of magnetic systems. The most well-known magnetic exchange interaction is the Heisenberg exchange interaction, which provides an isotropic interaction. Due to the symmetric nature with site-inversion invariance, the Heisenberg exchange interaction results in simple and conventional spin alignments either parallel (ferromagnetic) or antiparallel (antiferromagnetic) depending on the sign of J, without distinction in energy between right- and left-handed chiral spin alignments. However, as the dimension of magnetic structures decreases down to nanometer scale in nanoscience and technology, the symmetric nature becomes broken due to the existence of interfaces, where the inversion symmetry is inherently broken. This situation requires a consideration of additional interactions. The spin-orbit coupling across the interfaces provides such additional interaction—Dzyaloshinskii–Moriya interaction (DMI) [1-3]. Due to the chiral nature, the DMI prefers chiral spin alignments and thus, generates chiral magnetic structures such as chiral magnetic domain walls (DWs) [4] and magnetic skyrmions [5, 6]. These chiral structures provide rich physical phenomena and also, prospective technological opportunities. Here, we present our recent development of a measurement scheme for the DMI strength from a single metallic interface. The measurement scheme consists of a vacuum chamber, electromagnet, and optical microscope. The first experimental results will be discussed.

[1] K.-W. Kim *et al.*, Phys. Rev. Lett. 111, 216601 (2013).
[2] A. Kundu *et al.*, Phys. Rev. B 92, 094434 (2015).
[3] T. Kikuchi *et al.*, Phys. Rev. Lett. 116, 247201 (2016).
[4] S.-G. Je *et al.*, Phys. Rev. B 88, 214401 (2013).
[5] A. Fert *et al.*, Nat. Rev. Mater. 2, 17031 (2017).
[6] W. Jiang *et al.*, Nature Phys. 13, 162 (2017).

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E10.03

Skyrmion dynamics – from individual ultrafast motion to diffusion and collective crystallization of 2D lattices

KLäUI Mathias [*1,2]
[1]Institut für Physik and Graduate School of Excellence Materials Science in Mainz, Johannes Gutenberg-Universität Mainz
[2]Centre for Quantum Spintronics, NTNU
klaeui@uni-mainz.de

Abstract:

In our information-everywhere society IT is a major player for energy consumption. Novel spintronic devices can play a role in the quest for GreenIT if they are stable and can transport and manipulate spin with low power. Devices have been proposed, where switching by energy-efficient approaches, such as spin-polarized currents is used [1],
Firstly, to obtain ultimate stability of states, topological spin structures that emerge due to the Dzyaloshinskii-Moriya interaction (DMI) at structurally asymmetric interfaces, such as chiral domain walls and skyrmions with enhanced topological protection can be used [2-5]. We have investigated in detail their dynamics and find that it is governed by the topology of their spin structures [2]. By designing the materials, we can even obtain a skyrmion lattice phase as the ground state [3].
Secondly, for ultimately efficient spin manipulation, we use spin-orbit torques, that can transfer more than 1ħ per electron by transferring not only spin but also orbital angular momentum. We combine ultimately stable skyrmions with spin orbit torques into a skyrmion racetrack device [3-5], where the real time imaging of the trajectories allows us to quantify the novel skyrmion Hall effect [5,6].
Beyond conventional memory, we furthermore use spin-orbit torque induced skyrmion dynamics for non-conventional stochastic computing applications, where we have developed a skyrmion reshuffler device [6]. Here we use thermal skyrmion motion to implement a key component for stochastic computing [6]. Such thermal skyrmion diffusion can also be controlled by symmetry breaking [7] and this is useful for token – based Brownian computing.
Finally, the thermal dynamics of skyrmion quasi-particles lends itself to exploiting this system for the study of phases and phase transitions in 2D. We have studied the transition of skyrmion arrangements from the liquid phase across the hexatic phase unique to 2D systems into the solid phase [8]. These transitions occur in a wide range of skyrmions systems [8,9], thus showing that skyrmions have evolved from an object of study themselves and are now being understood controlled sufficiently well for use as model systems to study exciting statistical physics in 2D. And beyond continuous films, thermal skyrmion dynamics in confined geometries exhibits surprising commensurability effects opening new paths to tuning the dynamics [10].

References:

1. Reviews G. Finocchio et al., J. Phys. D: Appl. Phys. 49, 423001 (2016); K.

Everschor-Sitte et al., J. Appl. Phys. 124, 240901 (2018).
2. F. Büttner et al., Nature Phys. 11, 225 (2015).
3. S. Woo et al, Nature Mater. 15, 501 (2016).
4. K. Litzius et al., Nature Phys. 13, 170 (2017).
5. K. Litzius et al., Nature Electron. 3, 30 (2020).
6. J. Zazvorka et al., Nature Nano. 14, 658 (2019).
7. N. Kerber et al., arxiv:2004.07976 (2021).
8. J. Zazvorka et al., Adv. Funct. Mater. 30, 2004037 (2020).
9. P. Huang et al., Nature Nano. 15, 761 (2020)); M. Kläui, Nature Nano. 15, 726 (2020).
10. C. Song et al., Adv. Funct. Mater. 2010739 (2021).

Keywords:

E10.04

Stabilization of zero-field skyrmions in ferromagnetic and synthetic antiferromagnetic systems

CROS V. *[1], AJEJAS F. [1], SASSI Y. [1], LEGRAND W. [1], COLLIN S. [1], BOUZEHOUANE K. [1], REYREN N. [1], FERT A. [1], FINCO A. [2], HAYKAL A. [2], TANOS R. [2], FABRE F. [2], ROBERT-PHILIPP I. [2], JACQUES V. [2], KIM J. V. [3], DEVOLDER T. [3], LEVEILLé C. [4], BURGOS E. [4], POPESCU H. [4], JAOUEN N. [4]
[1]Unité Mixte de Physique CNRS, Thales, Université Paris-Saclay
[2]Laboratoire Charles Coulomb (L2C)
[3]Centre de Nanosciences et Nanotechnologies C2N, CNRS, Univ. Paris-Saclay
[4]SOLEIL Synchrotron

Abstract:

Recently room-temperature skyrmions stabilized in ferromagnetic films and multilayers by interfacial Dzyaloshinskii-Moriya interaction (DMI) has been demonstrated showing promise for encoding information bits in new computing technologies [1]. In ferromagnetic multilayered systems, the observation of skyrmions requires indeed the application of perpendicular field of a few tens of mT. Here we first show that inserting a bias layer in the multilayer stack, and utilizing interlayer electronic coupling between this bias layer and the ferromagnetic skyrmion multilayer, we successfully demonstrate the stabilization of sub 100 nm skyrmions at room temperature. However, a remaining challenge in ferromagnetic systems is that a transverse deflection of moving skyrmions is present that hinder their efficient manipulation. Antiferromagnetic skyrmions could lift these limitations [4-5]. In this study, we will show that room-temperature antiferromagnetic skyrmions can be stabilized in synthetic antiferromagnet (SAF) systems. Utilizing the same type of electronic bias layer, we demonstrate by Magnetic Force Microscopy [6] and by spin NV relaxometry [7] that the spin-spiral state obtained in a SAF system with vanishing perpendicular anisotropy can be turned into isolated antiferromagnetic skyrmions stable at zero field. These experimental results are completed with model-based estimations of their size and stability, showing that room-temperature stable antiferromagnetic skyrmions below 10 nm in radius can be anticipated in further optimized SAF systems [6]. Finally, we will show how non collinear spin textures stabilized in SAF systems can be electrically detected through the analysis of their magnetoresistive response [8].

[1] A. Fert, N. Reyren, V. Cros, Nat. Rev. Mat. 2, 17031 (2017) ; [2] C. Moreau-Luchaire et al., Nat. Nanotech. 11, 444 (2016) ; [3] W. Legrand et al., Nano Letters 17, 2703 (2017) ; [4] X. Zhang et al., Nat. Commun. 7, 10293 (2016) ; [5] R. Tomasello et al, Scie. Rep. 4, 6784 (2014) ; [6] W. Legrand et al, Nat. Materials, 19, 34 (2020) ; [7] A. Finco et al., Nature Comm. 12, 767 (2021) ; [8] D. Maccariello et al., Phys. Rev. Appl. 14, 051001 (2020)
Financial support from the Agence Nationale de la Recherche, France, No. ANR-17-CE24-0025 (TOPSKY), the Horizon2020 Framework Programme of the European Commission under FET-Proactive Grant agreement No. 824123 (SKYTOP), FLAGERA

SOGRaphMEM and the DARPA TEE programme through grant MIPR no. HR0011831554 are acknowledged

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E11.01

Label-free adaptive optical imaging of mouse brain through intact skull

YOON Seokchan *[1,2], LEE Hojun [1,2], HONG Jin-Hee [1,2], LIM Yong-Sik [3], CHOI Wonshik [1,2]
[1]Center for Molecular Spectroscopy and Dynamics, IBS
[2]Department of Physics, Korea University
[3]Department of Nano Science and Mechanical Engineering and Nanotechnology Research Center, Konkuk University
sdlkfwpeorup@gmail.com

Abstract:

When imaging deep into scattering media, optical microscopy suffers from multiple light scattering and sample-induced aberrations. We introduce a label-free adaptive optical imaging modality termed laser scanning reflection-matrix microscopy (LS-RMM) capable of correcting spatially varying sample-induced aberrations for up to 10,000 angular modes, despite the presence of strong multiple scattering. In contrast to conventional confocal microscopy which measures a reflection signal at only the focal point of illumination by using a confocal pinhole, the LS-RMM records a reflection matrix composed of all reflected signals at positions beyond the confocal focal point. A novel aberration correction algorithm is applied to the reflection matrix for the reconstruction of the aberration-free object image. Our aberration correction algorithm is unique in that an extended object and aberrations in the illumination and detection pathways are jointly identified with no need of guide stars. We demonstrate reflectance imaging of myelinated axons in the mouse brain through the intact skull with a diffraction-limited resolution of 450 nm. The LS-RMM is readily integrated with an adaptive optics multiphoton microscopy which offers deeper imaging depths and higher molecular specificity. We also demonstrate aberration correction in two-photon fluorescence imaging of neuronal dendrites and spines through the intact skull, which is made possible by displaying a correction map for the identified aberration on a spatial light modulator in the excitation beam path. The two-photon fluorescence image with aberration correction shows up to a 19-fold increase in fluorescence intensity, which enables us to see fine structures of dendritic spines with a spatial resolution of 500 nm, close to the diffraction-limited resolution of the imaging system, 380 nm.

Keywords:

Reflection matrix, Adaptive Optics, Deep tissue imaging

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E11.02

Non-interferometric holographic imaging and diffraction tomography via space-domain Kramers-Kronig relations

BAEK YoonSeok [1], PARK YongKeun [*1]
[1]Physics, KAIST
yk.park@kaist.ac.kr

Abstract:

Holography has advanced imaging science by measuring phase delays induced by light-matter interactions. However, holographic imaging is technically demanding because it usually requires an interferometric setup, a coherent source, and long-term stability. We present holographic imaging where the phase of light is obtained from the intensity measured at oblique illumination. Our approach, based on space-domain Kramers-Kronig relations, transforms the spatial variation in intensity to the spatial variation in phase. We demonstrate synthetic aperture holography and diffraction tomography with an optical microscope and illumination control. The proposed method opens up a new possibility of non-interferometric holographic imaging in various spectral regimes.

Keywords:

Holography, Phase retrieval, Quantitative phase imaging, Diffraction tomography

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E11.03

Fourier holographic endoscopy for label-free imaging through a narrow and curved passage

CHOI Wonshik *[1], CHOI Wonjun [1], KANG Munkyu [1]
[1]Department of Physics, Korea University
wonshik@korea.ac.kr

Abstract:

Ultrathin lensless fibre endoscopes offer minimally invasive investigation, but they mostly operate as a rigid type due to the need for prior calibration of a fibre probe. Furthermore, most implementations work in fluorescence mode rather than label-free imaging mode, making them unsuitable for medicine and industry. Herein, we report a fully flexible ultrathin fibre endoscope taking 3D holographic images of unstained tissues with 0.87-mm spatial resolution. Using a bare fibre bundle as thin as 200-mm diameter, we design a lensless Fourier holographic imaging configuration to selectively detect weak reflections from biological tissues, a critical step for stain-free reflectance imaging. A unique algorithm is developed for calibration-free holographic image reconstruction, allowing us to image through a narrow and curved passage regardless of fibre bending. We demonstrate endoscopic reflectance imaging of unstained rat intestine tissues that are completely invisible to conventional endoscopes. The proposed endoscope will expedite more accurate and earlier diagnosis than before with minimal complications.

Keywords:

endoscope, holographic, bioimaging

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E11.04

Disorder-based coherent imaging

LEE KyeoReh *1, LIM Jun 2, LEE Su Yong 2, PARK YongKeun *1
1Department of Physics, KAIST
2Pohang Accelerator Laboratory, POSTECH
kyeo@kaist.ac.kr, yk.park@kaist.ac.kr

Abstract:

Disorder, particularly in the names of defects or imperfections, increases the complexity of systems in general. Due to the random and unexpectable nature, the studies mainly have been focused on minimizing or overcoming the disorder. For example, the light propagations and scatterings in disordered (or scattering) media has been extensively studied, to see through natural disorders such as clouds, fog, and human tissue [1]. In recent years, however, a new perspective has been proposed – exploiting the disorder [2, 3]. A general question hen arises: can the disordered photonics be even better than the ordered and periodic ones?
Here we present an example that a disordered system actually performs better – an optical diffuser is better than a lens in the coherent imaging.
Unlike a lens that cannot directly provides the phase information of an incident field, we present the optical field (both the amplitude and phase) information can be reconstructed from the diffused intensity (speckle) pattern without additional constraints [4]. This is possible by exploiting both *deterministic* and *disordered* properties of diffuser, which may seem contradictory at first glance. We develop a theory and verify the feasibility in experiments using a laser.
We translate this idea to the X-ray regime, where refractive lenses become inefficient due to the near-unity refractive indices. We design an X-ray diffuser, build an X-ray optical system for synchrotron source, and successfully acquire a high-resolution phase image of a target. We believe the single-shot, constraint-free, and lithography-unlimited features promise the designed diffuser as a good X-ray (holographic) imaging lens.
1. Rotter, S. and S. Gigan, *Light fields in complex media: Mesoscopic scattering meets wave control.* Reviews of Modern Physics, 2017. **89**(1): p. 015005.
2. Vellekoop, I.M., A. Lagendijk, and A.P. Mosk, *Exploiting disorder for perfect focusing.* Nature Photonics, 2010. **4**(5): p. 320-322.
3. Wiersma, D.S., *Disordered photonics.* Nature Photonics, 2013. **7**(3): p. 188-196.
4. Lee, K. and Y. Park, *Exploiting the speckle-correlation scattering matrix for a compact reference-free holographic image sensor.* Nature Communications, 2016. **7**(1): p. 13359.

Keywords:

Disordered photonics, Speckle, Diffuser, Speckle-correlation scattering matrix

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E12.01

Photoelectrodes for Efficient Photoelectrochemical Water Splitting: from Oxides to Organometallic Halide Perovskite

LEE Sanghan *1
[1]School of Materials Science and Engineering, GIST
sanghan@gist.ac.kr

Abstract:

Solar-driven ecofriendly chemical fuel, especially, hydrogen has gained much attention owing to environmental issues such as abnormal climate change and global warming. Photoelecrochemical (PEC) water splitting is most promising process which can produce green hydrogen from solar light. In this talk, several recent studies on representative oxide photoelectrodes and organometallic halide perovskites (OHP)-based PEC water splitting will be presented. First, crystallographic orientation-dependent photocatalytic performance in $BiVO_4$ photoanode and enhanced stability in epitaxially grown $CuBi_2O_4$ photocathode will be discussed. Furthermore, beyond oxide photoelectrodes, highly efficient and stable OHP-based photocathode achieved by a eutectic gallium indium alloy (EGaIn) encapsulation method will be introduced. The EGaIn-incorporated Ti foil provides complete encapsulation from the external environment while maintaining good transport of photogenerated charges from OHPs. Thus, these photocathodes exhibit a remarkable average photocurrent density of 21.2 $mA \cdot cm^{-2}$ which has less than 5% current loss between PV cells and PEC cells. More admirably, the photocathode has the highest stability over 54 hours under continuous full sunlight illumination in a sulfuric acid electrolyte.

Keywords:

photoelectrochemical water splitting, Hydrogen production

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E12.02

Transition-metal oxide devices based on metal-insulator transition or Rashba spin-orbit interaction

LEE Jin Hong *1, TRIER Felix [1], HARADA Takayuki [2], GODEL Florian [1], CORNELISSEN Tom [1], PREZIOSI Daniele [3], BOUZEHOUANE Karim [1], TSUKAZAKI Atsushi [2,4], VALENCIA Sergio [5], BIBES Manuel *1

[1]Unité Mixte de Physique, CNRS, Thales, Université Paris Sud, Université Paris-Saclay

[2]Institute for Materials Research, Tohoku University

[3]Institut de Physique et Chimie des Matériaux de Strasbourg

[4]Center for Spintronics Research Network, Tohoku University

[5]Helmholtz-Zentrum Berlin für Materialien und Energie

jinhong.lee@cnrs-thales.fr, manuel.bibes@cnrs-thales.fr

Abstract:

Transition-metal oxides have been intensively studied as one family of future quantum materials. The wide spectrum of physical phenomena in these materials including high mobility transport, multiferroicity, metal-insulator transitions (MIT), magnetoresistance and superconductivity has provided a fruitful playground for strongly-correlated electron physics. In this presentation, transition-metal oxide devices based on the first-order MIT of perovskite $NdNiO_3$ (NNO) or on the Rashba effect in delafossite $PdCoO_2$ (PCO) will be discussed. In the first part, the percolative electronic transport in NNO nanogaps is investigated by reducing the transport measurement area to dimensions comparable to the domain size of insulating and metallic NNO phases around the MIT temperature. In the second part, the magnetotransport phenomena in PCO Hall bars are studied by analyzing the quadratic and bilinear magnetoresistance in order to characterize the Rashba spin-orbit interaction at the surface or interface of the high-mobility material and its interplay with surface ferromagnetism.

Keywords:

Transition-metal oxides, Metal-insulator transition, Rashba spin-orbit interaction, Magnetoresistance

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E12.03

Remote-epitaxially grown single-crystalline complex oxide for the integrated system

김성규*[1]
[1] 세종대학교 나노신소재공학과
sungkyu@sejong.ac.kr

Abstract:

Using the conventional epitaxy technology, various single-crystalline materials can be directly grown on single-crystalline substrates. The grown epitaxial materials exhibit excellent performance similar to the theoretical values, but there is a big challenge to independently operate from the seed substrate due to a strong atomic bonding. In order to fabricate the freestanding thin films, new concept growth methods using weak van der Waals force on two-dimensional materials (van der Waals epitaxy) and chemical etching/buffer layer (chemical lift-off) for oxide materials. However, the crystal structure of two-dimensional material and the insertion of the sacrificial layer could be limited in growing single-crystalline materials and their application for the future integrated system.

Here, we introduce a novel epitaxy method (remote epitaxy) for growing single-crystalline oxide films through the graphene on the substrate as a seed layer. Several important oxide structures including perovskite ($SrTiO_3$, $BaTiO_3$, $Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$), spinel ($CoFe_2O_4$), and garnet ($Y_3Fe_5O_{12}$) are successfully demonstrated via remote epitaxy technologies. In contrast to III-V compound[1] and III-Nitride[2] material that can stably exist in graphene during the growth process, monolayer graphene is very susceptible to physical damage and structural deformation due to high oxygen partial pressure and high temperature conditions. Because of these critical issues such as deformation and oxidation of graphene, the grown single-crystalline oxide films cannot be peeled off from the substrate or partially shows polycrystalline. The oxygen partial pressure was gradually increased to minimize the oxidation of graphene, and two layers of graphene were used to prevent the destruction of graphene at the same time. Based on these modifications, magnetoelectric coupling has been observed by stacking $CoFe_2O_4$ and PMN-PT structures[3]. These findings provide tremendous opportunities to fabricate various functional oxide materials, which could be eventually integrated for the future electronics.

[1] Bae, S.-H. et al. Graphene-assisted spontaneous relaxation towards dislocation-free heteroepitaxy. Nature Nanotechnology 15, 272-276 (2020)
[2] Kim, Y. et al. Remote epitaxy through graphene enables two-dimensional material-based layer transfer. Nature 544, 340-343 (2017)
[3] Kum, H. S. et al. Heterogeneous integration of single-crystalline complex-oxide membranes. Nature 578, 75-81 (2020)

Keywords:

Remote epitaxy, complex oxide, single-crystalline, graphene

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E13.01

Numerical approach for phase transitions in infinite-dimensional dissipative quantum systems

JO Minjae [1], JHUN Bukyoung [1], KAHNG Byungnam *[1]
[1]Department of Physics and Astronomy, Seoul National University
bkahng@snu.ac.kr

Abstract:

Phase transitions in dissipative quantum systems are investigated using various analytical approaches, particularly in the mean-field (MF) limit. Numerical verifications are necessary to confirm the analytical results because analytic results often depend on the methodology in such quantum systems. Thus, numerical results are requested; however, it is not feasible due to the computational complexity. A numerical method recently developed using the permutational symmetry of spin index on a fully connected graph reduces considerably this complexity from $₩mathcal{O}(2^{2N})$ to $₩mathcal{O}(N^3)$.
Here, using this method, we implement numerical simulations for several dissipative quantum systems, the dissipative transverse Ising model, driven-dissipative XY model, and quantum contact process (QCP). Our numerical results are overall consistent with those predicted by the fluctuationless MF approach; however, inconsistent with those by the Keldysh method. We remark that for the QCP, we discover that there exists a crossover region between the directed percolation (DP) class and the tricritical DP class. Finally, based on our numerical results, we discuss the strong and weak points of each analytic MF approach.

Keywords:

dissipative phase transitions, open quantum systems, Keldysh formalism, fluctuationless mean-field theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E13.02

Quantum contact process in scale-free networks

JHUN Bukyoung [1], JO Minjae [1], KAHNG Byungnam *[1]
[1]Department of Physics and Astronomy, Seoul National University
bkahng@snu.ac.kr

Abstract:

Quantum contact process has recently attracted significant attention from the research community due to its novel critical phenomena and experimental realizability in ultracold Rydberg atoms. The model is extensively studied in Euclidean lattices; however, such representation fails in the presence of long-range interaction and impurity. Instead, the system can be viewed as a complex network with nearest-neighbor interaction. Here, we study quantum contact process in scale-free networks. We perform numerical simulations to corroborate the analytical predictions. Finally, we discuss the similarities between the observed phenomena and their classical counterparts in hypergraphs. This research can lead to a comprehensive understanding of the effects of structural heterogeneity on nonequilibrium quantum phase transitions.

Keywords:

quantum contact process, open quantum system, nonequilibrium phase transition, absorbing phase transition, scale-free network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E13.03

Scaling behaviors of information entropy in explosive percolation transitions

CHO Young Sul *[1], KANG Yejun [1]
[1]department of physics, Jeonbuk National University
yscho@jbnu.ac.kr

Abstract:

An explosive percolation transition is the abrupt emergence of a giant cluster at a threshold
caused by a suppression of the growth of large clusters. In this paper, we consider the information entropy of the cluster size distribution which is the probability distribution for the size of a randomly chosen cluster.
It has been reported that information entropy does not reach its maximum at the threshold in explosive percolation models, a result seemingly contrary to other previous results that the cluster size distribution shows power-law behavior and the cluster size diversity (number of distinct cluster sizes) is maximum at the threshold.
Here, we show that this phenomenon is due to that the scaling form of the cluster size distribution is given
differently in the subcritical and supercritical regions.
We also establish the scaling behaviors of the first and second derivatives of the information entropy near the threshold to explain why the first derivative has a negative minimum at the threshold and the second derivative diverges negatively (positively) at the left (right) limit of the threshold, as predicted through previous simulation.

Keywords:

explosive percolation, information entropy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E13.04

Finite-size scaling of Lee-Yang zeros of the 2D XY model: Loop-TNR study

HONG Seongpyo [1], KIM Dong-Hee *[1]
[1]Department of Physics and Photon Science, GIST
dongheekim@gist.ac.kr

Abstract:

We investigate the finite-size scaling (FSS) behavior of the first Lee-Yang zeros to study the critical behavior of the two-dimensional XY model. We implement the loop optimization for tensor network renormalization (Loop-TNR) to calculate the partition function for a complex magnetic field with size up to L=512. We observe a strong finite-size effect to the first Lee-Yang zeros at β_c=1.1199, as seen in the previous study [R. Kenna and A.C. Irving, Phys. Lett. B **351**, 273 (1995).] The FSS behavior of the zeros follows the previous scaling ansatz including logarithmic corrections. We also show that the scaling exponent for the logarithmic correction is expected to converge to the RG-predicted one (r=-1/16) at large system sizes.

Keywords:

XY model, Lee-Yang zero, Phase transition, BKT transition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E13.05

Probing the quantum criticality of antiferromagnetic long-range transverse-field Ising chain with variational neural-network quantum states

KIM Dongkyu [1], KIM Dong-Hee [*1]
[1]Department of Physics and Photon Science, GIST
dongheekim@gist.ac.kr

Abstract:

We investigate the quantum criticality of a one-dimensional antiferromagnetic transverse-field Ising model with long-range power-law interaction 1/r^alpha via variational Monte Carlo on the neural-network quantum states. Here we argue that all quantum phase transitions with arbitrary alpha > 0 have Ising-like critical behavior. We take a periodic boundary condition where results of density-matrix renormalization group (DMRG) calculations remain controversial. We determine critical exponents through finite-size-scaling analysis on magnetic susceptibility, the fourth-order cumulant, and quantum fidelity susceptibility. We find that critical exponents keep constant while varying alpha, where error bars encompass the Ising critical exponent. We calculate the second Renyi entropies at critical points and determine the central charges from the universal logarithmic correction to entanglement entropy. Our method shows that the central charges for alphas' are close to the value (c=1/2) of the one-dimensional transverse-field Ising model.

Keywords:

quantum criticality, frustrated Ising model, variational Monte Carlo, machine learning

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.01

Rapid, uniform, and efficient heating of dense matter using laser-driven protons with a finite energy spread

SONG Chiwan [1,2], WON Junho [1,2], KIM Jaeyu [1], SONG Jaehyun [1,2], BANG Woosuk *[1,2]
[1]Department of Physics and Photon Science, GIST
[2]Center for Relativistic Laser Science, IBS
wbang@gist.ac.kr

Abstract:

Energetic laser-driven ions can heat a small solid-density sample rapidly before a significant hydrodynamic expansion. Uniform and efficient heating would be desirable when measuring the physical properties of the sample after heating, but heating a thick solid-density sample both uniformly and efficiently in a short time has been very challenging. Here we show that a thick (> 1 cm) solid-density aluminum sample can be heated rapidly, uniformly, and efficiently all at the same time using energetic laser-driven protons with a finite energy spread. We perform Monte Carlo simulations to study the relationship between the energy spread of the incident protons and the transferred energy onto the aluminum sample for rapid, uniform, and efficient heating. We find that a 100 MeV proton beam with a Gaussian energy spread of D*E*/*E* ~ 70% can heat a 32 mm thick solid-density aluminum sample uniformly (temperature nonuniformity < 2–6%) and efficiently (> 62% absorption) in a sub-ns time scale.

This work was supported by NRF-2018R1C1B6001580.

Keywords:

Laser-driven ion, Quasimonoenergetic spectrum, stopping power, heating efficiency, heating nonuniformity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.02

Experimental Setup and Preliminary Results of EBIS Charge Breeder for RAON Facility

YOO Kyoung-Hun [1,2], CHUNG Moses [*1], HEO Seongjin [2,3], LIM ChaeYoung [2,3], PARK Young-Ho [2], LEE Jin Ho [2], SHIN Taeksu [2]
[1]Department of Physics, UNIST
[2]Rare Isotope Science Project, IBS
[3]Department of Accelerator Science, Korea University
mchung@unist.ac.kr

Abstract:

The heavy-ion accelerator RAON is being developed by the Rare Isotope Science Project (RISP) in the Institute for Basic Science (IBS) for basic science research through the nuclear experiment with rare-isotope (RI) beam. Various RI beams are generated from Isotope Separation On-Line (ISOL) beamline, and they are accelerated in the post-accelerator. The energy requirement of RI beams for post-accelerator is 10 keV/u, the charge state of them must be adjusted to satisfy it. The Electron Beam Ion Source (EBIS) charge breeder is installed before the post-accelerator to match RI beams to the condition. The single charged beam is trapped in the EBIS and interacts with the compressed electron beam in a strong magnetic field. The electron beam removes the electrons of the ion beam by collision and produces highly charged ions. The mass-to-charge ratio (A/q) of highly charged RI beams from the EBIS can correspond to the accelerator condition. The experimental setup of the EBIS charge breeder for the on-line test and preliminary results will be described in this presentation.

Keywords:

RISP, RAON, EBIS, Charge Breeder

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.03

Advanced laser-plasma accelerator R&D plans at PAL-ITF

NAM Inhyuk *[1], KIM Minseok [1], CHO Myung-Hoon [1], JANG Dogeun [1], KWON Sung-hoon [1], SUNG Chang-kyu [2], KIM Seong-Yeol [2], LEE Si-hyun [3], KIM Changbum [1]
[1]PAL-XFEL, Pohang Accelerator Laboratory
[2]Department of Physics, UNIST
[3]Department of Physics and Photon Science, GIST
ihnam@postech.ac.kr

Abstract:

For future compact accelerators, laser-plasma accelerators have been the most promising candidates for next-generation free-electron lasers (FELs). However, the electron beam from the laser-plasma accelerator has a percent of energy spread, poor stability, and reproducibility. This beam is not satisfied with the X-ray free-electron lasers. In order to overcome this limitation, one of the most reliable ways is to use the electron beam from the RF photocathode as a seed beam for laser-plasma accelerators. PAL-ITF has an S-band RF photocathode gun and final energy of 70 MeV, few tens femtoseconds duration, and lower emittance, which can be used for the seed beam for advanced plasma accelerators. For the external injection scheme, the electron beam from the RF photocathode gun should be matched with the wakefield focusing strength for the beta motion of the electron beam inside the wakefield. Therefore, for good matching, the electron beam size should be decreased at the entrance of the plasma source, and for preserving the emittance, slowly increasing the plasma ramp is also required. We prepared the plasma lens experiments for focusing on the electron beam using the discharge capillary plasma source. We also have been developing the capillary source with a long ramp plasma for good emittance matching. In this presentation, we present on-going R&D plans for advanced accelerators at PAL-ITF.

Keywords:

laser-plasma accelerator , PAL-ITF, Laser wakefield acceleration , Plasma lens

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.04

Highly charged Argon ion spectroscopy experiment with the UNIST-EBIT.

PARK SungNam [1], SHIN Bokkyun [1], CHUNG Moses *[1]
[1]Department of Physics, UNIST
mchung@unist.ac.kr

Abstract:

We now know that the visible matter constitutes only about 5% of the universe. For those visible matters, unlike in the Earth, they are mostly in highly charged states. Owing to this fact, CHEA(Center for High Energy Astrophysics) has built an electron beam ion trap(EBIT) to obtain the spectroscopic data of single element in highly charged states. Our main target for this device is highly charged iron spectroscopy with the help of monochromatic photon beam from the PAL-XFEL(Pohang Accelerator Laboratory X-ray Free Electron Laser). In this work, we present the Argon spectroscopy measurements with the possible extension to experiments which use the EBIT as a source for highly charged ions.

Keywords:

EBIT(Electron Beam Ion Trap), HCI(Highly Charged Ion), spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.05

Achievement and Prospect of PAL-XFEL

KANG Heung-Sik *[1]
[1]Pohang Accelerator Laboratory, POSTECH
hskang@postech.ac.kr

Abstract:

PAL-XFEL, a hard X-ray free-electron laser facility in Korea, has shown excellent performances since its start of user service operation in June 2017, outperforming other XFEL facilities worldwide. The FEL timing stability achieved at PAL-XFEL is still the best, and recently we achieved the peak brightness of 3.2 x 10^{35} photons/(s·mm^2·mrad^2·0.1%BW)), the highest to date. It is our duty for the Korean scientific community to have an opportunity to use this unprecedented laser beam for their researches. So, we propose a second hard X-ray FEL line to double the user beamtime. And we propose an attosecond XFEL R&D to open a new science case.

Keywords:

X-ray free electron laser; brightness; attosecond

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E15.06

High-power bursts of THz radiation during the injection of electron beam into magnetized plasma

KUMAR Manoj [1], HUR Min Sup [*1]
[1]Physics, UNIST
minshur@daum.net

Abstract:

We studied and demonstrated the THz radiaton generated by a beam-plasma system using two-dimensional particle-in-cell (PIC) simulation. The Langmuir wave excited by the electron beam exerts a ponderomotive force on plasma electrons, which forms a high level density modulations in small-scale region, where the Langmuir wave is trapped. As a result, spatially-localized Langmuir wave packet with a large amplitude of longitudinal electric field is formed, which gives rise to a brust of radiation at the plasma frequency and its harmonics. 2D-PIC simulation results show that the possibilty of achieving high efficiency of beam-to-THz power conversion, which makes it suitable for applications requiring high-power narrow-band THz radiation sources.

Keywords:

THz, electron beam, plasma, PIC simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E16.01

Fully-Printed Active Plasmonic Metafilms

JEONG Hyeon-Ho *[1]
[1]School of Electrical Engineering and Computer Science, GIST
jeong323@gist.ac.kr

Abstract:

Combining plasmonic nanodimers with responsive polymers delivers extremely small active pixels, which not only show vivid nonfading colour dynamics in response to external stimuli but are also scalable from the single nanoparticle level to multi-centimetre scale films. Here we present colour-changing plasmonic metafilms constructed using a 'lithography-free' bottom-up solution process that controls the crucial plasmonic gaps and fills them with an active medium. Electrochromic nanoparticles are coated onto a metallic mirror, providing the smallest-area active plasmonic pixels to date. We demonstrate how these nano-pixels show strong scattering colours and are electrically tunable across *ca.* 70 nm wavelength ranges. We further show that these dynamics can be scalable to large scale flexible films and thus promise great potential for large-scale roll-to-roll manufacturing at industrial levels of active plasmonic colouration with ultralow energies.

Keywords:

Active Plasmonics, Flexible Metafilms, Nanophotonic Display

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E16.02

Ultrastrong Light-Matter Interactions in Two-Dimensional Materials Enabled by Surface Polaritons

LEE In-Ho *[1], YOO Daehan [2], AVOURIS Phaedon [3], LOW Tony [2], OH Sang-Hyun [2]
[1]Post-silicon Semiconductor Institute, KIST
[2]Department of Electrical and Computer Engineering, University of Minnesota
[3]IBM T. J. Watson Research Center, Yorktown Heights, USA
inholee87@kist.re.kr

Abstract:

Two-dimensional (2D) materials have been the focus of intense research owing to their potential for a variety of nanophotonic applications, including light sources, metasurfaces, and photodetectors. Weak light-matter interactions have been attributed as a fundamental bottleneck in improving the performances of the nanophotonic devices based on 2D materials. Until now, a number of approaches based on silicon waveguides, microcavities, and plasmonic antennas have been suggested to enhance the light-matter interactions in 2D materials harnessing the physical overlap between 2D materials and near-field hot spots generated by the photonic devices. However, the volume of near-field hot spots is significantly larger than that of a 2D material layer, which significantly limits the light-matter interactions. Surface polaritons, a result of strong coupling of photons with electrons, phonons, and excitons, have potential to overcome this fundamental limitation due to their extreme level of field confinement. However, the extreme field confinement comes at the expense of a coupling efficiency due to the serious momentum mismatch with far-field radiation.
In this presentation, we present how this fundamental trade-off between the field confinement and the coupling efficiency can be overcome. Based on the understanding on coupling mechanism, we have demonstrated polaritonic resonators that can simultaneously achieve extreme field confinement and near-unity coupling efficiency.

Keywords:

2D materials, plasmonics, surface polaritons

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E16.03

Probing single-molecule conformational heterogeneity at room temperature via hyperspectral tip-enhanced Raman imaging

KANG Mingu [1], KIM Hyunwoo [2], OLEIKI Elham [3], KOO Yeonjeong [1], LEE Hyeongwoo [1], EOM Taeyong [4], LEE Geunsik [3], SUH Yung Doug [2,5], PARK Kyoung-Duck [*1]
[1]Physics, UNIST
[2]Laboratory for Advanced Molecular Probing (LAMP), KRICT
[3]Chemistry, UNIST
[4]Thin Film Materials Research Center, KRICT
[5]Chemical Engineering, Sungkyunkwan University
kdpark@unist.ac.kr

Abstract:

Cryogenic tip-enhanced Raman spectroscopy (TERS) studies have revealed singlemolecule dynamics; however, understanding the nature of single molecules in ambient conditions has remained challenging. Here, we demonstrate the hyperspectral TERS imaging of single brilliant cresyl blue (BCB) molecules, along with quantitative spectral analyses, revealing their conformational heterogeneity in ambient conditions. Robust single-molecule imaging is enabled by encapsulating the molecules with a thin Al_2O_3 film, which suppresses spectral diffusions and inhibits chemical reactions and contaminations in air. For the single molecules resolved spatially in the TERS image, a clear Raman peak variation up to 7.5 cm^{-1} is observed, which cannot be found in molecular ensembles. From density functional theory-based quantitative analyses of the varied TERS peaks of single molecules, we reveal the single-molecule conformational heterogeneity at room temperature. This work provides a facile way to investigate the single-molecule properties in interacting media, expanding the scope of single-molecule vibrational spectroscopy studies.

Keywords:

Tip-enhanced Raman spectroscopy, Single molecule, Room temperature, Ambient conditions, Capping layer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E16.04

Observation of Multiple Interactions between Metallic Probe and Surface Plasmon Polariton on Mono-Crystalline Noble Metals Flakes

WOO Hwi Je [1], SONG Young Jae *[1,4], KIM Minwoo [2], KWON Nayoung [3], LIM Byungkwon [3]
[1]Depart. of Nano Engineering and Depart. of Physics, Sungkyunkwan University
[2]Yonesei Center for Research Facilities (YCRF), Yonsei University
[3]School of Advanced Materials Science and Engineering, Sungkyunkwan University
[4]Department of Nano Engineering, Department of Physics, Sungkyunkwan University
yjsong@skku.edu

Abstract:

Noble metals have been used as a platform to study surface plasmon or surface plasmon-polariton (SPP) because of their superior plasmonic properties. Furthermore, in the finite size of metal flakes, it is possible to investigate the interference pattern of surface plasmon polariton. In this work, we use high quality flakes of mono-crystalline noble metals, *i.e.*, silver and gold of laterally up to ~15 um, to analyze various interactions between a metal tip of atomic force microscopy (AFM), edge of the flakes and surface plasmon polariton with a home-built scattering-type scanning near-field microscopy (NSOM) at a 532 nm excitation. The long-range propagation of surface plasmon polariton could be visualized as wave interference patterns of ~10 μm in length on the flakes surface of each noble metal since an ultra-smooth surface and a high quality of crystallinity. By performing Fourier analysis, different scattering paths could be addressed, such as tip- or edge- launched one and tip- or edge- reflected one. The path-dependent wave lengths deconvoluted from surface interference patterns show a good agreement with theoretical predictions derived from a simple tip-sample model. The detailed studies on data analysis with visualized images will be addressed in the presentation.

Keywords:

Surface Plasmon Polariton, Near-Field Scanning Microscopy, Plasmon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E16.05

Fano-resonant hybrid colloids

CHO Yongdeok [1], LEE Seungwoo *[1,2,3,4]
[1]Graduate School of Converging Sci & Tech & Dept. of Integrative Energy Engineering, Korea University
[2]Department of Biomicrosystem Technology, Korea University
[3]Department of Integrative Energy Engineering, Korea University
[4]KU Photonics Center, Korea University, Korea University
seungwoo@korea.ac.kr

Abstract:

현대 나노광학에 있어 플라즈모닉스와 고굴절 유전물질은 각각의 광학적 특성을 지니며 양대 산맥을 이루어 왔다. 특히 공진기(Cavity) 측면에서 플라즈모닉스는 작은 모드 체적(mode volume)이라는 장점을 갖고 많은 연구가 되었으며 고굴절률 유전물질은 높은 Q 인자(Quality factor)를 내세워 많은 연구들이 진행되어왔다. 하지만 최근 이 두 장점을 융합할 수 있는 하이브리드 형태의 나노 구조체가 이론적으로 제안되었다. 이에 본 연구에서는 플라즈모닉스를 대표하는 골드입자와 고굴절 유전물질을 대표하는 셀레늄 (n~3.0) 나노 구조체를 융합하여 새로운 형태의 콜로이드를 소개하고, 하이브리드 콜로이드가 광학적으로 갖는 다양한 현상 분석을 집중적으로 보고할 예정이다. 특히, 고굴절률 셀레늄과 골드 나노 구조체 사이에 강한 상호작용으로 일어나는 산물인 Fano 현상을 집중적으로 관찰하고 이를 이용한 다양한 광학적 응용에 관하여 살펴볼 예정이다. 더 나아가, 골드와 셀레늄의 나노 구조체의 모양과 합성 크기를 제어할 수 있기 때문에 특정 파장(가시광역)에서 이러한 현상들을 더욱 자세히 살펴볼 예정이다. 이러한 새로운 하이브리드 형태의 콜로이드는 추후 플라즈모닉스와 고굴절률 유전물질 연구에 있어 서로의 융합의 장이 될 수 있을 것이라 기대된다.

Keywords:

고굴절 유전물질, 플라즈모닉스, 하이브리드 콜로이드, Fano resonant

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E17.01

Measuring the electron electric dipole moment using an array of ultracold molecules

LIM Jongseok *[1]
[1]Imperial College London
jlim@imperial.ac.uk

Abstract:

The Standard Model of particle physics is one of the greatest achievements of modern science. It has been fabulously successful in classifying the fundamental particles and explaining how they behave. Nevertheless, it is widely accepted that the Standard Model is incomplete because it fails to explain several important observations.

To build a more complete picture of the universe, physicists are striving to reveal what lies beyond the Standard Model. This is an important objective of much of the research being done at gigantic particle accelerators. There is an alternative, and ingenious, way to explore the same problem – measure the shape of an electron. The new forces needed to explain the matter/antimatter imbalance make electrons slightly non-spherical. This distortion – known as the electric dipole moment – changes the energy of an electron in an electric field, and that tiny change is amplified when the electron is bound to a molecule. In this talk, we will discuss how to build an apparatus that uses an array of molecules cooled to microkelvin temperatures to make an extremely precise measurement of the electron's shape. With very careful measurements, such table-top experiments will enable him to probe energies equal to, or even above, those reached by the particle accelerators.

Keywords:

ultracold molecules, laser cooling, precision measurement, electron electric dipole moment, physics beyond the standard model

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E17.02

Collisions between cold molecules in a superconducting magnetic trap

NAREVICIUS Edvardas *[1]
[1]Chemical Physics Department, Weizmann Institute of Science
edvardas.narevicius@weizmann.ac.il

Abstract:

Collisions between cold molecules are essential for studying fundamental aspects of quantum chemistry, and may enable formation of quantum degenerate molecular matter by evaporative cooling. However, collisions between trapped, naturally occurring molecules have so far eluded direct observation due to the low collision rates of dilute samples. I will present our experiment where we directly observed collisions between cold, trapped molecules, achieved without the need of laser cooling. We magnetically capture molecular oxygen in a 0.8K x kB deep superconducting trap, and set bounds on the ratio between the elastic and inelastic scattering rates, the key parameter determining the feasibility of evaporative cooling. We further co-trap and identify collisions between atoms and molecules, paving the way to studies of cold interspecies collisions in a magnetic trap.

Keywords:

Cold Molecules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E17.03

Cold-molecule techniques for ultrafast-dynamics studies

KüPPER Jochen *[1,2,3,4]
[1]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY
[2]Department of Physics, Universität Hamburg
[3]Department of Chemistry, Universität Hamburg
[4]Center for Ultrafast Imaging, Universität Hamburg
jochen.kuepper@cfel.de

Abstract:

Observing molecules in action through the recording of “molecular movies”, i. e., their spatiotemporal evolution during chemical dynamics, with atomic spatial and temporal resolution promises to revolutionize our understanding of the molecular sciences and to provide a time-dependent basis of chemistry. We build upon our approaches to prepare highly controlled samples that enable advanced imaging methods of individual molecular species and directly in the molecular frame.
We prepare highly-controlled molecular samples for advanced ultrafast imaging experiments. This includes the preparation of ensembles of individual molecular species, e.g., single microsolvation environments, single conformers, or even single quantum states. Furthermore, the generated very cold samples are ideally suited to fix the molecules in space in laser-alignment or mixed-field orientation approaches. Here, I will discuss how we use electric fields to control the neutral molecules, detail the inner workings of pendular states and kicked-rotor dynamics, and provide some experimental movies of molecular dynamics that visualize textbook quantum physics. Time permitting, I will provide a glimpse at the ultrafast-dynamics studies enabled by these controlled cold-molecule samples.

Keywords:

Cold Molecules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E17.04

Optical cycling of Aluminium Monofluoride (AlF) - towards a high-density gas of laser cooled polar molecules

TRUPPE Stefan *[1]
[1]Fritz Haber Institute of the Max Planck Society
truppe@fhi-berlin.mpg.de

Abstract:

Ultracold atomic gases have had a profound impact on science and technology. Polar molecules, cooled to low temperatures, offer even more; their rich energy level structure and their long-range dipolar interactions enable us to study exciting new phenomena in physics and chemistry. However, their complexity also makes molecules more challenging to cool.
Despite the great, recent progress in laser cooling molecules, their density in a magneto-optical trap (MOT) is many orders of magnitude lower compared to their atomic counterpart. This is preventing the realization of the full potential of laser-cooled molecules to study strongly interacting many-body quantum systems, for example.
We introduce aluminium monofluoride (AlF) as a new candidate molecule to overcome these limitations. AlF is a stable molecule with a deep molecular bond of nearly 7 eV. It can be produced in large quantities and offers a simple, highly-closed optical cycle that allows exerting a large spontaneous scattering force to slow the molecules and capture them in a MOT with high efficiency. We present the theoretical and experimental characterization of the optical cycle and high-precision spectroscopic experiments to determine important molecular constants. The losses to dark rovibronic states are small and can be well controlled which will allow us to capture and cool a large number of molecules.

Keywords:

Cold Molecules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E18.01

Two-Photon-Pumped Perovskite Plasmonic Nanolasers

LU Yu-Jung *[1,2]
[1]Research Center for Applied Sciences, Academia Sinica
[2]Department of Physics, National Taiwan University
yujunglu@gate.sinica.edu.tw

Abstract:

One of the main obstacles limiting potential applications of semiconductor nanolasers is the high threshold carrier density required for lasing, which makes them difficult to realize electrically driven lasing and integrate into optoelectronic devices. Organo-lead halide perovskite materials have recently received considerable attention for achieving an economic and tunable diode laser, owing to the use of solution-processable materials and the exceptional optical attributes of long carrier lifetimes and diffusion lengths, high fluorescence quantum yields, wavelength tenability, high optical gain coefficients[1] ($>10^4$ cm^{-1}) and promising two-photon absorption properties. However, reducing the volume of such lasers to the nanoscale is the challenge nanophotonics, with potential applications in arrays of ultra-compact lasers on a chip.

We report a novel plasmonic enhanced two-photon pumped nanolaser consisting of a subwavelength organo-lead-halide perovskite $MAPbBr_3$ nanocrystal on a 5-nm Al_2O_3 film on top of a plasmonic TiN film. A pump-probe transient absorption spectroscopy was used to study the photon-recycling-effect of perovskite nanocrystals as excellent optical gain media. Thus, we demonstrated single-mode laser emission through two-photon absorption in single perovskite nanocrystal coupled with plasmonic cavity. With the plasmonic cavity, the measured two-photon-pumped lasing threshold (200 nJ/cm^2) was reduced by two orders of magnitude. We will discuss the outlook for two-photon-pumped plasmonic nanolasers as well as perovskite quantum dot based plasmonic nanolasers as robust on-chip light sources for bio-imaging, optical communication applications.

Keywords:

Perovskite nanocrystal, Plasmonic structure, Nanolaser, Two-photon-pumped, MAPbBr3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E18.02

Realization of High Efficient and Stable Perovskite Quantum Dots for Light Emitting Diodes

LEE Chang-Lyoul *[1]
[1]Advanced Photonics Research Institute (APRI), Gwangju Institute of Science and Technology (GIST)
vsepr@gist.ac.kr

Abstract:

In this talk, I will talk about the preparation of multi-dimensional perovskites and their application as light emitting diodes. The first topic is improvement of optical and electrical properties perovskite quantum dots (QDs) through ligand exchange, second topic is investigation of photo-physical properties through the temperature-dependent PL experiment and third topic is improvement of environmental stability of perovskite QDs.

The ligand exchange to short alkyl chain length ligands could improve the packing density of perovskite QDs in film by reducing inter-particle distance between perovskite QDs. The maximum hole mobility of 6.2×10^{-3} $cm^2\cdot V^{-1}\cdot s^{-1}$, one order higher than that of pristine perovskite QDs, is obtained at perovskite QDs with hexyl ligands. The perovskite QD-LEDs with ligand exchange process exhibits 2.5 times higher current efficiency compared to pristine perovskite QD-LEDs.

The opto-physical properties, such as exciton-phonon scattering and exciton binding energy were investigated for $CH_3NH_3PbBr_3$ perovskites with various dimension sample. The exciton-phonon scattering of perovskites is responsible for both PL spectrum broadening and non-radiative decay path. From the integrated PL intensity, the exciton binding energy of three perovskites were estimated to be 388.2 meV, 124.3 meV, and 40.6 meV, respectively. Higher exciton binding energy of perovskite QDs is due to their low dimension with quantum confinement effect, which enables the formation of stable exciton even at RT. The main exciton decay path for perovskite QDs is phonon assisted thermal escape, while that for polycrystalline thin film and single crystal was the exciton dissociation due to low exciton binding energy.

The down-conversion perovskite LEDs with a high color purity and a large viewing angle were realized by utilizing perovskite NP-embedded 3D PCs. 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. The perovskite NPs embedded in polycrystalline 3D PCs showed enhanced environmental stability.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E18.03

Enhanced Stability of Cesium Lead Halide Quantum Dots through Nickel Substitution and Ligand Exchange

KIM Soo Young *[1]
[1]Department of Materials Science and Engineering, Korea University
sooyoungkim@korea.ac.kr

Abstract:

In this study, we investigated the methods for prolonged lifetime in the $CsPbX_3$ (X: Cl, Br, I) structured perovskite materials. First, the changes in structural and optical properties were compared by doping Ni in the $CsPbBr_3$ quantum dots (QDs). The steady-state photoluminescence (PL) intensity of Ni-doped QDs shows 3.8 times increase comparing with undoped QDs. $CsPbBr_3$ without nickel had a quantum efficiency of only 56.7 %, whereas $CsPbBr_3$ doped with nickel had a quantum efficiency of 82.9 %. It was found that the doped divalent element acts as a defect in the perovskite structure, reducing the recombination rate of electrons and holes. After 48 hours UV-light irradiation, PL intensity of $CsPbBr_3$ decreased about 70 % while that of Ni-substituted $CsPbBr_3$ QDs decreased only 18 %, indicating the prolonged stability against UV-light irradiation. Furthermore, Ni-substituted $CsPbBr_3$ QDs shows higher stability against temperature and moisture. These results confirmed that Ni substitution method is effective to increase the stability of $CsPbX_3$ QDs. Second, we used sulfur-oleylamine (S-OLA) complex which was utilized to etch the defect-rich surface of the $CsPbI_3$ QDs and then self-assembly to form a matrix outside the $CsPbI_3$ QDs protected the QDs from environmental moisture and solar irradiation. The PL intensity of the $CsPbI_3$ QDs increased by 21% of its initial value. There was a significant increase in the colloidal stability of the $CsPbI_3$ QDs. The introduction of S-OLA induced the recovery of the lost photoluminescence of the nonluminous aged $CsPbI_3$ QDs with time to 95% of that of the fresh QDs. Furthermore, the PL was maintained for one month. The increase in the stability and PL intensity are critical for realizing high-performance perovskite-QD-based devices.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E18.05

Bipolar Metal Oxide Charge Transporting Layers for Efficient Perovskite Solar Cells

SINGH Mriganka [1], YANG Rei-Ting [1], WENG Da-Wei [1], HU Hanlin [1], SINGH Anupriya [1], MOHAPATRA Anisha [1], LU Yu-Jung [1], GUO Tzung-Fang [1], LIN Hong-Cheu [1], CHU Chih-Wei [*1]
[1]Research Center for Applied Sciences, Academia Sinica
gchu@gate.sinica.edu.tw

Abstract:

Metal oxide charge transporting materials have been explored in numerous ways to fabricate efficient perovskite solar cells (PSCs) due to their excellent chemical stability, wide bandgap, and reasonable mobility. We report a low-temperature solution-processed intercalation method to allow metal oxide behave bipolar transporting capability for PSCs. A p-type nickel oxide (NiO) intercalated with cesium carbonate (Cs_2CO_3) can function as hole and electron transport layers for inverted and conventional planar PSCs, respectively. As compared to use only NiO as hole transporting layer, the Cs_2CO_3 intercalated NiO layer exhibit an enhanced electron extraction without scarifying a great deal of hole extraction. The power conversion efficiency of the inverted and conventional planar PSCs has been reached up to 12.08, and 13.98%, respectively. Our approach not only realizes the bipolar extraction capacity by intercalating Cs_2CO_3 in P-type metal oxides, but also open up a possible route to prepare an interconnecting layer for tandem optoelectronics.

Keywords:

Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E19.01

Exploring Defect-induced Raman mode of Transition Metal Dichalcogenides monolayer using tip-enhanced resonance Raman spectroscopy

JEONG Mun Seok *[1]
[1]Department of Physics, Hanyang University
mjeong@hanyang.ac.kr

Abstract:

A number of studies of tungsten disulfide (WS_2) have been conducted because monolayer WS_2 has a relatively high photoluminescence quantum yield. However, the defect-related Raman scattering which determines the quality of monolayer WS_2 has been rarely studied. In this study, we perform tip-enhanced Raman scattering experiments for the WS_2 monolayer to investigate the defect-induced Raman scattering properties. We 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 also identify that the emergence of new Raman vibrational modes can be induced by sulfur vacancies through the density functional theory calculations.

Keywords:

WS2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E19.02

Electron transport on the molecular scale via examples of π-conjugated oligomers: ab initio simulations and models

PETRESKA Irina *[1], PEJOV Ljupco [2], KOCAREV Ljupco [3]

[1]Faculty of Natural Sciences and Mathematics, Institute of Physics, Ss. Cyril and Methodius University in Skopje

[2]Faculty of Natural Sciences and Mathematics, Institute of Chemistry, Ss. Cyril and Methodius University in Skopje

[3]Macedonian Academy of Sciences and Arts

Irina.petreska@pmf.ukim.mk

Abstract:

This talk will provide an overview of a broader research related to some classes of π-conjugated organic molecules, considered as promising can- didates for molecular electronics. The main focus will be on the conforma- tional stochastic switching and its impact on the electron transport properties in several prototypical benzene based oligomers. The first part of the talk will comprise results from first-principles calculations of the molecular properties relevant for the electron transport, performed by employing a hybrid Hartree- Fock/Density Functional Theory (HF/DFT) approach. In the second part of the talk, we tackle the problem of *ab initio* parametrization of the model Hamil- tonians, aiming at incorporation of the quantum many body effects, such as electron correlations and electron-phonon coupling, in the transport properties. In addition to first-principles calculations of the single-molecule electronic struc- ture, our results from molecular dynamics (MD) simulations of the surrounding effects on the stochastic torsional motion of the studied molecular species will be also presented. It will be shown that combining mathematical models with *ab initio* simulations provides important prerequisites for a proper understand- ing of the complex electron transport phenomena on the molecular scale. This constitutes a very vivid research field, due to numerous potential applications of organic materials in future emerging technologies, such as, memory elements, solar cells, OLEDs, OFETs, as well as spintronic devices.

Keywords:

Electron transport

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E19.03

Synthesis of single-crystal two-dimensional monolayer films on a wafer scale

KIM Ki Kang *[1,2]
[1]Department of Energy Science, Sungkyunkwan University
[2]Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS)
kikangkim@skku.edu

Abstract:

Single-crystal two-dimensional 2D monolayers such as hexagonal boron nitride (hBN) and transition metal dichalcogenide (TMdC) on a water scale are highly desirable to realize the intrinsic material properties and unprecedent devices for industrial applications. Here, we present the recent progress of single-crystal growth for hBN and TMdCs monolayer films in a wafer scale. Two different growth mechanisms of self-collimation and epitaxial growth on liquid and atomic sawtooth surface are discussed accordingly [1,2].

[1] J. S. Lee, Science, 362, 817 (2018).
[2] S. H. Choi, Adv. Mater. Accepted in 2021.

Keywords:

Single-crystal two-dimensional 2D monolayers

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E19.04

Refined modeling of leakage and capacitance characteristics of nanostructures

NOVKOVSKI Nenad [*1]
[1]Institute of Physics, Faculty of Natural Sciences and Mathematics, University Ss. Cyril and Methodius
nenad@pmf.ukim.mk

Abstract:

In our previous studies, we have proposed modified modeling methods required to describe properly the functioning of new electronic devices from the nanoscale involving high-permittivity dielectrics [1]. It has been demonstrated that these methods provide precise characterization of devices using the electrical characteristics in the range of negligible degradation. The method demonstrated the ability to characterize the charging [2] and degradation of the structures exposed to high voltqge and high current stress conditions [3].

In our recent works, we proposed a modified Terman method for determination of interface state densities in MOS structures [4]. It allows to exclude the contribution of quantum charge from the stretched-out single high-frequency *C-V* curve. In [5] we demonstrated the use of the modified Terman method in characterization of ultrathin SiO_2 dielectrics.

Recently, we demonstrated that the use of combination of the model based analysis of leakage currents in ultrathin high permittivity (high-κ) dielectric layers and stacks along with the modified Terman method for determination of interface state densities in MOS structures can be further refined including additional effects, thus providing particularly precise characterization of the studied structures [6].

In this presentation, we expose the efficiency of the refined modeling modelling for leakage and capacitance characteristics for specific nanostructures and discuss ins advantages over the previously developed methods.

References

[1] N. Novkovski and E. Atanassova, A comprehensive model for the *I-V* characteristics of metal-Ta_2O_5/SiO_2-Si structures, Appl. Phys. A **83**, 435 (2006).
[2] N. Novkovski, A. Paskaleva, A. Skeparovski and D. Spassov, Analysis of conduction and charging mechanisms in atomic layer deposited multilayered HfO_2/Al_2O_3 stacks for use in charge trapping flash memories, Advances in Condensed Matter Physics **2018**, 3708901 (2018).
[3] N. Novkovski, E. Atanassova and A. Paskaleva, Stress-induced leakage currents of the RF sputtered Ta_2O_5 on N-implanted silicon, Appl. Surf. Sci. **253**, 4396 (2007).
[4] N. Novkovski, Modification of the Terman method for determination of interface states in metal-insulator-semiconductor, *Journal of Physics Communications* **1**, 035006 (2017).
[5] N. Novkovski and A. Skeparovski, Determination method for interface state

densities adapted to ultrathin dielectrics, in 2019 IEEE 31st International Conference on Microelectronics (MIEL) (pp. 63-66). IEEE.
[6] N. Novkovski, 2020. Refined analysis of *C–V* and *I–V* characteristics of Al/dielectric/Si structures containing nanosized Ta_2O_5/SiO_xN_y dielectric stack. J. Phys. D: Appl. Phys. **54**, 055103

Keywords:

nanostructures

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E20.01

IDP Phase Separation: Models and Implications

CHOI Jeong-Mo *[1]
[1]Department of Chemistry, Pusan National University
jeongmochoi@pusan.ac.kr

Abstract:

In the last decade, there has been a growing interest on the phase behavior of intrinsically disordered proteins (IDPs), especially after demonstration of its biological implications such as reversible formation/dissociation of membrane-less cellular organelles. Several model systems have been discovered and studied, and one of crucial questions in the field is how the phase behavior is encoded in an apparently random sequence. Focusing on a subset of IDPs that apparently exhibit a rather simple molecular grammar for phase behavior, I will present several models to predict a critical concentration, and discuss their implications.

Keywords:

intrinsically disordered proteins, phase transition, biomolecular phase separation, percolation theory, molecular modeling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E20.02

Development of High-Resolution NMR Techniques to Investigate Intrinsically Disordered Proteins in Solution

LEE Jung Ho *1
[1]Department of Chemistry, Seoul National University
jungho.lee@snu.ac.kr

Abstract:

Probing the atomic details of intrinsically disordered proteins (IDPs) is crucial to understanding their biological function and their relation to pathogenesis. Although NMR is a unique method to study the mechanistic details of IDPs, NMR signals of IDPs tend to significantly overlap. Here, I will present method developments in NMR that enhances the resolution of amide-detected multi-dimensional NMR experiments and that measures the diffusion of proteins at high resolution. The first method has enabled reduction of peak linewidth by 3-fold in the 1H dimension, whereas the second method has enabled high-resolution diffusion measurements of polypeptides in a mixture of biomolecules, thereby providing a powerful tool to investigate coexisting species under physiological conditions. Finally, I will introduce laser-assisted NMR experiments that probes the extent of solvent exposure of aromatic amino acids in IDPs. Our future directions on IDP research will be presented.

References

[1] Im J, Lee J, Lee JH. Pre-homonuclear decoupling enables high-resolution NMR analysis of intrinsically disordered proteins in solution. *J. Phys. Chem. Lett.* 10, 4720-4724 (2019)
[2] Lee J, Park SH, Cavagnero S, Lee JH. High-resolution diffusion measurements of proteins by NMR under near-physiological conditions. *Anal. Chem.* 92, 5073-5081 (2020)

Keywords:

Intrinsically Disordered Proteins, NMR Spectroscopy, Linewidth Narrowing, Diffusion

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E20.03

Local disorder of transthyretin modulates its aggregation-prone propensity

KIM Jin Hae *[1]
[1]Department of New Biology, DGIST
jinhaekim@dgist.ac.kr

Abstract:

Proteins are intrinsically dynamic. Many proteins accommodate structurally-distinctive conformations upon being exposed to different conditions or interacting with various molecules, and understanding to these structural transitions is a key to elucidate the mechanistic details of the protein functions and activities. Notably, the native equilibrium states over diverse structural conformations of proteins are maintained with delicate balance, perturbation of which could shift the original structural equilibrium. Diseases of proteinaceous origins are often caused by this disruption of protein dynamics, and, among various factors, 'protein aging' is one of the major culprits that break the dynamic balance of protein structures. This is particularly true for many proteins harboring intrinsic local or global disorder, such as intrinsically disordered proteins and amyloidogenic proteins. In this talk, I will introduce advanced techniques of nuclear magnetic resonance (NMR) spectroscopy and how these techniques have been contributed to appreciate structural dynamics of various proteins. In addition, I will present our work exemplifying direct correlation of structural disorder of a protein with its pathogenic mechanism. More specifically, I would like to discuss about 1) the structural feature of transthyretin in its monomeric amyloidogenic state, exhibiting local disorder in its C-terminal region, 2) the structural feature of transthyretin with its amyloidosis-suppressive mutation, and 3) the preferential binding interaction between Hsp90 and the amyloidogenic state of transthyretin.

Keywords:

Protein misfolding, Protein disorder, Transthyretin, Amyloidosis

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E21.01

인공지능과 입자물리학

CHO Kihyeon *1
[1]UST, KISTI
cho@kisti.re.kr

Abstract:

정부출연연구원에서 왜 인공지능을 활용하여 입자물리를 연구하는지, 어떻게 인공지능을 활용하여 입자물리를 연구하는지 소개한다. 입자물리학은 전통적으로 실험, 이론, 컴퓨팅시뮬레이션과 이를 융합한 e-Science 로 연구해 왔다. KISTI 에서는 언제, 어디서나 입자물리를 연구할 수 있는 e-Science 연구 환경을 구축하여 연구를 진행하고 있다. 입자물리에서 데이터가 증가함에 따라 자료를 정밀 처리하기 위하여 인공지능을 도입하게 된다. 인공지능은 기계학습, 딥 러닝으로 진화하면서 엄청난 양의 컴퓨팅 자원을 필요하게 되었는데, KISTI 에서는 25.7 PF 급 슈퍼컴퓨터 5 호기를 도입해 딥 러닝을 연구하기에 좋은 환경을 마련했다. 이를 활용하여 가속기충돌실험 데이터로 세계 최대의 KNL 노드를 활용하여 딥 러닝 연구를 수행한 예를 보여준다. 향후 2025 년 연간 100PB 이상의 입자가속기실험 빅데이터를 처리하기 위한 머신러닝기반 빅데이터 처리 시스템을 구상해본다.

Keywords:

입자물리학, 인공지능, 머신러닝, 딥 러닝, 슈퍼컴퓨터

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E21.02

Exploring super-functional materials with artificial intelligence

LEE In-Ho *[1]
[1]Korea Research Institute of Standards and Science
ihlee@kriss.re.kr

Abstract:

Recently, research on condensed matter using artificial intelligence has been actively conducted. In this presentation, we introduce crystal structure design applications based on both evolutionary learning methods and artificial neural networks. We present in detail the various super-functional materials with relevant performance indices. Examples include photovoltaic cells, light-emitting diodes, high-mobility, superconductivity, and topological features. We also discuss limitations that, in many cases, proposed materials are not experimentally implemented, although they present highly desirable properties. Finally, we introduce a general method for designing frequency-selective meta-surfaces that can be utilized for 5G wireless communications and present experimental results. We suggest that artificial intelligence can be applied well in the fields of electromagnetic waves and other scientific and engineering problems. In their cases, various types of research are expected because the experimental implementation is relatively easy.

Keywords:

Evolutionary learning, artificial neural networks, superfunctional materials, metasurfaces

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E21.03

Emergence of AI research topics from the calculation scale

SHIN Jeongkyu *[1], PARK Jonghyun [1], HWANG Eunjin [1]
[1]Lablup Inc.
jshin@lablup.com

Abstract:

The deep learning field, which has become rapidly popular in the last decade, requires a huge amount of matrix operations for model training. When the deep learning models' size and the amount of computation for model training exceed a certain criterion, various phenomena that cannot be explained by conventional linear and nonlinear analysis methods emerge. In this talk, we will explore research topics that have been newly discovered and developed as computational systems grow in size, and that have become possible with scale change of computational systems. To access these research topics, researchers need a platform that maintains flexible scalability and convenient usability. We introduce our open source platform to handle scientific workloads in deep learning and high performance computing. In addition, we introduce examples of large models created by combining MPI and distributed computing with deep learning training using this platform.

Keywords:

Deep Learning, AI, Complex System, Neuroscience

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

E21.04

Magnetic Hamiltonian parameter estimation using deep learning techniques

KWON Hee Young *1, YOON Han Gyu [2], LEE Chanki [2], CHEN Gong [3], LIU Kai [4], SCHMID Andreas K[5], WU Yi Zheng [6], CHOI Jun Woo [1], WON Changyeon *2

[1]Korea Institute of Science and Technology (KIST)

[2]Kyung Hee University

[3]University of California, Davis

[4]Georgetown University

[5]Lawrence Berkeley National laboratory

[6]Fudan University

d19611@kist.re.kr, cywon@khu.ac.kr

Abstract:

Understanding spin textures in magnetic systems is extremely important to the spintronics and it is vital to extrapolate the magnetic Hamiltonian parameters through the experimentally determined spin. It can provide a better complementary link between theories and experimental results. We demonstrate deep learning can quantify the magnetic Hamiltonian from magnetic domain images. To train the deep neural network, we generated domain configurations with Monte Carlo method. The errors from the estimations was analyzed with statistical methods and confirmed the network was successfully trained to relate the Hamiltonian parameters with magnetic structure characteristics. The network was applied to estimate experimentally observed domain images. The results are consistent with the reported results, which verifies the effectiveness of our methods. On the basis of our study, we anticipate that the deep learning techniques make a bridge to connect the experimental and theoretical approaches not only in magnetism but also throughout any scientific research.

Keywords:

Magnetism, Machine learning, Deep learning, Hamiltonian parameter estimation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.01

Study on transport properties in a zigzag MoS_2 nanoribbon with interactive quantum structures

JEONG You Su*[1], HEESANG KIM [1], HAN PARK Dae[1], NAMMEE KIM [1]
[1]Physics, Soongsil University
suejeong0428@gmail.com

Abstract:

A numerical study on transport properties in a zigzag MoS_2 nanoribbon with a quantum dot and a quantum point contact structure is presented. Additional quantum structures are formed by the electrostatic potentials. Ballistic spin-dependent electron transmission, energy dispersions and density profiles are obtained by using KWANT which is a Python package for numerical calculations based on tight-binding method. The spin transmission probability is tuned by geometric values of the quantum structures, an external exchange field and in-plane electric fields. The results would enlighten us with potential opportunities in various future spintronic applications.

Keywords:

MoS2, tight-binding method, transport, numerical calculation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.02

Ultra-sensitive graphene-barristor biosensor

JEONG Nae bong [1], LEE Jun-Ho [1], CHOI Inchul [1], KIM Min Jeong [1], LEE Hakho [2], CHUNG Hyun-Jong [*1]

[1]Department of Physics, Konkuk University
[2]Center of Systems Biology, Massachusetts General hospital
hjchung@konkuk.ac.kr

Abstract:

We present a new, highly sensitive biosensing approach using a graphene-based barristor [1]. The sensor is formed by interfacing graphene with semiconductor. The resulting Schottky barrier (between graphene and semiconductor) is highly susceptible to the device surface condition; binding of target biological molecules can turn on the device with very largest signal gain. This mechanism makes the barristor far superior to conventional graphene FET sensors that are based on Fermi level changes [2]. To prove the concept, we fabricated n-type barristor sensors and used them to detect DNA molecules. With target DNA binding, the height of the Schottky barrier increases, leading to the decrease in device currents. Even at very low DNA concentrations (~1 aM), we observed more than 40% changes in the device conductance. The technology may open up a new material and device concept for ultrasensitive biosensing.

Keywords:

Bio sensor, Barristor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.03

Abrupt Conductance Enhancement of Multilayer ReS_2

JOO Min-Kyu *[1], KIM Soo yeon [2]
[1]Department of Applied Physics, Sookmyung Women's University
[2]Department of Physics, Sookmyung Women's University
mkjoo@sookmyung.ac.kr

Abstract:

Electrical conductivity, which is the reciprocal quantity of resistivity, demonstrates the degree of current flow through a material and directly links to both carrier density (n_{2D}) and mobility (m). In addition, since they (n_{2D} and m) strongly rely on experiment temperature (T), the T-dependent conductivity behaviors allow us to study various carrier transport mechanisms such as metal-insulator phase transition, Coulomb impurity scattering, metal-semiconductor Schottky barrier, and quantum tunneling features. Herein, we report the anomalous conductance and mobility enhancement of multilayer rhenium disulfide (ReS_2) with rising T at a given carrier density. We attribute this anomalous m increase to formation of additional conducting path and/or conduction channel migration along the c-axis of ReS_2 driven by rapid reduction of the effective interlayer tunneling barrier (E_{int}) at high temperatures. The drain bias-dependent interlayer resistance obtained from a conducting atomic force microscope and numerical simulation on the basis of resistance network and Thomas-Fermi charge screening theory further rationalize our observation. The contact resistance/Schottky barrier effects were ruled out by presenting drain bias-dependent carrier mobility, flat-band voltage, on-/off-current ratio, and activation energy.

Keywords:

2D multilayer , Rhenium disulfide (ReS2), interlayer resistance, carrier transport , carrier mobility

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.04

Frequency Doubler and Universal Logic Gate with Low Power Consumption based on Ambipolar type Two Dimensional Transition Metal Dichalcogenide

KIM Tae Wook [1,2], RA Hyun Soo [1], AHN Jongtae [1], JANG Jisu [1], SONG Seungho [1], HWANG Do Kyung [*1]

[1]Post-Silicon Semiconductor Institute, Center for Opto-Electronic Materials and Devices, Korea Institute of Science and Technology (KIST)
[2]Department of Electronic Engineering, Korea University
dkhwang@kist.re.kr

Abstract:

Two-dimensional transition metal dichalcogenide semiconductors are very promising candidates for future electronic applications with low power consumption due to a low leakage current and high on—off current ratio. In this study, we suggest a complementary circuit consisting of ambipolar WSe_2 and *n*-MoS_2 field-effect transistors (FETs), which demonstrate dual functions of a frequency doubler and single inversion AND (SAND) logic gate. As a result, the WSe_2 FET in the circuit shows hole mobility as high as ~100 $cm^2\ V^{-1}\ s^{-1}$, an on-off current ratio of ~10^6, and moderated subthreshold swing (SS) of 106 mV dec^{-1} at room temperature. In order to reduce the power consumption, a high-quality thin *h*-BN single crystal is used as a gate dielectric that leads to a low operating voltage of less than 5 V. By combining the low operating voltage with a low operating current in the complementary circuit, a low power consumption of 300 nW (a minimum of 10 pW) has been achieved, which is a significant improvement compared to the tens of μW consumed by a graphene channel. The complementary circuit shows the effective frequency doubling of the input with a dynamic range from 20 to 100 Hz. Furthermore, this circuit satisfies all the truth tables of a SAND logic gate that can be used as a universal logic gate like NAND. Considering that the NAND logic gate generally consists of four transistors, it is significantly advantageous to implement the equivalent circuit SAND logic gate with only two FETs. The temporal output voltage responses satisfied the truth table for all cases of the SAND logic gate without significant waveform distortion. The complementary circuit with a low power consumption that functions as a frequency doubling circuit and SAND logic gate shows potential for future nano-electronic applications based on low-dimensional semiconductors.

Keywords:

2D semiconductor, complementary circuit, frequency doubler, low power consumption, universal logic gate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.05

Epitaxial single-crystal growth of transition metal dichalcogenide monolayers via atomic sawtooth Au surface

CHOI Soo Ho [2], KIM Hyung-Jin [3], SONG Bumsub [4], KIM Yong In [4], HAN Gyengtak [4], THANH Huong Nguyen Thi[4], KO Hayoung [4], BOANDOH Stephen [2], OH Chang Seok [4], JIN Jeong Won [4], WON Yo Seob [4], LEE Byung Hoon [4], YUN Seok Joon [2], JEONG Hu Young [5], KIM Young-Min [1], HAN Young-Kyu [3], LEE Young Hee [1], KIM Soo Min [6], KIM Ki Kang [*1]

[1]Department of Energy Science and Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Sungkyunkwan University

[2]Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Sungkyunkwan University

[3]Department of Energy and Materials Engineering, Dongguk University

[4]Department of Energy Science, Sungkyunkwan University

[5]UNIST Central Research Facilities, School of Materials Science and Engineering, UNIST

[6]Department of Chemistry, Sookmyung Women's University

kikangkim@skku.edu

Abstract:

Growth of two-dimensional van der Waals layered single-crystal (SC) films is highly desired to manifest intrinsic material sciences and unprecedented devices for industrial applications. While wafer-scale SC hexagonal boron nitride film has been successfully grown, an ideal growth platform for diatomic transition metal dichalcogenide (TMD) film has not been established to date. Here, we report the SC growth of TMD monolayers in a centimeter-scale via atomic sawtooth gold surface as a universal growth template. Atomic tooth-gullet surface is constructed by the one-step solidification of liquid gold, evidenced by transmission-electron-microscopy. The anisotropic adsorption energy of the TMD cluster, confirmed by density-functional calculations, prevails at the periodic atomic-step edge to yield unidirectional epitaxial growth of triangular TMD grains, eventually forming the SC film, regardless of Miller indices. Growth using atomic sawtooth gold surface as a universal growth template is demonstrated for several TMD monolayer films, including WS_2, WSe_2, MoS_2, $MoSe_2/WSe_2$ heterostructure, and $W_{1-x}Mo_xS_2$ alloy. Our strategy provides a general avenue for the SC growth of diatomic van der Waals heterostructures in a wafer-scale, to further facilitate the applications of TMDs in post-silicon technology.

Keywords:

transition metal dichalcogenides, single-crystal, chemical vapor deposition, epitaxial growth, atomic-sawtooth surface

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.06

Room-temperature ferromagnetism in monolayer WSe_2 semiconductor via vanadium dopant

KIM Ki Kang [*1,2], YUN Seok Joon [1,2], LEE Young Hee [1,2]
[1]Department of Energy Science and Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Sungkyunkwan University
[2]Center for integrated nanostructure and physics, Institute of basic science
kikangkim@skku.edu

Abstract:

Diluted magnetic semiconductors including Mn-doped GaAs are attractive for gate-controlled spintronics but Curie transition at room-temperature with long-range ferromagnetic order is still debatable to date. Here, we report the room-temperature ferromagnetism with long-range order in semiconducting V-doped WSe_2 monolayer synthesized by chemical vapor deposition. Ferromagnetic hysteresis curves are clearly manifested with exclusive Al_2O_3 passivation via vibrating-sample-magnetometer, exhibiting coercivity remanent to 360K, while retaining high on/off current ratio of 10^5 at 0.1% V-doping. This is also confirmed by the presence of magnetic domains from magnetic force microscopy. V-substituted W atoms keep a V-V separation distance of 5 nm without V-V aggregation, scrutinized by high-resolution transmission-electron-microscopy. We further demonstrate that the magnetic order and Curie temperature can be modulated by applying the back gate, implying the validation of the Zener model in establishing the long-range ferromagnetic order in V-doped WSe_2 monolayer, which is consistently supported by our density functional theory calculations. Interestingly, the competition between ferromagnetic and antiferromagnetic states is theoretically predicted. Our findings open new opportunities for using two-dimensional transition metal dichalcogenides for future spintronics.

Keywords:

2D diluted semiconductor, magnetic force microscopy, gate-tunalble magnetism.

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.07

Two-dimensional deep ultraviolet light emitter based hexagonal boron nitride

PARK Seungmin [1], SEO Dongjae [2,3], PARK Kyungho [1], CHO Minhyun [1], PARK Sunho [1], LEE Seungjoon [1], CHOI Heon-jin [3], KIM Young Dong [1], YOO Keon-ho [1], HAN Il Ki [4,6], KWON Young-Kyun [1,5], KIM Young Duck [*1,5,6]

[1]Physics, Kyung Hee University
[2]Department of Electrical and Computer Engineering, University of Minnesota
[3]Department of Materials Science and Engineering, Yonsei University
[4]Nano Photonics Research Center, KIST
[5]Department of Information Display, Kyung Hee University
[6]Department of Converging Science and Technology, Kyung See University-KIST
ydk@khu.ac.kr

Abstract:

Hexagonal boron nitride(hBN) is wide bandgap semiconductor that has bandgap of about 5.8 eV, and it has 215 nm peak at photoluminescence and cathodoluminescence but no result from electroluminescence. Because of this, hBN has been used to encapsulate other two-dimensional materials like graphene and transition metal dichalcogenides until now. In this research, we used five-layered device that includes two hBN encapsulation layers, two graphene electrodes and a hBN tunneling layer. When the electric field is applied over 0.7 V/nm, the tunneling current increases rapidly and makes color centers at hBN. The electric field goes over 1.0 V/nm, electroluminescence starts whose peaks are 5.63 eV from the band edge and 4.09 eV from the color centers. We also observed the phonon side bands of these peaks that is same as previous photoluminescence and cathodoluminescence works. By adjust the shape of graphene electrode, we can control the electric field. This gives us the probability of nanoscale display or deterministic quantum emitters.

Keywords:

two-dimensional material, van der Waals heterostrucrure, hexagonal boron nitride, ultraviolet, electroluminescence

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE18.08

Fabrication and characterizations of MoS_2/SiO_2-nanopillar array photodetectors

CHOI Hyeji [1], SONG Jungeun [1], NGUYEN Anh Thi[1], LIM Jaerang [1], AN Bojung [1], LEE Byoung Hoon [2], KIM Dong-Wook [*1]
[1]Department of Physics, Ewha Womans University
[2]Division of Chemical Engineering and Materials Science, Ewha Womans University
dwkim@ewha.ac.kr

Abstract:

Transition metal dichalcogenide (TMD) materials have attracted great attention for optoelectronic device applications, due to their sizable bandgap energy, high carrier mobility and large optical absorption coefficients. In this work, CVD-grown MoS_2 monolayer flakes were transferred on SiO_2/Si substrates with 50-nm height SiO_2 nanopillar (NP) arrays. The NP arrays can improve optical absorption in the MoS_2 layers on them. To measure the electrical properties of MoS_2 monolayers, Au interdigitated electrodes were prepared on the flat and NP regions using photolithography and lift-off techniques. Optical microscopy images revealed that there were many cracks in the MoS_2 layers on transferred on the NPs. The transport characterization in dark and under illumination showed the slow decay of photo-current, so called persistent photocurrent (PPC) effect, in our MoS_2 devices. The physical origins of PPC has been attributed to intrinsic and extrinsic defects. Light-induced surface potential maps on the MoS_2 flakes on both flat and NP regions were obtained using Kelvin probe force microscopy. All the experimental results will help us to clarify the roles of the structural defects on the PPC effects.

Keywords:

MoS2, nanopillar, photodetector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE19.01

Unoccupied states in oxide thin film transistor using analysis of electronic structure

CHUNG Kwun Bum *[1]
[1]Division of Physics and Semiconductor Science, Dongguk University
kbchung@dongguk.edu

Abstract:

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 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 oxide semiconductor films with multi-cations will be discussed in terms of electronic structure related to oxygen vacancies, local coordination, and defect states below the conduction band, and behavior of hydrogen under multi-layer structure and by process. This interpretation could be helpful to figure out the interference between process, electrical properties of films, and to predict performance and reliability of oxide TFTs.

Keywords:

Unoccupied states, Oxide thin film transistor, Electronic structure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE19.03

Influence of thermal treatment of thin films of SnS with $SnCl_2$ solution on their structural and optical properties

TANUSHEVSKI Atanas *[1]
[1]Institute of Physics, Faculty of Natural Sciences and Mathematics, University Ss. Cyril and Methodius
atanas@pmf.ukim.mk

Abstract:

SnS thin films were obtained by chemical bath deposition and they were denoted as-prepared films. The films had polycrystalline orthorhombic structure, with preferred orientation in the (111) plane. The thin films of SnS had been thermally treated at a temperature of 300 °C, after they were immersed in $SnCl_2$ solution for one minute and three minutes. The films of SnS show that they are p-type semiconductors, with increase in diffraction peaks, after they were immersed in $SnCl_2$ solution for one minute and their thermal treatment at a temperature of 300 °C. On the other hand, the films which were immersed in $SnCl_2$ solution for three minute and their thermal treatment at a temperature of 300 °C, show that they are n-type semiconductors, with little increase in diffraction peaks.
The optical bandgap of 1.24 eV was determined for as-prepared SnS films and increased to 1.3 eV for films immersed in $SnCl_2$ solution for one minute or three minutes, after being thermally treated at a temperature of 300 °C. The surface resistance of the films decreased by a factor of ten, when they were immersed in $SnCl_2$ solution for one minute or three minutes and their thermal treatment at a temperature of 300 °C.

Keywords:

SnS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE19.04

Inhomogeneity of calcium alginate hydrogels inspected by dynamic light scattering

RENDEVSKI Stojan *[1,2]
[1]Nazarbayev Intellectual School
[2]Institute of Physics, Faculty of Natural Sciences and Mathematics, University Ss. Cyril and Methodius
srendevski@yahoo.com

Abstract:

Dynamic light scattering studies have been done on gelling solutions of sodium alginate and on calcium alginate hydrogels prepared from aqueous sodium alginate solution and calcium chloride as a gelling agent according to the egg-box model of physical gelation. In the experiments, the intensity correlation function $G_2(\tau) \sim < I(t)I(t+\tau) >$ has been measured and normalized to find the collective diffusion coefficient *D*. The values of the hydrodynamic characteristic length $\xi_h = kT/6\pi\eta D$ of the gel network relaxation and full width at half maximum of the distribution of the characteristic length (FWHM) have been obtained for a different position of the laser beam scattered from the hydrogels formed in a cylindrical glass cell of the diameter of 1 cm. The correlation length for the hydrogels has been found the same throughout the gel, with the ξ_h values in the region of several millimeters beyond the size of the gels which indicates that the gels can be considered as infinite networks and homogenous. The characteristic length of calcium alginate hydrogels decreases with the increase of temperature, which is a characteristic behavior for physical hydrogels to which calcium alginate gels belong. The chemical gels, i.e. gels built by chemical bonding, have opposite behavior – the values of the characteristic length increases with the increase of temperature. The inhomogeneity of the hydrogels has been induced by creating microgel regions with addition of a small amount of calcium chloride ions in the gelling solution before the gelation takes place. The characteristic length of the polymer relaxation decreases with the increase of the inhomogeneity of the gel (size and distribution of the microgel regions). The method of inspection of the inhomogeneity with dynamic light scattering shows potential application for non-destructive quality measurement of other hydrogels used for contact lenses, controlled release drug carriers, swelling and absorption media, etc.

Keywords:

dynamic light scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

EE19.05

2D dimensional van der Walls heterostructure for advanced optoelectronic applications

HWANG Do Kyung *[1]
[1]Post-Silicon Semiconductor Institute, Center for Opto-Electronic Materials and Devices, Korea Institute of Science and Technology (KIST)
dkhwang@kist.re.kr

Abstract:

Two-dimensional (2D) van der Waals (vdW) atomic crystals have become an important material class owing to their extraordinary physical and chemical properties. One of the most significant advantages of using 2D vdW materials is the freedom from the constraint of atomic lattice matching for vertical stacking due to the dangling-bond-free nature. vdW heterostructures can be readily implemented, thereby facilitating fundamental studies of new phenomena, such as magic-angle-induced superconductivity in bilayer graphene. Additionally, such heterostructures provide a versatile platform for diverse device applications. In fact, 2D heterojunction devices have been extensively studied, and several high-performance optoelectronic devices have been demonstrated.

Here, we report several vdW heterostructures for advanced optoelectronic applications. 2D WSe_2/MoS_2 heterojunction PN diode shows excellent performance with an ideality factor of 1.5 and a high rectification (ON/OFF) ratio of over 106. This PN diode exhibits spectral photo-responses from the ultraviolet (405 nm) region to the near infrared (808 nm) region with obvious photovoltaic behaviors. On the other hand, 2D $MoTe_2/MoS_2$ multilayers van der Waals heterojunction PN diode also shows excellent performance with an ideality factor of 1.7 and high rectification (ON/OFF) ratio of over 10^4 and broad spectral hotodetection capability over the range from violet (405 nm) to near-infrared (1310 nm) wavelengths and a remarkable linear ynamic range of 130 dB. Beyond basic photodetection, we successfully demonstrate a prototype self-powered visible-invisible multiband image sensors based on both WSe_2/MoS_2 and $MoTe_2/MoS_2$ photodiodes. We believe that our results pave the way for more advanced developments in optoelectronic systems based on 2D vdW heterostructures.

Keywords:

Two dimensional semiconductor, van der Walls heterostructure, optoelectronic device

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.01

Beam-test Results of Silicon PIN Photodiode at PAL-XFEL

BAEK Jongmin [1], HWANG Sunmin [2], HYUN Hyojung [2], JANG Hoyoung [2], KIM Jinyong [1], KIM Seonghan [2], LEE Seungcheol [1], PARK Hwanbae [*1]
[1]Kyungpook National University
[2]XFEL Beamline Division, Pohang Accelerator Laboratory
sunshine@knu.ac.kr

Abstract:

Silicon photodiode (PD) is widely used for X-ray detection. We developed a silicon PIN PD, so-called “PAL-PD”, using a 500 um thickness n-type high resistivity silicon wafer. It has 1 cm x 1 cm size because the size is widely used in X-ray diagnostics and alignment. The fabricated PAL-PD has both guard ring and field shaper structures and is designed into 4 types to compare the performance depending on the metal shape of the signal readout and light entrance surfaces. We measured the electrical characteristics of the PAL-PD as a function of voltage, and the leakage current per unit area was measured to be about 20 nA/cm2 and the capacitance was measured to be about 20 pF. Quantum efficiency (Q.E.) as a function of wavelength was measured and it was 100% at 550 nm wavelength. The beam-test was performed using a soft X-ray beam (600, 900, and 1200 eV) at Pohang Accelerator Laboratory X-ray Free Electron Laser (PAL-XFEL). The performance of the PAL-PD was compared with a commercial PD that is currently used at the PAL-XFEL. The PAL-PD shows better performances in the normalized charge at 600 and 900 eV beam compared to the commercial. In this presentation, we present the results of measurements and beam-test.

Keywords:

PAL-XFEL, PIN photodiode, Quantum efficiency, X-ray detection, Electrical characteristics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.02

Study of Neutron Induced Electro-magnetic Backgrounds to an Axion-like Particle Search at the DAMSA Experiment

RYU Min Sang *[1,9], JANG Wooyoung [2], KIM Doojin [3], KONG Kyoungchul [4], KWON Youngjoon [5], PARK Jong-Chul [6], SHIN Seodong [7], YANG Un-Ki [8], YU Jaehoon [2]
[1]The Center for High Energy Physics, Kyungpook National University
[2]/Dept. of Physics, University of Texas at Arlington
[3]/Dept. of Physics, Texas A&M University
[4]/Dept. of Physics, University of Kansas
[5]/Dept. of Physics, Yonsei University
[6]/Dept. of Physics, Chungnam National University
[7]/Dept. of Physics, Jeonbuk National University
[8]/Dept. of Physics, Seoul National University
[9]Natural Science Research Center, University of Seoul
mryu194@knu.ac.kr

Abstract:

With the 2012 discovery of the Higgs-like particle at CERN and its increasingly Standard Model-like properties, the primary interests of the field of particle physics are shifting to the study of the remaining 95% of the matter and energy in the universe, using accelerators. The so-called unseen aboriginal particles (UAPs) that make up a large fraction of the 95% could be produced and discovered in particle accelerators with high-intensity beams. Rare nuclear isotope accelerator facility, such as Rare isotope Accelerator complex for ON-line experiment (RAON) provides an excellent opportunity for discovery of UAPs. The axion-like particle (ALP) is a good candidate for the UAP and thus provides an excellent case study at the DAMSA (Dump produced Aboriginal Matter Searches at an Accelerator) experiment, a 610-ton liquid argon time projection chamber (LArTPC) detector at the immediate downstream of the beam dump, as a part of the proposed ARI^{3}AA (A Research Innovation and Infrastructure Initiative for the discovery of unseen Aboriginal particles at Accelerators) project. The primary background to the charge-neutral UAP searches at DAMSA, using the RAON facility, would be the secondary electromagnetic particles produced in the interactions of neutrons that come from the high-intensity 600MeV proton beams impinging on the iron dump, given the proximity of the detector to the source of the beam. In this talk, I will present a detailed GEANT4 based study on the neutron-induced backgrounds to the ALP search case study and a potential strategy to minimize the impact of the background from the secondary neutron interactions in the DAMSA detector.

Keywords:

axion-like particles, LArTPC, beam dump, GEANT4, Neutron Induced Electro-magnetic Backgrounds

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.03

A Simulation Study of Neutron Production and Modulation for an Axion-like Particle Search at the DAMSA Experiment of the ARI^{3}AA Project

JANG Wooyoung *[1], KIM Doojin [2], RYU Min Sang [3,4], KONG Kyongchul [5], KWON Youngjoon [6], PARK Jong-Chul [7], SHIN Seodong [8], YANG Un-Ki [9], YU Jaehoon [1]
[1]Department of Physics, University of Texas at Arlington
[2]Department of Physics and Astronomy, Texas A&M University
[3]Natural Science Research Institute, University of Seoul
[4]The Center for High Energy Physics (CHEP), Kyungpook National University
[5]Department of Physics and Astronomy, University of Kansas
[6]Department of Physics, Yonsei University
[7]Department of Physics, Chungnam National University
[8]Department of Physics, Jeonbuk National University
[9]Department of Physics and Astronomy, Seoul National University
wyjang.physics@gmail.com

Abstract:

Axion-like Particle (ALP) is a promising candidate for an unseen aboriginal particle (UAP) that can direct us toward paradigm-changing new physics. High intensity accelerator facilities in Korea, such as the Rare Isotope Accelerator complex for ON-line experiment (RAON), under construction in Korea, provides an opportunity to search for ALPs and other UAPs using its high-intensity proton beam. The proposed Dump produced Aboriginal Matter Searches at an Accelerator (DAMSA) is an on-shore experimental proposal to take advantage of such high-intensity accelerator facility in Korea, as a sub-program of the recently proposed ARI^{3}AA (A Research Innovation and Infrastructure Initiative for the discovery of unseen Aboriginal particles at Accelerators) project. The main scientific goal of the DAMSA is searching for a UAP produced in the accelerator. The ALP search at DAMSA is a case study using 1 m thick iron beam dump and a 610-ton liquid argon time projection chamber (LArTPC) detector at the immediate downstream of the dump. The ALP can be produced through the Primakoff process via photons created from the interaction between the beam and the dump and be observed at the detector via the inverse Primakoff process or decaying into two photons. The primary backgrounds to the ALP stem from neutrons or neutrinos from the beam-dump interactions. The neutrinos, however, are rarely produced in the case of RAON SCL2 beams due to its energy of 600 MeV. Therefore, evaluating the effect of the neutron background is a critical step in designing such experiments. In this presentation, I will discuss our background evaluation study based on GEANT4 simulation toolkit. I will focus on the production of neutrons in the dump and will discuss neutron mitigation, through modification of dump materials, and its energy degradation strategies, using polyurethane and other moderators of various thicknesses.

Keywords:

Axion-like Particle, ALP, Beam dump, RAON, DAMSA

F1.04

Search for Axion-like Particles at the DAMSA experiment

KIM Doojin [1], JANG Wooyoung [2], KONG Kyoungchul [3], KWON Youngjoon [4], PARK Jong-Chul [5], RYU Min Sang [6,7], SHIN Seodong [8], YANG Un-ki [*9], YU Jaehoon [2]

[1]Department of Physics and Astronomy, Texas A&M University
[2]Department of Physics, University of Texas at Arlington
[3]Department of Physics and Astronomy, University of Kansas
[4]Department of Physics, Yonsei University
[5]Department of Physics, Chungnam National University
[6]Natural Science Research Institute, University of Seoul
[7]Department of Physics, Kyungpook National University
[8]Department of Physics, Jeonbuk National University
[9]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

Accelerator facilities with high intensity beams, such as rare nuclear isotope accelerator facilities enable investigating unseen aboriginal particles (UAPs), including the axion-like particles (ALPs). In this talk, I will discuss a case study on the prospects of the ALP with its coupling to Standard Model photons, in the DAMSA (Dump-produced Aboriginal Matter Searches at Accelerator) experiment, an on-shore beam dump experiment in the proposed ARI^{3}AA (A Research Innovation and Infrastructure Initiative for the discovery of unseen Aboriginal particles at Accelerators) project, using RAON (Rare isotope Accelerator complex for Online experiment) as an example facility. Thanks to the just-right 600-MeV proton beam energy, the backgrounds produced in the beam dump and subsequently entering the detector are greatly suppressed. I will demonstrate that DAMSA is capable of probing the region of the ALP parameter space below the so-called ``cosmological triangle,'' benefiting from the high-intensity photon flux and maximizing the on-axis angular coverage. I will further show that the close proximity of the detector to the ALP production dump makes it possible to probe a high-mass region of ALP parameter space which has never been explored by the existing experiments.

Keywords:

Axion-like Particle, RAON, DAMSA,

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.05

Progress of DUNE (Deep Underground Neutrino Experiment)

JEONG Yu Seon *1
[1]High Energy Physics Center, Chung-Ang University
jeong.yuseon@gmail.com

Abstract:

DUNE is a neutrino facility to elucidate unanswered questions on the fundamental physics such as matter-antimatter asymmetry and neutrino mass ordering, and also to probe neutrino interactions at sub GeV to a few GeV energy range. In order to achieve the goals, DUNE uses the 60 GeV to 120 GeV proton beam and install two detectors, which are placed at 574 m from the target (near detector, ND) and at ~1300 km (far detector, FD) from the ND. In this talk, I will introduce the science goals of DUNE briefly, and present the current status of DUNE and its near detector component, which is one of the parts that the Korean group contributes.

Keywords:

DUNE, neutrino oscillation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.06

A segmented scintillator detector for 3-D positioning of neutrino interactions using neutron detection.

HA Chang Hyon *[1]
[1]Department of Physics, Chung-Ang University
chha@cau.ac.kr

Abstract:

The Deep Underground Neutrino Experiment (DUNE) is a long baseline neutrino facility with a goal of measuring the charge-parity violation in lepton sector. To achieve the goal, the facility hosts a far detector in South Dakota and a near detector at Chicago which requires precise understanding of the beam flux and interaction cross section. Among the various DUNE near detector systems, the Korean group focuses on studying the last missing energy or the neutron detection in neutrino interactions using a segmented scintillator tracker called 3DST. In this talk, I will describe the overall concept of the 3DST detector and related activities in Korea.

Keywords:

DUNE, neutrino, scintillation tracker

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.07

Flux constraining for anti neutrino charged current interaction in 3DST with low-v method.

GWON Sunwoo *1
[1]Physics, Chung-Ang University
tnsdn302@naver.com

Abstract:

One of the purpose of the System for on-Axis Neutrino Detection (SAND) is constraining neutrino flux.
The 3 Demensional scintillator tracker (3DST) is a inner tracker of SAND.
3DST can detect neutrons, and the information of selected primary neutrons can provide a good reconstruction of energy transfer (v) to the nuclear system.
Thus, we performed flux contraining by using the "low-v" method, where the cross section does not vary in energy.
The result of analysis of neutron detection in the 3DST will be presented in this talk.

Keywords:

DUNE

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F1.08

Reconstruction of anti-neutrino event at Dune near detector SAND(3DST):

JUNG KiYoung *1
[1]physics, Chung-Ang University
dmsrl1100@cau.ac.kr

Abstract:

SAND is one of the DUNE near detector complex. And SAND is consisted of 3-Dimensional Projection Scintillator Tracker(3DST) and TPC and ECAL and so on, especially now we analyze anti-neutrino interaction at 3DST.
3DST is a 3-D stack of 1.5×1.5×1.5cm3 plastic cube unit, where each cube is optically isolated, and its signal is read out by three orthogonal fibers.
The 3DST can detect neutrons as final state particles from a neutrino interaction so we can reconstruct the neutrino energy from those final states.
I will talk about the study of low transverse momentum events, which is known as effective in reconstructing neutrino energy by measuring neutron momentum especially the CC0π 1n channel.

Keywords:

3DST, neutron, transverse momentum,

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.01

Status of Neutrino Elastic-scattering Observation with NaI(Tl) experiment (NEON)

LEE In soo *1
[1]Center for underground physics, IBS
islee@ibs.re.kr

Abstract:

Neutrino Elastic-scattering Observation with NaI(Tl) (NEON) experiment aims to detect a coherent elastic neutrino-nucleus scattering (CEνNS) using reactor anti-electron neutrino which has important role to provide other new physics such as neutrino magnetic moment and non-standard interactions.
In November 2020, the NEON detector was installed 24-m distance away from the active reactor core at Hanbit nuclear power plant in Yeounggwang.
The NEON detector consists of a 15 kg NaI(Tl) in the radiation shielding structures including a ~700 L liquid scintillator.
Data taking has been operating from November 2020 which includes ~1 month reactor-on data and ~1 month reactor-off data.
In this talk, we will present the current status of the NEON experiment.

Keywords:

Neutrino, NEON, Reactor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.02

Data understanding for Neutrino Elastic-scattering Observation with NaI(Tl)(NEON) experiment in IBS headquarters(Deajeon)

PARK ByungJu *[2,1]
[1]IBS, UST
[2]Center for Underground Physics, IBS
pbj7363@gmail.com

Abstract:

NEON (Neutrino Elastic-scattering Observation with NaI) aims an observation of a coherent elastic neutrino-nucleus scattering (CEvNS) using reactor anti-electron neutrino which has not been measured yet with NaI(Tl) crystal detectors at Hanbit nuclear power plant in Yeounggwang. It had been installed in the IBS headquarters(Daejeon) to measure background and threshold. The background level is approximately 4 counts/day/kg/keV. The details of background modeling using Monte Carlo simulation and Threshold study using machine learning methods will be presented here.

Keywords:

NEON, Neutrino, CEvNS, IBS, Reactor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.03

Seasonal variation of solar neutrino in Super-Kamiokande 3 and 4 periods

YANG JEONGYEOL *[1]
[1]physics and astronomy, Seoul National University
x0109@snu.ac.kr

Abstract:

Super-Kamiokande is the large water Cherenkov detector measuring the elastic scattering rate of solar neutrinos with electrons.The observed rate of solar neutrinos varies with the distance between the Sun and the Earth. A precise measurement of solar neutrino flux shows a seasonal variation. Any additional variation in a shorter time period may provide interesting information on the interior of the Sun. This presentation includes a preliminary measurement of the solar neutrino seasonal variation during the Super-Kamiokande 3 and 4 periods of total 3513 days.

Keywords:

Super Kamiokande, water cherenkov detector, solar neutrino flux, neutrino

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.04

New Photon Trap Design proposed for IceCube-Gen2, Hyper-Kamiokande and KNO

CHOI Koun *[1], ROTT Carsten [1]
[1]Sungkyunkwan University
kounchoi@hawaii.edu

Abstract:

We propose a photon trap designed for improved photon detection efficiency in a cost-efficient way. Wavelength Shifting plastic sheets (WLS) are deployed at the bottom of a PMT, surrounded by dichroic film by which photons are efficiently trapped and guided to the PMT. We measured wave-length dependent transmittance of a commercially available dichroic film in water, a key variable determining photon trapping efficiency. We ran a Geant4 based simulation with the property of the commercially available dichroic film as a realistic case. We also ran a simulation with a hypothetical dichroic film whose bandpass is optimized to absorption and reemission spectra of the WLS and the quantum efficiency of the PMT, as an ideal case. The preliminary results of the photon collection and detection efficiency enhancements are computed, as well as timing distribution of the photons. We discuss how this new conceptual design can be applied to next-generation neutrino telescopes.

Keywords:

Experimental Methods & Instrumentation, Cherenkov detectors, Neutrino detectors, Detector simulation, Photon detectors for UV, visible and IR photons

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.05

Measurement of cosmogenic Li/He production rate at RENO

LEE Hyungi *[1], PAC Myoung Youl [4], CHOI Juneho [4], JANG Hanil [3], KWON Eunhyang [2], KIM Sang yong [1], SEO Hyunkwan [1], KIM Jonggun [2], SEO Jiwoong [2], YU Intae [2], JEON Sanghoon [2], JUNG Daeun [2], KIM Jaeyool [7], MOON Dongho [7], SHIN Changdong [7], JOO Kyungkwang [7], LIM Intaek [7], JANG Jeeseung [5], YOO Jonghee [6], YOON Seok-Gyeong [6], KIM Soo-Bong [2]

[1]physics, Seoul National University
[2]Department of Physics, Sungkyunkwan University
[3]Department of Physics, Seoyeong Univsersity
[4]Department of Physics, Dongshin University
[5]Department of Physics, GIST
[6]Department of Physics, KAIST
[7]Department of Physics, Chonnam National University
physilhg@snu.ac.kr

Abstract:

A high energy cosmic muon produces various spallation isotopes in the RENO detector. Among them, unstable isotopes of 9Li and 8He can mimic reactor neutrino candidate events and become one of the most serious backgrounds in precise determination of the neutrino mixing angle theta13. The spectral shape of the 9Li/8He is measured using the time correlation relative to their preceding muon. The fractional ratio of 9Li and 8He is also measured from the energy spectrum of 9Li/8He decay products. The production rate of 9Li/8He was measured at 7~12MeV and extrapolated to 1.2MeV. In this talk, we present the measured production rate of cosmogenic 9Li/8He background in the RENO detector.

Keywords:

RENO, background, 9Li, 8He

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.06

Measurement Search for sterile neutrino oscillation using RENO and NEOS data

YOON Seok-Gyeong [1], YOO Jonghee *[1], YANG Byeongsu [1], JANG Jeeseung [2], LIM Intaek [3], KIM Baro [3], JOO Kyungkwang [3], KIM Jaeyool [3], MOON Dongho [3], JOHAAIB Atif [3], SHIN Changdong [3], KIM Soo-Bong [4], YU Intae [4], KWON Eunhyang [4], JUNG Daeun [4], SEO Jiwoong [4], JEON Sanghoon [4], KIM Jonggun [4], KIM Sangyong [5], SEO Hyunkwan [5], LEE Hyungi [5], JANG Hanil [6], PARK Myoung-Youl [7], CHOI Juneho [7], OH Yoonmin [8], HAN Boyoung [9], JANG Changhwan [10], JEON Eunju [8], KIM Hongjoo [11], KIM Hyunsoo [12], KIM Jinyu [12], KIM Yeongduk [8,12,13], KO Yongju [8], LEE Jason [8], LEE Jooyoung [11], LEE Moohyun [8], PARK Hyangkyu [14], PARK KangSoon [8], SEO KyungMin [12], KIM Simeon [10], SUN Gwangmin [9]

[1]KAIST
[2]GIST
[3] 전남대학교
[4] 성균관대학교
[5] 서울대학교
[6] 서영대학교
[7] 동신대학교
[8]IBS
[9]KAERI
[10] 중앙대학교
[11] 경북대학교
[12] 세종대학교
[13]UST
[14] 고려대학교
yoo.jonghee@kaist.ac.kr

Abstract:

We present a model independent search for sterile neutrino oscillation using $2\,508.9$ days of RENO near detector data and 180 days of NEOS data. The reactor related systematic uncertainties are significantly suppressed as both detectors are located at the same reactor complex of Hanbit Nuclear Power Plant. The search is performed by electron antineutrino ($\overline{\nu}_e$) disappearance between six reactors and two detectors with baselines of 294m (RENO) and 24m (NEOS). A spectral comparison of the NEOS prompt-energy spectrum with a prediction from the RENO measurement can explore reactor $\overline{\nu}_e$oscillations to sterile neutrino. Based on the spectral comparison, we obtain a 95% C.L. excluded region of $10^{-3} < |\Delta m^2_{41}| < 7\,\mathrm{eV}^2$. We also obtain a 68% C.L. allowed region with the best fit of $|\Delta m^2_{41}| = 2.40\,\pm\,0.04\ \mathrm{eV}^2$and $\sin^2 2\theta_{14}{=}0.08 \pm 0.03$. Comparisons of obtained reactor antineutrino spectra at reactor sources are made among RENO, NEOS and Daya Bay to find a possible spectral variation. The unfolded reactor antineutrino spectra will be useful for studying reactor neutrino physics and particle physics beyond the Standard Model.

Keywords:

RENO, NEOS, sterile neutrino, neutrino

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F2.07

Spectrum Decomposition for Prompt Energy of Reactor Antineutrinos at NEOS-II

KIM Jinyu *[1]
[1]Department of Physics, Sejong University
kazides@naver.com

Abstract:

The NEOS experiment, carried out in the tendon gallery of the Hanbit reactor unit 5, detects electron antineutrinos from the reactor core at 24 m distance to search for sterile neutrinos. Antineutrinos and their energy spectrum were measured at NEOS-I for 180-days of reactor-on period. A 5 MeV excess was observed in the prompt energy spectrum. NEOS-II has taken 500 days of reactor-on data from 2018 to 2020, covering a whole burnup cycle. In this talk, measurements and spectrum decomposition for prompt energy of reactor antineutrinos with the fission fractions for a whole burnup cycle are represented.

Keywords:

Reactor Neutrino Experiment, Sterile Neutrino, Reactor Antineutrino Anomaly

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.01

Model study on the collective behavior in small collision systems

LEE Sangyun *[1], LIM Sanghoon [1], PARK Woohyeong [1]
[1]Physics, Pusan National University
kiloki2000@gmail.com

Abstract:

There has been extensive study on the collective behavior of produced particles in small collision systems both at RHIC and the LHC. In order to understand the origin of collectivity, various theoretical approaches and model studies have been performed. Recently, not only flow coefficients but the correlation between flow coefficients and transverse momentum have been studied for further investigation. We have studied with the transport model (AMPT) and the hydrodynamic model(SONIC) to compare with the data from small collision systems mainly p+Au,d+Au, and 3He+Au collisions at RHIC in various aspects. In this presentation, we will present the detailed model study to understand particle production in small collision systems.

Keywords:

small collision system, AMPT, SONIC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.02

Long-range correlations in small systems with ALICE

KIM Junlee *[1], KIM Eun-Joo [1], KIM Beomkyu [2]
[1]Division of Science Education, Jeonbuk National University
[2]Department of Physics, Pusan National University
jikim1290@gmail.com

Abstract:

Recent observation of long-range correlations in small systems has shown similar features to those in heavy-ion collisions. There have been many theoretical approaches to understand the origin of the collectivity in small systems. To achieve further understanding of the origin of the collectivity, requirement and constraints were applied to the traditional measurements. In this contribution we will present second flow harmonic v_{2} as a function of pseudorapidity using the Forward Multiplicity Detector, which allow one to access a very large pseudorapidity gap up to 8 in small systems. We will also present ridge yields and values of second-flow harmonic v_{2} extracted from those with the presence of the hard-scattering observables, defined by jets and leading particles in high-multiplicity pp collisions with ALICE.

Keywords:

LHC, ALICE, Correlations, Ridge, small system

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.03

Measurement of jet fragmentation function in ALICE

RYU Jaehyeok *[1], LIM Sanghoon [1], KIM Beomkyu [1]
[1]Department of Physics, Pusan National University
fbwogur0203@gmail.com

Abstract:

In relativistic heavy-ion collisions, a hot and dense medium called Quark-Gluon Plasma(QGP) is created, and jets produced from hard parton scatterings in the early collision are used to study the QGP. Jet measurements can provide detailed information on how hard partons interacting with the medium and fragmenting into hadrons, and this is crucial to understand the properties of the medium. For more detailed study of jet quenching, It is necessary to understand substructure of jets like jet fragmentation functions. In the ALICE experiment at the LHC, jets are reconstructed with tracking detectors and electromagnetic calorimeter, and the jet fragmentation transverse momentum(j_T) is calculated with charged particles inside a jet cone. We are analyzing data of proton-proton(pp) and proton-lead(p-Pb) collisions at $\sqrt{s_{NN}}$ = 5.02 TeV to measure j_T distribution in various longitudinal fragmentation function bins. Results from this analysis with pp and p-Pb data can be compared with the pQCD calculation to test our understanding of the jet fragmentation function, and these measurements are expected to be able to provide constraints on models of jet fragmentation and hadronization. The analysis framework developed in this work will be extended to analyses of heavy-ion data. In this presentation, current status and future plan of the analysis will be presented.

Keywords:

heavy-ion collision, QGP, pQCD, jet fragmentation function

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.04

Charmed baryon measurements in pp, p-Pb and Pb-Pb collsions with ALICE at the LHC

SEO Jinjoo *[1]
[1]Dept. of Physics, Inha University
jin.joo.seo@cern.ch

Abstract:

The high-collision energies available at the LHC allow for an abundant production of heavy quarks (charm and beauty), which are sensitive probes for investigating the properties of the Quark-Gluon Plasma (QGP) formed in relativistic heavy-ion collisions. Due to their large masses, they are produced in initial hard parton scattering processes on a timescale shorter than the QGP formation time and experience the whole evolution of the system. There have been extensive researches regarding the production of charm mesons in order to investigate the interactions of charm quarks with the QGP constituents and the transport properties of the medium. The measurement of charm-baryon production, and in particular the baryon-to-meson production ratios, provides unique information on hadronisation mechanisms, constraining the role of coalescence and testing the universality of the fragmentation function. Measurements of charm-baryon production in pp collisions are important to set up a benchmark for Pb-Pb collisions and provide essential tests of pQCD calculations and models of charm hadronisation process. Measurements in p-Pb collisions are used to investigate cold-nuclear matter effects that are related to the presence of nuclei in the colliding system and that could mimic final-state medium-related effects.
In this presentation, LICE results on charmed baryon production such as Λc and Ξc will be shown. The charmed baryon-to-meson ratio and the charmed baryon-to- baryon ratio will be discussed and compared with model predictions. Morewover, The decay branching ratio of Ξc0 between the electronic and hadronic decays and the nuclear modification factor in p-Pb and Pb-Pb will be reported.

Keywords:

Charmed baryon, heavy-ion collisions

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.05

Study of multiplicity dependent J/ψ and ψ(2S) production in pp collisions

OH JongHo *[1], LIM SangHoon [1], KIM Chong [1]
[1]Physics, Pusan National University
ojh7976@gmail.com

Abstract:

PHENIX experiment at RHIC has a special ability to muons, and muons from heavy quarks havebeen studied extensively to understand their production and modification in high energy hadron-hadron collisions. Quarkonia states like J/ψ and ψ(2S) of different binding energies are expected tobe modified differently, and ψ(2S) is significantly more suppressed than J/ψ in heavy-ion collisions by color screening effect. Quarkonia production in small collision systems like pA collisions is alsomodified due to initial state and final state effects, and a relative modification between J/ψ and ψ(2S) can provide an important information on final state effects. We have been studied multiplicity dependence of the production of J/ψ and ψ(2S) in pp collisions at PHENIX. In this presentation,we will present current status and future plan of the analysis will be presented.

Keywords:

qurkonia, heavy iron collision, PHENIX

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.06

Review and future prospects of Upsilon measurements in pp, pPb, and PbPb in the CMS Detector

LEE Soohwan [1], HONG Byungsik [*1]
[1]Department of Physics, Korea University
bhong@korea.ac.kr

Abstract:

Inspection of quarkonium measurement in different collision systems has been used to understand the properties of the hot, dense matter, quark-gluon-plasma(QGP). We present the recent results of the cross-sections and nuclear modification factors of bottomonium states as well as the elliptic flow parameter v2 in PbPb collisions $₩sqrt{s_{NN}}=5.02$ TeV. We also report the bottomonium measurements in pPb at the same energy regime to investigate the contribution of the initial cold medium effects.

Keywords:

QGP, Bottomonia, elliptic flow, RAA

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.07

Study on long-range two-particle correlation in pPb collisions in ALICE

JI SuJeong *[1], LIM Sanghoon [1], KIM Beomkyu [1], KIM Junlee [2]
[1]Department of Physics, Pusan National University
[2]Division of Science Education, Jeonbuk National University
crystineji@gmail.com

Abstract:

In the collisions of heavy nuclei at relativistic energies, a hot and dense medium called Quark-Gluon Plasma (QGP) is created. Intriguingly, collective motion of the generated particles, which is thought to be a strong evidence of the formation of QGP, is also seen in small systems like *pp* and *p*Pb collisions. Such study can be done in the ALICE experiment at the LHC via long-range two-particle correlation. Recently, associated yields and flow coefficients have been measured in high-multiplicity *pp* collisions at 13 TeV, and detailed study with various event scale has been also performed by requiring high p_T particles and jets. We are interested in extending the analysis with the *p*Pb data collected in LHC Run 2 and *p*O and OO data which will be collected in LHC Run 3. For the prior research of that, a model study with PYTHIA in *pp* and *p*Pb collisions has been conducted to verify the analysis in the ALICE acceptance. In this talk, the model study and status of data analysis will be shown to understand the origin of collective motion in small collision systems.

Keywords:

ALICE, PYTHIA8, Correlations, Small System

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.08

The study on the medium parton distribution from momentum kick model in Heavy-Ion Collisions

YOON Jin-Hee *[1], CHO Soyeon [1]
[1]Dept. of Physics, Inha University
jinyoon@inha.ac.kr

Abstract:

One of the current hot issues in high-energy heavy-ion collisions is the Ridge behavior in small systems. It is hard to beleive that the collective flows are in charge of this behavior since small systems like proton-proton collisions even with high-multiplicity are not considered to be able to create a thermalized and dense medium, called QGP, as in nucleus-nucleus collisions,
To calculate any physical observables such as the two-particle correlation, we need the information on the medium produced from the collisions, especially momentum distributions of partons in the medium. We will try several forms in this distributions such as the Maxwell-Boltzmann distribution (MB) and its relativistic version, Juttner-Synge distribution(JS). However both distributions fail in explaining the wide range of rapidity in the parton distribution from experiments and therefore we focus on phenomenological PDF from the soft scattering model (phPDs), which is tested in various collisions.
The phPDs is characterized by a temperature of the system, a lightcone variable, and a fall-out parameter. The temperature is related to transverse momentum distribution and the lightcone variable and the fallout parameter are connected to rapidity distribution. The lightcone variable refers to the portion of parallel components between beam and partons' momentum and the fallout parameter modulates the decreasing slope at a high-rapidity region.
In former studies of phPDs, these characteristic parameters are determined by fitting to data from Au-Au collision experiments with sqrt{sNN} = 200GeV at STAR and proportionally determined in high energy collisions. However the collision energy at LHC is much higher by more than 10 times besides the different system sizes in pp collision. Therefore the systematic study of phPDs in determination of parameters tends to be important. We perform the dependency check of phPDs on the fallout parameter and the temperature. We find some evidence of fallout parameter related to the multiplicity. Finally, we find the fallout parameter to be 10 and the temperature of medium to be 0.25GeV by comparing the phPDs and MC simulation for pp collisions at sqrt{sNN} = 2.76TeV.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F3.09

Ξ_c^0 production in p+Pb collisions at √sNN = 5.02 TeV

BOK Jeongsu *[1]
[1]Inha University
physicsbok@gmail.com

Abstract:

Studying charmed-baryon production could play an important role in the investigation of strongly-interacting matter at extreme temperatures and densities in heavy-ion collisions because heavy quarks pass through the entire evolution of the medium. The measurement in proton-nucleus collisions is crucial to disentangle cold nuclear matter effect from the effects related to the formation of the Quark Gluon Plasma. Also, studying the production of Ξ_c^0 hadron is sensitive to the hadronization mechanism in particular to the production of baryons. In this study, The Ξ_c^0 is reconstructed via the semileptonic channel $\Xi_c^0 \rightarrow \Xi^- e^+ \nu_e$ (and charge conjugates) using ALICE detector. Status of the analysis to obtain a nuclear modification factor R_{pPb} and charmed baryon per meson ratio will be presented.

Keywords:

Heavy Ion Collisions, Quark Gluon Plasma , Charmed Baryon , ALICE

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.01

Search for secluded dark matter with 6 years of IceCube data

CHRISTOPH Toennis *[1]
[1]Physics, Sungkyunkwan University
christoph.toennis@gmx.de

Abstract:

The IceCube neutrino observatory consists of 5160 photomultiplier-tubes spread among 86 vertical strings making a total detector volume of more than a cubic kilometer. It detects neutrinos via Cherenkov light of charged relativistic particles from neutrino interactions with the detector volume. In this analysis we search for secluded dark matter which annihilates into metastable mediator particles that subsequently decay into neutrinos. Regular signals from dark matter annihilations in the Sun are strongly attenuated at higher energies due to absorption in the solar plasma. Secluded dark matter models allow the mediator to escape the Sun before producing any neutrinos, there by avoiding attenuation and yielding an enhanced neutrino signal. IceCube is ideal to search for this enhanced high-energy neutrino signal due to its good sensitivity to high energy neutrinos. We present the sensitivities of an analysis of six years of IceCube data looking for dark matter in the Sun. Mediator lifetimes between 1 ms to 10 s, dark matter masses between 100 GeV and 75 TeV and mediator decays into neutrinos, W-Bosons, tauons and bottom quarks are considered in this analysis.

Keywords:

Dark Matter, Secluded dark matter, IceCube, Sun, South Pole

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.02

The potential of the Korea Neutrino Observatory for High Energy Cosmic Neutrino Research

CHUNG Moses *[1], SHIN Bokkyun [1], LEE Namuk [1], HA Ji-Hoon [1], RYU Dongsu [1]
[1]Department of Physics, UNIST
mchung@unist.ac.kr

Abstract:

In this presentation, we will report the potential of the Korean Neutrino Observatory (KNO) for high-energy cosmic neutrino research.
The KNO is planned to construct the world largest water tank neutrino observatory for multi-purpose science in the southern part of Korea.
And the KNO can catch GeV-TeV muon neutrinos by the upward-going-muon (UGM) events. The UGM is when a muon is generated from out of the tank and passing through the tank. So that case, the detection volume is larger than the tank but losing its primary energy.
The Center for High Energy Astrophysics is aimed to research high energy (GeV~TeV) comic neutrinos from gamma-ray sources with the KNO. The astronomic gamma-ray sources such as Supernova remnants eventually generate neutrinos. Researching the flavor of neutrinos or count muon neutrino is key to estimate fractions of leptonic and hadronic gamma-ray generation processes in the sources. With expected neutrino flux from Gamma-ray sources, we estimate the expected number of the detected muon from high energy cosmic neutrino by the KNO with UGM event generation using GEANT4.

Keywords:

KNO, Korea Neutrino Observatory, Neutrinos, Cosmic Neutrinos, Muon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.03

Deployment of the IceCube upgrade camera in the SPIceCore hole

CHRISTOPH Toennis *[1], KIM Danim [1]
[1]Physics, Sungkyunkwan University
christoph.toennis@gmx.de

Abstract:

The Spicecore hole is a drillhole about 1 km off the IceCube site of 1.7 km depth, which is filled with an anti-freeze substance so it can be used for various studies related to Ice properties. In the winter 2019/2020 season the IceCube upgrade camera and illumination system was deployed inside the luminescence logger developed by the IceCube collaboration. The cameras captured the light from the illumination system that was backscattered in the surrounding ice. The amount and distribution of light in the captured images was used to study the scattering length of Ice and compared to other calibration measurements in the SPIceCore hole. We adapted a Photon Propagation Code(PPC) to simulate the scattering of the light in the ice and to compare the images to the generated simulation data.

Keywords:

Camera, IceCube, Calibration, South Pole, scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.04

Search for Decaying Dark Matter in Galaxy Clusters and Galaxies with IceCube

JEONG Minjin *[1]
[1]Department of Physics, Sungkyunkwan University
minjin.jeong@g.skku.edu

Abstract:

The IceCube Neutrino Observatory is a cubic kilometer scale neutrino telescope, deployed in deep glacial ice in Antarctica. The telescope consists of 5,160 optical sensor modules spread over 86 strings and utilizes the extremely transparent Antarctic ice to detect Cherenkov radiation from neutrino interactions with the detector medium. Being the world's largest neutrino telescope to date, IceCube has a large effective area for high energy neutrinos, and a large number of high-energy astrophysical neutrinos have been observed in the detector. Various analyses are on-going to identify the sources of these astrophysical neutrinos. In this work, we search the IceCube data for neutrinos from heavy, decaying dark matter in extragalactic sources. This study focuses on dark matter masses from 10 TeV to 10 PeV and two-body decay scenarios. The targeted dark matter reservoirs are galaxy clusters and galaxies. In this talk, we present the analysis method and preliminary sensitivities of the analysis.

Keywords:

dark matter, astrophysical neutrinos, IceCube

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.05

Dark Matter Deficient Galaxies Produced via High-velocity Galaxy Collisions in High-resolution Numerical Simulations

SHIN Eun-jin [1], JUNG Minyong [1], KWON Goojin [2], KIM Ji-hoon [*1], LEE Joohyun [1], JO Yongseok [1], OH Boon Kiat [1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Physics, University of Cambridge
mornkr@snu.ac.kr

Abstract:

The recent discovery of diffuse dwarf galaxies that are deficient in dark matter appears to challenge the current paradigm of structure formation in our universe. We describe numerical experiments to determine if so-called dark matter deficient galaxies (DMDGs) could be produced when two gas-rich, dwarf-sized galaxies collide with a high relative velocity of ~300 km/s. Using idealized high-resolution simulations with both mesh-based and particle-based gravito-hydrodynamics codes, we find that DMDGs can form as high-velocity galaxy collisions and separate dark matter from the warm disk gas, which subsequently is compressed by shock and tidal interaction to form stars. Then using the large simulated universe ILLUSTRISTNG, we discover a number of high-velocity galaxy collision events in which DMDGs are expected to form. However, we did not find evidence that these types of collisions actually produced DMDGs in the TNG100-1 run. We argue that the resolution of the numerical experiment is critical to realizing the “collision-induced” DMDG formation scenario. Our results demonstrate one of many routes in which galaxies could form with unconventional dark matter fractions.

Keywords:

Galaxy formation, Galaxy evolution, Cosmology, Dark matter, Large-scale structure of the universe

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.06

Study of Cosmic-ray Heavy Nuclei Spectra Using the ISS-CREAM Instrument

KANG Sinchul [1], KIM Hong Joo [*1], PARK Hwanbae [1], LEE Jik [1], JEONG Dongwoo [1], PARK Jeongmin [2], LEE Moohyun [3]

[1]Department of Physics, Kyungpook National University

[2]Advanced Radiation Technology Institute, KAERI

[3]Center for Underground Physics, Institute for Basic Science

hongjoo@knu.ac.kr

Abstract:

Cosmic Ray Energetic And Mass for the International Space Station (ISS-CREAM) was designed to investigate high-energy cosmic-rays. The data from the ISS-CREAM instrument was measured from August 22nd, 2017 to February 25th, 2019. In this study, the silicon charge detector (SCD), calorimeter (CAL), and top and bottom counting detectors (TCD/BCD) are used. The SCD is composed of 4 layers and provides the measurement of cosmic-ray charges. The CAL is composed of 20 interleaved tungsten plates and scintillators. It measures the energies of the incident cosmic-ray particles and provides a high-energy trigger. The TCD/BCD provide a low energy trigger. In this analysis, the measured energy distribution from CAL is deconvolved into an incident energy distribution using deconvolution matrix. The SCD top two layers are used for charge determination. Geant4 Monte-Carlo simulation data is used to get efficiency. We will present preliminary results of cosmic-ray heavy nuclei spectra from the ISS-CREAM instrument.

Keywords:

ISS-CREAM, Heavy Nuclei, Cosmic Ray

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F4.07

Result of the cosmic-ray proton spectrum for the ISS-CREAM experiment

CHOI Gwangho [1], TAKEISHI Ryuji [1], PARK IL Hung *[1]
[1]Physics, Sungkyunkwan University
ilpark@skku.edu

Abstract:

The Cosmic Ray Energetics And Mass for the International Space Station (ISS-CREAM) experiment successfully recorded the data for about 539 days from August 2017 to February 2019. The ISS-CREAM instrument can measure protons to iron nuclei in the energy range of TeV – PeV. For the elemental identification of cosmic rays, we use the silicon charge detector (SCD) with 10,752 tiny silicon pixels as 1.57 x 1.37 x 0.05 cm^3 each of size. The energy measurements are made with the calorimeter with carbon target, which also provides the tracks of incident cosmic rays. In this talk, we report the measurement of the cosmic-ray proton energy spectrum from the ISS-CREAM experiment in the energy range of 2.5 TeV–655 TeV. The measured proton spectral index of 2.67 ± 0.01 between 2.5 and 12.5 TeV is consistent with prior CREAM measurements. The spectrum softens above ~ 10 TeV consistent with the bump-like structure as reported by CREAM I+III, DAMPE, and NUCLEON, but ISS-CREAM extends measurements to higher energies than those prior measurements. Furthermore, we present the helium elemental spectrum and discuss the next analysis with the ISS-CREAM protons analysis.

Keywords:

ISS-CREAM, Proton spectrum, High-energy cosmic ray

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F6.01

Discovery of Superconductivity in (Ba,K)SbO_3

KIM Minu *[1], MCNALLY Graham M.[1], KIM Hun-Ho [1], OUDAH Mohamed [2], GIBBS Alexandra [3], MANUEL Pascal [3], GREEN Robert [4], TAKAYAMA Tomohiro [1], YARESKO A. [1], WEDIG Ulrich [1], ISOBE Masahiko [1], KREMER Reinhard K.[1], BONN Douglas [2], KEIMER Bernhard [1], TAKAGI Hidenori [1,5]
[1]Max Planck Institute for Solid State Research
[2]Stewart Blusson Quantum Matter Institute, University of British Columbia
[3]ISIS Facility, STFC Rutherford Appleton Laboratory, Harwell Science and Innovation Campus
[4]Department of Physics & Engineering Physics, University of Saskatchewan
[5]Department of Physics, University of Tokyo
minukim@fkf.mpg.de

Abstract:

Perovskite bismuthate (Ba,K)BiO_3 (BKBO) has been widely known as one of the earliest high-T_c oxide superconductors, where superconductivity at remarkably high T_c of 30 K arises in proximity to a charge density wave (CDW) order. Prior understanding on the driving mechanism of the CDW and superconductivity emphasizes the role of either bismuth (negative U model) or oxygen (ligand holes). While BKBO is presumably in the scheme of oxygen holes owing to its negative charge transfer energy, there had been no additional material to verify the comparative effects of the two ions. Here, we show a newly synthesized (Ba,K)SbO_3 (BKSO) in which the Sb 5*s* orbital energy is higher than the Bi 6*s* and enables tuning of the charge transfer energy from negative to positive. The parent compound $\mathrm{BaSbO_{3-\delta}}$ is found to show an increased CDW gap compared to the undoped bismuthate. As the CDW order is melted via potassium doping up to 65 %, superconductivity emerges at the maximum T_c = 15 K. The value is lower than the maximum T_c of BKBO, but higher by more than factor of two at the same potassium concentration. The observation of enhanced CDW and superconductivity in BKSO indicates that whether the charge transfer energy is negative or positive may not be crucial, but strong metal-oxygen covalency may play the essential role in constituting CDW and superconductivity in the main-group perovskite oxides.

Keywords:

High-Tc Superconductivity, Oxygen Holes, High-Pressure Synthesis

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F6.02

Oxygen sponge effects on structure and magnetism of manganite thin film

KANG Kyeong Tae [1], ZHANG Bruce [1,2], SHARMA Yogesh [1], PAUDEL Binod [1,3], WANG Haiyan [2], CHEN Aiping [*1]
[1]Center for Integrated Nanotechnologies (CINT), Los Alamos National Laboratory
[2]School of Materials Engineering, Purdue University
[3]Department of Physics, New Mexico State University
apchen@lanl.gov

Abstract:

Since reaching high-temperature superconducting thin films, pulsed laser deposition (PLD) has realized high-quality complex oxides with utilized properties of variety such as ferroelectricity, magnetism. Among the PLD parameters, background oxygen gas and oxide target have been known as the primary oxygen sources determining the oxygen amount within oxide thin films. Therefore, the conventional oxide films requred the relatively high oxygen partial pressure (50~250 mTorr). Meanwhile some oxide heterostructures are fabricated in low oxygen partial pressure, and herein the oxygen vacancies are hardly removed due to the entanglement with the cation off-stoichiometry. In turn, it is extensively demanded to develop a parameter of controlling the oxygen content regardless of the growth pressure, by which enough oxygen can be supply to films for full oxidation even in the low oxygen pressure growth.

Here, we propose the oxygen sponge effect's hypothesis in controlling the oxygen content within the films by using the $La_{0.7}Sr_{0.3}MnO_3$ system [1]. The pre-substrate-annealing (PSA) helps the oxide substrate serve as an oxygen sponge, providing an oxygen-rich or oxygen-poor environment for the film growth. During the PSA, the substrate is heated up in a given oxygen partial pressure right before the film deposition. Moreover, depending on the PSA conditions, the remarkable changes in oxygen content, structure, and functionalities in the as-grown oxide films emerge. The substrate oxygen sponge effect, with the large oxygen concentration gradient at high temperatures, can be applied for emergent interfacial phenomena and the growth of functional oxide thin films and nanocomposites.

[1] K. T. Kang *et al., Appl. Phys. Lett.* **117**, 151601 (2020).

Keywords:

pulsed laser deposition, oxygen sponge, oxygen vacancy, nanocomposite, magnetism

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F6.03

Oxygen incorporation induced stabilization of M3-phase VO_2

LEE Dooyong [1,2,3], SONG Sehwan [1], KIM Hyegyeong [4], KIM Jiwoong [1], BAE Jong-Seong [5], KIM Yooseok [2], LEE Jouhahn [2], PARK Sungkyun [*1]
[1]Department of Physics, Pusan National University
[2]Advanced Nano Surface Research Group, Korea Basic Science Institute
[3]Chemical Engineering & Materials Science, University of Minnesota
[4]Core Research Facilities, Pusan National University
[5]Busan Center, Korea Basic Science Institute
psk@pusan.ac.kr

Abstract:

M3-phase is an intermediate phase that occurs during a phase transition from an insulating monoclinic VO_2 (M1-phase) to a metallic rutile VO_2 (R-phase). Recently, the stabilizing M3-phase has attracted a lot of attention as a key in understanding the origin of the phase transition of VO_2 and realizing a true Mott insulator. However, the realization of the M3-phase is challenging due to a narrow window growth by vanadium multivalence state.
In this presentation, we show the stabilized M3-phase VO_2 films grown on Al_2O_3 substrate using RF-magnetron sputtering under various oxygen flow rates. Structural analyses show that the high oxygen flow rate expands a zig-zag V-V dimer by providing additional oxygen ions into the interstitial VO_2, resulting in stabilizing the M3-phase. Furthermore, temperature-dependent Raman spectra reveal the structural phase transition of the M3-phase directly to the R-phase and the more rapid structural phase transition of the M3-phase than the M1-phase at the transition temperature. The more rapid structural phase transition of the M3 phase may be related to the lower thermodynamic energy of the M3-phase than that of the M1-phase due to the more symmetrical local structure of the M3-phase. Our results show that the M3-phase can be stabilized by oxygen incorporation.

This work is supported in part by NRF-Korea (NRF-2018R1D1A1B07045663 and NRF-2020K1A3A7A09077715).

Keywords:

VO2, M3-phase, Insulator-Metal transition, Local structural symmetry

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F6.04

Emergent phenomena and interface symmetry in delafossite oxide heterostructures: Opportunities and challenges

YOON Sangmoon [1], OK Jong Mok [1], YOON Mina [2], YEOM Sinchul [3], ICHIBA Tomohiro [1], REBOREDO Fernando A.[1], HUON Amanda [1], LUPINI Andrew R.[2], LEE Ho Nyung [*1]
[1]Materials Science and Technology Division, Oak Ridge National Laboratory
[2]Center for Nanophase Materials Sciences, Oak Ridge National Laboratory
[3]Department of Physics and Astronomy, University of Tennessee
helee@ornl.gov

Abstract:

Metallic delafossite oxides ABO_2 (A = Pd and Pt) have attracted considerable attention for their natural heterostructures that highlight the combination of nearly free electrons and band/Mott insulating states. Thus, this materials system is a great platform for exploring exotic quantum phenomena emerging from highly conductive electrons manipulated by the extreme anisotropy or by the interlayer magnetic couplings e.g., hydrodynamic electron flow[1], maximal Rashba-like spin splitting[2], and unconventional anomalous/topological Hall effects[3-4]. To date, all these physical phenomena have been observed only in bulk single crystals.

Such intriguing properties have motivated recent attempts to grow delafossite thin films or heterostructures using the state-of-the-art molecular beam epitaxy and pulsed laser deposition techniques. The precision growth of metallic delafossites not only provides a route to utilize their diverse properties in future technological applications, but also enables the design of artificially-structured delafossite metals, in which new quantum phenomena may emerge. For example, if the $(Pd_{1-x}Cu_x)CrO_2$ and $(Pd_{1-x}Ag_x)CrO_2$ with honeycomb or kagome lattices (x = 0.25 and 0.33) are achieved by the precision doping, Dirac and flat bands may be stabilized in correlated delafossites and convert the $PdCrO_2$ delafossite metal to topologically active delafossites. Despite vast research efforts, the synthesis of high-quality delafossite metals in thin-film forms still remains a challenge. This is mainly due to the volatile nature of PdO, which makes the initial nucleation hard as the surface adsorption is limited on structurally dissimilar substrates, such as $SrTiO_3$ (111) and Al_2O_3 (0001). Control of the chemistry and structure of the interface to allow the growth of high-quality delafossite thin films will be an important milestone for exploring new quantum phenomena in delafossite-based quantum heterostructures.

In this talk, we will show that the use of a $CuCrO_2$ buffer layer is a way to control the interface delafossite symmetry and facilitate the synthesis of high-quality $PdCrO_2$ thin films.[5] Confusingly, the thinner the buffer layer, the better the crystal quality and transport properties. Furthermore, the $CuCrO_2$ buffer layers are not detected in the HAADF STEM images. Through the systematic STEM/EELS and DFT studies, we reveal the Cu ions are pumped out to the surface while Pd ions are sucked into the $CuCrO_2$ buffer layer during the $PdCrO_2$ deposition. We further find that the addition of excess electrons from Pd-terminated surfaces, dominantly exposed during the deposition, provides a strong driving force to induce the reaction. It indicates that

$CuCrO_2$ buffer layer plays a sacrificial role as it provides the interface delafossite symmetry to $PdCrO_2$. Based on our results, we will discuss opportunities and challenges in precisely synthesizing the artificially-structured delafossite oxides and exploring new quantum phenomena in those heterostructure.

[1] P. J. Moll *et al.*, *Science* **351**, 1061-1064 (2016).
[2] V. Sunko *et al.*, *Nature* **549**, 492-496 (2017).
[3] H. Takatsu *et al.*, *Phys. Rev. Lett.* **105**, 137201 (2010).
[4] J. M. Ok *et al.*, *Phys. Rev. Lett.* **111**, 176405 (2013).
[5] J. M. Ok *et al.*, *APL Mater.* **8**, 051104 (2020).

Keywords:

Delafossite oxides, Heterostructure, Interfaces, Scanning transmission electron microscopy (STEM)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F7.02

Electronic structure of CeNiSn investigated by soft X-ray ARPES

SEONG SeungHo [1], DENLINGER J. D.[2], KIM Kyoo [3], MIN B. I. [4], TAKABATAKE T. [5], KANG Jeongsoo [*1]
[1]Physics, The Catholic University of Korea
[2]ALS, Lawrence Berkeley National Lab
[3]Advanced Materials Research Division, KAERI
[4]Department of Physics, POSTECH
[5]Graduate School of Advanced Sciences of Matter, Hiroshima University
kangjs@catholic.ac.kr

Abstract:

Recently, there has been growing interest in the rare-earth-based Kondo insulators. Kondo insulators are understood as those materials, for which an energy gap is formed below the Kondo temperature due to the hybridization between the localized f electrons and conduction electrons. In particular, CeNiSn has a non-symmorphic symmetry, which gives rise to a Z_4 topological invariant, and so CeNiSn corresponds to a topological insulator with the Mobius-twisted surface state [1]. We have investigated the electronic structure of CeNiSn employing soft X-ray angle-resolved photoemission spectroscopy (ARPES). We have succeeded in obtaining the Fermi surface (FS) and ARPES data for the (010) and (001) planes, which agree with the calculated results obtained by the density functional theory (DFT) calculations. The measured photon energy (hv) map shows that the electronic states near the Fermi level have a three-dimensional character, contrary to the predicted topological surface states in CeNiSn. From the temperature-dependent ARPES data, we have estimated the coherent temperature of CeNiSn to be around 70 K.

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

Keywords:

Kondo insulator, CeNiSn, ARPES

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F7.03

Parity violation and new physics in superconductors

HONG Deog Ki *[1]
[1]Department of Physics, Pusan National University
deogki@gmail.com

Abstract:

We propose a new method, using the Andreev reflection at superconductors, to measure parity violation induced by the standard electroweak theory, which in turn constrains the possible parity-violating effects of new physics. The weak neutral currents induce parity-violating, marginal effective operators, though quite tiny, in superconductors. We estimate their effects on superconducting gaps and propose a method to measure the parity-violation from the spin polarization effect, when electrons or holes get Andreev-reflected at the interface between normal metal and a superconductor. Such polarization effects might be comparable to the atomic parity violation and thus naturally give an interesting bound on certain models of new physics, that couples to electrons, such as Majorana mass of active neutrinos or doubly charged Higgs

Keywords:

superconductivity, parity violation, Andreev reflection

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F7.04

Room-temperature superconducting T_c driven by strong electron correlation

KIM Hyun-Tak *[1]
[1]ETRI
htkim@etri.re.kr

Abstract:

The room-temperature superconducting T_c=287.7±12 K at 267±10 GPa in a H-S-C compound, T_c-discontinuity around $P_{transition}$=225GPa, and T_c-divergence over $P_{transition}$ were observed [1]. Explaining the phenomena including the T_c is a core problem for the mechanism of room-temperature superconductivity.

The phenomena result from the density of states, $N(0)^*\propto m^*n^{1/3}$ at E_F, with the diverging behavior of the effective mass of quasiparticle, $m^*=m/[1-(U/U_c)^2]=m/[1-\kappa_{BR}^2\rho^4]$, induced by a large electron correlation strength of $\kappa_{BR}=U/U_c$ near $\rho\approx1$ in the Brinkman-Rice(BR) picture [2], where U is the on-site repulsive Coulomb energy, $n=\rho n_{tot}$, $0<\rho=n/n_{tot}<1$ of the band-filling factor (normalized carrier density), n_{tot} of the number of atoms [2] are defined in an inhomogeneous system such as compounds with metal and insulator phases in the measurement region.

We calculate a generalized BR-BCS $T_c\approx 1.13\Theta^* exp[-coth(z)/\lambda^*]=1.13\rho^{(1/3)}\Theta exp[-coth(z)/\{\rho^{(1/3)}/(1-\rho^4)\}\lambda_{BCS}]$, where $z=\Theta/2T_c$, an effective Debye-temperature $\Theta^*=\rho^{(1/3)}\Theta$, $\lambda^*=A\lambda_{BCS}=A(N(0)V_{e-ph})$, $A=N(0)^*/N(0)=\rho^{(1/3)}/(1-\rho^4)$ from $N(0)^*\propto m^*n^{(1/3)}$ at E_F, $m^*=m/(1-\rho^4)$ at $\kappa_{BR}=U/U_c\approx1$ (not one) are given. The BR-BCS T_c closely fits the near and room-tem. experimental T_c's [1]. [1] Nature 586 (2020) 373. [2] arXiv:1710.07754.

This was supported by IITP grant funded by the Korea government(MSIT) [Grant 2017-0-00830].

Keywords:

Room temperature superconductivity, Hydride superconductor, Brinkman-Rice picture, BCS theory, Strong correlation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F7.05

Anisotropic electron-boson coupling in the electron-doped high-T_c cuprates

KIM Changyoung *[1], SONG Dongjoon [1]
[1]Department of Physics and Astronomy, Seoul National University
changyoung@snu.ac.kr

Abstract:

Kink in the electronic band dispersion has been universally observed in cuprates. It has been understood to be a renormalization of fermionic quasiparticle state attributed to electron excitation mediated by various bosonic excitations. Extensive angle-resolve photoelectron spectroscopy (ARPES) experiments have been revealed that the kink exhibits dramatic doping and momentum dependence. For instance, coupling constant extracted from the kink spectra shows gradual decrease with increasing doping. For the geometrical effect in momentum space, the kink appears at a binding energy of ~70 meV along the nodal direction in many hole-doped cuprates, while near the anti-nodal region, stronger kink is observed at lower energy scale with ~20-40 meV. However, there has been a contradict evidence that electron-doped cuprates show doping and momentum independent kink feature. Moreover, energy scale of anti-nodal kink is higher than that of nodal kink. These discrepancies between hole and electron doped cuprates hinder the establishment of universal connection between the kink and superconductivity in cuprates. Two major scenarios have been proposed for the origin of the kink. One scenario is that electron-phonon coupling is responsible the kink in the band dispersion. Meanwhile, another suggestion is that the electron-spin fluctuation coupling results in the kink. Yet the origin of this universal kink is controversially discussed.
In this ARPES study, we investigated temperature and doping dependence of the kink feature in the electron-doped cuprate $Pr_{1-x}LaCe_xCuO_4$. We observed gradual weakening of the kink feature as doping increase in both the nodal and anti-nodal region. On the other hand, we found a crucial evidence that the mechanism of the kink between the two region would be different from each other. Intriguingly, the anti-nodal kink feature resembles with the nodal kink feature of hole doped cuprates, which have an implication that those kinks in different region as well as in different system has the same mechanism. Possible scenarios for the origin of the kinks will be discussed in this presentation.

Keywords:

ARPES, Cuprate, Electron-boson coupling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F7.06

The Angular dependent Wigner solid transport on ^{3}He Stripe phase

KIM Kitak [1], IKEGAMI Hiroki [2], CHOI Hyoungsoon *[1]
[1]Department of Physics, KAIST
[2]the Center for Emergent Matter Science (CEMS), RIKEN
h.choi@kaist.ac.kr

Abstract:

A new superfluid phase with broken translational symmetry is expected to be realized in the superfluid ^{3}He confined in sub-micron length scale along one axis. Similar to the Fulde-Ferrell, Larkin, and Ovchinnikov state, the order parameter of the new superfluid phase is modulated periodically in the direction with broken translational symmetry, leaving the system with stripe domains. Though the existence of a new superfluid phase in thin superfluid ^{3}He film, different from the bulk superfluid ^{3}He phases, has been shown through multiple experiments, whether the new phase indeed forms stripe domains remains to be confirmed. We present a new experimental method using the angular dependence of the mobility of Wigner solid(WS), formed by free electrons at the surface of the liquid ^{3}He, to determine the periodic structure of the order parameter. Unlike the mobility of the WS on homogenous superfluid ^{3}He which shows no angular dependence, we show that the mobility of WS formed on the stripe phase should differ by as much as 1 % in different directions with an angular periodicity of π. Measurement of angle-dependent mobility of SSE thus would provide unambiguous evidence of FFLO-like phase in superfluid ^{3}He film.

Keywords:

Superfluid 3He, Stripe phase, Wigner Solid

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.01

빛의 전방 산란을 이용한 콜로이드 입자 크기 측정.

JU Gyeongbin [1], LEE Hyungil [2], HAN Younghee [2], LEE Manhee [*1]
[1]Department of Physics, Chungbuk National University
[2]R&D, LTH Corp.
mlee@cbnu.ac.kr

Abstract:

반도체공정의 미세화에 따라 CMP 공정에 사용되는 슬러리의 연마입자 크기도 꾸준히 작아져 왔다. 연마 과정에서 상대적으로 큰 입자들은 웨이퍼 표면에 스크래치를 유발하고 반도체 칩 제조 수율에도 영향을 미친다. 따라서 연마입자들의 크기분포를 정확하게 측정하는 것은 매우 중요하고, 이를 위해 입자 홀로그램 또는 빛의 산란현상에 기반한 상용 장비들이 소개되었다. 하지만 국내에서는 유체 입자 측정 원천기술에 대한 연구가 활발히 이루어지지 않기 때문에 장비국산화에 어려움이 따른다. 본 연구에서는 전방 산란을 이용한 입자의 크기와 굴절률을 측정하는 방법을 제시한다. 유체 관에 집속된 레이저의 중앙을 지나는 입자들에 의해 감소되는 빛의 세기를 사분할 광검출기로 측정하고 Mie 산란 이론으로 분석한다. 나아가 고도의 정교한 광학계 배열 없이도 선형 대수 기반으로 입자를 측정하는 방법을 소개한다.

Keywords:

슬러리, 폴리스티렌, 광 산란, 입자계수기, CMP 공정

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.02

결정질 SiO_2의 볼밀링에 의한 비정질화 기작에 대한 NMR 연구

KWEON Jin Jung *[1], KHIM Hoon [1], LEE Sung Keun [1,2]
[1]School of Earth and Environmental Sciences, Seoul National University
[2]Institute of Applied Physics, Seoul National University
jjkweon@snu.ac.kr

Abstract:

최근에 볼밀링 (ball milling)의 기계적 분쇄 방법에 의해 다양한 물질이 합성이 되고 있으며 여러 응용분야에서 활용되고 있다. 볼밀링에 의해 결정질 SiO_2를 비정질화시켜 Li-ion 배터리의 양극물질의 성능을 크게 향상시킬 수 있는 것으로 알려져 있다. 결정질 물질의 비정질화 과정에 대한 탐구는 지진과 같은 지질현상에서 일어나는 미시적 규모에서의 물질 변화에 대하여 이해하는 데도 중요하다. SiO_2의 비정질화 과정에서 Si 원자 주변의 구조적인 변화가 있게 되며, 공기나 수분에 의한 수소와의 상호작용에 의한 변화를 고려할 필요가 있다. NMR (nuclear magnetic resonance)은 SiO_2의 비정질화 과정에 대한 원자환경의 변화에 대하여 자세하게 알게 하고, 관련된 변화에 대한 정량적인 정보를 제공해 준다. 볼밀링된 SiO_2 시료에 대하여 ^{29}Si, ^{1}H MAS (magic angle spinning) NMR 실험을 수행하였다. 결정질 SiO_2 시료에 대하여 볼밀링 속도가 증가할수록 main peak에 해당하는 Q^4 구조의 polymerization 되는 양이 증가하는 것으로 나타났다.
또한 볼밀링 속도의 증가에 의해 main peak의 위치가 less shielding 하는 방향으로 이동하는 것으로 보아, Si-O-Si bond angle이 감소하는 것으로 보인다. 볼밀링 과정에서 공기나 수분이 SiO_2의 표면에 hydroxyl group으로 결합하여 Q^2와 Q^3 구조가 부분적으로 형성되어 있는 것을 보였다.

Keywords:

SiO2, ball milling, amorphization, 29Si and 1H MAS NMR

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.03

전도도에 따른 세리아 슬러리의 분산 안정성 변화

KWON Dohyeon [1], LEE Manhee [*1], SUK Eumine [2], KWOUN Hounsoo [2], JANG Yunseo [2], BAE Sanghyun [2]

[1]Department of Physics, Chungbuk National University
[2]synopex, synopex
mlee@cbnu.ac.kr

Abstract:

반도체 CMP 공정에서 사용되는 슬러리 연마입자는 여러 요인들에 의해 응집될 수 있다. 응집된 거대 입자는 웨이퍼를 연마하는 도중 웨이퍼 표면에 스크래치를 유발할 수 있기 때문에, 슬러리 분산 안정성을 저해하는 원인을 이해하는것은 매우 중요하다. 우리는 세리아 슬러리 용액의 전도도 변화에 따른 슬러리 연마입자 분산성 변화 및 응집현상을 연구하였다. 슬러리 용액의 전도도의 증가에 따라 연마입자의 제타 포텐셜은 약화되고 입자들 사이 반발력이 작아지며, 입자들의 자발적인 확산 정도에 따라 입자들은 응집하여 거대입자를 형성한다. 이러한 연구를 통하여 입자 응집의 열역학적 원리의 확립하고, 나아가 반도체 제조 CMP 공정에서 슬러리 입자가 응집하지 않는 최적의 전도도 범위를 제시한다.

Keywords:

슬러리, CMP 공정, 응집현상, 제타 포텐셜, 전도도

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.04

Stacking-dependent quasiparticle band structure, spontaneous polarization, and spin-splitting in few-layer and bulk ɣ-GeSe

KIM Han-gyu [1], CHOI Hyoung Joon [*1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

The group-IV monochalcogenide has attracted interest due to its potentials of ferroelectric and multiferroic properties. Recently, centrosymmetric ɣ-phase GeSe in the double-layer honeycomb lattice was theoretically predicted, but synthesized ɣ-phase GeSe showed noncentrosymmetric atomic structure, opening a chance for ferroelectricity and spin-splitting. In our present work, we study electronic band structures of the centrosymmetric and noncentrosymmetric few-layer and bulk ɣ-GeSe using density functional theory and GW calculations. We discuss stacking-dependent band gaps, spontaneous polarizations, and spin-splitting in centrosymmetric and noncentrosymmetric ɣ-GeSe which show different stacking sequences of atomic layers. We also investigate ferroelectric switching pathways, ferroelectric energy barriers, and origin of spontaneous polarizations in ɣ-GeSe from its unique stacking geometries. This work is supported by the NRF of Korea (Grant No. 2020R1A2C3013673). Computational resources have been provided by KISTI Supercomputing Center (Project No. KSC-2020-CRE-0335).

Keywords:

Group-IV monochalcogenide, ɣ-phase GeSe, ferroelectricity, spin-splitting

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.05

Study on improvement of Low-Energy Inverse Photoemission Spectroscopy (LEIPS) performance using mirror

PARK Yongsup *[1], HONG Jong-Am [1]
[1]Kyung Hee University
parky@khu.ac.kr

Abstract:

Studying the electronic structure of the interior, surface, and interface is important to understanding how electrons and holes are transported and how semiconductor devices are driven. However, instruments that measure electronic structures such as cyclic voltammetry (CV) and absorption spectroscopy measure each substance independently. However, the measured electron level measures the optical bandgap, resulting in errors due to polarons inside the actual device. Therefore, more accurate measurements are required using high energy inverse photoemission spectroscopy (HEIPS), low energy photoemission spectroscopy(LEIPS), and ultraviolet emission spectroscopy(UPS). HEIPS and UPS have been around for a long time, many improvements have been made, and in modern times they are used in many laboratories. LEIPS is a measurement method that can be combined with UPS to accurately measure electron transport gaps with higher resolution than HEIPS. However, compared to PES and other electronic level measurement methods, the measurement efficiency and the resolution is low, so there are many problems to be improved. We have worked to improve efficiency by solving these problems. What we are trying to do is collect more photon to increase efficiency. In most LEIPS, the detector is placed close to the sample, but nevertheless, most solid angles should be discarded. The improvement method used in our lab is to install a parabolic mirror in front of the sample to collect most of the photon and accumulate it into the detector. Using this method, we found an efficiency improvement of about 10 times over previously known methods. At this time, a 10-fold efficiency improvement index was calculated based on the ratio of detected photons per electron.

Keywords:

LEIPS, IPES, LUMO(lowest unoccupied molecular orbital), Advanced low-energy inverse photoemission spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F8.06

Tip-Substrate Shear Interaction in Quartz Tuning Fork-Based Atomic Force Microscopy in Air

CHOI Hyoju [1], KIM Dongwon [1], CHOI Myugnchul [*2], LEE Manhee [*1]
[1]Department of Physics, Chungbuk National University
[2]Division of Scientific Instrumentation & Management Center for Scientific Instrumentation, Cheongju, Republic of Korea, Korea Basic Science Institute
cmc@kbsi.re.kr, mlee@cbnu.ac.kr

Abstract:

We present the tip-substrate shear interaction and its origin in shear-mode, quartz tuning fork-based atomic force microscopy in air. The tip-substrate normal interaction is usually characterized by the long-range attractive force and the short-rage repulsive force, but little is known about the shear interaction in shear-mode atomic force microscopy in air. We show that the shear interaction is a result of the capillary-condensation occurred within the a few nanometers gap between the tip and the substrate, and the interaction increases with decreasing the tip-substrate gap distance owing to the tip-substrate mechanical hard contact. This shear interaction must be considered in shear-mode atomic force microscopy, spectroscopy, and manipulation of nano-objects in air.

Keywords:

Atomic force microscopy, shear interaction, capillary condensation, viscoelasticity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.02

Positive charge mediated phase transition in MBE grown $MoTe_2$

JEONG Jaehun [2], CHO Mann Ho [*2], KIM Hyeonsik [2], KWON Gihyeon [2]
[1]Yonsei University
[2]Department of physics, Yonsei University
mh.cho@yonsei.ac.kr

Abstract:

Layered molybdenum ditelluride (MoTe2) has garnered significant interest due to charge doping or strain induced structural phase transition between semiconducting hexagonal (2H) and semimetallic monoclinic (1T') phases. Here, we report growth conditions for controlling the structure of $MoTe_2$ using molecular beam epitaxy (MBE). We observed that the structure of $MoTe_2$ was significantly influenced by Mo / Te ratio and the excess tellurium makes the 1T' phase more stable than the 2H phase. Furthermore, under tellurium deficient conditon, one-dimensional Mo_6Te_6 wire structure is grown. This study on the structure control is expected to be the basis for the development of memory devices based on two-dimensional materials.

Keywords:

MoTe2, MBE, phase transition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.03

Synthesis and characterization of hexagonal GeSe

LEE Sol [1,2], JUNG Joong-Eon [1], KIM Han-gyu [1], LEE Yangjin [1,2], PARK Je Myoung [3], JANG Jeongsu [1], YOON Sangho [4,5], GHOSH Arnab [1], KIM Minseol [1], NA Woongki [3], KIM Jonghwan [4,5], CHOI Hyoung Joon [1], CHEONG Hyeonsik [3], KIM Kwanpyo [*1,2]
[1]Physics, Yonsei University
[2]Center for Nanomedicine, IBS
[3]Physics, Sogang University
[4]Materials Science and Engineering, POSTECH
[5]Center for Artificial Low Dimensional Electronic Systems, IBS
kpkim@yonsei.ac.kr

Abstract:

The family of IV-VI mono-chalcogenides, such as GeSe, GeS, SnS, SnSe, have gathered wide research interest due to its peculiar structure with atomically puckered layers and associated interesting anisotropic physical properties. The atomic boding configuration in this family allows the formation of other type of polymorphs, which is supported by previous theoretical investigations. Here, we report the synthesis of a new polymorph of GeSe, which possesses a hexagonal crystal structure (ɣ-phase) using physical vapor deposition method. The elemental analysis, electron diffraction, high resolution scanning transmission electron microscopy imaging and polarized Raman spectroscopy clearly confirm the successful synthesis of the new phase GeSe(ɣ-GeSe). Metallicity of ɣ-GeSe was observed from electrical and optical absorption measurements and elucidated by bandstructure calculation of doped ɣ-GeSe.

Keywords:

IV-VI monochalcogenides, new polymorph, physical vapor deposition, transmission electron microscopy, polarized Raman spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.04

Phase transition in $GeTe/Sb_2Te_3$ superlattices through Ge vacancies ordering

CHO Mann Ho *[1], LEE Chang Woo [1], LIM Hyeon Wook [1], KIM Da sol [1]
[1]Yonsei University
mh.cho@yonsei.ac.kr

Abstract:

The phase-change memory (PCM) has attracted scientific interest for next generation nonvolatile memory. Unfortunately, since the conventional phase-change memories, which are based on the reversible phase-change between amorphous and crystalline state, consumes too much energy, it required improvement with respect to its power consumption for commercial application. Recently, the new concept PCM material, so called interfacial phase change memory (iPCM), has been demonstrated to significantly reduce power consumption, owing to entropy control. Even though there have been a lot of efforts to figure out the atomic structure and switching mechanism of this new material, the comprehensive understanding still under intense debating. In this study, we confirmed that GeSbTe (9-layer) structures are formed for high resistance state, and [GeTe (7-layer)/Sb_2Te_3 (5-layer)] for low resistance state by transmission electron microscopy (TEM). We also verified that the new GeSbTe structures are formed in long-range order from X-ray diffraction (XRD). Moreover, X-ray photoelectron spectroscopy (XPS) provides the critical evidence related to the change of chemical bonding caused by the structural change through Ge vacancies ordering. By combining the experimental and theoretical results, this study presents a new methodology for the $GeTe/Sb_2Te_3$ superlattice atomic local environment analysis and we suggest the new phase change mechanism about GST-SL as well as the control of disorder in phase change materials.

Keywords:

Interfacial phase change memory(iPCM), GeTe/Sb2Te3 superlattice, X-ray diffraction, X-ray photoelectron spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.05

Charge-trapping memory device based on a heterostructure of MoS_2 and $CrPS_4$

PARK Bae Ho [*1], SHIN Minjeong [1], LEE Mi Jung [1], YOON Chansoo [1], PARK Je-Geun [2], LEE Sungmin [2]
[1]Department of Physics, Konkuk University
[2]Department of Physics and Astronomy, Seoul National University
baehpark@konkuk.ac.kr

Abstract:

Atomically thin two-dimensional (2D) materials have emerged as promising candidates for flexible and transparent electronic applications. Here, we introduce non-volatile charge trapping memory devices, based on the 2D heterostructure field-effect transistor consisting of a few-layer MoS_2 channel and $CrPS_4$ charge-trapping gate stack. Clockwise hysteresis behaviors in transfer curves measured at room temperature show a strong dependence on the thickness of $CrPS_4$, which are attributed to charge trapping at trap sites in the $CrPS_4$ layers. Our heterostructure memory device with 75 nm-thick $CrPS_4$ layer exhibits both large memory windows up to 99.7 V and a high on/off current ratio (3×10^5) with good endurance during 625 cycles because of its excellent trapping ability of trap sites in the $CrPS_4$. Especially, the memory window size can be effectively tuned from 7.6 V to 99.7 V by changing the sweep range of gate voltage. Such high performances of the charge trapping memory device with a simple heterostructure provide a promising route towards next-generation memory devices utilizing 2D materials.

Keywords:

Charge-trapping memory, MoS2, CrPS4, Heterostructure device

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.06

Atomically Thin Multiferroic van der Waals Material NiI_2

JU Hwiin [1], LEE Youjin [2,3,4], CHOI In Hyuk [1], ROH Chang Jae [1], SON Suhan [2,3,4], PARK Pyeongjae [2,3,4], KIM Jae Ha [5], JUNG Taek Sun [5], KIM Jae Hoon [5], PARK Je-Geun [2,3,4], LEE Jong Seok *[1]
[1]Department of Physics and Photon Science, GIST
[2]Center for Quantum Materials, Seoul National University
[3]Department of Physics and Astronomy, Seoul National University
[4]Institute of Applied Physics, Seoul National University
[5]Department of Physics, Yonsei University
jsl@gist.ac.kr

Abstract:

Recently, van der Waals materials have been fast becoming one of the hottest materials groups. And we are witnessing an increasingly large volume of literature reporting electric and magnetic orders in their monolayer or bilayer thickness limits. However, most of such active research has dealt with single ferroic orders in given materials. In this work, we demonstrate, for the first time, a robust persistence of the multiferroic state, coexisting ferroelectric and antiferromagnetic orders, in atomically thin van der Waals material NiI_2. Using the optical second-harmonic generation technique, we successfully trace the development of the ferroelectric order which arises from the cycloidal spin order. We find that the multiferroic phase remains robustly the ground state for the bilayer NiI_2 below 20 K, but it is found unstable for the monolayer down to at least 4 K.

Keywords:

multiferroicity, atomic thickness, van der Waals material, NiI2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F9.07

Ordering of Fe-Ge pairs in van der Waals ferromagnetic Fe_5GeTe_2

LY Trinh Thi[1], PARK Jungmin [2], KIM Kyoo [3], DUVJIR Ganbat [1], LAM Nguyen Huu[1], LEE Changgu [4], KIM Sanghoon [1], KIM Jungdae [*1]
[1]Physics, University of Ulsan
[2]Center for Scientific Instrumentation, Division of Scientific Instrumentation & Management, Korea Basic Science Institute, Daejeon 34133, Korea
[3]Korea Atomic Energy Research Institute, Daejeon 34057, Korea
[4]School of Mechanical Engineering, Sungkyunkwan University, Suwon 16419, Korea
kimjd@ulsan.ac.kr

Abstract:

van der Waals ferromagnetic materials of Fe_nGeTe_2 family (n = 3, 4, 5) have been received many interests because of their high T_C (260 ~310 K). Among Fe_nGeTe_2 family, Fe_5GeTe_2 exhibits the highest T_C due to the additional Fe layers called Fe(1). The Fe(1) layer locating in the outermost of Fe_5Ge sublayer has two possible split-sites which are either above or below the Ge atom. However, the detailed structural information of Fe_5GeTe_2 is still lacking. In this study, we use scanning tunneling microscope (STM) to investigate the atomistic structure of Fe_5GeTe_2. We find that Fe_5GeTe_2 surface exhibits $\sqrt{3}\times\sqrt{3}$ superstructures attributed by Fe(1)-Ge ordering. The $\sqrt{3}\times\sqrt{3}$ superstructures have two different phases due to the symmetry of Fe(1) ordering such as $Fe(1)_{up}$-$Fe(1)_{down}$-$Fe(1)_{down}$ and $Fe(1)_{down}$-$Fe(1)_{up}$-$Fe(1)_{up}$. The observed $\sqrt{3}\times\sqrt{3}$ ordering of Fe(1)-Ge pair breaks the inversion symmetry, which gives rise to intriguing helimagnetism in Fe_5GeTe_2. More details of magnetic properties are discussed in our recent publication at Adv. Funct. Mater. (https://doi.org/10.1002/adfm.202009758).

Keywords:

STM, Fe5GeTe2, van der Waals, ferromagnet

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F10.01

Strong Superexchange in a $d^{9-\delta}$ Nickelate Revealed by Resonant Inelastic X-Ray Scattering

DEAN Mark *[1]
[1]Brookhaven National Laboratory
mdean@bnl.gov

Abstract:

The discovery of superconductivity in a $d^{9-\delta}$ nickelate has inspired disparate theoretical perspectives regarding the essential physics of this class of materials [1]. A key issue is the magnitude of the magnetic superexchange, which relates to whether cuprate-like high-temperature nickelate superconductivity could be realized. We address this question using Ni L-edge and O K-edge spectroscopy of the reduced trilayer nickelate $d^{9-1/3}$ $La_4Ni_3O_8$ and associated theoretical modeling [2]. A magnon energy scale of ~80 meV resulting from a nearest-neighbor magnetic exchange of J=69(4) meV is observed, proving that $d^{9-\delta}$ nickelates can host a large superexchange. This value, along with that of the charge transfer energy and Ni-O hybridization estimated from our O K- edge data, implies that trilayer nickelates represent an intermediate case between the infinite-layer nickelates and the cuprates, and suggests that they represent a promising route towards higher-temperature nickelate superconductivity.

References

[1] D. Li et al., Nature 572, 624 (2019).
[2] J. Q. Lin et al., Phys. Rev. Lett. 126, 087001 (2021)

Keywords:

RIXS, Nickelate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F10.02

Resonant inelastic X-ray scattering studies on Kitaev spin liquid candidates, honeycomb iridates A2IrO3 (A = Na, Li)

CHUN SAE HWAN *[1]
[1]XFEL Division, Pohang Accelerator Laboratory
pokchun81@postech.ac.kr

Abstract:

Kitaev spin liquid is a quantum spin liquid (QSL) state that emerges out of the magnetic frustration driven by bond-directional Ising interactions between S = 1/2 spins on the honeycomb lattice. This quantum state is an outcome of an exactly solvable Z2 spin liquid model proposed by Kitaev, and predicted to host intriguing topologically non-trivial properties such as Majorana fermion and gauge flux excitations following non-Abelian statistics. In this talk, I will discuss resonant inelastic X-ray scattering (RIXS) investigations of honeycomb iridates Na2IrO3 and alpha-Li2IrO3 considered the candidate materials for Kitaev QSL. These iridates have long-range magnetic orders below 12-15 K, complicating the prediction. The hard X-ray RIXS experiments around Ir L3 edge allow us to measure momentum-resolved spectra of magnetically excited states in the honeycomb iridates. This X-ray investigation reveals short-range magnetic orders above the transition temperature and dispersive magnetic excitations, pointing to the dominance of Kitaev exchange interactions and the relevance to the Kitaev QSL.

Keywords:

quantum spin liquid, Kitaev model, RIXS, iridate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F10.03

Spin waves in a $Sr_2IrO_4/Sr_3Ir_2O_7$ superlattice

KIM Bumjoon *[1]
[1]Department of Physics, POSTECH
bjkim6@gmail.com

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 on our recent resonant inelastic x-ray scattering experiment on a magnetic heterostructure composed of Sr_2IrO_4 and $Sr_3Ir_2O_7$, which are magnetic insulators with predominantly Heisenberg and Ising interactions, respectively. Relative to its bulk counterpart, we observe that spin waves of the Sr_2IrO_4 layer in the superlattice are broadened by more than a factor of two, while the dispersion remains almost unchanged. I will discuss possible origins of this phenomenon.

Keywords:

RIXS, iridates, spin-orbit coupling, spin wave, exciton

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F10.04

RIXS study of Infinite-layer Nickelate Superconductors

LEE Wei-Sheng *[1]
[1]Stanford Institute of Materials and Energy Sciences, SLAC National Accelerator Lab
leews@stanford.edu

Abstract:

After decades of efforts, the first nickelate superconductor has been recently discovered in Sr-doped infinite-layer nickel oxides $Nd_{1-x}Sr_xNiO_2$, soon followed by the doped Pr-doped infinite-layer nickelates. They are isostructural to the infinite-layer cuprates and nominally possess nine electrons in the 3d orbitals, like cuprates. At this early stage, characterizing the underlying elementary excitations to clarify the differences and similarities to the cuprates are urgent experimental tasks to gain further insight into these new materials. In this talk, I will present our recent RIXS experiments about the electronic structures and magnetic excitations in the infinite-layer nickelates $Nd_{1-x}Sr_xNiO_2$. Comparisons to cuprates will also be discussed.

Keywords:

RIXS, Nickelate, Superconductors

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F11.01

Multi-qubit system based on superconducting qubit in circuit QED

CHOI Gahyun *[1], LEE Sunkyung [1]
[1]Quantum Technology Institute, KRISS
ghchoi@kriss.re.kr

Abstract:

Superconducting circuit is the most promising platform for realizing large-scale universal quantum computing system. The superconducting device including resonators and qubits can be fabricated on a single wafer chip as designed and even expanded to 3D integration using through-Silicon via (TSV) method. As the number of qubits increases, the computing capability grows exponentially but undesirable issues such as crosstalk and frequency crowding arise in the superconducting qubit system. In this talk, we present our recent progress on multi-qubit system based on superconducting circuit. Each qubit is controlled by microwave pulses and its quantum state is measured by multiplexed readout where each qubit has own readout resonator. In addition, we are able to observe two-qubit entanglement in this system, in which two adjacent qubits are connected with a coupler.

Keywords:

superconducting qubit, Multi-qubit

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F11.02

Tunable Cavity QED system with parametrically induced dispersive shifts

NOH Taewan *[1]
[1]National Institute of Standards and Technology (NIST)
taewan.noh1985@gmail.com

Abstract:

Engineered dispersive shifts in cavity-QED systems are important for enabling high fidelity qubit measurement, fast logic gates, state preparation and error correction protocols. Standard superconducting circuit-QED systems typically rely on static coupling between qubits and cavities. Here, tunable dispersive shifts are only possible by in-situ frequency tuning of either the qubit or cavity. Manipulation of dispersive shifts in this way can be cumbersome and restricted. In this talk, we will describe our experiments with a transmon qubit coupled to a cavity via a dc-SQUID. We show that our system can avoid qubit decoherence by minimizing coupling to the readout cavity during qubit operations. With both the qubit and cavity at fixed frequencies, we can dynamically produce large positive or negative dispersive shifts, achieving high fidelity qubit measurements. In addition to realizing many features of standard cavity-QED, this system also exhibits a unique tunability along with qualitatively new features not supported by static circuit-QED setups, thus opening up a new paradigm for controlling light-matter interactions.

T. Noh et al., Strong parametric dispersive shifts in a statically decoupled multi-qubit cavity QED system, arXiv:2103.09277 (2021)

Keywords:

quantum information

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F11.03

Waveguide quantum electrodynamics in superconducting circuits

KIM Eunjong *[1,2]
[1]Thomas J. Watson Sr., Laboratory of Applied Physics and Kavli Nanoscience Institute, California Institute of Technology
[2]Institute for Quantum Information and Matter, California Institute of Technology
eunjongkim@caltech.edu

Abstract:

Achieving an efficient interface of light and matter has been a principal goal in quantum optics. A burgeoning paradigm in the study of light-matter interface is waveguide quantum electrodynamics (QED), where quantum emitters are coupled to a common one-dimensional waveguide channel. In this scenario, cooperative effects among quantum emitters emerge as a result of real and virtual exchange of photons, giving rise to new ways of controlling matter. In this talk, we discuss waveguide QED experiments in superconducting circuits where transmon qubits are coupled to engineered microwave waveguides. Employing the high flexibility and controllability of superconducting quantum circuits, we realize and probe a variety of waveguide-mediated interactions between qubits. Our work marks an important step towards quantum simulation of many-body models beyond nearest-neighbor coupling and realization of efficient coupling schemes for quantum computation.

Keywords:

quantum information

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F11.04

High-fidelity two-qubit gates using a tunable coupler

SUNG Youngkyu *1
[1]Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology
youngkyu@mit.edu

Abstract:

The promise of quantum computation is contingent upon the ability to perform qubit operations with low error rates. While there has been tremendous progress toward achieving low error rates with superconducting qubits over the past two decades, error-prone two-qubit gates remain a bottleneck for quantum information processing at scale. Hence, the success of quantum computation heavily relies on both theoretical and experimental advances in the implementation of high fidelity two-qubit gates. In this talk, we discuss our latest two-qubit gate experiments that use a tunable coupler [1] to demonstrate CZ and iSWAP gates with two-qubit interaction fidelities approaching 99.7–99.8%, which are close to their T_1 limits [2].

[1] F. Yan, P. Krantz, **Y. Sung**, *et al.* Tunable coupling scheme for implementing high-fidelity two-qubit gates, *Phys. Rev. Applied* **10**, 054062 (2018).
[2] **Y. Sung**, L. Ding, J. Braumüller, *et al.* Realization of high-fidelity CZ and ZZ-free iSWAP gates with a tunable coupler, arXiv:2011.01261 (2020).

Keywords:

Quantum gates, Quantum control, Superconducting qubits

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F12.01

Ferroelectricity with stable subloop behavior of Si-doped HfO_2 thin film

CHAE Seung Chul *[1]
[1]Dept. of Physics Education, Seoul National University
scchae@snu.ac.kr

Abstract:

Ferroelectricity with controllable partial polarization is considered as one of the feasible candidates for an analog device for the neuromorphic device in the form of the ferroelectric tunnel junction and ferroelectric transistor. However, in the case of conventional ferroelectric materials, the complex nature of the ferroelectric switching mechanism and/or defect mediated uncertainty hinders the deterministic control of ferroelectric subloop switching. This stochastic nature in the control of ferroelectric polarization states is of interest prior to the device application.

Recently, ferroelectric HfO2 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 HfO2. We suggest that the enhanced stability and accessibility of intermediate states in HfO2 can be attributed to the large activation field for ferroelectric switching with a small critical volume for the ferroelectric nucleation of HfO2. We measured switching dynamics and temperature dependence hysteresis of HfO2 thin films. The characteristic switching time and temperature dependence of hysteresis showed that ferroelectric HfO2 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 HfO2 during a single dipole flip. Monte-Carlo simulation confirmed the relation between stable accessibility and the small volume of the ferroelectric domain.

Keywords:

ferroelectric HfO2, subloop behavior

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F12.02

Delafossite oxides: A natural heterostructure with a great variety of physical properties

OK Jong Mok *[1]
[1]Department of Physics, Pusan National University
okjongmok@pusan.ac.kr

Abstract:

ABO_2 delafossite oxides have attracted recent attention, especially from the oxide thin film community, because they have a natural heterostructure of hexagonal A and BO_2 layers that provide a diverse set of physical properties. In the delafossite oxides, A-site electrons occupy a band near the Fermi level with steep band dispersion, while B-site electrons are strongly correlated and have Mott-insulating characteristics. The diverse combination of A and B atoms provides a wide range of fascinating properties. The most notable properties found in delafossites include the highest figure of merit among the p-type transparent conducting oxides; geometrically frustrated magnetism; and extremely high conductivity. Layer-by-layer growth of delafossites not only provides a route to utilize their diverse properties in future devices, but also enables the design of artificial delafossite heterostructures with which new physics and chemistry can be realized. Despite the efforts to grow delafossite thin films thus far, many challenges still must be solved to enable the growth of high-quality thin films.

Keywords:

Oxide thin films, Delafossite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F12.03

First-principles calculation of two dimensional 1T oxides

KIM Inseo [1], LEE Hyungwoo [1], CHOI Minseok *[1]
[1]Department of Physics, Inha University
minseokchoi.phd@gmail.com

Abstract:

Two-dimensional (2D) transition materials have been attracted attention since they are not only ideal platforms to investigate exotic physical phenomena but also are technically promising for applications. However, it has been difficult to experimentally realize 2D oxides in which plentiful new physics may emerge associated with strong interactions between many degree of freedom. Recently, it is reported that 2D oxide layer (1*T* structure) can be obtained from the layered hexagonal oxide ABO_2 using the by a two-step process involving exfoliation and heat treatment. In this talk, we present first-principles study of the electronic and magnetic structures, stability, and defect property in several 2D 1*T* oxides. In addition, the impacts of mechanical strains on the physical properties are investigated.

Keywords:

first-principles calculation, two dimensional oxides

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.01

물리식의 존재론적 의미와 인식론적 의미에 대한 학생들의 이해

KIM Minchul [1], CHEONG Yongwook [2], SONG Jinwoong [*3]
[1]Department of Physics Education, Kongju National University
[2]Department of Physics Education, Gyeongsang National University
[3]Department of Physics Education, Seoul National University
jwsong@snu.ac.kr

Abstract:

물리식은 물리 개념들 간의 관계를 수학적인 기호들로 나타낸 것이다. 물리학과 수학의 상호작용은 다양하였지만 물리 교수 학습 상황에서는 수학적인 면만 지나치게 강조되는 경향을 보인다. 이에 본 연구에서는 물리식이 갖는 존재론적, 인식론적 의미에 대한 과학영재학교 학생들의 이해의 특징을 분석하였다. 학생들의 존재론적 범주에 따른 의미 구분에서, 상태관계식은 비교적 정확하게 구분하였으나 상호작용관계식과 인과관계식은 그렇지 못하였다. 학생들의 인식론적 범주에 따른 구분에서, 경험법칙은 비교적 정확하게 구분하였으나 원리는 그렇지 못하였다. 특히 많은 학생들이 원리에 해당하는 물리식을 경험법칙으로 구분하는 경향을 보였다. 이와 관련한 교육적 시사점을 논의하였다.

Keywords:

물리식, 존재론적 의미, 인식론적 의미, 학생의 이해

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.02

Collaborative exams for learning: Challenging problems and more opportunities

JANG Hyewon *[1]
[1]Strategic planning center, KAIST
wanypie@gmail.com

Abstract:

Collaborative exams(two-stage exams) have been successfully used in several disciplines to promote students' learning in the United States and Canada. This presentation introduces how physics scholars can better adopt collaborative exams in physics classrooms considering item difficulty and logistics of answering. First, this study shows that an item that 20% of individuals could solve is most beneficial comparing individual correctness and team correctness for a function of item difficulty. Secondly, comparing between the individual correctness and team correctness after each trial, providing at least three times for a team to answer is the key to successful collaborative exams. As the first presentation on collaborative exams in the Korean Physical Society, this study will give insight and practical advice for the physics scholars who are interested in the innovation of higher education.

Keywords:

Collaborative exams, Two-stage exams, Assessment, Team-based learning

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.03

Derivation of Jacobian Formula with Dirac Delta Function

KIM Dohyun [1], EE June-Haak [1], YU Chaehyun [1], LEE Jungil [*1]
[1]Korea University
jungil@korea.ac.kr

Abstract:

We demonstrate how to make the coordinate transformation or change of variables from Cartesian coordinates to curvilinear coordinates by making use of a convolution of a function with Dirac delta functions whose arguments are determined by the transformation functions between the two coordinate systems. By integrating out an original coordinate with a Dirac delta function, we replace the original coordinate with a new coordinate in a systematic way. A recursive use of Dirac delta functions allows the coordinate transformation successively. After replacing every original coordinate into a new curvilinear coordinate, we find that the resultant Jacobian of the corresponding coordinate transformation is automatically obtained in a completely algebraic way. In order to provide insights on this method, we present a few examples of evaluating the Jacobian explicitly without resort to the known general formula.

Keywords:

Jacobian, Dirac delta function, Camer's rule, Chain rule

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.04

Determination of Eigenvectors with Lagrange Multiplier

HAN Wooyong [1], JUNG Dong-Won [1], LEE Jungil [*1], YU Chaehyun [1]
[1]Korea University
jungil@korea.ac.kr

Abstract:

We present a method to determine the eigenvectors of an $n₩times n$ Hermitian matrix by introducing Lagrange undetermined multiplier. In contrast to a usual Lagrange multiplier that is a number, we introduce matrix-valued multipliers with a constraint equation, which make the eigenvalue equation directly solvable. Then, there exists a unique solution for each eigenvalue equation and the eigenvectors are obtained by imposing the constraint limit. This method is in clear contrast to the conventional approach of Gaussian elimination and it will be a good pedagogical example for conceptual understanding for the gauge symmetry just with the knowledge of quantum physics and linear algebra at undergraduate level.

Keywords:

Eigenvalue Problem, Eigenvector, Lagrange multiplier, Hermitian Matrix, Diagonalization

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.05

수평잡기를 이용한 저울의 민감도를 높이는 간단한 방법 제안

CHEONG Yong Wook *1
[1]physics education, Gyeongsang National University
zimusa92@naver.com

Abstract:

양팔저울과 윗접시저울은 수평잡기의 원리를 이용한 저울로 학교현장에서 널리 활용된다. 그런데 학교에서 사용하는 양팔저울과 윗접시저울은 작은 질량을 접시에 추가로 올릴 때 저울대의 회전이 미미하다는 점에서 저울의 민감도가 상대적으로 낮은 편이다. 이러한 문제는 저울로 물체의 무게를 보다 정확하게 어림하지 못하게 한다. 본 연구에서는 이러한 문제를 해결하고 접시에 작은 질량을 추가할 때 저울대가 보다 많이 회전하는 민감한 저울을 만드는 방법을 소개하고자 한다. 이를 위해 이론적 분석을 통해 저울의 민감도를 낮추는 구조적인 요인을 찾았다. 또한 저울을 새로 구입할 필요없이 기존의 저울에 하중을 추가하는 간단한 방법으로 저울의 민감도를 높이는 방안을 제시하였다.

Keywords:

양팔저울, 윗접시 저울, 로베르발 저울

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.06

Changes in The Concept of Mechanical Energy of 3rd Graders in Middle School Through Pendulum Motion Video Analysis Activity.

OH Won Kun *[1], JEONG Hyeon [1]
[1]Dept. Physics Education, Chungbuk National University
wkoh@cbnu.ac.kr

Abstract:

본 연구의 목적은 중학교 3 학년 학생들의 역학적 에너지 개념을 알아보고 진자 운동 영상 분석 활동에서 역학적 에너지 전환 및 보존 개념 변화에 대해 알아보는 것이다. 111 명의 중학교 3 학년 학생을 대상으로 진자 운동 영상 분석 활동을 진행하였다. 학생이 가진 위치 에너지와 운동 에너지 개념을 사례에 따라 분류하고 이에 따라 진자 운동 영상 분석 활동 후 역학적 에너지 전환 및 보존 개념 변화를 알아보았다. 또, 역학적 에너지 전환 및 보존 개념 변화에 대한 영상 분석 활동의 영향에 대해 분석하였다. 그 결과는 다음과 같다.
첫째, 활동 전에 학생들이 가진 역학적 에너지 개념은 위치 에너지 개념보다 운동 에너지 개념이 물리 개념에 대해 부적절한 경우가 많았다. 둘째, 진자 운동 영상 분석 활동에서 학생들은 활동 전 가진 역학적 에너지 개념과 관계없이 역학적 에너지 전환 및 보존 개념 변화를 보여주었다. 셋째, 학생들은 영상 분석 활동을 통해 역학적 에너지 개념 변화에 영향을 받았다고 응답하였다. 이를 종합해 볼 때, 진자 운동 영상 분석 활동이 학생들의 역학적 에너지 전환 및 보존 개념을 물리 개념으로 변화시키는데 긍정적인 역할을 하였다고 판단할 수 있다. 또, 학생의 물리 개념 획득을 위하여 영상 분석을 활용한 수업 방략에 관한 연구가 진행될 필요가 있다.

Keywords:

진자운동, 영상분석

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F14.07

역량중심 교육과정에서의 물리 교과 ‘지식’의 방향성 -2015 개정 교육과정과 IB 의 비교 분석을 중심으로-

KIM Hyojoon *[1], SONG Jinwoong [1], KIM Eiseul [1], HAN Chaerin [1]
[1]Department of Physics Education, Seoul National University
hy013013@gmail.com

Abstract:

OECD 는 ‘학습 프레임워크(Learning Framework)’에서 역량 개념을 구성하는 ‘지식’과 그 유형을 명시하였다. 본 연구에서는 이 지식의 유형 중 ‘학문적 지식’과 ‘간학문적 지식’을 바탕으로, 2015 개정 교육과정과 IB DP(International Baccalaureate Diploma Programme)의 물리 교과의 문서를 비교하여 지식 내용의 구성 방향성을 제안하고자 하였다. 우선, 두 교육과정의 구성, 문서 체계, 평가 방식에 대해 살펴보았다. 다음으로 ‘학문적 지식’에 관하여, 두 교육과정에 제시된 지식 내용의 변화 경향성과 특징에 대해 분석하였고, 핵심개념-성취기준-평가기준의 일관성과 평가 문항의 사례를 비교 검토하였다. ‘간학문적 지식’에 관하여는 통합과학의 주제중심 접근과 IB DP 에서 제시하는 간학문적 연계에 대해 비교하였다. 비교 결과를 바탕으로, 역량중심 교육과정의 맥락에서 지식 내용 제시에 대한 논의와 평가로 일관성있게 이어지는 방안이 필요함을 제언하였다. 또한, 간학문적 지식의 함양을 위한 방안 등 미래 물리 교과 교육과정에서 고려해야 할 사항에 대해 논의하였다.

Keywords:

2015 개정 물리 교과 교육과정, 국제 바칼로레아 디플로마 프로그램, 학문적 지식, 간학문적 지식, 지식 내용

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F15.01

Overview of KSTAR Experiment

KO Won-Ha *[1], YOON S.W. [1], KIM W.C. [1], KWAK J.G. [1], PARK K. L. [1], NAM Y. U. [1], WANG S.J. [1], CHUNG J. [1], PARK B.H. [1], PARK G.Y. [1], LEE H.H. [1], HAN H.S. [1], CHOI M.J. [1], NA Y.S. [2], YUN G.S. [3], IN Y. [4], CHOE W.H. [5], KWON J.M. [1], LEE J.P. [6], JEON Y.M. [1], NA B.K. [1], KO J.S. [1], LEE J.H. [1], SHIN G.W. [1], LEE K. D. [1], KIM J. [1], LEE J. [1], HAHN S.H. [1], LEE J.W. [1], KIM H.S. [1], KIM M. [1], BAK J. G. [1], LEE S. G. [1], KANG J.S. [1], LEE Y.H. [1], JEON J.H. [1], WOO M.H. [1], KIM J.H. [1], JUHN J.W. [1], YOO J.W. [1], KIM G. [1], CHU Y. [1], KIM K. P. [1], KIM H.S. [1], KIM J.S. [1], JOUNG M. [1], PARK S.H. [1], KIM H.J. [1], WI H.M. [1], HONG J.S. [1], SEO D.C. [1], SEO S.H. [1], LEE Y.S. [1], KIM Y.S. [1], JANG J.H. [1], LEE K.C. [1], KIM K. [1], JHANG H.G. [1], LEE J.K. [1], SON S.H. [1], KO S.H. [1], LEE W. [1], RHEE T. [1], YEOM J.H. [1], KIM J.W. [1], HAN K.S. [4], SEOL J. [1], LEE M.W. [1], JUNG L. [1], LEE S.I. [1], LEE Y.J. [1], PARK H.T. [1], CHO W. [1], CHOI D.J. [1], KIM S.G. [1], WI H.H. [1], HAN J.W. [1], RHEE I.H. [1], JANG K.H. [1], LEE H.Y. [1], LEE H.J. [1], QI L. [1], SEO J.H. [1], BANG E.N. [1], AHN H.J. [1], WOO I.S. [1], KIM Y.O. [1], LEE T.G. [1], YUN S.W. [1], LEE S.J. [1], LEE K.S. [1], KWON G.I. [1], KONG J.D. [1], KIM S.T. [1], KWAG S.W. [1], JIN J.K. [1], KIM C.H. [1], AHN H.S. [1], PARK D.S. [1], CHOI J.H. [1], SUNG C. [5], YOON J.H. [5], PARK M.S. [5], KIM B.S. [2], HWANG J.H. [5], SHIN H.W [5], PARK J.M. [7], KIM S.K. [2,8], PARK J. K. [8], LOGAN N.C. [8], YANG S.M. [8], HU Q. [8], KOLEMEN E. [8], SHOUSHA R. [8], BARR J. [9], PAZ-SOLDAN C. [9], WEHNER W. [9], PARK Y. S. [10], SABBAGH S. A. [10], OGAWA K. [11], KIM S. [12], LOARTE A. [12], SCHUSTER E. [13], HOLE M. [14], NAZIKIAN R. [8], GILSON E. [8], ELDON D. [9], SCHMITZ O. [15], NAKANO T. [16], TALA T. [17], NELSON A.O. [8], OKABAYASHI M. [8], PARK H. [4], The KSTAR Team [1]

[1]Korea Institute of Fusion Energy
[2]Seoul National University
[3]Pohang University of Science and Technology
[4]Ulsan National Institute of Science and Technology
[5]Korea Advanced Institute of Science and Technology
[6]Hanyang University
[7]Oak Ridge National Laboratory
[8]Princeton Plasma Physics Lab
[9]General Atomics
[10]Columbia University
[11]National Institute of Fusion Science
[12]ITER Organization, Saint-Paul-lès-Durance
[13]Lehigh University
[14]Australian National University
[15]University of Wisconsin-Madison
[16]National Institutes for Quantum and Radiological Science and Technology
[17]VTT Technical Research Center
whko@kfe.re.kr

Abstract:

Korean Superconducting Tokamak Advanced Research (KSTAR) has been focused on exploring the key physics and engineering issues of the high-performance steady-state operation for ITER and future fusion reactors utilizing unique capabilities of KSTAR with low intrinsic error field, toroidal field ripple, etc. [1, 2]. First of all, a new advanced scenario was developed targeting steady-state operation based on the early diverting and heating during the ramp-up phase of plasma current and significant progress has been made in shape and heating control to address the MA level of plasma current, stationary high ion temperature, and high li scenario with beta_N ~3 and newly observed I-mode-like regime

Non-diffusive avalanche-like electron heat transport events are observed by the

ECEI in the recent MHD-quiescent KSTAR plasma. The observations have been successfully reproduced by gyro-kinetic simulations indicating the broad range of spatial scales up to the minor radius. Strong interaction between fast-ion and EP driven MHD mode was identified with Fast ion Da (FIDA) diagnostics.
Symmetric multiple Shattered Pellet Injections (SPIs) for ITER disruption mitigation was installed and uniquely demonstrated on its performance in KSTAR. It was shown successfully the current quench rate changes proportionally as the time difference varies from several percent to several tens of percent of the thermal quench duration (1~2 ms) and it was demonstrated that peak density was increased twice with dual SPIs compared with a single SPI.

Recent KSTAR 3D Recent KSTAR 3D magnetic field experiments have observed q95 window dependence on RMP-driven ELM suppression which is consistent with prediction confirmed the importance of edge toroidal rotation and associated turbulence motion and validated poloidal asymmetry in RMP plasma coupling in RMP ELM suppression.

RMP ELM optimization and automatic control techniques such as adapted ELM controller and Machin Learning algorithm in order to suppress ELM were successfully implemented in KSTAR PCS. Adapted ELM controller enhanced plasma performance about 60% during ELM suppression. Machin Learning algorithm successfully suppressed the first ELMs and almost full ELM-crash with high performance in RMP ELM suppression experiments

The coming KSTAR research plan will be focused on the machine upgrades such as extensive heating & current drive capabilities including off-axis NBI with 6MW and Helicon current drive with 4MW, the installation of new tungsten divertors with active cooling for the development of the DEMO/ITER relevant operational scenario. The scenario includes high-beta steady-state operation with benign MHD activities which will require robust plasma control in strong shaping, control of MHD modes and thorough analysis of the key physics.

* This research was supported by R&D Program of "KSTAR Experimental Collaboration and Fusion Plasma Research (EN2021-12)" through the Korea Institute of Fusion Energy (KFE) funded by the Government funds.

[1] G.S. Lee et al, Nucl. Fusion 40 575 (2000) 575
[2] H. K. Park et al, Nucl. Fusion 59 (2019) 112020 (13pp)

Keywords:

High ion temperature, high-beta plasma, SPI, Machin Learning algorithm, automatic control techniques in ELM suppression

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F15.02

핵융합 시뮬레이션 기술과 가상 KSTAR 개발

KWON Jae Min *[1]
[1]KFE
jmkwon74@kfe.re.kr

Abstract:

토카막 플라즈마의 거동과 물성 예측은 핵융합로의 성능과 안전성 예측을 위해 필수적이다. 토카막의 강한 자기장에 의해 감금된 초고온 플라즈마는 살펴보려하는 물성에 따라 다양한 축약 모델을 통해 기술되는데, 본 발표에서는 핵융합 플라즈마의 감금 성능을 결정하는 난류 모사를 위한 자기회전동역학 모델과 관련 시뮬레이션 기술 현황에 대해 소개한다. 현재 진행되고 있는 노심-언저리-SOL(Scarpe-off Layer) 전 영역을 포괄하는 자기회전동역학 시뮬레이션 코드 개발 노력에 대해서 설명하고, 함께 진행 중인 플라즈마 난류와 유동 현상의 분석 연구에 대해서도 소개한다.
시뮬레이션을 통한 예측은 핵융합 플라즈마가 토카막 장치에 미치는 영향 분석과 핵융합로 설계를 위한 물리 요건 도출에 필수적으로, 현재 진행 중인 시뮬레이션 코드 개발이 미래 핵융합 실증로 설계로 이어질 수 있는 연계 기술 개발이 중요하다. 본 발표에서는 시뮬레이션 코드 개발과 함께 진행 중인 토카막 가상 플랫폼 개발 노력에 대해서도 소개한다. 가상 플랫폼에 KSTAR 설계 데이터를 결합하여 구현한 가상 KSTAR 에 대해 설명하고 앞으로 계획 중인 시뮬레이션 기능 구현 및 통합에 대해서도 함께 소개한다.

Keywords:

토카막, 플라즈마, 회전동역학(gyrokinetic), 난류, 가상화

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F15.03

Investigating runaway electrons from the induced radio frequency emissions

KIM M.H. [1,2], THATIPAMULA Shekar G.[1], KIM J. [2], LEE J. [2], KIM J.H. [2], YUN G.S. *[1]
[1]Pohang University of Science and Technology
[2]Korea Institute of Fusion Energy
gunsu@postech.ac.kr

Abstract:

The relaxation oscillations in tokamak plasmas are the consequence of the explosive crash of the magneto-hydrodynamic instabilities. For instance, the sawtooth crash in the core degrades the heat confinement, and the edge-localized mode (ELM) crash prompts excess heat load on the plasma-facing components. On the KSTAR tokamak, a high-speed RF spectrometer revealed that a dynamic evolution in the electromagnetic burst emissions in radio frequency (RF) range (0.1~1 GHz) accompanies the ELM crash followed by the collapse of the confinement barrier [1]. This RF emission results from plasma wave interaction with energetic ions resulting from fusion reactions or the neutral beam injection [2]. More recently, demonstrating the localized measurement of plasma waves using mm-wave mixer antenna technology, the time trace of the RF emission is retrieved from the modulations in the second harmonic electron cyclotron emission (ECE) [3]. Using this new RF diagnostics technique, the electromagnetic bursts generated by runaway electrons (RE) in the low-density ohmic plasma were identified. In the sawtooth inter-crash period, abrupt RF bursts in a wideband frequency (<5 GHz) are captured from a region midway between the plasma core and the edge. This wideband RF burst is followed by additional narrowband bursts delayed by a few tens of microseconds, chirping-down in frequency. Close to the wideband burst, a harmonic structure is observed in the emission frequency band of 4 - 5 GHz, with a spacing of 15 MHz. The observed harmonic structure can be explained using an analytical model for ECE signal modulation with the RE' toroidal rotation frequency. Hence, such a harmonic structure in the RF emission spectrum can be utilized to determine the RE energy. The present observations indicate the expanding scope of RF diagnostics as a reliable tool to investigate a range of plasma waves in fusion devices. *Work supported by NRF Korea under grant No. NRF-2019M1A7A1A03088456, BK21+ program and partially under grant No. NRF-2019R1F1A1057545. This work is also supported by the Korea Hydro & Nuclear Power company under the K-CLOUD program.

References:

[1] Distinct stages of radio frequency emission at the onset of pedestal collapse in KSTAR H-mode plasmas, M.H. Kim et al, Nuclear Fusion 58 (2018) 096034.
[2] Radio frequency emissions driven by energetic ions from neutral beam in KSTAR low confinement mode plasma, Shekar G. Thatipamula et al, Plasma Phys. Control. Fusion 62 (2020) 035004.

[3] Intense whistler-frequency emissions at the pedestal collapse in KSTAR H-mode plasmas, M.H. Kim et al, Nuclear Fusion 60 (2020) 126021.

Keywords:

particle-wave interaction, radio-frequency emission, electron cyclotron emission, runaway electron, KSTAR

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F15.04

Feedforward Beta Control by Deep Reinforcement Learning in KSTAR

SEO J. [1], NA Y.-S. *[1], KIM B. [1], LEE C.Y. [1], PARK M.S. [1], PARK S.J. [1], LEE Y.H. [2]
[1]Department of Nuclear Engineering, Seoul National University
[2]Korea Institute of Fusion Energy
ysna@snu.ac.kr

Abstract:

In this work, we address a new feedforward control scheme of the normalized beta (β_N) in tokamak plasmas, using the deep reinforcement learning (RL) technique [1,2]. The deep RL algorithm optimizes an artificial decision-making agent that adjusts the discharge scenario to obtain the given target β_N, from the state-action-reward sets explored by trials and errors of itself in the virtual tokamak environment. The virtual environment for the RL training is constructed with the LSTM network [3] that imitates the plasma responses by external actuator controls, which is trained with the 5-year KSTAR experimental data. Then, the RL agent experiences tons of discharges with different actuator controls in the LSTM simulator, and its internal parameters are optimized in the direction of maximizing the reward. We analyze a series of real experiments conducted with the RL-determined scenarios to validate the feasibility of the beta control scheme on KSTAR. We discuss the successes and limitations of the feedforward beta control by RL, and suggest future directions. This work can be the first step for the development of the autonomous operation of tokamak by machine-learning-based feedback controls, which is essential for the stable and efficient fusion reactor operation in the future.

References

[1] V. Mnih et al., *Nature* **518** 529-533 (2015)
[2] S. Fujimoto et al., *35th International Conference on Machine Learning* p 1-15 (2018)
[3] S. Hochreiter and J. Schmidhuber, *Neural Comput.* **9** 1735-1780 (1997)

Keywords:

Machine Learning, Reinforcement Learning, Beta Control, KSTAR, Data-driven Simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.01

Light perturbed by gravitational wave

PARK Chan *[1]
[1]Division of Basic Researches for Industrial Mathematics, NIMS
iamparkchan@gmail.com

Abstract:

At least so far, light is the most promising mean to observe gravitational waves. For example, LIGO, the first successful gravitational wave observation in 2015, is a huge and precise light interferometer that measures phase perturbation of light caused by gravitational waves. We focus on that light is an electromagnetic wave having phase and polarization, simultaneously. Thus, not only the phase but also the polarization (amplitude) is perturbed by the gravitational wave. We analyze the polarization perturbation of electromagnetic waves caused by gravitational waves and show our interpretation of the results. As an observation for polarization perturbation, we introduce the Stokes parameters and show the expected observations.

Keywords:

perturbed light, gravitational wave, Stokes parameters

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.02

Nd:Y_2O_3 광대역 NIR 투과율 측정을 위한 스캐닝 백색광 간섭계 개발

LEE Hee Su [1], HWANG Seung Jin [4], LEE Sung Yoon [2,4], CHO Seryeyohan [3], PARK Dae Woong [2], LEE Gun Hui [2], CHO Han Jin [2], OH Hyeon Myeong [5], PARK Young Jo [5], KO Jae Woong [5], KIM Ha Neul [5], YU Tae Jun [*2,4]

[1]Department of Information and Communication Engineering, Handong Global University
[2]Department of Advanced Convergence, Handong Global University
[3]Advanced AI Talent Education and Research Group for Industrial Innovation, Handong Global University
[4]R&D, Hil Lab. Inc.
[5]Department of Engineering Ceramics, Korea Institue of Materials Science
taejunyu@handong.edu

Abstract:

Nd:Y_2O_3는 Nd:YAG 대비 열 팽창 계수가 낮고 열 전도율이 높다. 이처럼 우수한 열 특성을 가진 Nd:Y_2O_3는 고출력 고체레이저에서 상대적으로 많이 쓰이는 추세이다. 본 연구는 재료연구원에서 개발한 Nd: Y_2O_3 매질의 투과율 측정 장치 개발 및 투과율 측정을 수행했다. 투과율 측정을 위해 마하-젠더 기반의 스캐닝 백색광 간섭계를 개발했다. 간섭 신호의 지연 보정을 위해 He-Ne 레이저를 사용했고, 백색광원으로는 광섬유로 전달되는 텅스텐-할로겐 광원을 사용했다. 이로부터 발생한 He-Ne, 백색광 각각의 간섭 신호를 계측했고, 주파수 분석을 통해 850-1100 nm 대역의 스펙트럼을 얻었다. 샘플 유/무에 따라 스펙트럼을 비교해서 투과율을 얻었고, 이론 투과율과 근접도를 비교하기위해 FOM을 정의했다. 최대 FOM은 1078 nm에서 240(이론 투과율의 99.6%)으로 나타났다. 본 연구를 발전시켜 광학 매질의 굴절율과 열-광학 계수 측정에도 활용할 계획이다.

Acknowledgements:
This work was financially supported by Fundamental Research Program of Korea Institute of Materials Science (Grant no. PNK7450).

Keywords:

Nd:Y2O3, Transmission, SWLI, Interferometer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.03

고출력 피코초 레이저용 CVBG 광 압축기의 열적 효과 모델 및 보상 설계

CHO Seryeyohan [*1,2,3], LEE Heesu [2], YU Tae Jun [*1,2], NOVAK Ondrej [3], SMRZ Martin [3], MOCEK Tomas [3]
[1]Department of Advanced Convergence, Handong Global University
[2]Dept. of Information and Communication Engineering, Handong Global University
[3]Advanced Laser Development group, HiLASE Centre
sycho@handong.edu, taejunyu@handong.edu

Abstract:

고출력 레이저에서 광 압축기로 사용되는 CVBG(Chiped-pulse Volume Bragg Grating)의 열 효과에 대한 수치적 연구 결과를 소개한다. 개발한 피코초 레이저 시스템의 출력이 CVBG 의 열 효과로 인한 빔 왜곡으로 인해 출력이 제한되어 이를 해결하기 위한 연구를 수행하였으며, CVBG 에 의한 열 왜곡 효과 모델을 개발하고 이를 활용해 열 효과를 완화하고 효과적으로 시스템을 냉각할 수 있는 마운트를 설계하였다. 본 연구를 평균 출력이 250W 인 Yb:YAG 레이저에 적용하였으며, CVBG 의 온도 분포, 열 렌즈 효과, 열 렌즈로 인한 빔 전파 경로 변화 및 압축 위상 지연으로 인한 효율 감소 등을 분석하였다. 250 W 의 동작 조건을 유지할 때, 첨두 출력이 63.9 % 가량 감소하였으나, 새롭게 제안하는 마운트를 사용하는 경우 첨두 출력 손실이 1.1%로 크게 개선될 것으로 예상되며, 향후 본 레이저의 평균 출력을 더욱 높일 수 있을 것으로 기대한다.

Keywords:

CVBG, Thermal effect, Pico-second lasers

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.04

텐덤 펌핑용 고출력 1018 nm Yb 광섬유 레이저

OH Ye Jin [1], PARK Hye Mi [1], KIM Jin Pil [1], PARK Eun Ji [1], PARK Jong Seon [1,2], KIM Ji Won [*1], JEONG Hoon [2]
[1]Hanyang University ERICA
[2]research institute of sustainable manufacturing system, KITECH
jwk7417@hanyang.ac.kr

Abstract:

이터븀(Yb)이 도핑된 광섬유 레이저는 우수한 빔 품질, 고효율, 소형화 등 다양한 장점을 가지기 때문에 지난 수십년간 산업, 국방 분야에서 광범위하게 발전되어 왔다. 하지만 수 kW 이상의 고출력 레이저 발진시 열 문제, 비선형 광학 현상, 모드 불안정 등의 문제로 인해 출력을 증강시키는데 많은 어려움이 있다. 이러한 한계를 뛰어넘기 위해 9xx nm 파장대의 다이오드 레이저 대신 1010 ~ 1030 nm 파장대의 레이저를 펌핑 광원으로 사용하는 탠덤 펌핑 방식이 제안되었다. 탠덤 펌핑은 다이오드 레이저 펌핑 대비 낮은 양자 결함을 가지므로 열문제를 완화할 수 있고, 높은 휘도의 레이저를 펌핑 광원으로 사용하므로 다이오드 레이저 대비 더 많은 수의 펌프 빔을 광섬유에 커플링 시킬 수 있으며, 이득률이 낮으므로 고차 모드 레이저빔의 발진이 억제되어 고출력에서도 좋은 빔 품질을 유지하며 높은 출력을 얻을 수 있다. 그러나 탠덤 펌핑에서 사용되는 ~1018 nm 근처의 광섬유 레이저 동작 파장 대역은 Yb 광섬유의 주발진 파장 범위 (1030~1080 nm)에서 벗어나 있어 레이저 동작 시 자발형광의 증폭 혹은 기생 발진 등이 쉽게 일어나 고출력을 얻는 것이 쉽지 않다.
본 논문에서는 텐덤 펌핑용 1018 nm 발진 고출력 Yb 광섬유 레이저에 대한 연구를 보고하고자 한다. 우선 이론적 시뮬레이션을 통해 가장 적합한 광섬유와 동작 조건을 조사하였고, 그 결과를 바탕으로 976 nm 의 파장 안정화 다이오드 레이저를 펌핑 광원으로 사용하여 1018 nm 발진 Yb 광섬유 레이저 시스템을 구축하였다. 그 결과 최고 출력 300 W 를 얻는데 성공하였으며, 이때 기울기 효율은 입사된 펌프 출력 대비 89.1%, 최고 출력에서의 빔질 (M2)은 1.8 로 이론값과 잘 일치함을 확인하였다.

Keywords:

Yb 광섬유 레이저, 탠덤 펌핑, 고출력 레이저

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.05

Attosecond photoemission delay in two-dimensional atomic arrangements: A velocity cone of earlier electron emission

PARK Hyosub [1], KIM Youngjae [1], LEE JaeDong [*1]
[1]Department of Emerging Materials Science, DGIST
jdlee@dgist.ac.kr

Abstract:

In two-dimensional semiconductors, the density fluctuation potential created by a screening of the photohole is intrinsically anisotropic because of the infinitely periodic planar arrangements of atoms. Modeling the anisotropic localized screening with the cylindrical geometry, we investigate the emission delay of the photoelectron for $2s$ and $2p_z$ states of graphene in an angle-resolved mode of the attosecond streaking by solving the time-dependent Schrödinger equation. Strong angle dependencies in absolute delays of $2s$ and $2p_z$ photoelectron states are obtained, from which the effects of the infrared (IR) streaking field are excluded and those of the anisotropic screening could be isolated. Consequently, the anisotropic screening is found to drive the conic electron emission with appreciable negative delays.

Keywords:

Anisotropic screening, Delay, Angle-resolved, Attosecond Streaking

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F16.06

Universal time delays in the inelastic photoelectron emission of metals

BAE Gimin [1], PARK Hyosub [1], LEE JaeDong [*1]
[1]Department of Emerging Materials Science, DGIST
jdlee@dgist.ac.kr

Abstract:

Proposing a theoretical model of the core level photoemission of metals, we investigate the plasmon-driven inelastic photoemission delays based on a nonperturbative treatment of many-electron responses due to the long-range Coulomb potential. Being irrelevant to the plasmon coupling strength as well as the plasmon frequency, the emission delays $\Delta\tau_n$ of the n-th order plasmon satellites (n=1,2,3,⋯) are found to be universal order by order among the metals. In particular, for a main line with its weight $e^{-\gamma}$, where γ quantifies the plasmon coupling strength, the average inelastic photoemission delay $\langle\Delta\tau\rangle$ is found to be $\gamma(1-e^{-\gamma})^{-1} \times \Delta\tau_1$ and thus simply scaled by a universal time delay $\Delta\tau_1$. This finding is sharply contrasted with the emission delays under the localized potential, which indicates a fundamental difference in the emission process between extended and localized screenings.

Keywords:

inelastic photoemission delay, universality, nonperturbative treatment, plasmon, metallic system

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.01

Inducing and probing localized excitons via tip-enhanced cavity-spectroscopy

LEE Hyeongwoo [1], PARK Kyoung-Duck *[1]
[1]Physics, UNIST
kdpark@unist.ac.kr

Abstract:

We present a plasmonic antenna with a triple-sharp-tips geometry to induce and control the X_L emission of a WSe_2 monolayer (ML) at room temperature. By placing a ML crystal on the two sharp Au tips in a bowtie antenna fabricated through cascade domino lithography with a radius of curvature of <1 nm, we effectively induce tensile strain in the nanoscale region to create robust X_L states. An Au tip with tip-enhanced photoluminescence (TEPL) spectroscopy is then added to the strained region to probe and control the X_L emission.

Keywords:

TEPL, Localized exciton, Single photon emission, Plasmonic cavity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.02

Enhanced Production Yield of MoS_2 Quantum Dots

BYEON Clare Chisu*[1], ALI Luqman [1], KAGOIYA Ng'ang'a Douglas[1], LEE Yong Joong[1]
[1]School of Mechanical Engineering, Kyungpook National University
byeon@knu.ac.kr

Abstract:

We report the exfoliation of MoS_2 quantum dots (QDs) by a sonication-assisted ion-intercalation exfoliation method, with a better final production yield and well exfoliated small sizes. NaOH was employed as ion-source to intercalate between the MoS_2 layers and exfoliate them, while the sonication further improved the exfoliation efficiency. The production yield, determined by comparing the mass of the exfoliated QDs compared to the initial mass of the bulk powder, was □ 21%. The TEM and AFM analysis showed that the exfoliated QDs have lateral sizes □3.4 ± 1.5 nm and thickness of about 1.5 nm, depicting the very small sizes and mono/few layered structures for the QDs. XPS and XRD analysis revealed that the QDs are of high purity and have well crystal nature. The UV-Vis absorbance of the as prepared QDs was in the near UV region ($\lambda < 270$ nm) as illustrated by the UV/Vis analysis.

Keywords:

Quantum dots, Ion-intercalation , production yield, MoS2

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.03

Hexagonal boron nitride encapsulation passivates defects of 2D materials

JUNG Jin-Woo [1], CHOI Hyeon-Seo [1], LEE Young-Jun [1], KIM Dohun [1], KIM Youngwook [1], CHO Chang-Hee *[1]
[1]Department of Emerging Materials Science, DGIST
chcho@dgist.ac.kr

Abstract:

이차원 반도체 단층 전이금속 디칼코겐화합물(Transition metal dichalcogenides)은 원자층 수준의 매우 얇은 두께를 가져, 그 물성이 변형(Strain), 흡착물(Adsorbates), 기판 거칠기(Substrate roughness)와 같은 물질 주변 외부 disorder 요인들에 의해 강하게 영향을 받는다. 따라서, 이차원 반도체 물질의 고유한 물성을 탐구하고 발현시키기 위해서는 물질에 가해지는 외부 disorder 요인들을 최소화하는 것이 중요하며, 최근 육방정계 질화붕소(Hexagonal boron nitride)를 이용한 encapsulation 이 이차원 반도체 물질에 가해지는 외부 disorder 요인들을 막아 줄 수 있음이 보고되면서, 이를 활용한 물성 연구 및 소자 개발이 활발히 수행되고 있다. 하지만, 현재까지 육방정계 질화붕소를 이용한 encapsulation 의 역할은 명확히 규명되지 않았고, 단순히 기판 표면 거칠기로부터 기인한 이차원 반도체 내의 전하 요동(Charge fluctuation)을 막아주 것이 주요한 역할로 알려져 있다. 본 연구에서는 기판 효과 외에 육방정계 질화붕소를 이용한 encapsulation 이 이차원 반도체 물질에 미치는 영향 및 역할에 대하여 탐구하였다. 기판 효과를 배제하기 위하여 이차원 반도체 WS_2 와 육방정계 질화붕소로 encapsulation 된 WS_2 를 라인 트렌치 위로 전사한 두 시스템을 제작하였고, 두 시스템에 대한 대기 및 진공 환경 변화에 따른 파워-의존, 시간-분해, 밸리 분극률 photoluminescence 분광법을 통해서 두 시스템에서 나타나는 엑시톤의 발광 특성을 비교하였다. 이러한 실험 결과는 이차원 반도체 표면 결함 부위에 흡착되어 있는 가스 분자들의 탈착 및 흡착이 이차원 반도체 물질의 엑시톤 발광 특성에 매우 강하게 영향을 미침을 보여주었고, 육방정계 질화붕소를 이용한 이차원 반도체 물질의 encapsulation 이 이차원 반도체 표면 결함 부위에 흡착된 가스 분자들의 탈착을 막아주어, 일종의 passivation 층으로써 역활을 함을 규명하였다.

Keywords:

전이금속 디칼코겐화합물, 육방정계 질화붕소, Encapsulation, Defects, Passivation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.04

Observance of Negative Differential Resistance without Heterojunctions

KIM Yeeun [1], JOO Min-Kyu [*2]
[1]Department of Physics, Sookmyung Women's University
[2]Department of Applied Physics, Sookmyung Women's University
mkjoo@sookmyung.ac.kr

Abstract:

Negative differential resistance (NDR) is a representative quantum tunneling phenomenon, which occurs at narrow p-n junction with heavy doping concentration. Over the last few years, numerous applications based on NDR characteristics have been reported such as voltage-controlled oscillator, high-frequency amplifier, multi-valued logic devices, and neuromorphic computing. However, a conventional device configuration for NDR requires multiple heterojunctions or multi-gate for reconfigurable device, considerably limiting active channel area and more importantly increasing device fabrication complexity. Herein, we demonstrate a precursor to NDR in ambipolar black phosphorous (BP) multilayers at room temperature. The abrupt suppression of off-current nearby charge neutrality regime at a specific drain bias (V_D) condition clearly indicates inhomogenous local Fermi-level and creates electron-hole puddles inside BP channel, consequently leading to emergence of NDR. The temperature (T)- and V_D-dependent NDR, V_{CNP}, and carrier mobility further support our observation. Our results pave the way for understanding the fundamental NDR of single two-dimensional material-based NDR devices and their diverse applications.

Keywords:

Negative differential resistance, Black phosphorous, Heterojunction, Tunneling, 2D materials

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.05

Switched Valley Polarization of Intralayer Exciton via One-Step-Grown WS_2/MoS_2 Vertical Heterostructure

LE Chinh Tam [1], LEE Je-Ho [2], KIM Jungcheol [3], SEONG Maeng-Je [2], JANG Jon Ik [3], KIM Yong Soo [*1]
[1]Department of Physics, University of Ulsan
[2]Department of Physics, Chung-Ang University
[3]Department of Physics, Sogang University
yskim2@ulsan.ac.kr

Abstract:

Type-II van der Waals heterobilayer of transition metal dichalcogenide have been attracted much spotlight due to their distinctive features as compared to its constituent layers, mostly arising from the emergence of different electronic band structure and relaxed optical selection rule established by an additional breaking of mirror symmetry. Not only the emerging interlayer exciton (*K-Q)* transitions but also widely studied intralayer *(K-K*) transition is a sort of fundamental interest in the regard of the spin-valley coupling phenomenon. In this study, we systemically investigated the valley-polarized properties of intralayer transition at room temperature and at 77 K using CVD-grown heterobilayers in microscopic scale (~2μm laser spot). Interestingly, we observed a small but nonzero, negative helicity for *A*-exciton at room temperature and even more robust valley selectivity with an averaged degree of circular polarization (DOP) of ~30% at 77 K, whose magnitude is as high as that of MoS_2 at the same measurement condition. After excluding the effect of defect, we attribute the valley polarization switching to *i)* local nanoscale Moiré atomic registries and *ii)* unexpectedly amplified by local strain due to large thermal expansion coefficient than that of substrate, which allows the strong coupling right-handed circular propagation in stark contrast to monolayer cases. Compared with *A*-exciton, *B*-exciton of VHS seems to less prone to external facts, *i.e.*, defect density, Moiré potential and strain. These findings imply that the impact of paring WX_2 with MoX_2 would be beneficial not only for interlayer exciton but also for intralayer excitons.

Keywords:

vertical heterostructure, 2D materials, intralayer exciton, valley polarization

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.06

Auger process of the electron-hole pair in anisotropic quantum rings

KYHM Kwangseuk *[1,2], KIM Minju [2]
[1]Optomechatronics, Pusan National University
[2]cogno-mechatronics engineering, Pusan National University
kskyhm@pusan.ac.kr

Abstract:

Despite the terminology of quantum ring, the droplet quantum rings look different from the ideal donut shape. Due to the rim height anisotropy, the carriers in quantum rings are likely localized with a crescent-like lateral shape. In this case, the confinement energy is enhanced, and the carrier relaxation can be associated with the Auger process. In this work, we have investigated the carrier dynamics of the localized structure for increasing excitation intensity of fs-pulse. Linear and non-linear time-resolved PL spectrum were measured using streak Camera and excitation-correlation spectroscopy. A saturation of the initial luminescence intensity was observed for increasing excitation intensity, and the decay dynamics was interpreted with numerical rate equations. With an intermediate regime of excitation intensity, we found the electron-hole pairs in droplet quantum rings decay through the bimolecular annihilation process of exciton-exciton scattering. However, the Auger process becomes dominant as excitation becomes increased.

Keywords:

Auger process, quantum ring, excitation correlation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.07

Electric field induced giant valley polarization in two dimensional ferromagnetic $WSe_2/CrSnSe_3$ heterostructure

MARFOUA Brahim [1], HONG Ji Sang *[1]
[1]Physics, Pukyong National University
hongj@pknu.ac.kr

Abstract:

Study on two-dimensional (2D) materials has become one of the most fascinating issues in condensed matter physics and materials sciences because many intriguing physical quantities have been found in 2D materials. In these 2D materials, along with the traditional charge and spin degree of freedom physical quantities, another physical quantity namely valley state has been introduced as a new degree of freedom which can be utilized for future quantum information storage devices[1]. The valleytronics (valley-dependent electronics) is receiving extensive research efforts [2-4]. Thus, we investigated the electric field-induced valley polarization in the $WSe_2/CrSnSe_3$ heterostructures by varying the stacking order. The heterostructure shows indirect band gaps of 270 and 330 meV in the two most stable structures. The $WSe_2/CrSnSe_3$ heterostructure displays a ferromagnetic ground state with out-of-plane anisotropy (0.02 meV) in one stable stacking (S-1) while a small in-plane anisotropy (-0.01 meV) is found in other stacking (S-2). The Curie temperature is slightly enhanced to 73 K compared to the monolayer $CrSnSe_3$. We have found the valley splitting of 4 meV in S-1whereas it became 9 meV in the S-2 system. The valley splitting is further enhanced if an electric field is applied from $CrSnSe_3$ to the WSe_2 layer whereas it is suppressed in the reversed electric field. Particularly, the S-2 structure shows a giant valley splitting of 67 meV at an electric field of 0.6 V/Å. We attribute this electric field-dependency to the dipolar effect. Overall, we propose that the $WSe_2/CrSnSe_3$ heterostructure can be a potential structure for obtaining a giant valley splitting.

Keywords:

valleytronics, electric field, 2D WSe2/CrSnSe3 heterostructure

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.08

Tip-induced strain engineering of a single metal halide perovskite quantum dots

LEE Hyeongwoo [1], PARK Kyoung-Duck *[1]
[1]Physics, UNIST
kdpark@unist.ac.kr

Abstract:

Metal halide perovskite quantum dots (QDs), e.g., $CsPbBr_xI_{3-x}$, have received increasing attentions for their outstanding optical and electrical properties, which enable versatile device applications, such as light-emitting diodes (LEDs), lasers, photodetectors, and photovoltaics. we present a tip-force control combined with tip-enhanced photoluminescence (TEPL) to engineer the opto-mechanical characteristics of $CsPbBr_xI_{3-x}$ QDs at the nanoscale. The single $CsPbBr_xI_{3-x}$ QDs are clearly resolved through spatio-spectral TEPL imaging with a spatial resolution of ~10 nm.

Keywords:

Perovskite, Strain engineering , Plsmonic cavity, Single quantum dot, Quantum dot coupling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F18.09

Tip-induced nano-engineering of strain, bandgap, and exciton funneling in 2D semiconductors

PARK Kyoung-Duck *[1], KOO Yeonjeong [1], KIM Yongchul [2], CHOI Soo Ho [3], LEE Hyeongwoo [1], CHOI Jinseong [1], LEE DongYun [1], KANG Mingu [1], LEE HyunSeok [4], KIM Ki Kang [3,6], LEE Geunsik [2,5]
[1]Physics, UNIST
[2]Chemistry, UNIST
[3]Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Sungkyunkwan University
[4]Department of Physics, Research Institute for Nanoscale Science and Technology, Chungbuk National University
[5]Center for Wave Energy Materials, UNIST
[6]Energy Science, Sungkyunkwan University
kdpark@unist.ac.kr

Abstract:

The tunability of the bandgap, absorption and emission energies, photoluminescence (PL) quantum yield, exciton transport, and energy transfer in transition metal dichalcogenide (TMD) monolayers provides a new class of functions for a wide range of ultrathin photonic devices. Recent strain-engineering approaches have enabled us to tune some of these properties, yet dynamic control at the nanoscale with real-time and -space characterizations remains a challenge. Here, we demonstrate a dynamic nano-mechanical strain-engineering of naturally-formed wrinkles in a WSe2 monolayer, with real-time investigation of nano-spectroscopic properties using hyperspectral adaptive tip-enhanced PL (a-TEPL) spectroscopy. First, we characterize nanoscale wrinkles through hyperspectral a-TEPL nano-imaging with <15 nm spatial resolution which reveals the modified nano-excitonic properties by the induced tensile strain at the wrinkle apex, e.g., an increase in the quantum yield due to the exciton funneling, decrease in PL energy up to ~10 meV, and a symmetry change in the TEPL spectra caused by the reconfigured electronic bandstructure. We then dynamically engineer the local strain by pressing and releasing the wrinkle apex through an atomic force tip control. This nano-mechanical strain-engineering allows us to tune the exciton dynamics and emission properties at the nanoscale in a reversible fashion. In addition, we demonstrate a systematic switching and modulation platform of the wrinkle emission, which provides a new strategy for robust, tunable, and ultracompact nano-optical sources in atomically thin semiconductors.

Keywords:

Transition metal dichalcogenide monolayer, wrinkle, strain-engineering, tip-enhanced photoluminescence spectroscopy, exciton funneling

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.01

전계 효과로 반응을 조절할 수 있는 박막트랜지스터 기반의 압력 감지 센서 및 이의 해석적 모델

오홍석*[1]
[1] 숭실대학교 물리학과
hoh@ssu.ac.kr

Abstract:

본 연구는 압전 소재를 활성층으로 사용하는 박막트랜지스터 의 제작 및 이의 압력 감지 원리에 대한 것이다. 해당 소자는 게이트 전극의 전압에 따라 일반적인 트랜지스터로 동작하는 동시에, 외부 압력이 내부 압전 효과에 의해 전류를 변화시켜 압력센서로도 구동할 수 있다. 이러한 특성을 활용하여 단일 트랜지스터 어레이로 고성능의 능동구동어레이를 구성할 수 있어, 다수의 센서를 효율적으로 제어하는 것이 필수적인 터치 인터페이스 및 전자 피부 기술 등에 널리 응용될 것으로 기대되고 있다. 하지만 아직 외부 압력에 따른 내부 압전 전하가 트랜지스터의 동작에 어떻게 영향을 끼치는지에 대한 정량적인 모델은 제시되지 않아, 보다 발전적인 응용 연구에 어려움이 있었다.
이번 발표에서는 해석적 모델을 사용하여 해당 소자의 압력 감지 원리를 설명하고, 게이트 전압에 따라 압력에 대한 전류반응의 크기와 부호를 조절 할 수 있음을 밝힌다. 특히, 실제로 제조된 소자의 파라미터를 이용하여 해당 모델의 유효성을 실험적으로 증명하였다. 본 연구는 압전소재를 활용한 센서 겸 트랜지스터라는 2-in-1 소자의 개념 및 원리를 명확히 함으로써 향후 고성능 압력센서 어레이의 제조 및 이의 다양한 응용에 기여할 것이다.

Keywords:

Piezoelectric, Thin film transistor, analytic model, ZnO, pressure sensor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.02

All-optical photoacoustic measurement on Rhodamine-6G

KYHM Kwangseuk *[1,2], KIM Minwoo [2]
[1]Optomechatronics, Pusan National University
[2]cognomechatronics, Pusan National University
kskyhm@pusan.ac.kr

Abstract:

While ultrasound images have a poor resolution due to the low contrast, optical images have a shallow depth. Currently, photoacoustic imaging is developed to resolve those drawbacks. Because the photoacoustic signals are generated by laser, the spatial resolution is improved. However, the sensitivity limits still remain while the signal is measured electrically by a piezoelectric transducer.
In this work, the transducer was replaced by an optical microphone to measure photoacoustic signals. While the transducer is limited in detection frequency, the optical microphone is free from this issue. First of all an optical microphone was constructed using a Fabry-Perot interferometer. To verify its performance, various sound waves were measured by the optical microphone, and compared with the sound spectrum measured by electric transducer. Afterward, the photoacoustic signals of Rhodamine-6G generated by a pulsed laser were measured by the optical microphone. We found the optical microphone is highly sensitive in a low frequency range compared to piezoelectric transducers, and all-optical photoacoustic imaging can be possible

Keywords:

photoacoustic, rhodamine 6g, optical microphone

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.03

Optical imaging of dentinal tubules with two-photon microscopy.

KYHM Kwangseuk *[1,2], LEE Seunghwan [2]
[1]Optomechatronics, Pusan National University
[2]Cogno-mechatronics, Pusan National University
kskyhm@pusan.ac.kr

Abstract:

Recently, the structural study of human teeth has been a fascinating subject of both biology and physics, where optical microscopic imaging and hydrodynamic thoery are utilized. Especially the relation between pain sensation and the fluid pressure of dentinal tubules was considered a key pathological factor of hypersensitivity disease. However, the structural modeling is yet to be done due to the poor spatial resolution of conventional microscopes.

In this work, we utilized two-photon microscope (TPM) to achieve a high resolution and a longer penetration depth, whereby layered images of dentinal tubules construct an elaborate tubular image. We found the structure of dentinal tubules is distorted in an elliptical shape particularly in the secondary dentin region. Utilizing a model of hydrodynamics, the fluid pressure of the distorted tubules was found to be higher than those of normal tubules. Therefore, we coclude that the structural deformity of dentinal tubules is the main cause of the hypersensitivity disease.

Keywords:

Dentinal tubule, Hypersensitivity, Two photon microscope, computational fluid dynamics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.04

Buckling tip-based atomic force microscope for nonlinear sensor, negative elasticity, nanoscratching, and nanolithography

AN Sangmin *[1]
[1]Department of Physics, Institute of Photonics and Information Technology, Jeonbuk National University
san@jbnu.ac.kr

Abstract:

Buckling, which shows a sudden mechanical sideways deflection of a structural system under compressive stress, represents a bifurcation in the solution to the equations of static equilibrium. Although it has been investigated in diverse research areas, such a common nonlinear phenomenon may be useful to devise a unique mechanical sensor that addresses the still-challenging features. Here, I demonstrate the bifurcation-enhanced sensitive measurement of mechanical vibrations using the nonlinear buckled tip [1] including negative elasticity (stiffness) when the tip pinned on the surface and deflected in a circumstance of liquid environment. In addition, I show bucking tip-based nanoscratching [2] and nanolithography [3] techniques.

[1] An et al., “Bifurcation-enhanced ultrahigh sensitivity of a buckled cantilever”, Proc. Natl. Acad. Sci. USA 115(12), 2884-2889 (2018).
[2] An et al., “Buckling tip-based nanoscratching with in situ direct measurement of shear dynamics”, Appl. Nanosci. 9, 67-76 (2019).
[3] Sangmin An and Wonho Jhe, “Nanopipette/nanorod-combined quartz tuning fork-atomic force microscope”, Sensors 19, 1794 (2019).

Keywords:

Buckling tip, Atomic force microscopy, low dimensional material

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.05

Epitaxial ZnTe thin flims for Ovonic threshold switching selector device

KIM MinJay [1,2], LEE InHak [1], KIM HyukJin [1], CHOI ByungKi [1], LEE KyeongJun [3], HEO JinEun [3], KIM JaeYeon [4], SOHN HyunChul [4], CHANG Young Jun *[1,2]
[1]Department of Physics, University of Seoul
[2]Smart Cities, University of Seoul
[3]Department of Physics, Chung-Ang University
[4]Department of Material Science and Engineering, Yonsei University
yjunchang@gmail.com

Abstract:

Chalcogenide materials with amorphous phases, such as GeSe, GeTe, and AsTeSi, were reported to show Ovonic threshold switching (OTS). The OTS is known for its volatile bidirectional resistive switching with a high selective ratio and low off-current value. The OTS selector devices have attracted much attention for developing high density cross-point array structures, which has huge potential of high density memories for next-generation neuromorphic memory devices. Zinc Telluride (ZnTe) is a II-VI semiconductor with a direct band gap of 2.26 eV at room temperature. It has a zinc-blende crystal structure with lattice constant of 0.61037 nm, widely used in solar cells, light emitting diodes, and electro-optic devices. Recently, ZnTe films with polycrystalline phases and varied stoichiometries also show OTS behavior. However, the role of crystallinity and stoichiometry is still a highly debated issue. Here, we report synthesis of ZnTe thin films with different crystalline states and stoichiometries. ZnTe thin films were deposited by molecular beam epitaxy. X-ray diffraction analysis showed that the films were single-crystalline on GaAs wafer or polycrystalline on polycrystalline TiN/Si wafer. The X-ray photoemission spectroscopy result indicated that the chemical stoichiometry can be varied from Zn:Te = 3:1 ~ 1:1 depending on the source flux ratio during the film growth. Finally, we analyze the electrical characteristics by using conductive atomic force microscopy (C-AFM) and discuss the local I-V characters.

Keywords:

OTS, selector device, zinc telluride, epitaxy, MBE

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.06

Effects of dielectric passivation on device performance of AlGaN/GaN high-electron-mobility transistors

KIM Jaeho [1], CHO Jaehee *[1]
[1]Department of Semiconductor Science and Technology, Jeonbuk National University
jcho@jbnu.ac.kr

Abstract:

AlGaN/GaN 이종접합구조 high-electron-mobility transistor (HEMT)는 고온, 고주파, 고전력 소자를 필요로 하는 다양한 응용 분야에서 큰 주목을 받고 있다. 무엇보다 추가적인 도핑 과정 없이 AlGaN 와 GaN 계면에 자발적으로 존재하는 2-dimensional electron gas (2DEG)는 높은 이동도를 요구하는 소자에 적합한 플랫폼을 제공한다. 2DEG 의 sheet carrier density 는 AlGaN 의 두께와 Al 함량에 크게 영향을 받고, 동시에 에피 내 결함과 표면 에너지 준위에 의해서도 영향을 받는다. 유전체 박막을 소자 표면에 증착하는 공정은 전극 간 절연의 용도 뿐 아니라 표면 에너지 준위를 안정화시키기 위해 제안되었고 SiO_2 를 포함한 다양한 유전체 박막이 실제 소자에 적용되고 있다.

본 연구는 AlGaN/GaN 이종접합구조 HEMT 소자의 표면에 유전체 박막 증착 후 나타나는 소자의 전기적 특성 변화를 다양한 실험 변수를 포함한 분석을 통해 논의하고자 한다. 첫째로, 대표적인 유전체 박막인 SiO_2 의 박막 두께의 변화가 2DEG sheet carrier density 에 미치는 영향을 조사하고, 라만 분광법과 capacitance-voltage 측정을 통해 AlGaN 층에 가해지는 응력과 표면 에너지 준위 안정화의 정도를 비교 분석하였다. 둘째로, 다양한 유전체 박막(SiO_2, Si_3N_4, Al_2O_3)의 증착에 따른 효과를 트랜지스터의 동작 특성을 통해 조사하였다. 유전체 박막 증착 후, 포화 전류, 온-저항, 트랜스 컨덕턴스 등에서 상당 수준의 향상이 발견되었고, 특히 원자층 증착법을 적용한 Al_2O_3 박막에서 가장 우수한 특성을 확인하였다. 이러한 결과의 원인으로, 유전체 박막 증착에 따른 AlGaN 층에 가해진 응력의 변화와 더불어 서로 다른 유전체 박막이 표면 에너지 준위 안정화에 미치는 효과를 비교하여 분석하였다.

Keywords:

AlGaN/GaN, HEMT, 2DEG, Passivation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.07

Lead-free (K,Na)NbO_3 thick films for flexible non-volatile memory applications

KWAK Yeong Min [1], LEE Tae Kwon [1], KONG Dae Sol [1], KO Young Joon [1], JEONG Dong Geun [1], JUNG Jong Hoon [*1]
[1]Inha University
jhjung@inha.ac.kr

Abstract:

Highly piezoelectric lead-free thin films of $(K_{0.5}Na_{0.5})NbO_3$ were prepared via chemical solution deposition on flexible thick substrate Muscovite mica. It allows the growth of high-quality polycrystalline KNN thick films with flexible functionality. Due to the trade-off between volatilization of alkaline ions and increase of grain-size, we investigate the dependence of polarization verses temperature. It is optimized at certain temperature of 720 °C. The remnant and saturation polarization of flexible KNN films were recorded to P_r=10.3 mC/cm2 and P_s=23.3 mC/cm^2, respectively. These polycrystalline flexible ferroelectric KNN films not only retain their performance, retention (10^4 s), fatigue tests (10^8 cycles) comparable to those on rigid counterparts in tests of nonvolatile memory elements but also exhibit remarkable mechanical properties with robust operation in bent states(bending radii down to 3.1 mm). Even in the bending states, the KNN thick films show excellent non-volatile characteristics. The P_r is almost the same even after the 10^8 times of switching and the 10^4 sec of retention.

Keywords:

Lead-free, (K,Na)NbO3, Flexible memory, Fatigue, Retention

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.08

Perovskite quantum dot hybrid light-emitting transistors for display applications

SEO Jung Hwa *[1], PARK Yu Jung [1], KIM Minseong [2], SONG Aeran [3], KIM Jin Young [2], CHUNG Kwun-Bum [3], WALKER Bright [4], WANG Dong Hwan [2]
[1]physics, Dong-A University
[2]School of Intergrative Engineering, Chung-Ang University
[3]division of Physics and Semiconductor, Dongguk University
[4]Department of Chemistry, Kyung Hee University
seojh@dau.ac.kr

Abstract:

The class of organic—inorganic lead halides with perovskite crystal structures has recently emerged as promising materials for a variety of practical optoelectronic applications. In particular, hybrid halide perovskite quantum dots possess excellent intrinsic optoelectronic properties such as high color purity (full width at half-maximum of 24.59 nm) and photoluminescence quantum yields (92.7%). In this work, we demonstrate the use of perovskite quantum dot materials as an emissive layer of hybrid light-emitting transistors. To investigate the working mechanism of perovskite quantum dots in light-emitting transistors, we investigated the electrical and optical characteristics under both p-channel and n-channel operation. Using these materials, we have achieved perovskite quantum dot light-emitting transistors with high electron mobilities of up to 12.06 $cm^2 \cdot V^{-1} s^{-1}$, high brightness of up to 1.41 $\times 10^4$ $cd \cdot m^{-2}$, and enhanced external quantum efficiencies of up to 1.79% operating at a source-drain potential of 40 V.

Keywords:

Perovskite, quantum dots, light-emitting transistors, Zinc-oxinitride, external quantum efficiency

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.09

Influences of ionic moieties on energy band structures of organic and hybrid semiconducting devices and their functions

KHAN Yeasin [1], 서정화*[1]
[1]Physics, Dong-A University
seojh@dau.ac.kr

Abstract:

The presence of ionic moieties sometimes show surprising effects like inducing interfacial dipoles, electrochemical doping and band bending in organic semiconductors. The dynamic motion of ions under electric fields and the induced changes in conductivity can make it difficult to de-convolute the various mechanisms at play. Here we made attempts to provide a perspective on different types of interactions between ions and semiconductors and addressing the application of solution-processed polyelectrolyte and oligoelectrolyte materials to control the energy band structures and behaviour of organic and hybrid semiconducting optoelectronic devices. Highlights of different types of ionic materials (such as conjugated polyelectrolytes and molecular ionic dopants) that have been used to achieve different effects (such as creating interfacial dipoles, vacuum energy shifts, changes in Fermi energies and doping) in organic and hybrid semiconducting devices will be discussed. Before going into greater depth with the emerging class of non-conjugated polyelectrolytes and oligoelectrolytes, a comprehensive summary of recent progress using these materials in semiconducting devices will be provided. This class of materials has been receiving increasing attention recently and provides insights into the fundamental effects of ionic functionalities on the energy band structures and functions in organic and hybrid semiconductors.

Keywords:

polyelectrolytes, Semiconductor, Band bending, Oligoelectrolytes

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

F19.10

Orbital gating in $MoTe_2$ tunneling opto-electronic device

HWANG Geunwoo [2], KIM Eunah [2], SUN Linfeng [2], YANG Heejun [*1]
[1]Department of Physics, KAIST
[2]Department of Energy Science, Sungkyunkwan University
h.yang@kaist.ac.kr

Abstract:

Coventional gating in transistors uses electric field through external dielectrics. Optoelectronic devices deploy photogating by electric fields trapped charges in neighbor nanoparticles or dielectircs under light illumination. We report orbital gating in tunneling phototransistors based on 2H-$MoTe_2$ without using external gating bias or slow charge trapping dynamics in photogating.
The original self-gating by light illumination modulates the interlayer potential gradient by switching on and off the gaint Stark effect where the d_{s2}-orbitals of molybdenum atoms play the dominant role. The orbital gating shifts the electronic bands of the top atomic layer of the $MoTe_2$ by up to 100 meV. Suppressing conventional photoconductivity , the oribtal gating in tunneling phototransistors achieves low dark current, practical photo-responsitivity(3357 A/W), and fast on/off time (0.5 ms) simutaneously.

Keywords:

MoTe2, 2D materials, Novel gating, phototransistor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G1.01

Dark Matter and New Physics from Belle II Experiment

LEE Hyun Min *[1]
[1]Department of Physics, Chung-Ang University
hminlee@cau.ac.kr

Abstract:

We present the recent development of models for light dark matter in light of Belle II experiments and discuss the interplay with direct detection experiments. Motivated by some flavor anomalies in B-meson decays for the past years, we also entertain the possibility to test new physics scenarios with Z' and leptoquarks from other rare decays at Belle II and make a connection to direct searches of new resonances at High Luminosity Large Hadron Collider.

Keywords:

Dark matter, B-meson decays, New resonances

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G1.02

The SuperKEKB & Belle II status

KIM Doris Yangsoo*[1]
[1]Department of Physics, Soongsil University
dorisykim@ssu.ac.kr

Abstract:

The SuperKEKB collider and Belle II experiment started the physics run at the beginning 2019. The SuperKEKB, an upgraded $e^+ e^-$ collider at KEK, Japan, reached the world record in the instantaneous luminosity in June 2020, which was previously held by the LHC at CERN. As a next generation heavy flavor experiment, the Belle II detector is fully functional with improved track resolution, particle identification ability, and tighter hermiticity compared to its predecessor, the Belle detector. In this talk, we present the current status of the SuperKEKB collider and summarize the initial physics reports by the Belle II experiment. The upcoming long shutdown to improve the beam interaction region during 2021-2022 will be also reported.

Keywords:

SuperKEKB, Belle II, new physics, heavy flavor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G1.03

Belle II result on Heavy Flavor Physics

KANG Kookhyun *1
[1]Kyungpook National University
khkang@knu.ac.kr

Abstract:

The heavy flavor physics (HFP) aims to measure precisely Standard Model (SM) parameters and to search new physics beyond the SM by studying interactions among flavor. An investigation of the HFP is the main purpose offered by B-factories. The Belle II experiment at SuperKEKB energy-asymmetric e+e- collider in Japan has been taking physics data since 2018. It aims 40 times higher instantaneous luminosity and 50 times higher integrated luminosity than those of KEKB collider. In this talk we report recent Belle II result of HFP.

Keywords:

Belle II, Heavy flavor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G1.04

Dark Sector study at Belle II

PARK Seokhee [2], KWON Youngjoon *[1]
[1]Physics, Yonsei University
[2]IPNS, High Energy Accelerator Research Organization, KEK
yjkwon63@yonsei.ac.kr

Abstract:

Belle II experiment is one of the world-leading high energy particle experiments which consists of Belle II detector and SuperKEKB electron-positron collider with 10.57 GeV center-of-mass energy. The Belle II focuses on rich physics programs, for both the Standard Model and new physics beyond the Standard Model. Especially, Belle II has a high potential to access the dark sector parameters with clean event signatures, precise beam energy, and high luminosity. In this presentation, we introduce the latest dark sector studies based on the early phase 3 data collected by the Belle II detector.

Keywords:

Belle II, dark sector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.01

Relativistic spinning particle and twistor theory

LEE Sangmin *[1], KIM Jung-Wook [2], KIM Joon-Hwi [3]
[1]College of Liberal Studies, Seoul National University
[2]Physics, Queen Mary University of London
[3]Physics and Astronomy, Seoul National University
sangmin@snu.ac.kr

Abstract:

We prove the equivalence between two traditional approaches to the classical mechanics of a massive spinning particle in special relativity. One is the spherical top model of Hanson and Regge, recast in a Hamiltonian formulation with improved treatment of covariant spin constraints. The other is the massive twistor model, slightly generalized to incorporate the Regge trajectory relating the mass to the total spin angular momentum. We establish the equivalence by computing the Dirac brackets of the physical phase space carrying three translation and three rotation degrees of freedom. Lorentz covariance and little group covariance uniquely determine the structure of the physical phase space. The Regge trajectory does not affect the phase space but enters the equations of motion. Upon quantization, the twistor model produces a spectrum that agrees perfectly with the massive spinor-helicity description proposed by Arkani-Hamed, Huang and Huang for scattering amplitudes for all masses and spins.

Keywords:

spinor, twistor, spherical top

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.02

Spinning particles in external fields: from spin precession to twistors

LEE Sangmin *[1], KIM Jung-Wook [2], KIM Joon-Hwi [3]
[1]College of Liberal Studies, Seoul National University
[2]Physics, Queen Mary University of London
[3]Physics and Astronomy, Seoul National University
sangmin@snu.ac.kr

Abstract:

The dynamics of relativistic massive spinning particles interacting with external fields is an old subject that traces back to the Bargmann-Michel-Telegdi (BMT) and Mathisson-Papapetrou-Dixon (MPD) equations of motion in the fifties. While deriving these equations in a manifestly covariant Hamiltonian framework is a not-so-obvious task, recently the phase space structure of the Hanson-Regge spherical top has been clarified with improved treatment of constraints. Based on this work, we couple the spherical top model of spinning particles to electromagnetism as well as tetrad gravity and then obtain BMT and MPD equations in a fully gauge-invariant manner, employing exclusively the kinematic momentum rather than the canonical momentum. Minimal coupling alters the Poisson brackets between the constraints, and treating them perturbatively leads to Dirac brackets that reproduce the BMT and MPD equations at the leading perturbative order. Next, we explore the possibility of understanding interacting massive spinning particles in the twistor language, based on the recent work that showed the equivalence of the Hanson-Regge spherical top to the "massive twistor" system. We anticipate that these classical considerations can provide an alternative insight to the naturalness of g=2, while the double copy relation between electromagnetic and gravitational scattering amplitudes predicts 2 as the "default" gyromagnetic ratio.

Keywords:

Massive spinning particles, Bargmann-Michel-Telegdi equation, Mathisson-Papapetrou-Dixon equation, Gyromagnetic ratio, Twistor theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.03

Scrutinizing the Dynamics of Conformal Gravity Using Free Differential Algebras and Unfolding Strategy

KIM Mingi *[1], BOULANGER Nicolas [2], JOUNG Euihun [1], KIM Yujin [1]
[1]School of Science, Department of Physics, Kyung Hee University
[2]Department of Theoritical Physics, Universite de Mons
xp2425@khu.ac.kr

Abstract:

We have used unfolding strategy in order to look for the dynamics of conformal gravity. In turn, we can gather the whole irreducible Weyl descendents and manufacture the Weyl invariant scalars in any dimension.

Keywords:

unfolding, Free differential algebra, AdS/CFT, Conformal gravity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.04

Classifying Gravitational Systems

KIM Yujin *[1], BOULANGER Nicolas [2], JOUNG Euihun [1], KIM Mingi *[1]
[1]Kyung Hee University
[2]Department of Physics, University of Mons
4happpiness@khu.ac.kr, xp2425@khu.ac.kr

Abstract:

In this talk, we analyze the linearized gravity using unfolding formulation.
With these analysis, we can construct the basis of Weyl-invariant scalars.

Keywords:

Linearized gravtiy, Unfolding formulation, Weyl-invariant scalars, Conformal group, Weyl anomaly

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.05

Thermodynamic properties of strongly interacting non-Dirac materials

SEO Yunseok *[1], SIN Sang-Jin [2], SONG Geunho [2]
[1]College of General Education, Kookmin University
[2]Department of Physics, Hanyang University
seo.yunseok@gmail.com

Abstract:

We study thermodynamic properties of strongly interacting non-Dirac materials using gauge/gravity duality. We introduce hyperscaling violation geometry as a background geomety which is controlled by hyperscaling violation exponent and critical dynamic exponent. We perform proper holographic renormalization such that the thermodynamic first law is well defined in the boundary theory. We calculate several thermodynamic quantities from renormalized on-shell action and investigate temperature behavior of thermodynamic varialbles for different exponent. We copare our result to the experimetal data of spin liquid.

Keywords:

Gauge/gravity duality, Strongly correlated system, Spin liquid

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.06

The emergence of Strange metal and Topological Liquid in a solvable model of Quantum Phase Transitions

SIN Sang Jin *[1], OH Eunseok [1], YUK Taewon [1]
[1]physics department, Hanyang University
sangjin.sin@gmail.com

Abstract:

We show that there is a topologically protected fermion zero mode, which provides a stable particle. We suggest that this can be the origin of the Fermi liquid appearing in very strongly correlated system. We also show that the strange metal phase with T-linear resistivity emerges at high enough temperature if the gravity has a horizon, and we calculate the strucure of phase diagram near the QCP analytically.

Keywords:

quantum critical point, quantum phase transition, holography, strange metal, strongly correlated electron system

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G2.07

Topological Material in Holography

SIN Sang Jin *[1], YUK Taewon [1]
[1]physics department, Hanyang University
sangjin.sin@gmail.com

Abstract:

We investigate the topological materials in gauge/gravity duality theory. It is known that fermi-arc is created by axial vector interaction, a bulk zero mode by scalar interaction and flat band by tensor interaction. We will study the results of turning on combinations of two interactions and try to match experiment to theoretical results.

Keywords:

topological material, strongly correlated electron system, fermi-arc, flat band

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.01

Simulation of the beam drift chamber for LAMPS at RAON

HONG Byungsik *[1], HWANG Jaein *[1], MOON Dongho [2], KIM Hyunchul [2], LEE Jongwon [1], HWANG Sanghoon [3], SEO Junhu [2]
[1]Department of Physics, Korea University
[2]Department of Physics, Chonnam National University
[3]Center for Ionizing Radiation, KRISS
bhong@korea.ac.kr, jaeinhwang213@gmail.com

Abstract:

The Large Acceptance Multi-Purpose Spectrometer (LAMPS) at RAON is a dedicated system for the nuclear symmetry energy, which is crucial to understand the strong interactions in dense matter like the internal structure of neutron stars as the one of examples. The beam drift chamber (BDC) is one of the essential detector components for LAMPS to diagnose the trajectories of beam nuclides. To understand the performance of BDC for LAMPS, the detailed simulation of BDC has been carried out by using the Garfield++ package. In this presentation, the results of the simulation, including the various characteristics of the detector, will be presented.

Keywords:

nuclear symmetry energy, RAON, LAMPS, beam drift chamber, Garfield++

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.02

Status of the bent ALPIDE chip beam test data Analysis for ITS3 upgrade

KWEON Min Jung *[1], CHO Jae Yoon [2]
[1]Inha University
[2]Department of Physics, Inha University
minjung@inha.ac.kr

Abstract:

CERN 의 거대강입자 가속기를 이용한 ALICE 실험에서는 우주 초기의 상태라고 여겨지는 QGP 상태를 연구하기 위한 실험을 수행하고 있다. ALICE 검출기는 Time Projection Chamber, Time of Flight 검출기 등의 여러 종류의 검출기들로 구성되어 있다. 그 중, 충돌 지점으로부터 가장 가까이 놓이는 Inner Tracking System(ITS)은 실리콘 검출기로, 뛰어난 위치 분해능을 가지며, 신호가 빠르다는 장점때문에, 충돌로부터 생성된 수많은 입자들의 운동량과 충돌 지점을 정밀하게 측정할 수 있다.

ALICE 에서는 기존의 ITS 보다 성능이 향상된 검출기로 업그레이드(ITS2)를 진행중이며, 이는 곧 완료될 예정이다. 2025 년으로 예정된 다음 업그레이드(ITS3)에서는, ITS2 에서 설치된 7 개의 Layer 중, 내부의 Layer 3 개를 웨이퍼 크기의 칩을 휘어 만든 실리콘 검출기로 교체할 계획이다. 현재, ITS2 업그레이드를 위해 개발된 ALPIDE 칩을 기반으로 업그레이드를 위한 R&D 가 진행되고 있다. 현재 진행되고 있는 연구에서는, 기존의 50um 두께의 ALPIDE 칩을 손상 없이 구부릴 수 있음을 확인하였고, 구부러진 칩의 Tracking 성능을 확인하기 위하여 Beam test 를 여러차례 진행하였다.

본 발표에서는 ITS3 업그레이드의 아이디어를 소개하고 Beam test 결과를 분석하는 Framework 과 데이터 분석 결과에 대해 발표할 것이다.

Keywords:

CERN,ALICE,ITS3,Bent ALPIDE

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.03

A three-dimensional electromagnetic sampling calorimeter for the future KL0 -> pi0 nu nu_bar experiment

KIM Young Jun *[1], KIM Jun Lee [2], LIM Gei Youb [3], KIM Eun-Joo [2], AHN Jung Keun [1]
[1]Department of Physics, Korea University
[2]Division of Science Education, Jeonbuk National University
[3]IPNS, High Energy Accelerator Research Organization, KEK
rladudwns118@korea.ac.kr

Abstract:

We present designs of the three-dimensional (3D) sampling electromagnetic calorimeter (ECAL) for the KOTO2 experiment. The KOTO2 experiment aims at observing high-statistics CP-violating KL0->pi0 nu nu_bar decays. The 3D ECAL will substitute for a CsI detector array of the KOTO experiment, which will measure several hundred MeV photons from pi0 decays with good energy resolution and angle information. We will present a design optimization result of the 3D ECAL based on Geant4 simulation and the gamma reconstruction performance.

Keywords:

3D EMCal, KOTO

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.04

Beauty production with ALICE

PARK Jong Han *[1]
[1]Inha University
jonghan@cern.ch

Abstract:

The LHC heavy-ion physics program aims at investigating the properties of strongly-interacting matter in extreme conditions of temperature and energy density, where the formation of the quark-gluon plasma (QGP) is expected.
Heavy quarks (charm and beauty) are regarded as efficient probes to investigate the properties of the QGP as they are created on a very short time scale in initial hard scattering processes and subsequently interact with the medium. In particular, beauty quarks, being four times heavier than charm quarks, can be utilized to study the in-medium mass-dependent energy loss.
The measurement of beauty quark production in pp collisions provides an important test of perturbative QCD calculations and can be used as a reference for measuring the nuclear modifications. The measurement in p-Pb collisions are crucial to investigate the effects of cold nuclear matter on their production.
In this contribution, the measurements of beauty-hadron decay electrons, non-prompt D mesons, non-prompt J/psi, and b-tagged jets in pp collisions at $\sqrt{s}$ = 5.02 TeV and 13 TeV will be presented. In addition, the measurements of electrons from beauty-hadrons and b-tagged jets in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, and the beauty-hadron decay electrons and non-prompt D mesons in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV will be discussed.

Keywords:

CERN, ALICE, heavy flavour

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.05

Probing the gluonic intial state with inclusive dijets in pPb and exclusive dijets in ultra-peripheral PbPb collision at 5.02 TeV with the CMS experiment

KIM Yongsun *[1]
[1]Sejong University
kingmking@gmail.com

Abstract:

Dijet processes can be used in several ways to probe the nuclear initial state. Exclusive dijet photoproduction in ultra-peripheral heavy-ion collisions has recently been suggested as a probe of the gluon Wigner distribution. In particular, the angular correlation of exclusive dijets can assess the azimuthal anisotropy of the gluon distribution in the nuclear target. In this talk, we present the measurement of the angular correlations of dijets in ultra-peripheral PbPb collisions at 5.02 TeV with the CMS experiment. The dependence of the second harmonic of the angular distribution as a function of the vectorial sum of the leading and subleading jets will be discussed. In addition, the pseudorapidity of the inclusive dijet system in pPb collisions is a probe of the nuclear parton distribution function (nPDF) of the gluon: the recent CMS result will be presented, and its impact on nPDF models will be discussed.

Keywords:

heavy ion, cms, upc

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.06

Study of Monte Carlo simulation for quarkonia production in heavy-ion collisions

LIM Sang Hoon *[1], LEE Su Houng [2], HONG Juhee [2], KIM Eun-Joo [3], KWEON MinJung [4], PARK Jaebeom [5], KIM Junlee [3], SEO Jinjoo [4]
[1]Physics Department, Pusan National University
[2]Physics Department, Yonsei University
[3]Division of Science Education , Jeonbuk National University
[4]Physics Department, Inha University
[5]Physics Department, Korea University
shlim@pusan.ac.kr

Abstract:

Heavy quarkonia production has been studied extensively in relativistic heavy-ion collision experiments to understand the properties of a hot and dense medium from heavy-ion collisions. Model study to fully understand experimental results show that it is important to consider not only suppression eects but also eects to regenerate quarkonia particularly at the LHC energies. A theoretical calculation taking into account the gluo-dissociation and inelastic parton scattering, and their inverse reaction reasonably describe the suppression of Y(1S) in Pb+Pb collisions. Based on this theory, a Monte Carlo simulation is under development to incorporate the medium produced heavy-ion collisions more realistically with hydrodynamics simulations. Heavy quarkonia production in small collision systems is also interesting, because a hydrodynamic behavior of produced particles has been observed in many experimental results. The modication of Y(1S) in small collision systems can be also studied with this MC simulation considering the same eects in heavy-ion collisions. A model study in various small collision systems such as pp, p+Pb, p+O, and O+O will help to understand nuclear eects on the Y(1S) production more quantitatively. In this talk, we will introduce the Monte Carlo simulation for Y(1S) production and present the current status of development.

Keywords:

Heavy Ion Collision, Quarkonia, Simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.07

HPGe and Alpha counting measurements of detector material samples at Yangyang underground laboratory

KIM Yeongduk *[1,2], LEE Eunkyung [1], HAHN Insik Kevin[3], KANG Woongu [1], KIM Gowoon [1], LEE Moo Hyun [1,2], LEONARD Douglas S.[1], PARK Su-yeon [1], KAZALOV Vladimir [4]
[1]IBS Center for Underground Physics, IBS
[2]Department of Physics, University of Science and Technology
[3]IBS Center for Exotic Nuclear Studies, IBS
[4]Baksan Neutrino Pbservatory, INR
ydkim@ibs.re.kr

Abstract:

The Center for Underground Physics (CUP) is conducting two main rare event search experiments, the AMoRE experiment, which searches for neutrinoless double-beta decay, and COSINE which searches for WIMP dark matter, both operating at the Yangyang underground laboratory. It is important to reduce levels of radioactivities (U/Th/K/Pb) in the respective detector materials of the two rare-event experiments. There are three techniques generally used for radioactive assay in the CUP, inductively coupled plasma mass spectrometry (ICP-MS), high purity germanium detection (HPGe), and alpha counting. Each technique has different characteristics, which measure the activity value of the sample and cross-check various aspects of the same samples to enable material selection. HPGe detectors have an advantage of analyzing activity levels of various radioactive isotopes because of their fine resolution. Ionization chamber alpha counters have an advantage of distinguishing the surface alpha contamination which can affect experiment sensitivities. In this talk, alpha counting and HPGe measurements of detector materials to be used in the rare-event search experiments will be presented.

Keywords:

HPGe detector, Alpha counter, Radioactive assay, Y2L, Material selection

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.08

Active Target Development for Multiple Nuclear Astrophysics Experiments at CENS

AHN Sunghoon(Tony) *1, KIM Dahee [1], HAHN Kevin Insik[1], MOON Byul [1], CHAE Kyungyuk [2], CHA Soomi [1,2], KIM Minju [2], KIM Chanhee [2]
[1]Center for Exotic Nuclear Studies, IBS
[2]Department of Physics, Sungkyunkwan University
saint@nuclearemail.org

Abstract:

In order to answer the fundamental open question of "Where do nuclei and elements come from", experimental studies of nuclear properties with powerful rare isotope beam(RIB) facilities are critical. However, because most of the key nuclei providing important constraints for the nucleosynthesis models are far from stability, beam intensities of the nuclei from the facilities are currently very limited. Therefore, a new detector system development is required to provide a high detection efficiency as well as a high energy and position resolution of particles.

Active Target for Multiple nuclear astrophysics eXperiments (AToM-X) at the Center for Exotic Nuclear Studies (CENS) is under development in order to perform experimental studies of the key nuclei. The new active target detector will enable us to measure key nuclear reactions, related to the nuclear astrophysical processes, with high resolutions for track, energy and position of detected particles.

Details of the detector design and a status report on the development will be presented. We will also discuss plans to utilize this system for experiments of nuclear reactions using radioactive ion beams.

Keywords:

Active Target, Nuclear Astrophysics Experiments, AToM-X

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G3.09

Simulation study on beam test at KOMAC of prototype detectors for LAMPS

KIM Yongjun *[1], KIM Chong [1], KIM Beomkyu [1], LIM Sanghoon [1]
[1]Department of Physics, Pusan National University
kyj8668@gmail.com

Abstract:

The Large Acceptance Multi-Purpose Spectrometer(LAMPS) is a detector system to study rare isotope collisions and the nuclear symmetry energy at the RAON accelerator facility.Several detector systems are under development and construction, and prototype detectors have tested with proton beams at KOMACIn order to optimize the beam test configuration with high intensity proton beams at KOMAC, a dedicated simulation study is necessary.We have prepared a Geant4 simulation setup and performed an extensive study to optimize the experiment configuration such as collimator, absorber, and shielding.Further analysis of simulation data has been also done to understand the data collected at the beam test. In this presentation, we will present the simulation study of beam test of prototype detectors for LAMPS.

Keywords:

LAMPS, KOMAC, Geant4

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G5.01

Cascade of electronic transitions and strongly correlated topological phases in magic-angle twisted bilayer graphene

OH Myungchul *1
[1]Princeton University
mo8@princeton.edu

Abstract:

Discovery of emergent phenomena, such as superconductivity, magnetism and correlated insulating phases in flat bands [1][2] has evinced magic-angle twisted bilayer graphene (MATBG) as a fertile platform to explore strongly correlated many-body systems. Besides, unlike the most topological systems found so far where electrons interact weakly, strong electronic interactions in MATBG gives rise to exotic topological phases. Scanning tunneling microscopy and spectroscopy (STM/STS) capable of studying excited electronic states, provides us key information unveiling the nature of many-body physics on moiré heterostructures [3]. In this talk, we report on the observation of cascades of electronic transitions and strongly correlated Chern insulator phases studied by density-tunned STM/STS (DT-STM/STS). Our recent experimental results not only reveal new distinct carrier density dependent spectroscopic features that reflect correlated electronic behaviors, but also manifest a correlation between non-trivial topology and electron-electron interaction in moiré flat-bands in the presence of magnetic field.

[1] Y. Cao et al. *Nature* **556**, 43-50 (2018)
[2] M. Serlin et al. *Science* 367(6480), 900-903 (2020)
[3] Y. Xie et al. *Nature* 572, 101-105 (2019)

Keywords:

MATBG, Chern insulators, moiré flat-bands, STM

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G5.02

Correlated topological phases in moiré flat bands

XIE Yonglong *[1]
[1]Harvard University
yxie1@g.harvard.edu

Abstract:

The interplay between strong electron-electron interactions and band topology can lead to novel electronic states that spontaneously break symmetries. The discovery of flat bands in magic-angle twisted bilayer graphene (MATBG) with nontrivial topology has provided a unique platform in which to search for new symmetry-broken phases. Recent scanning tunneling microscopy and transport experiments have revealed a sequence of topological insulating phases in MATBG with Chern numbers $C=\pm3, \pm2, \pm1$ near moiré band filling factors $\nu = \pm1, \pm2, \pm3$, corresponding to a simple pattern of flavor-symmetry breaking Chern insulators. In this talk, we report high-resolution local compressibility measurements of MATBG with a scanning single electron transistor that reveal a new sequence of incompressible states with unexpected Chern numbers observed down to zero magnetic field. We find that the Chern numbers for eight of the observed incompressible states are incompatible with the simple picture in which the $C=\pm1$ bands are sequentially filled. We show that the emergence of these unusual incompressible phases can be understood as a consequence of broken translation symmetry that doubles the moiré unit cell and splits each $C=\pm1$ band into a $C=\pm1$ band and a $C=0$ band. I will describe these experiments and other ongoing efforts, that illustrate the power of local compressibility measurements in discovering novel emergent phases in moiré flat bands.

Keywords:

MATBG, Chern insulators, Scanning single electron transistor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G5.03

Higher-Order topology in Twisted Bilayer Graphene

PARK Moon Jip *[1]
[1]Department of Physics, KAIST
moonjippark@kaist.ac.kr

Abstract:

There have been numerous works attempting to develop a general theory of the twisted bilayer graphene. So far, most of the previous theoretical works rely on the small-angle limit, where a simple Dirac model is approximable. However, there exist, in principle, infinitely many numbers of the large commensurate angles that do not fit in this small angle limit. In this talk, we tackle the problem of the twisted bilayer graphene at arbitrary angles. We show that all moiré patterns of twisted bilayer graphene share the same non-trivial higher-order band topology, which is irrespective of the specific angles as long as the underlying symmetries are intact. Besides, we propose a novel transport effect, which we refer to as higher-order topological instanton tunneling. We show that this tunneling effect can distinguishes the topological corner states from trivial impurity bound states.

Ref:
[1] Higher-Order Topological Insulator in Twisted Bilayer Graphene
M. J. Park, Y. Kim, G. Y. Cho, S. Lee, Phys. Rev. Lett. 123, 216803 (2019)
[2] *Higher-Order Topological Corner State Tunneling in Twisted Bilayer Graphene*
M. J. Park, S. Jeon, S. Lee, H. C. Park, Youngkuk Kim, Carbon 174 (2021).

Keywords:

Twisted bilayer graphene, Higher order topological insulator, Instanton tunneling, Quantum transport

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G5.04

Flat bands and the geometry of Bloch wave function

RHIM Jun Won *[1], HWANG Yoonseok [2], YANG Bohm-Jung [2]
[1]Department of Physics, Ajou University
[2]Department of Physics & Astronomy, Seoul National University
phyruth@gmail.com

Abstract:

Since the discovery of the superconductivity in the twisted bilayer graphene, which hosts nearly flat bands at the magic angle, flat band systems have been studied intensively recently. In the topological sense, flat bands are believed to be trivial because the corresponding Bloch wavefunction is analytic in the Brillouin zone. However, in the point of view of other geometric notions, such as the quantum distance and the cross-gap Berry connection, the flat bands can be non-trivial. We show that flat bands can show anomalous features under the magnetic field, and they can be characterized by such geometric properties of the Bloch wave function.

[1] Nature 584 59, Jun-Won Rhim, Kyoo Kim, and Bohm-Jung Yang
[2] arXiv:2012.15132, Yoonseok Hwang, Jun-Won Rhim, and Bohm-Jung Yang

Keywords:

flat band, quantum distance, cross-gap Berry connection, Landau level

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G6.01

Large-gap insulating dimer ground state in monolayer $IrTe_2$

HWANG Jinwoong *[1,2,3], KIM Kyoo [4], ZHANG Canxun [5,6,7], ZHU Tiancong [5,6], HERBIG Charlotte [5,6], KIM Sooran [8], KIM Bongjae [9], ZONG Yong [1,2], SALAH Mohamed [1,10], EL-DESOKY Mohamed M.[1,10], SHEN Zhi-Xun [2,11], HWANG Choongyu [3], CROMMIE Michael F.[5,6,7], MO Sung-Kwan *[1]
[1]Advanced Light Source, Lawrence Berkeley National Laboratory
[2]Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory
[3]Department of Physics, Pusan National University
[4]Korea Atomic Energy Research Institute
[5]Department of Physics, University of California
[6]Materials Science Division, Lawrence Berkeley National Laboratory
[7]Kavli Energy NanoSciences Institute, University of California
[8]Department of Physics Education, Kyungpook National University
[9]Department of Physics, Kunsan National University
[10]Physics Department, Faculty of Science, Suez University
[11]Geballe Laboratory for Advanced Materials, Department of Physics and Applied Physics, Stanford University
jwhwang@stanford.edu, skmo@lbl.gov

Abstract:

Monolayer (ML) of two-dimensional van der Waals (vdW) materials exhibit novel electronic phases distinct from their bulk due to the absence of interlayer coupling and the resulting electronic structure and symmetry changes. Here, by a combined study of angle-resolved photoemission spectroscopy and scanning tunneling microscopy/spectroscopy, we report the emergence of unique 2 x 1 insulating Ir dimerized ground state in monolayer $IrTe_2$ with a larger than 1 eV band gap, which is distinct from the metallic bilayer (BL) and bulk. First-principle calculations reveal that the strong Te-Te interlayer coupling plays a vital role in $IrTe_2$ layer resulting in the large-gap metal-to-insulator transition, when the thickness changes from BL to ML, by strongly affecting the charge and phonon properties. Our findings provide compelling case of an emergent novel ground state caused by the strong interlayer coupling in vdW layered materials and its absence in the monolayer.

Keywords:

IrTe2, Metal-to-insulator transition, 2D materials

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G6.02

Hund's metallic properties of ruthenates

KIM Choong Hyun *[1]
[1]Seoul National University
chkim82@snu.ac.kr

Abstract:

Hund's coupling J_H, instead of Hubbard interaction U, is a new knob to manipulate the physical properties of various strongly correlated materials. For example, the role of Hund's coupling in the unconventional superconductors such as Fe-pnictide or Sr_2RuO_4 has been re-examined from the perspective of the newly proposed correlated metallic phase called Hund's metal. In this talk, we present a systematic theoretical study on the novel metallic properties of various ruthenates and related systems by means of density functional theory plus dynamical mean-field theory (DMFT) with an exact diagonalization solver. We will specifically show in detail how van Hove singularity affects Hund's metal to Fermi liquid crossover in the relevant material system.

Keywords:

Hund's coupling, ruthenates, Sr2RuO4, DMFT

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G6.03

Understanding the normal state of nickelate superconductors: recent progress and open problems

RYEE Siheon [1], CHOI Sangkook [2], HAN Myung Joon *[1]
[1]Department of Physics, KAIST
[2]CMPMS Department, Brookhaven National Lab.
mj.han@kaist.ac.kr

Abstract:

The long-standing quest for finding non-Cu-based cuprate-like superconductors finally culminated in the recent discovery of superconductivity in 2019 in hole-doped infinite-layer nickelates, $RE_{1-x}Sr_xNiO_2$ (RE = Nd, Pr). Quite naturally, the main focus of the subsequent research has been to what extent these nickelates are close to cuprates. Early theoretical studies unveiled two key features of the nickelates in terms of electronic structure: i) the suppressed charge-transfer physics compared to cuprates and ii) contribution of the so-called self-doping RE-5*d* bands to the Fermi level in contrast to cuprates; see, for example, Ref. [1] and references therein. These observations led to the advent of a variety of "pictures" defining the normal state of nickelates which are now under active debate. Roughly speaking, this debate is related to whether or not the Hund's coupling and multiple Ni-*d* orbitals are essential ingredients for understanding the low-energy physics. In this talk, I will review some of the recent progress in this line of research including our own results and viewpoints [1, 2, 3] and discuss related open questions.

[1] S. Ryee, H. Yoon, T. J. Kim, M. Y. Jeong, and M. J. Han, Phys. Rev. B 101, 064513 (2020)
[2] B. Kang, C. Melnick, P. Semon, S. Ryee, M. J. Han, G. Kotliar, and S. Choi, arXiv:2007.14610
[3] S. Ryee, M. J. Han, and S. Choi, arXiv:2008.13171

Keywords:

Nickelate superconductors

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G6.04

Observation of the Chiral Spin structure in Ferromagnetic $SrRuO_3$ Thin Film

KIM Bongju *[1,3,4], HUANG Hai [2], LEE Sang-Jun [2], SOHN Byungmin [3,4], CHANG Seo Hyoung [6], BOMBARDI Alessandro [7], PORTER Dan. G.[7], KIM Changyoung [3,4], KAO Chi-Chang [5], LEE Jun-Sik [2]
[1]department of energy science, Sungkyunkwan University
[2]Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratory
[3]Department of Physics and Astronomy, Seoul National University
[4]Center for Correlated Electron Systems, Institute for Basic Science
[5]SLAC National Accelerator Laboratory, SLAC National Accelerator Laboratory
[6]Department of Physics, Chung-Ang University
[7]Diamond Light Source Ltd, Harwell Science and Innovation Campus
plant0011@gmail.com

Abstract:

$SrRuO_3$ (SRO) ultra-thin films and their heterostructure have attracted much attention because of the recently reported fascinating properties, such as topological Hall effect. Critical to the understanding of those new phenomena is the study of the spin configuration. Here, we performed resonant soft X-ray scattering (RSXS) at the oxygen K edge to confirm the spin configuration of ultra-thin SRO film that was prepared epitaxially on top of a single-crystal $SrTiO_3$ substrate. The RSXS signal under a magnetic field (~0.4 tesla) clearly shows a magnetic dichroism pattern around the specular reflection. Furthermore, the model calculations on the RSXS signal demonstrate that the magnetic dichroism pattern originates from a Néel-type chiral spin structure in this SRO thin film. We believe that this observed spin structure of the SRO system is a critical piece of information for understanding its intriguing magnetic and transport properties.

Keywords:

ultra thin film, spin chirality, resonant soft xray scattering, skyrmion, SrRuO3

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G7.01

Density functional theory studies of superconducting infinite-layer nickelate

LEE Kwan-Woo *1
[1]Division of Display and Semiconductor Physics, Korea University
mckwan@korea.ac.kr

Abstract:

For a long time, condensed matter physicists have a question whether there may be nickelates that can host a cuprate-type superconductor. As a most promising candidate, $LaNiO_2$, which is isostructural with the high T_c cuprate patent compound $CaCuO_2$, has been investigated, but never been superconducting so far. In another isostructural and isoelectronic system $NdNiO_2$, recently, 20%-Sr doping leads to superconducting up to T_c=15 K. Experimentally, the undoped $CaCuO_2$ is insulating and antiferromagnetically ordered, whereas both undoped $LaNiO_2$ and $NdNiO_2$ are (badly) metallic and do not order magnetically. These similarities and contrasts have been rejuvenated the long standing issue.
In this presentation, we will focus on the following two primary questions, using the density functional theory based calculations. (1) What are distinctions between $NdNiO_2$ and $LaNiO_2$, which are superconducting and non-superconducting, respectively, when 20% hole-doped? (2) Why does not the itinerant $NdNiO_2$ order antiferromagnetically, in contrast to the insulating antiferromagnet $CaCuO_2$ with the small d^9 configuration?

[Acknowledgements] We acknowledge collaborations with W. E. Pickett and M.-Y. Choi. This research was supported by National Research Foundation (NRF) of Korea Grants No.NRF-2019R1A2C1009588.

Keywords:

NdNiO2, LaNiO2, first principles calculations

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G7.02

Nature of electronic correlations in the infinite-layer nickelates and hidden Hund's physics

KANG Chang-Jong *[1]
[1]Department of Physics, Chungnam National University
cjkang87@cnu.ac.kr

Abstract:

We investigate the optical properties of the normal state of the infinite-layer nickelates using density-functional theory plus dynamical mean-field theory (DFT+DMFT). We find a correlated metal which exhibits substantial transfer of spectral weight to high energies relative to the density functional theory. The correlations are not due to Mott physics, which would suppress the charge fluctuations and the integrated optical spectral weight as we approach a putative insulating state. Instead, we find the unusual situation, that the integrated optical spectral weight decreases with doping and increases with increasing temperature. We contrast this with the coherent component of the optical conductivity, which decreases with increasing temperature as a result of a coherence-incoherence crossover. Our studies reveal that the effective crystal field splitting is dynamical and increases strongly at low frequency. This leads to a picture of a Hund's metallic state, where dynamical orbital fluctuations are visible at intermediate energies, while at low energies a Fermi surface with primarily dx2-y2 character emerges. The nickelates are thus in an intermediate position between the iron-based high-temperature superconductors where multiorbital Hund's physics dominates, and a one band system such as the cuprates. To capture this physics we propose a low-energy two-band model with atom-centered eg states.

Keywords:

Infinite-layer nickelate, Hidden Hund's physics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G7.03

First-principles study of superconducting $Ba_2CuO_{3+\delta}$

JIN Hyo-Sun [1], LEE Kwan-Woo [*1]
[1]Division of Display and Semiconductor Physics, Korea University
mckwan@korea.ac.kr

Abstract:

Recently, a new high Tc superconducting cuprate was discovered in the heavily doped $Ba_2CuO_{3+\delta}$ with Tc=73 K at δ~0.2. Compared with conventional superconducting cuprates, the superconductor has several remarkable aspects in structure: significantly compressed Cu-apical oxygen separation and stretched Cu-planar oxygen separation. Additionally, as doping, the CuO_2 square lattice, which has been considered as a crucial ingredient to emerge the superconductivity in cuprates, is broken. This leads to a one-dimensional Cu-O chain of spin 1/2 that has been extensively investigated in the isovalent and isostructural Sr_2CuO_3 system.
In this presentation, we will address the electronic structures and effects of the structural uniqueness of the δ=0 normal phase. Interestingly, our results indicate that the δ=0 phase shows a strong instability induced by the chain structure. Besides, we will discuss on the electronic structure of the superconducting phase, using approaches of a supercell and a virtual crystal approximation at δ=0.25.

Acknowledgements: This research was supported by NRF-2019R1A2C1009588.

Keywords:

cuprate, first principles, Ba2CuO3+δ

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G7.05

Proposals to detect Bogoliubov Fermi surfaces

OH Hanbit [1], MOON Eun-Gook [*1]
[1]physics, KAIST
egmoon@kaist.ac.kr

Abstract:

An exotic superconducting state with Fermi surfaces of Bogoliubov quasiparticles, Bogoliubov Fermi-surface (BG-FS), has recently been proposed in a centrosymmetric $j=3/2$ system with a Z$_2$ topological invariant. Several candidate materials of a BG-FS are proposed in Sr$_2$RuO$_4$ and doped FeSe, but its existence has not been confirmed yet. In this work, we provide theoretical proposals to pin down a BG-FS. First, we use the inversion instability of a BG-FS and suggest that second-harmonic-generation (SHG) experiments with a strain gradient to identify enhanced fluctuations of an inversion order parameter. [1] Second, a nontrivial disorder effect of a Bogoliubov Fermi surface superconductivity is used. Specifically, we derive the expressions for the optical conductivity and compare them with that of conventional Bardeen-Cooper-Schrieffer superconductivity. Generalized Anderson's theorem in BG-FSs is briefly explained. Possible applications of our theory to iron-based superconductors and heavy fermion systems including FeSe will also be discussed.

[1] Hanbit Oh and Eun-Gook Moon,Phys. Rev. B 102, 020501(R)

Keywords:

Bogoliubov Fermi surfaces, Disorder effects , Optical conductivity, Anderson's theorem

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G7.06

Formation of buried superconducting Mo_2N by nitrogen-ion-implantation

JEEN Hyoung Jeen *[1], LEE Joonhyuk [1], PARK Jun Kue [2], LEE Joon Woo [3], HEO Yunseok [1], OH Yoon Seok [3], LEE Jae S. [2], CHO Jinhyoung [4]

[1]Department of Physics, Pusan National University
[2]Korea Multi-Purpose Accelerator Complex, KAERI
[3]Department of Physics, UNIST
[4]Department of Physics Education, Pusan National University
hjeen@pusan.ac.kr

Abstract:

Ion implantation is a technique injecting a single ion into matter giving rise to changes in the physical, chemical, or electrical properties of the samples. In this study, the changes of physical, chemical, and electrical properties through nitrogen ion beam implantation on the (110) Mo thin film were checked and their physical origin was investigated. A (110) Mo thin film was deposited on the (0001) Al_2O_3 substrate through RF sputtering. Nitrogen ions were implanted into the Mo thin film using a nitrogen ion beam. With varying doses of a 20-keV nitrogen ion beam, the structural change was checked through x-ray diffraction. Through the transport of ions in matter simulation, field emission transmission electron microscope, and energy dispersive x-ray spectroscopy, the change in the atomic structure of Mo and nitrogen due to the implanted ions was tracked. To understand the change of the Mo layer through nitrogen implantation, x-ray reflectometry and GenX fitting were performed and thus identified a layer with a broken structure at the top, a layer with a large amount of nitrogen, and a Mo layer that nitrogen ions did not reach. Superconductivity was checked through SQUID and transport of the nitrogen-ion-implanted Mo thin film. It is revealed that the layer showing superconductivity is the buried layer, not the surface.

Keywords:

Phase formation, ɣ-Mo2N, Ion implantation, Superconductivity, Nitridation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G9.01

Fabrication of silicon nano-/microstructures by fab-free process and analysis of hole behavior during metal-assisted chemical etching

JO Jeong-Sik [1], HONG Young Ki [2], JANG Jae Won *[1]
[1]Division of Physics and Semiconductor Science, Dongguk University
[2]Department of Physics, Gyeongsang National University
jwjang@dgu.ac.kr

Abstract:

Silicon (Si) nano-/microfabrication through metal-assisted chemical etching (MACE) is regarded as one of the influential methods due to its simplicity, low cost, high-throughput, high-crystalline quality, and applicability under ambient condition. In particular, MACE has high availability because it can produce various shapes of Si nano-/microstructures when combined with lithography. However, it is still difficult to fabricate elaborated Si nano-/microstructures for high-value applications. In particular, further studies about effective factors in the MACE process with systematical approaches are highly required to obtain controlled MACE products. In this study, it is investigated influences on MACE products in terms of the view of hole behaviors during the MACE. As a result, various shape of controlled Si nano-/micro structures can be obtained through scanning probe lithography combined with MACE of optimized hole behavior. In addition, the mass production of arbitrarily shaped Si microparticles at submicrometer resolution is developed using silicon-on-insulator substrates, as demonstrated using optical microresonators, surface-enhanced Raman scattering templates, and smart microparticles for fluorescence signal coding.

Keywords:

silicon nano-/microstructure, silicon nano-/microfabrication, scanning probe lithography, metal-assisted chemical etching

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G9.02

Reducing surface roughness of sputtered $CoFe_2O_4$ films using two-step growth mode

LEE Hyunkyung [1], SONG Sehwan [1], KIM Byeongwan [1], PARK Sungkyun [1], KANG Haeyong [*1]
[1]Department of Physics, Pusan National University
haeyong.kang@pusan.ac.kr

Abstract:

본 연구에서는 $CoFe_2O_4$(CFO) 박막이 기판의 종류에 상관없이 자기적 특성을 유지하면서 표면 거칠기를 감소시킬 수 있는 실험을 진행하였다. CFO 는 coercivity 가 큰 hard magnetic 물질로 soft magnet 과 heterostructure 를 이루었을 때 coercivity 와 saturation magnetization 을 증가시키는 물질로 많은 관심을 가지고 있다. 그러나, RF magnetron sputter 를 이용한 CFO 박막 시료는 성장 과정에서 기판의 종류와 물질의 두께 등의 성장환경에 따라 박막의 표면 거칠기가 변해 얇은 박막의 경우 CFO 본연의 물리적 특성 구현과 혹은 다른 물질과 접합을 통한 새로운 물성 연구에 어려움이 있다. 이를 해결하기 위해 SiO_2 기판위에 500℃에서 80W 로 박막을 성장 후 상온에서 낮은 RF 파워로 성장시키는 'two-step growth' 방법을 이용하여 표면 거칠기를 감소시킬 수 있도록 하였다. 그 결과 박막의 표면 거칠기는 기존의 one-step 증착 방법에 비해 성장된 박막에 비해 56% 감소하였음을 AFM 분석을 통해 확인하였다. 또한, 시편의 자기적 특성이 one-step 증착 방법으로 제작한 박막과 유사함도 확인할 수 있었다. 이러한 결과로부터 CFO 박막에 다른 물질을 증착 시켜 계면 특성 연구를 진행할 예정이다.

Keywords:

CoFe2O4, surface roughness, RF magnetron sputter, two-step growth, thin film

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G9.03

Acoustic phonon transmission spectroscopy on metal-semiconductor interfaces

LEE Jong Seok *[1], JEONG Do Gyeom [1]
[1]Department of Physics and Photon Science, GIST
jsl@gist.ac.kr

Abstract:

Although we are familiar with transmission spectroscopy of electromagnetic waves through the thin specimens of samples, it is not straightforward to conceive the corresponding spectrum for the lattice waves across the interface formed between two media. In this presentation, we demonstrate an experimental technique combined with the fitting algorithm employed to obtain frequency and polarization-dependent acoustic phonon transmission profiles. We conduct time-domain thermoreflectance (TDTR) measurement on the heterostructures of Al(70 nm)/Si and Al(70 nm)/GaAs with the pulsed laser used as heat sources and solve the phonon Boltzmann transport equation with transmission profiles as variables to fit the TDTR results. As the wavelength of phonons investigated in this work ranges from 0.5 nm to 5 nm, we note that the optimized acoustic phonon transmission has a high sensitivity to several different kinds of the scattering sources, such as interface roughness, artificial geometries, impurities, electrons, and so on.

Keywords:

phonon, interface, acoustic, spectrum, scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G9.04

Optical Horn Effect via Hourglass type Nanoslit Nanostructure II

CHOI Seong Soo *[1,2], PARK Myoung Jin [4], BAE Byoung Seong [3], KIM Hyun Tae [5], CHOI Soo Bong [5], LEE Yong Min [2]
[1]Sun Moon University
[2]Research Center for Nano-Bio Science, SunMoon University
[3]Display, Hoseo University
[4]Physics, Korea Military Academy
[5]Physics, Incheon National University
sscphy1982@daum.net

Abstract:

The horn structure has been utilized to enhance the sound wave intensity via various hour-glass type structures from ancient Viking ages. We reported before the optical enhancement from the nanometer size circular aperture on the hour glass type nanostructure. In this report, we will address the optical horn effect in the visible range from microfabricated hourglass type naoslits. The naoslit nanostructures are fabricated and its optical characterizations are followed using ND YAG 532 nm laser along with Nikon Ti Halogen lamp equipped with Princeton Spectrophotometer. The huge optical enhancements from the fabricated nanoslit with its ranging from ~ 1 nm to 30 nm are obtained and will be discussed.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G9.05

Gas Cluster Ion Beam Sputtering Yield Measurement on Silicon and OLED Surfaces

CHO Jinwan [1,2], CHOI Myongchul [2], LEE Sangju [2], LEE Manhee [*1]
[1]Department of Physics, Chungbuk National University
[2]Division of Scientific Instrumentation % Management Center for Scientific Instrumentation, Cheongju, Republic of Korea, Korea Basic Science Institute
mlee@cbnu.ac.kr

Abstract:

There have been used various kinds of ion beams in the time of flight secondary ion mass spectrometer. Notably, the Argon gas cluster ion beam was reported to be useful for sputtering of organic samples. In this study, we measure the sputtering yield for an organic material, TAPC, and silicon samples. We measure 3D structure of the sample surfaces by using Coherence Correlation Interferometry (CCI), stylus profilometry, and atomic force microscopy (AFM). Based on the measured data, the results of the optical interferometer CCI are shown to be very equivalent to that of the profiler and AFM. Therefore, the CCI is a fast, accurate, and reliable methodology for measuring sputtering yield.

Keywords:

GCIB, Gas Cluster Ion Beam, OLED, Sputtering yield

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.01

Anisotropic ionic conduction in Ca-doped bismuth ferrite thin films measured by electrochromism and impedance spectroscopy

SUH Jeonghun [1,2], LIM Ji Soo [1,2], PARK Heung-Sik [1,2], YANG Chan-Ho *[1,2,3]
[1]Physics, KAIST
[2]Center for Lattice Defectronics, KAIST
[3]KAIST Institute for the NanoCentury, KAIST
chyang@kaist.ac.kr

Abstract:

Ca-doped bismuth ferrite is a promising material for studying collective ionic migration and electrochromism for optical visualization.[1,2] We measure the ionic conductivity of Ca 30% doped bismuth ferrite (BCFO30) films on $SrTiO_3$ (110) substrate using both methods, AC impedance spectroscopy and optical visualization. To suppress the electronic contribution to the conductivity,[3] we anneal the BCFO30 films in a N_2 gas environment at elevated temperatures before measuring the AC impedance spectroscopy. The ionic conductivities from both methods, the optical microscope and AC impedance spectroscopy surprisingly show almost similar value. We also explore the ionic conductivity depending on its film orientation and analyze oxygen vacancy flow by combining the crystal structure. This work provides a useful insight on measuring the ionic conductivities in solids.

[1] H. S. Park *et al.*, Applied Physics Letters **115**, 183901, (2019)
[2] J. S. Lim *et al.*, NPG Asia Materials **10**, 943-955, (2018)
[3] N. Masó *et al.*, Chemistry of Materials **24**, 2127-2132, (2012)

Keywords:

Oxygen vacancy, Ionic migration, Electrochromism, Impedance spectroscopy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.02

The Role of Ferroelectric toward High Synaptic Performance Based on Au/Ni/Pb($Zr_{0.52}Ti_{0.48}$)O_3/Nb doped $SrTiO_3$ Structure.

PARK Bae Ho [*1], KIM Sohwi [1], YOON Chansoo [1], LEE Ji Hye [2,3], PARK Sanghyun [4], KANG Bo Soo [4], KIM Young Heon [5]

[1]Department of Physics, Konkuk University
[2]Center for Correlated Electron Systems (CCES), Institute of Basic Science (IBS)
[3]Department of Physics and Astronomy, Seoul National University
[4]Department of Applied Physics, Hanyang University ERICA
[5]Graduate School of Analytical Science and Technology, Chungnam National University
baehpark@konkuk.ac.kr

Abstract:

Hardware implementation of neuromorphic computing has been evolving to improve the computing performance in the so-called “big data” era. Combination of energy-efficient operation from low reading current and short operation time, linear and symmetric weight update, and high reliability should be satisfied in a single synaptic device to accomplish large-scale array. Here we exhibit outstanding performances in a single synaptic device consisting of Au/Ni/Pb($Zr_{0.52}Ti_{0.48}$)O_3/Nb-doped $SrTiO_3$ heterojunction. To clarify the role of ferroelectric on synaptic behaviors, all of electrical and synaptic performances are also conducted in Au/Ni/ Nb-doped $SrTiO_3$. Linear/symmetric behaviors in weight updates are, minimal temporal variation (0.9 %) of weight updates are achieved from reproducible domain switching from the progressive partial domains switching in ferroelectric. Therefore, our two-terminal synaptic memristor with low reading current, small variation with linear/symmetric behaviors, and high energy efficiency can pave the way for fabrication of large neuromorphic arrays and high precision neuromorphic computing in the future.

Keywords:

neuromorphic, ferroelectric, linearity, variation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.03

Systematic studies on ferroelectric properties in epitaxial Mn-doped $(K,Na)NbO_3$ thin films

DUONG Nguyen Xuan [1], AHN Chang Won [1], THUY Nguyen Bich [1], KIM Gyehyeon [2], BAE Jong-Seong [3], SHEERAZ Muhammad [1], LEE Myang Hwan [4], HAN Hyoung-Su [5], CHO Shinuk [1], SONG Tae Kwon [4], SOHN Changhee [2], KIM Ill Won [1], KIM Tae Heon *[1]
[1]Department of Physics, University of Ulsan
[2]Department of Physics, Ulsan National Institute of Science and Technology (UNIST)
[3]Busan Center, Korea Basic Science Institute (KBSI)
[4]School of Materials Science and Engineering, Changwon National University
[5]School of Materials Science and Engineering, University of Ulsan
thkim79@ulsan.ac.kr

Abstract:

$(K,Na)NbO_3$ (KNN) has attracted much interest as a promising candidate with its excellent physical properties for potential applications to novel nano-devices such as non-volatile ferroelectric memory. However, its use in actual devices has been limited due to concerns in the operational reliability (e.g., polarization fatigue and retention loss). In this work, we fabricated epitaxial KNN thin films exhibiting the suppression of polarization fatigue and retention loss behaviors. The device characteristics were suppressed by doping of multivalent Mn ions to the ferroelectric KNN films. We found that Mn doing plays a key role in the enhancement of the polarization fatigue and retention properties. A possible mechanism of the suppressed polarization fatigue/retention behaviors will be discussed in conjunction with the effect of Mn substitutions on the migration of charged defects.

Keywords:

Ferroelectric, (K,Na)NbO3, polarization fatigue, retention loss

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.04

Nanoscale mapping of local conductance changes at different temperatures in an epitaxial VO_2 thin film

KIM Ahyoung [1], PARK Jung Hyun [2], LIM Soo Yeon [1], CHUNG Jin-Seok [2], CHEONG Hyeonsik [1], KO Changhyun [3], YOON Jong-Gul [4], YANG Sang Mo [*1]
[1]Department of Physics, Sogang University
[2]Department of Physics, Soongsil University
[3]Department of Applied Physics, Sookmyung Women's University
[4]Department of Physics, The University of Suwon
smyang@sogang.ac.kr

Abstract:

Vanadium dioxide (VO_2) is one of the extensively studied correlated oxides in condensed matter physics due to an intriguing metal-insulator transition (MIT). Especially, its transition temperature is relatively close to room temperature (about 340 K in bulk) and thus it has also attracted considerable interest in the viewpoint of applications such as thermal sensors, thermal switches, and memristive devices. However, in spite of many studies so far, there is still a lack of comprehensive understanding of the primary MIT mechanism. In this respect, the direct observation of temperature-dependent local conductance changes can be a good clue to get further insight into the detailed MIT behavior of VO_2. In this study, we investigate the temperature-dependent local conductance changes of epitaxial VO_2/Al_2O_3 heterostructures using conductive-atomic force microscopy (c-AFM). We measured the local conductance between the tip and the planar Au electrode (i.e., lateral transport) at different temperatures (from room temperature to 355 K). Interestingly, we observed the ring patterns in the c-AFM images, indicating that the grain boundaries are more conductive than the center of the grain. In addition, such ring patterns were observed at the whole measured temperature ranges, which is different from the previous c-AFM study in the polycrystalline VO_2 films grown on Si substrates [1]. Based on the Raman spectroscopy, we found that the ring patterns originate from the coexistence of different insulating monoclinic phases (the so-called M1 and M2). Furthermore, we studied local conduction mechanism in the grain boundary regions using current-voltage (I-V) spectroscopy.

[1] H. Kim *et al.*, Appl. Phys. Lett. 109, 233104 (2016)

Keywords:

VO2, Metal-insulator transition, Conductive-AFM

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.05

Spin-orbit Torque Magnetization Switching in an All-Van der Waals WTe_2/Fe_3GeTe_2 Heterostructure

SHIN Inseob [1], CHO Won Joon [2], AN Eun-Su [1,3], PARK Sungyu [3], JEONG Hyeon-Woo [1], JANG Seong [1], BAEK Woon Joong [2], PARK Seong Yong [2], YANG Dong-Hwan [4], SEO Jun Ho [1], KIM Gi-Yeop [4], ALI Mazhar Nawaz[5], CHOI Si-Young [4], LEE Hyun-Woo [1,6], KIM Jun Sung [1,3], KIM Sungdug [2], LEE Gil-Ho [*1,6]

[1]Department of Physics, POSTECH
[2]Material Research Center, Samsung Advanced Institute of Technology
[3]Center for Artificial Low Dimensional Electronic Systems, Institute for Basic Science
[4]Department of Materials Science and Engineering, POSTECH
[5]Microstructure Physics, Max Plank Institute
[6]Theoretical Physics, Asia Pacific Center
lghman@postech.ac.kr

Abstract:

Current-induced control of magnetization in ferromagnets (FMs) using spin-orbit torque (SOT) has drawn attention as a new mechanism for fast and energy efficient magnetic memory devices. There are roughly two approaches to improve the SOT device performance. One is to search for suitable materials. So far, various high spin-orbit coupling materials, including heavy metals, topological insulators , and recently, topological semimetals , have been studied to maximize their SOT efficiency. Another is the interface engineering between the FMs and high spin Hall effect materials for maximizing spin transparency across the interface. Herein, we use single crystals of the van der Waals (vdW) topological semimetal WTe_2 and vdW ferromagnet Fe_3GeTe_2 to satisfy the requirements in their all-vdW-heterostructure with an atomically sharp interface. The results exhibit values of ξ (SOT efficiency) ≈ 4.6 and $\sigma \approx 2.25 \times 10^5\ \Omega^{-1}m^{-1}$ for WTe_2. Moreover, we obtain the significantly reduced switching current density of 3.90×10^6 A/cm^2 at 150 K, which is an order of magnitude smaller than those of conventional heavy-metal/ferromagnet thin films. These findings highlight that engineering vdW-type topological materials and magnets offers a promising route to energy-efficient magnetization control in SOT-based spintronics.

Keywords:

all-van der Waals heterostructure, spin-orbit torque, current induced magnetization switching, spintronics

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.06

Observation of Weak Antilocalization in Co-dusted Graphene films

DO Thi Nga [1,2], LEE Sehee [3], HWANG Chanyong [3], KIM Tae Hee [*1,2]
[1]Center for Quantum Nanoscience, Ewha Womans University
[2]Department of Physics, Ewha Womans University
[3]Quantum Spin Team, KRISS
taehee@ewha.ac.kr

Abstract:

In this work, we focused on determining the interface between graphene and Co layers for the observation of quantum interference. The graphene-based devices of *x*-nm Co (x = 0 – 2.5)/3-nm Pt Hall bar were prepared on top of the large-area CVD-grown graphene using the UHV-MBE system. A 1.2-nm-thick MgO layer was also performed in between graphene and Co layer as comparative devices in order to study the impact of the interface on the quantum interference effect.
Based on the temperature-dependent resistivity results, we clearly remarked the interplay of Co/Graphene interface which was represented by the observation of the metal-insulator transition from room temperature to 77K regarding the changing of the Co thickness. Interestingly, the magnetoresistance results clearly determined the co-exist of weak localization (WL) as well as weak antilocalization (WAL) effects in the graphene-based devices without thin MgO layer, which may be explained by the Co clusters act as the magnetic scattering centers. In addition, we observed the enhanced WAL effect at 77K as the Co thickness decreases down to 0.5 Å at the large applied perpendicular magnetic field.
Our results suggest that hybrid structure ultra-thin Co/Graphene with Pt as the Hall bar sufficiently could help observe the W(A)L effect at 77K, paving the way for a better and more effectively understanding and detection of the difficult touchable defects at the interface of heavy metal/graphene to develop novel spintronic devices.

Keywords:

2D materials, Quantum interference effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G10.07

자구벽 운동에서 임계 전류의 이해

CHANG Jun-Young [1,2], PARK Min-Ho [1], YU Ji-Sung [1], NAM Yune-Seok [1], KIM Myeong-hoe [1], KIM Dae-Yun [3], KIM Duck-Ho [*2], CHOE Sug-Bong [1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Center for Spintronics, Korea Institute of Science and Technology (KIST)
[3]Department of Electrical and Computer Engineering, National University of Singapore
uzes@kist.re.kr

Abstract:

자구벽 메모리 소자에서 저전류 구동은 에너지 소비를 줄이고[1] 안정성을 향상[2]시키는 데 있어 중요하다. 소자는 임계 전류 이상에서 동작하는데, 임계 전류를 결정하는 요인으로 자성층의 두께[3,4], 자기 이방성 상수[4-6] 등이 있음이 알려져 있다. 기존 연구들의 경우 임계 전류와 개별 변수들의 관계를 설명하기 위한 모델에 시료의 피닝 에너지를 고려하지 않아[4,7], 소자 구동에 대한 물리적 이해가 부족하다. 본 연구는 피닝 에너지를 도입해 임계 전류의 이론 모델을 수립하고, 이를 바탕으로 얻은 중요 변수들과 임계 전류의 관계를 실험적으로 확인하고자 한다. 이를 위하여 DC 마그네트론 스퍼터 방식을 통해 Ta (5 nm) / Pt (3 nm) / Co (x) / TiO_x (y) / Pt (2 nm) 의 구조에서 Co 층과 TiO_x층 두께를 바꿔가며 시료를 제작하였다. 광자기 커 효과(MOKE) 현미경을 통해 전류 인가 자구벽 운동의 속도를 측정하여 임계 전류를 얻었다. 이론으로 수립한 관계식을 이용해, 자성층의 두께, 자기 이방성 에너지의 변화에 따른 임계 전류의 변화를 실험적으로 관찰하였고, 기존에 보고된 값들[3,8-10]과 비교하여 이 관계식에 보편성이 있음을 확인하였다. 따라서 본 연구를 통해 자구벽 구동 및 임계 전류에 대한 더 깊은 이해가 가능해, 자구벽 메모리 소자 개발에 큰 도움이 될 것으로 기대한다.

참고문헌

[1] Y. Xu et al., Handbook of Spintronics (Springer, 2016).
[2] A. Yamaguchi et al., Appl. Phys. Lett. **86**, 012511 (2005).
[3] K. -S. Ryu et al., IEEE Trans. Mag. **52**, 1400404 (2016).
[4] Y. Guan et al., Adv. Mater. 2007991 (2021).
[5] G. Tatara and H. Kohno, Phys. Rev. Lett. **92**, 086601 (2004).
[6] Y. M. Hung et al., Appl. Phys. Express **14**, 023001 (2021).
[7] S. Fukami et al., Appl. Phys. Lett. **95**, 232504 (2009).
[8] Y. Guan et al., AIP Advances **7**, 085123 (2017).
[9] K. -S. Ryu et al., Nat. Nanotech. **8**, 527 (2013).
[10] I. M. Miron et al., Nat. Mater. **10**, 419 (2011)

Keywords:

임계 전류, 자구벽 운동

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.01

Parametrization of the Gaussian Disorder Model to Account for the High Carrier Mobility in Disordered Organic Transistors

JUNG Sungyeop *[1,2,3], LEE Yongjeong [4], PLEWS Andrew [6], NEIJIM Ahmed [6], SIMONETTI Olivier [7], GIRAUDET Louis [7], BARANOVSKII Sergei D.[5,8], GEBHARD Florian [8], MEERHOLZ Klaus [5], JUNG Sungjune [2,3], HOROWITZ Gilles [4], BONNASSIEUX Yvan [4]
[1]Advanced Institute of Convergence Technology
[2]Future IT Innovation Laboratory, POSTECH
[3]Department of Convergence IT Engineering, POSTECH
[4]LPICM, CNRS UMR 7647, Ecole Polytechnique
[5]TCAD Division, Silvaco Europe Ltd.
[6]LRN-EA 4682, Universite de Reims Champagne Ardenne
[7]Faculty of Physics and Material Sciences Center, Philipps-Universitat
[8]Department für Chemie, Universität zu Köln
sungyeopj@gmail.com

Abstract:

The Gaussian disorder model (GDM) describes charge transport in organic disordered semiconductors, such as conjugated polymers and small molecules, as thermally assisted hopping via randomly distributed localized states with the Gaussian density-of-states [1]. The model accounts for the electric field, charge density, and temperature dependences of charge transport. Correct parameterization of the GDM on spatially random sites is necessary for a complete description of charge transport in disordered materials and concomitant device characteristics. Because the GDM on spatially random sites considers both energetic and spatial disorder, it is superior to the GDM on a cubic lattice. However, analytical arguments and experimental evidence are still lacking for correct parameterization of the model over a wide range of model parameters, energetic and spatial disorder, and electric fields. We show that the model requires a set of parameters to correctly account for high mobility and its charge density dependence, and we develop such a model [2]. The model is implemented in a numerical simulation tool for comparison with the measured device characteristics. Accurate agreement with experimental data, particularly with the high mobility values in organic field-effect transistors, is achieved throughout a wide range of temperature by adjusting both the localization length and the attempt-to-escape frequency. Remarkably, it is shown that the localization length has a similar order of magnitude to the intermolecular distance of the semiconductor along the π-π stacking direction. In addition, the attempt-to-escape frequency must be elevated up to the range of $10^{14} - 10^{17}$ s^{-1}, depending on the materials, maintaining the calculated charge-transition rate within the physically accepted range. The sets of parameters enable an accurate fit of the transfer curves of various OFETs over a wide range of temperatures. We expect that this improvement in the theoretical tool will facilitate further improvement and correct evaluation of the device performance.

[1] S. D. Baranovskii, "Theoretical Description of Charge Transport in Disordered

Organic Semiconductors," *Phys. status solidi*, vol. 251, no. 3, pp. 487–525, 2014. DOI:10.1002/pssb.201350339
[2] Y. Lee *et al.*, "Parametrization of the Gaussian Disorder Model to Account for the High Carrier Mobility in Disordered Organic Transistors," *Phys. Rev. Appl.*, vol. 15, no. 2, p. 024021, Feb. 2021. DOI:10.1103/PhysRevApplied.15.024021

Keywords:

organic semiconductor, Gaussian disorder model, charge transport, hopping, field-effect transistor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.02

Improvement on Performance of Perovskite Solar Cells Introducing Cu:PSS as a Hole Transport Material

KANG JuHwan [1], ALI Azmat [1,2], PARK YuJung [1], KHAWAJA Kausar Ali[1], SEO JungHwa *[1,2]
[1]physis, Dong-A University
[2]Graduate School of Chemical Engineering, Dong-A University
seojh@dau.ac.kr

Abstract:

One effective strategy to improve the performance of perovskite solar cells (PSCs) is to develop new hole transport layers (HTLs). In this work, we have investigated a simple polyelectrolyte HTL, copper (II) poly(styrene sulfonate) (Cu:PSS), which comprises easily reduced Cu^{2+} counter-ions with an anionic PSS polyelectrolyte backbone. Photoelectron spectroscopy revealed an increase in the work function of the anode and upward band bending effect upon incorporation of Cu:PSS in PSC devices. Cu:PSS showed a synergistic effect when mixed with PEDOT:PSS in various proportions and resulted in a decrease in the acidity of PEDOT:PSS as well as reduced hysteresis in completed devices. Cu:PSS functioned effectively as a HTL in PSCs, with device parameters comparable to PEDOT:PSS, while mixtures of Cu:PSS with PEDOT:PSS showed greatly improved performance compared to PEDOT:PSS alone. Optimized devices incorporating Cu:PSS / PEDOT:PSS mixtures showed an improvement in efficiency from 14.35 to 19.44 % using a simple $MAPbI_3$ active layer in an inverted (P-I-N) geometry, which is one of the highest values yet reported for this type of device. We expect that this type of HTL can be employed to create p-type contacts and improve performance in other types of semiconducting devices as well.

Keywords:

perovskite solar cells, hole transport materials, p-type doping

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.03

Time-dependent Evolution of Structural and Optical Properties of Mechanochemically Synthesized Zero Dimensional Cesium Lead Bromide Perovskite

BAEK Kyeong Yoon [1], LEE Woocheol [1], LEE Jeongjae [2], KIM Jaeyoung [1], LIM Hyungbin [1], LEE Jonghoon [1], AHN Heebeom [1], KIM Junwoo [1], KANG Keehoon [1], LEE Takhee [*1]
[1]Department of Physics and Astronomy, Seoul National University
[2]School of Earth and Environmental Sciences, Seoul National University
tlee@snu.ac.kr

Abstract:

Over the past decade, lead halide perovskites (LHPs) have gained significant interest due to their attractive optoelectronic properties with photoconversion efficiency (PCE) exhibiting ca. 22% in perovskite solar-cell (PSC) technologies [1]. Generally, solvent-based synthesis has been utilized as a synthetic method of LHPs. Recently, mechanochemical synthesis (MCS) has emerged as an appealing alternative due to many distinctive advantages such as its solvent-free nature of the process. MCS enables a well-controlled environment where intermediate phases can be analyzed [2]. In this study, we investigated the time-dependent behavior in the synthesis of Cs_4PbBr_6 (referred to as
“0D perovskite”) by ball milling of stoichiometric precursor mixtures. During the synthesis process, we could identify the coexisting two additional phases: $CsPb_2Br_5$ and $CsPbBr_3$, referred to as 2D and 3D phases, respectively, and derived the weight fraction of each phase from Rietveld refinement and NMR analysis. In addition, the peak photoluminescence (PL) intensity centered at 523 nm was observed to vary depending on the duration time of the synthesis and reached the maximum at around 3 hours of ball milling. The phase fraction analysis of the 0D powders with the maximum PL intensity indicates the presence of a finite amount of 3D phase, which agrees well with previous reports that proposed $CsPbBr_3$ nanocrystals embedded in solution-synthesized Cs_4PbBr_6 microcrystals as the origin of a highly efficient green light with a PLQY of 90% [3]. Furthermore, through its facile tunability between 3D and 0D phases, we propose a method to efficiently encapsulating 3D particles in a stable 0D host matrix which is by initiating a process from 3D and CsBr powders. Our results provide a controllable synthetic methodology for acquiring 0D Cs-based perovskites with an efficient green emission through MCS and paves way for developing high performance perovskite light emitting devices in the future.

References

[1] W. S. Yang et al., Science, 348, 1234 (2015).
[2] F. Palazon et al., Adv. Energy Mater. 10, 1902499 (2020).
[3] L. N. Quan et al., Adv. Mater. 29, 1605945 (2017).

Keywords:

Ball milling, Mechanochemical Synthesis, Time-dependence, Cesium Lead Bromide Perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.04

Impact of sodium lignosulfonate interlayer in perovskite and organic solar cells

SHIN Woojin [1,2], KIM Wonsik [1,2], CHOI Seungsun [1,2], JUNG Sehyun [1], OH Hyesung [1], KO Moonseock [1], LEE Hyun Bok *[1,2]
[1]Department of Physics, Kangwon National University
[2]Institute for Accelerator Science, Kangwon National University
hyunbok@kangwon.ac.kr

Abstract:

In solar cell devices, an efficient energy-level alignment at the semiconductor/electrode interface is very important for the enhancement in their power conversion efficiency. An energy offset between the Fermi-level of a cathode and the conduction band maximum of a semiconductor can be reduced by an insertion of a proper interlayer. For example, sodium lignosulfonate (SLS) contains SO_3^-, and Na^+ ions. These form an interface dipole decreasing the work function of the cathode surface. Morever, the SLS does not require complex chemical synthesis because it is a byproduct in the extraction process of pulp from wood. However, the electronic properties of the SLS and its application in solar cells have not been investigated well.

In this study, we fabricated perovskite and organic solar cells using the SLS interlayer. In both case, the SLS layer was inserted between the phenyl-C_{61}-butyric acid methyl ester (PCBM) layer and the indium tin oxide (ITO) cathode. The thickness of the SLS layer was controlled by changing the solution concentration. To understand the role of the SLS in solar cells, the electronic structure of the SLS on ITO was measured using X-ray and ultraviolet photoelectron spectroscopy. Through these results, we revealed that the SLS can be an efficient cathode modifier.

Keywords:

sodium lignosulfonate, perovskite solar cells, organic solar cells, cathode interlayer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.05

Layer-specific, in situ Analysis of OLED for Unraveling the Degradation Mechanism

손정배 [1], 강주연 [1], 배소현 [1], 민경석 [2], 양기영 [3], 한종석 [3], 이창희 [3], 김성근*[1,2]
[1] 서울대학교 화학부
[2] 서울대학교 생물물리 및 화학생물학과
[3] 서울대학교 전기·정보공학부
seongkim@snu.ac.kr

Abstract:

Despite the importance of unraveling the degradation mechanism of the organic light-emitting diodes (OLEDs) and each layer's role played in degradation, little is known to date. Since the typical OLED device has a multilayer structure, it is crucial to know what happens in each layer under device operation photophysically and photochemically in order to identify the culprit and improve OLED performance. We here present a new, non-destructive method that allows layer-specific, *in situ* analysis of OLED device, which enables to track photophysical and photochemical changes virtually independently in each layer. We found two types of degradation mechanism and each layer's different degradation features and its relative importance to OLED emission intensity drop. These results raise the prospect of understanding the ultimate cause of degradation by noninvasively tracking the whole layers during actual operation. In addition, the method we developed here can be readily adopted in other studies as a powerful diagnostic tool for improving device characteristics.

Keywords:

OLED, degradation mechanism, layer-specific spectroscopic analysis, luminescence quenching, material bleaching

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.06

Polarized-Raman scattering study of crystal structure in methylammonium lead halide chloride single crystals $CH_3NH_3PbCl_3$

YOON Seokhyun *[1], KIM Yejin [1], PARK Joohee [1], JUNG Hyeri [1], JO William [1], BAE Soungmin [2], RAEBIGER Hannes [2], NGUYEN Trang Thi Thu[3]
[1]Department of Physics, Ewha Womans University
[2]Department of Physics, Yokohama National Univeristy
[3]Department of Physics, Danang University of Science and Technology
syoon@ewha.ac.kr

Abstract:

Over the years, many studies on photovoltaic absorber materials have been conducted to improve the efficiency of photovoltaic devices. However, there are many challenging issues to overcome for the solar cell materials research ensuring longer lifetime of the cell and better chemical stability for practical application, for example. In particular, for hybrid organic perovskites (HOPs), the role and characteristics of organic cations are yet unclear. In this study, we focus on understanding the fundamental structural properties of $CH_3NH_3PbCl_3$.. $CH_3NH_3PbCl_3$ has a structure in which $PbCl_6$ forms a skeleton and a MA (methyl ammonium) ion in it has degrees of freedom at room temperature. As the temperature decreases, hydrogen bonds between the MA ion and Cl make the lattice parameters of the outer shell change, resulting in structural phase transition and MA ion orientation in a specific direction. Cages undergoing these phase transitions are highly influenced by MA ions, so understanding the specific orientation of MA ions is important in structural studies. We experimentally show by using polarized-Raman scattering measurements that MA ion is oriented in a specific direction, and propose an approximate direction with calculations using Raman tensor.

Keywords:

Perovskite, HOPs, Crystal structure, CH3NH3PbCl3, Polarized Raman

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.07

Analyze of optical property of Photonic Glass with high refractive index sphere particle

IM Eunji [1], LEE Seungwoo *[1,2,3,4]
[1]Department of Biomicrosystem Technology, Korea University
[2]KU-KIST Graduate School of Converging Science and Technology, Korea University
[3]Graduate School of Converging Sci & Tech & Dept. of Integrative Energy Engineering, Korea University
[4]KU Photonics Center, Korea University
seungwoo@korea.ac.kr

Abstract:

구조색에 대한 연구가 수십년간 진행되었지만, 여전히 흡수 기반의 안료들이 우리의 주변에서 주로 사용되고 있다. 흡수 기반의 안료들은 유독한 성분이 대부분이며, 태양빛이나 높은 열에 의해서 쉽게 변하는 단점이 있다. 이에 대한 대체제로 최근 구조색(Structural Color)을 실용적으로 바꾸려는 노력들이 활발하다. 구조색에는 흔히 일정한 간격으로 배열된 구조를 가지는 광결정(PhC, Photonic Crystal)과 무질서한 구조를 갖는 광유리(PhG, Photonic Glass)로 나뉜다. 광결정은 각도에 따라 다른 색을 보이는 반면, 광유리는 모든 각도에 무관하게 동일한 색을 보인다. 이런 점 때문에 실제 물체에 색을 표현하기에는 광유리가 더 적합하다.

본 연구에서는 광유리의 반사 스펙트럼을 구조 인자(Structure factor)와 형태 인자(Form factor)로 나누어서 분석한다. 또한, 굴절률에 따른 광유리의 색 변화를 실험적으로 구현해보고자 한다. 구조 인자는 광유리를 이루는 입자의 위치에 의해 정해지며, 형태 인자는 입자의 굴절률에 의해 크게 영향을 받는다. 이를 이용한 광유리의 반사 스펙트럼 조절을 위해, 본 연구에서는 이산화규소(SiO_2) 구 입자와 셀레늄(Se) 구 입자를 사용하고자 한다. 이산화규소와 셀레늄은 가시광선 영역에서 굴절률이 2 배 정도 차이가 난다. 광유리의 부피비가 50%로 동일할 때, 동일한 지름(240nm)의 이산화규소 구입자와 셀레늄 구입자로 이루어진 광유리의 산란세기는 다른 스펙트럼을 보인다. 이산화규소로 이루어진 광유리는 구조 인자에 의한 영향이 큰 반면, 셀레늄으로 이루어진 광유리는 형태 인자에 의한 영향이 복합적으로 나타난다. 이를 이용한다면, 광유리의 반사 스펙트럼 조절이 용이할 것으로 기대된다.

Keywords:

Photonic Glass

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.08

Topological interface states between trivial and nontrivial two-dimensional Su-Schrieffer-Heeger circuits

KIM Yung [1], PARK Jagang [1], KYUNG Minwook [1], LEE Kyungmin [1], MIN Bumki [*1]
[1]KAIST
bmin@kaist.ac.kr

Abstract:

A topological interface state, existing between two different topological phases of matters, has been extensively investigated with comprehensive theoretical models to explore exotic topological phenomena. Among those, the Su-Schrieffer-Heeger (SSH) model is one of the simplest model to describe topological behaviors in quantum and classical systems. In the classical domain, various kinds of topoelectric circuits have been proposed as a simple platform for the observation of topological phenomena and turned out to be very powerful owing to their utmost simplicity and adjustability. Here we investigate the topological interface states between trivial and nontrivial two-dimensional SSH circuits with strong or weak bonding interfaces. By using the circuit grounded Laplacian formalism, topological interface states are identified within the bandgap of admittance band structures and the spatial localization of topological interface modes is clearly revealed by numerical calculations. We also show that different interface connectivity leads to distinct spatial and spectral behaviors of associated topological interface modes.

Keywords:

topological interface states, topological circuit, SSH model, edge states

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G11.09

High quality factor toroidal metasurfaces for enhanced light-matter interactions

JEONG Jeeyoon *[1]
[1]Department of Physics, Kangwon National University
peterjjy@kangwon.ac.kr

Abstract:

In this work we report dielectric metasurfaces with high quality factor toroidal resonances and their applications in enhancing light-matter interactions. Arrays of dielectric cuboids support toroidal resonances in visible and infrared wavelengths, depending on type of the dielectric and size of the cuboids. Observed Q-factors reach 728 at a wavelength of 1500 nm and 160 at 700 nm, when silicon and titanium oxide are used as the dielectric, respectively. With the metasurfaces we demonstrate (1) refractometric sensing of liquids with indices differing by 0.02, and (2) modulation of exciton recombination and annihilation in a two-dimensional transition metal dichalcogenide placed atop the metasurface. We expect the metasurface can provide an ideal platform for strong coupling of light and matter in low-dimensional materials such as quantum dots.

Keywords:

metasurface, toroidal resonance, sensing, Purcell effect

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G12.01

Two-dimensional electron gas and its applications to electronic devices using thin film oxide heterostructures grown by atomic layer deposition

LEE Sang Woon *[1]
[1]Ajou University
slee01@ajou.ac.kr

Abstract:

Two-dimensional electron gas (2DEG) at oxide heterostructures has gained interests owing to their unique physical/electrical properties. Electrons (10^{13}~10^{14}/cm^2) are confined in a few nanometer (out-of-plane direction) near the interface of oxide heterojunction while move freely along the in-plane direction. $LaAlO_3/SrTiO_3$ (LAO/STO) interface is a model system for 2DEG at the oxide heterostructure. LAO layer is grown epitaxially on single crystalline STO substrate using pulsed layer deposition. Unfortunately, the fabrication scheme to create 2DEG is not suitable for the practical use because of their high cost in the production of the oxide epitaxial layer and single crystal substrate.
In this presentation, we will show the creation and tailoring of 2DEG at the non-epitaxial interface of thin film heterostructure (<15 nm) using atomic layer deposition (ALD). High density electrons up to (10^{13}~10^{14}/cm^2) were confined at the interface of thin film heterostructure grown by ALD. The electrical properties of thin film heterostructure are comparable to those of the epitaxial LAO/STO heterostructures. With the 2DEG at thin film heterostructures, I will show their applications to electronic devices such as transistors and memories.

Keywords:

two-dimensional electron gas, atomic layer deposition

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G12.03

Design of Transition Metal Oxides for Neuromorphic Synaptic and Neuronal Devices

우지용*[1]
[1] 경북대학교 전자공학부
jiyong.woo@knu.ac.kr

Abstract:

Brain-inspired neuromorphic technology has been considered to demonstrate new computing systems that efficiently process explosively generated data. Since the data is transferred through synapses connected in parallel between neurons, computational performance can be dramatically improved. In order to implement the function in hardware, analog synaptic devices that store data need to be demonstrated using non-volatile memory with multilevel cell. Among the many candidates, the study of synaptic devices using resistive switching memory (RRAM) based on HfO_2 materials has shown significant progress from microscopic understanding to chip-level demonstration. However, the inherent drawbacks of the RRAM due to the random motion of oxygen ions may limit neuromorphic computing performance. Many attempts have been thus performed to utilize polarization as an alternative switching mechanism for uniform synaptic properties even in the same HfO_2 material. In this talk, how HfO_2 material has been designed for the analog synaptic device will be discussed first.
In addition to the synaptic element, the role of the neuron in determining signal activation needs to be emulated. Since the neurons only work when a certain amount of synaptic weights is accumulated, their properties can be demonstrated using volatile switch based on metal-insulator transition in Mott insulators. The voltage oscillation of NbO_2 based volatile switch depending on the input signal was exploited. It was further identified in the integrated neuromorphic system, where multiple HfO_2 RRAM synapses were connected to the single NbO_2 oscillation neuron.

Keywords:

Transition metal oxide, Neuromorphic device

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G14.01

고교학점제 기반 교육과정 논의와 과학교육

KWON Oh-Hyun *1
[1]Department of German Language Education, Seoul National University
kwonohyn@snu.ac.kr

Abstract:

본 발표는 2022 년 고시를 염두에 두고 개발 예정인 고교학점제 기반 교육과정의 주요 내용을 검토하고, 과학교육의 관점에서 새로운 교육과정을 구성하는 방향과 지향점을 제안한다. 주요 내용들은 ①학교교육의 변화 방향 ②학점제의 구성요소, ③고교 편제표 구성 방향 ④대입제도와 교육과정의 연계 등이다. 오늘날 학교는 표준화를 추구하기보다는 각자 자신에게 맞는 성장이 일어나게 하는 힘을 길러주는 것을 교육의 목적으로 여긴다. 따라서 고교학점제가 도입되면 과학교육도 학생들이 자기맞춤형 진로와 학업계획에 따라 원하는 과목을 공부할 수 있도록 수요 맞춤형 교육과정과 수업을 디자인하는 다양한 방안을 모색해야 한다. 본 발표문은 고교학점제의 큰 방향과 세부적 내용을 아우르며 향후 교육과정 설계에서 과학교과 개설 방안과 제반 문제의 해결책, 학생이 실제로 선택권을 발휘하도록 지원하는 제도, 이를 실현하는 데 보조를 맞추는 주변 환경(예, 대입제도) 등 복합적 요소들을 정리하여 제시함으로써 차기 과학교과 교육과정 설계에 조금이라도 일조할 수 있기를 기대한다.

Keywords:

고교학점제

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G14.02

새로운 시대의 물리학 인재 양성을 위한 교육과정 변화의 필요성

JHO Hunkoog *[1]
[1]Graduate school of education, Dankook University
hjho80@dankook.ac.kr

Abstract:

최근 교육부는 2022 년 교육과정 개정을 위한 여러 기초 연구를 수행하고 있다. 특히 과학에서도 고교학점제와 같은 새로운 제도의 변화 및 빅데이터, 인공지능, 로보틱스 등 첨단 과학기술에 대응하기 위한 과학교육에서의 대응에 대해 강조하고 있다. 이에 본 연구에서는 앞으로 일어나게 될 교육과정 개정의 변화에 대해 예상하고 우수한 물리학 인재 양성을 위해 고려해야 할 개선 방향 및 과제를 도출하고 논의하고자 한다.

Keywords:

과학 교육과정, 고교학점제, 물리 학습

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G14.03

고교학점제에 따른 물리교육의 현안과 과제

HONG Oksu *[1]
[1]Office of Science & Math Education Development, KOFAC
oksu@kofac.re.kr

Abstract:

2021 년 2 월, 교육부가 발표한 <고교학점제 종합 추진계획>은 "모든 학생의 성장을 돕는 포용적 고교교육 실현"을 비전으로 제시하면서 (1) 학점제형 교육제도 설계, (2) 학생 중심 학교 운영 지원, (3) 고교학점제 지원체제 구축을 주요과제로 선정하였다. 특히 "학점제형 교육과정 개정"과 관련하여 학생의 진로와 적성에 따른 맞춤형 교육과정을 구현하겠다는 계획과 함께 공통과목과 선택과목(일반선택, 융합선택, 진로선택)으로 구성된 과목구조 개편 방안을 제시하였다. 이는 현재 연구되고 있는 2022 개정 과학과 교육과정의 가이드라인이 될 예정이다. 본 발표에서는 고교학점제의 추진 현황과 2022 개정 과학과 교육과정 연구 현황을 전반적으로 살펴보고, 이를 토대로 물리교육의 현안과 과제를 논의하고자 한다.

Keywords:

고교학점제, 과학과 교육과정, 자기주도적 학습자, 물리교육

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G14.04

고등학교 현장에서의 고교학점제와 물리교육

CHOI Kyungmi *[1]
[1]Hyehwa girls' high school
kmchoi94@hanmail.net

Abstract:

본 발표는 2019 년도에 고교학점제 선도학교로 지정되어 3 년차 운영중이고, 2017 년도에 과학중점학교로 지정되어 5 년차 운영 중인 여자고등학교를 중심으로, 고교학점제 운영이 현장의 물리교육에 어떤 변화를 가져왔는지에 관하여 소개할 것이다. 또한, 이번 발표에서는 고교학점제를 3 년 차 이상으로 운영하는 고등학교로 남여공학, 남고, 여고별 고교학점제 도입이 물리교육에 어떤 영향을 미쳤는지와 학교별 고교학점제의 운영 방향에 따른 물리교육의 변화를 조사하여 발표할 것이다. 고교학점제 이전에는 물리라는 과목이 개설이 되지 않았던 여학교들이 있었으나, 고교학점제의 도입으로 물리 과목이 2, 3 학년에 개설할 수 있게 된 것은 다행한 일이다. 그러나, 해가 지나면서 고교학점제는 '진로에 맞는 과목 선택'에서 '수능 과목과 쉬운 과목 선택'으로 빠르게 변해가고, 이에 따라 학생들이 기피하는 물리 과목의 선택률은 처음보다 감소하였으며, 물리과목 선택의 감소와 함께 전체 이과 계열의 학생들이 감소하여 많은 학생들이 인문 계열과목을 선택하는 상황으로 바뀌어 가고 있다. 즉, 고교학점제의 취지는 교육적이나 학교의 현실은 학생들이 선택하는 수능과목을 제외하고는 어려운 과목 특히 이과 계열쪽의 과목은 진로와 관련 없이 선택률이 떨어지고, 이공계를 진로로 희망하는 학생들은 3 학년의 과목이 수능과목이 아닌 진로과목으로 교육과정이 편성되면서 학교 내신을 포기하는 학생들마저 증가하고 있다. 특히 정시를 준비하는 학생들은 더욱더 심해지고 있는 게 현실이다. 고교학점제를 도입하여 운영하되 입시와 학교의 현실이 반영된 교육과정이 필요하며 고등학교 교육이 수능과목과 쉬운 과목으로 전락해서는 안 되므로 이공계열의 진로를 희망하는 학생들에게 진로에 맞는 교육과정을 선택할 수 있도록 정책과 제도를 마련하여야 할 것이다.

Keywords:

고교학점제

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.01

Quantitative measurement of plasma radiation power during disruption in KSTAR

BAE Sehyun [1], LEE Min Uk [1], THATIPAMULA Shekar Goud[1], KIM Jayhyun [2], YUN GUNSU *[1]
[1]Department of Physics, POSTECH
[2]MHD Stability Research Team, Korea Institute of Fusion Energy
gunsu@postech.ac.kr

Abstract:

Plasma radiation power has been quantitatively measured during plasma disruptions in the KSTAR tokamak. We have performed 0-D and 2-D heat transfer simulations to estimate the radiation power from the infrared sensor bolometer (IRSB) signal in the shattered pellet injection (SPI) experiments. The analytic solutions of a 0-D heat transfer model in the linear response regime give practical ways of evaluating the plasma radiation power by measuring the cooling time scale of the IRSB signal. We have also constructed a prototype of a resistive-foil pulsed-current (RFPC) bolometer to improve the signal-to-noise ratio. The design and performance of the RFPC bolometer are presented based on 442 nm laser experiments.
*Work supported by the Korea Institute for Fusion Energy under the KSTAR research collaboration program and by the National Research Foundation of Korea under grant No. 2019M1A7A1A03088456.

Keywords:

plasma disruption, shattered pellet injection, plasma radiation power, infrared sensor bolometer, resistive-foil pulsed-current bolometer

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.02

KSTAR Ohmic Start-Up Runaway/Supra-Thermal Electrons 2020

LEE Yeongsun [1], NA Yong Su *[1], VRIES Peter De[2]
[1]Nuclear Engineering, Seoul National University
[2]Science Division, ITER Organization
ysna@snu.ac.kr

Abstract:

Korea Superconducting Tokamak Advanced Research (KSTAR) plasma ohmic start-up discharges that have signs of supra-thermal/runaway electrons have been studied. Operation window of KSTAR 2020 ohmic start-up (p~1.2 mPa, E~0.29 V/m) is near to that of International Thermonuclear Experimental Reactor (p~1 mPa, E~0.3 V/m). It implies that all ohmic start-up discharges in the 2020 campaign carry supra-thermal/runaway electrons. Hard X ray signals, which is one of the signs of their existence, suggest that all cases carry them until the end of the discharge. However, their intensity behaviors are different. In some cases, they are maintained during the discharge but in others, they are decreased during the current flattop phase. Moreover, 2020 ohmic start-up discharges are clearly categorized into 2 groups. Group A shows early increase in electron cyclotron emission temperature (ECE) and the high level of hard X ray intensity. Group B shows a delayed increase in ECE and the low level of hard X ray intensity. Both groups show slow building-up of hard X ray, which means that supra-thermal/runaway electrons collide with the poloidal limiter during wandering after their formation. There is a clear discrepancy between the two groups in the development of the plasma current in the early stage from 40 ms to 200 ms. It implies that an avoidance strategy should focus on this early stage. It is likely that the discrepancy comes from the amount of the primary generation that is dominant in the early stage. Shortening of this stage, at least understanding this stage, would be key to set up avoidance strategy. However, in this time window, plasma is not fully ionized, which requires to consider the ionization collision in the primary generation mechanism in order to understand more reliably.

Keywords:

KSTAR, Runaway Electrons, Supra-thermal Electrons, Start-Up, Ohmic Breakdown

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.03

산소 추가에 따른 저온 대기압 플라즈마의 특성 변화 및 표면처리 연구

BAE JINHEE [1], JOH HEAMIN *[1], CHUNG TAEHUN [1]
[1]physics, Dong-A University
hmjoh@dau.ac.kr

Abstract:

대기압 플라즈마는 저온에서 동작하고, 라디칼이 풍부하기 때문에 열에 민감한 재료의 표면 개질 및 생의학적 적용에 있어서 응용이 가능하다. 이에 저온 대기압 플라즈마를 유기 발광 다이오드나 태양 전지의 투명 전극 소재로 사용되는 인듐 주석 산화물(Indium Tin Oxide, ITO)에 조사하여 표면 처리 효과를 알아보고자 하였다.

50 kHz 에서 동작하는 저주파 플라즈마 발생장치를 사용하여 헬륨 플라즈마의 전기적, 광학적 특성을 알아본 후, 이를 ITO glass 에 적용시켰다. 특히, 헬륨 기체에 산소기체를 추가하여 산소 유입량(0~40 sccm)에 따른 플라즈마 상태를 확인하였고, 플라즈마 처리된 ITO 표면에서의 접촉각을 측정, 비교하였다. 3 L/min 의 헬륨 기체에 산소 기체 5 sccm 을 추가하였을 때 방전 전류가 가장 높게 측정되었고, 짧은 시간동안 ITO 에 처리하였을 때 접촉각의 크기가 차이를 보였다. 헬륨 기체에 소량의 산소 기체를 추가함으로써 표면의 친수성이 높아진 것을 확인할 수 있었다.

Keywords:

저온 대기압 플라즈마, 표면 개질, 친수성

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.04

Afterpeak mechanism and parametric dependence in terms of energy release timescale

YUN GUNSU *[1,2], JEONG Seokyong [1], NAM Woojin [1]
[1]Department of Physics, POSTECH
[2]Division of Advanced Nuclear Engineering, POSTECH
gunsu@postech.ac.kr

Abstract:

We performed a global model simulation on atmospheric pressure pulsed argon plasma to study the afterpeak phenomenon. The afterpeak is a sudden increase in the plasma emission during the inter-pulse time. This unintuitive phenomenon occurs through a series of energy transport processes after the pulse power turns off. At the pulse off, the electron temperature T_e drops rapidly while the electron density n_e is relatively unchanged. The plasma with low T_e and high n_e undergoes enhanced recombination reaction and reduced the ionization reaction, resulting in an increase of excited argon, i.e., afterpeak. In later stages, the afterpeak intensity follows the slow decrease of n_e because n_e is the bottle-neck for the recombination – n_e has the longest timescale among the plasma properties affecting the afterpeak. The time scale of n_e is determined by the diffusive loss, which is the dominant loss channel during the inter-pulse time. We simulated and analyzed the parametric dependence of the afterpeak on the operation conditions (power, plasma size, pressure) in the same framework, providing systematic principles on the optimization of pulsed plasma sources for applications such as mass spectroscopy and atomic layer etching. *This work is supported by the National Research Foundation of Korea under grant No. 2019R1A2C3011474, by the Korea Hydro and Nuclear Power corporation under the Haeorum research program, and the POSTECH-Samsung eduction program.

Keywords:

afterpeak, afterglow, pulsed plasma , atmospheric pressure plasma, plasma simulation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.05

Aggregation growth and morphology of icy dust grains formed in astrophysically-relevant laboratory experiment

CHAI Kil-Byoung *1
1 Nuclear Physic Engineering Research Division, KAERI
kbchai@kaeri.re.kr

Abstract:

Ice dust grains are frequently observed in many astrophysical objects such as molecular clouds, protoplanetary disks, planetary ring systems, and comets. These ice dust grains play an important role in the astrophysical objects such that they stick other dust grains together like a glue and help to form planetesimals. However, the growth and morphology of dust grains formed in actual astrophysical objects are not directly observable. Thus, a laboratory experiment is necessary to understand what is happening to these dust grains. To do so, we built tabletop experiments and studied astrophysically-relevant ice dust grains using the experiments [1-4]. In this work, we produced ice dust grains made of water, methanol and ethanol in a laboratory plasma experiment and we studied the growth mechanism and surface morphology of ice dust grains. We observed that both methanol and ethanol ice grains grow elongated and branchy similar to water ice grains formed in a plasma [1,2]. The experiment also reveals that methanol and ethanol ice grains grow faster, larger, and more branched than water ice grains. The observed growth features and the morphology can be explained well by the diffusion-limited aggregation [5]. We also observed that larger and more branched ice grains are formed when the ambient gas pressure is low or when the ambient gas is light, indicating the aggregation growth of small monomer grains is enhanced under these conditions [5].

[1] K.-B. Chai and P. M. Bellan, Geophys. Res. Lett. **40**, 6258 (2013).
[2] K.-B. Chai and P. B. Bellan, Astrophys. J. **802**, 112 (2015).
[3] R. S. Marshall, K.-B. Chai, and P. M. Bellan, Astrophys. J. **837**, 56 (2017)
[4] K.-B. Chai, IEEE Transaction Plasma Sci. **46**, 668 (2018).
[5] K.-B. Chai, Astrophys. J. **908**, 130 (2021).

Keywords:

dusty plasma, laboratory astrophysics, dust growth, interstellar dust, circumstellar dust

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G15.06

Mode transitions (ɣ-α) and hysteresis in microwave-driven low-temperature plasmas

KIM KyungTae [1], NAM WOOJIN [2], YUN GUNSU *[1,2]
[1]Division of advanced nuclear engineering, POSTECH
[2]Department of Physics, POSTECH
gunsu@postech.ac.kr

Abstract:

We found a hysteresis in microwave-driven low-temperature plasmas across the discharge mode transition (α-ɣ). For the same global operation parameters (pressure, power, gas composition), the discharge mode differs depending on the pressure change direction. This observation suggests that the plasma under the same operation parameters can have two different stable states. The experiment was conducted for argon plasmas generated by a cylindrical resonator electrode at 900 MHz with varying pressure. We have identified the pressure at which the discharge mode change occurs by observing two separate plasma properties related to the electron kinetics that depend on the neutral particle density and the electron temperature: the plasma volume and the ratio of two emission peaks from different excitation processes. We interpret that the hysteresis is caused by the difference in the electron temperature depending on the pressure change direction.
* Work supported by the BK21+ program of the National Research Foundation (NRF) and by the POSTECH-Samsung education program.

Keywords:

hysteresis, discharge mode, microwave, low-temperature plasma

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G16.01

Photonic variational quantum eigensolver for quantum computational chemistry applications

REHMAN Junaid Ur[1,3], LEE Donghwa [1,2], LEE Jinil [1,2], CHO Young-Wook [1], LIM Hyang-Tag [1,2], KIM Yong-Su *[1,2]
[1]Center for quantum information, KIST
[2]Division of Nano & IT Technology, UST
[3]Department of Electronics and Convergence Engineering, Kyung Hee University
yskim25@gmail.com

Abstract:

Quantum computing has attracted a lot of attention due to the potential applications in many area. Yet, it seems challenging to implement a fully working quantum computer near in the future. On the other hand, rapid development of noisy intermediate-scale quantum computers (NISQ) opens a new avenue to find practical applications using those imperfect devices with hands. Variational quantum eigensolver (VQE) is a typical example on this direction. In this talk, we propose the implementation of a VQE using a photonic ququart. We use the VQE to estimate the ground state energy of $He-H^+$ cation. We also present a simple but powerful quantum error mitigation to obtain the ground state energy to the chemical accuracy.

Keywords:

Quantum computer, Variational quantum eigensolver, Quantum computational chemistry, Photonic qubits

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G16.02

Anti-PT symmetry in effective band structure of photonic Floquet media

PARK Jagang [1], CHO Hyukjoon [1], LEE Seojoo [1], LEE Kyungmin [1], LEE Kanghee [1], MIN Bumki *[1]
[1]KAIST
bmin@kaist.ac.kr

Abstract:

Space-time periodic driving of photonic media is now considered to be the most generalized way of engineering photonic band structures. Broken time-reversal and/or continuous time-translational symmetry in the Floquet media allow observation of exotic wave dynamics that are forbidden in ordinary linear time-invariant media, such as nonreciprocal transmission, frequency conversion and driving-induced topological edge states. One of the most intriguing features in the band structure of a Floquet medium is the momentum gap, which opens due to the driving-induced interaction between a positive frequency band and a negative one. Here, we analyze the momentum gaps of Floquet media in the context of non-Hermitian physics, and experimentally verify their existence at microwave frequencies. The effective Floquet Hamiltonian is found to be anti-parity-time (PT) symmetric, and the consecutive PT phase transitions define the momentum gap in the band structure. A generalized dispersion relation defined in the complex wavenumber domain is utilized for the interpretation of the momentum gap opening in the experiments. We also show that parametric oscillation can be achieved when the coherent energy injection from the external driving compensates the total loss of the system.

Keywords:

anti-parity-time symmetry, non-Hermitian, time-varying, Floquet media, parametric oscillation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G16.03

Shannon entropy around an exceptional point in an open microcavity

AN Kyungwon *[1], PARK Kyu-Won [1], KIM Jinuk [1], MOON Songky [1]
[1]Department of Physics and Astronomy, Seoul National University
kwan@phya.snu.ac.kr

Abstract:

We study the exceptional point (EP) in the frame work of information theory by using Shannon entropy. The Shannon entropy as a measure of information contents is investigated in an open elliptical microcavity as a non-Hermitian system. The Shannon entropy is maximized near the EP in the parameter space for two interacting modes, but the exact maximum position is slightly off the EP toward the weak interaction region while the slopes of the Shannon entropies diverge at the EP. This feature can be utilized in sensors for external perturbations.

Keywords:

Non-Hermitian, Exceptional point, Shannon entropy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G16.04

칩 스케일 세슘 증기 셀에서 광자-쌍 생성

KIM HeeWoo [1], PARK JiHo [1], HONG Hyun Gue [2], KWON Taeg Yong [2], MOON Han Seb [*1]
[1]Pusan National University
[2]Time and Frequency Group, KRISS
hsmoon@pusan.ac.kr

Abstract:

양자광학 실험을 위한 첫번째 단계는 적합한 광원을 갖는 것이고 실험의 목적에 따라 다양한 방법으로 만들어진 광원을 사용한다. 선폭이 좁고 얽힘을 가지는 단일-광자 광원을 만드는 대표적인 방법으로는 증기셀에서 SpFWM(Spontaneous Four Wave Mixing)과정을 통하여 얻는 방법이 있다 [1-2]. 하지만 광원을 만들기위해 사용되는 기존의 원자 증기셀을 비롯한 광학장비들의 부피가 커서 다른 실험과의 연계를 위한 접근성, 공간적인 설계에 제약이 존재한다는 문제가 있다.
본 연구에서는 마이크로 세슘 증기 셀과 기존에 사용되던 세슘 증기셀의 광학적 특성과장.단점을 비교하였으며, 마이크로 세슘 증기 셀에서 SpFWM 과정을 통하여 생성된 광자-쌍을 측정하였다. 광자 생성에 사용된 레이저들의 출력, 주파수 및 셀의 온도를 변화시키며 광자-쌍의 이차간섭성함수($g^{(2)}$), Heralding efficiency 등의 특성 변화를 확인하였고, 마이크로 셀이 기존의 셀을 대체하여 선폭이 좁고 소형화가능한 단일-광자 광원을 만들 수 있다는 가능성을 확인하였다.

References :
[1] J. Park, H. Kim, and H. S. Moon, “Polarization-entangled photons from a warm atomic ensemble using a Sagnac interferometer,” Phys. Rev. Lett. 122, 143601 (2019).
[2] J. Park, H. Kim, and H. S. Moon, “Entanglement Sweeping with Polarization-Entangled Photon-Pairs from Warm Atomic Ensemble,” Optics Letters 45(8), 2403-2406 (2020).

Keywords:

사광파조합(FWM,Four-wave mixing), 편광 양자얽힘, 원자결맞음, 양자광원

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G16.05

A broadband solid-immersion-lens planar-microcavity quantum-dot single-photon emitter

AHN Daehyun [2], JANG Yudong [3], BAEK Jongseo [2], SCHNEIDER Christian [4], HöFLING Sven [5], LEE Donghan [*1,2,3]
[1]Chungnam National University
[2]Department of Physics, Chungnam National University
[3]Institute of Quantum Systems, Chungnam National University
[4]Institute of Physics, University of Oldenburg
[5]Technische Physik, Universität Würzburg
dleee@cnu.ac.kr

Abstract:

평면 마이크로공진기 구조는 단일양자점의 발광패턴을 개선하여 양자점의 집광효율을 높일 수 있어 단일광자광원과 양자점 연구에 많이 사용되어왔다. 하지만 공진파장폭이 작은 특성 때문에 양자얽힘쌍 광원이나 양자점의 엑시톤 에너지 완화 특성을 연구하는 데에 한계가 있다. 본 연구에서는 평면 마이크로 공진기 양자점 구조의 양자점에 이광자흡수 방법으로 Solid immersion lens(SIL)를 정확하게 제작해서 공진파장폭을 두배 이상 넓혔다. FDTD (Finite-difference time-domain method) 시뮬레이션으로 계산한 결과, 공진파장폭이 27 nm 까지 늘어나고 23%의 단일광자 집광효율을 갖는 것을 확인했다. 제작한 평면 마이크로공진기 양자점 단광자광원은 양자점의 다양한 여기상태 연구와 양자얽힘쌍 광원 연구에 사용할 수 있다.

Keywords:

quantum dot, single photon, entangled photon, microcavity, solid immersion lens

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G18.01

III-V 족 화합물반도체 기반 센서 기술

박경호*[1]
[1] 한국나노기술원 소자기술개발본부
kyungho.park@kanc.re.kr

Abstract:

질화갈륨(GaN), 갈륨비소(GaAs)와 같은 III-V 족 화합물반도체는 실리콘 소재가 갖지 못하는 우수한 물성 (넓은 밴드갭, 높은 전자이동도 등) 으로 인하여 5G 통신, 전력 소자, 자동차 레이더, 우주, 방위산업, 산업용 센서 등으로 응용 분야를 확대하고 있으며, 이에 따른 시장 수요 증가 및 산업적, 사회적 파급 효과가 증대하고 있다. 이들 중 표면 흡착물의 전하변화에 따라 매우 민감하게 반응하는 AlGaN/GaN HEMT (High Electron Mobility Transistor) 구조는 가스, 바이오와 같은 화학센서에 그 사용 용도를 넓혀가고 있으며, 높은 전자이동도를 갖는 갈륨비소 또는 인듐비소(InAs) 등은 고감도 자기 홀 센서에 활용 되고 있다.

본 세션발표에서는 III-V 족 기반 화합물반도체를 이용한 센서의 동작 원리, 제작 방법 및 연구현황 등을 소개하고 그 응용 분야에 대하여 논의하고자 한다.

Keywords:

III-V 족

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G18.02

Light Emitting Materials for Post-OLED Technology

CHANG Kiseok *[1]
[1]LG Display, LG Science Park
kschang@lgdisplay.com

Abstract:

Since the first 55” full high-definition OLED TV fabricated on Gen 8.5 Glass was successfully launched into the TV market at 2014, the OLED technology has been continuously developed to offer a new value to consumers. Transparent display and ultrahigh-definition display are already commercialized and a rollable TV is facing to commercialization within a step. In order to keep creating the new value, utmost image quality as well as diverse form factors is a critical issue in display performance. In this talk, we introduce the current technology of OLED display and the next challenges to realize the utmost image in a light emitting material point of view, and discuss its requirements and prospective to achieve ultimate color gamut.

Keywords:

Light emitting materials, OLED, Display, Color Gamut

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G18.03

Understanding the optoelectronic properties of metal halide perovskite single crystals

LIM Jongchul *[1], LEE Won Jong [1]
[1]Graduate School of Energy Science and Technology (GEST), Chungnam National University
jclim@cnu.ac.kr

Abstract:

Many different characterisation methods have been employed for assessing the optoelectronic properties of metal halide perovskites. For metal halide perovskites, a broad range of charge carrier mobilities have been estimated via different techniques. Using transient methods, mobilities are often estimated assuming an initial charge carrier population following an optical excitation pulse, and simultaneously measuring the photo-conductivity via either non-contact or contact methods. However, for nanosecond to millisecond transient methods, an accurate determination of the carrier mobility is hindered by both early-time recombination, often during the photo-excitation pulse, and the branching ratio of excitons to free-carriers. Here we demonstrate how these effects can be accounted for in order to reliably estimate charge carrier mobilities over a broad range of photo-excitation densities. We determine the optoelectronic properties of metal halide perovskite single crystals via various photophysical methods.

Keywords:

perovskite

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G18.04

Characteristics and Applications of Graphene by Nitrogen Atoms Doped with Various Structures

KIM Keun Soo *[1]
[1]Department of Physics & Graphene Research Institute, Sejong University
kskim2676@sejong.ac.kr

Abstract:

Controlling the properties of graphene is very important and attractive issue in graphene research. As we know the graphene get from natural graphite or artificially synthesized it and the latter case is easier than former which is manipulating the properties of graphene, relatively.

Based on this motivation, we have investigated the synthesis conditions of pristine and doped graphene using chemical vapor deposition (CVD)[1, 2] method with various organic precursors, such as methane(CH_4), liquid petroleum(LPG)[3], pyridine(C_5H_5N)[4, 5], and so on.

For the synthesis of high-quality graphene, the growth condition has optimized by controlling the CVD parameters. As a result, we have successfully grown the graphene and doped graphene under very short growth time. Rapid chemical vapor deposition was attempted using a liquid carbon precursor, and 1 minute is enough for graphene synthesis at 900 °C. It has shown 10 times faster than typical growth condition using CVD with methane (CH_4), previously.

To realize the mass-production, we designed an advanced chemical vapor deposition system capable of producing 12 graphene sheets per 1 hour. The optimal recipe was applied to the developed CVD equipment to synthesize 12 sheets of pure and N-doped large-area graphene sheets per 1 hour (including heating / synthesis / cooling; total 3 hours).

In Raman spectra, 2D/G ratio and D/G ratio of samples have shown significantly different results according to supplying sources. Especially, in the case of N-doped graphene grown by pyridine source, D-peak intensity is increased, G-peak is blue shifted and 2D-peak intensity is suppressed.

In x-ray photoelectron spectra, our pristine graphene has shown clear C1s-peak, and N-doped graphene has shown asymmetric broad C1s-peak from C-N bond and N1s-peak from graphitic-N bond, dominantly.

In addition, according to electrical characterizations, positions of Dirac point have shown neutral (methane ; V_D=~5V, LPG + H_2 ; V_D=~0V), p-type (alcohol ; V_D=~55V) and n-type (LPG only ; V_D=~-22V, pyridine ; V_D=~-95V) behaviors depend on the organic precursors.

Finally, we have fabricate, measure and analyze some applications such as field effect transistors and gas sensors using these kinds of graphene samples to evaluate their potentiality.
More details will be provided in the presentation.

Keywords:

N-doped Graphene, CVD, Synthesis, Characterization, Application

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.01

Unbiased and Enhanced Photoelectrochemical water splitting performance of Au-NPs decorated gallium nitride Nanowires photoanode

ABDULLAH Ameer [1], WASEEM Aadil [1], RYU Sang Wan [*1]
[1]Department of Physics, Chonnam National University
sangwan@chonnam.ac.kr

Abstract:

Photoelectrochemical (PEC) water splitting is a promising approach for conversion of ample solar energy into chemical energy. Still, it needs a lot of effort to approach commercial scale production. A key issue in PEC water splitting is the evolution of photoelectrodes, which needs to be optically efficient and chemically stable. Coupling of noble metal nanoparticles with semiconductors is a promising approach to boost up the PEC water splitting efficiency of photoelectrodes. Here, we reported a facile fabrication method for photoanodes by depositing gold nanoparticles (Au NPs) on GaN nanowires (GNG). An electron microscopy confirmed the growth of GNG and formation of Au NPs. The Au NPs/GNG composite photoanode has shown 55% improvement in photocurrent density compared to pristine GNG, at zero bias. The photoconversion efficiency of Au NPs/GNG composite photoanode is achieved 2.56 times with respect to pristine GNG at 0V versus Ag/AgCl. The IPCE improvement in ultraviolet region is 41% and in visible region about 22%. The stability of Au NPs/GNG composite photoanode is also improved. These significant improvements in efficiency and stability of Au NPs/GNG composite photoanodes are associated with light harvesting and trapping of hot electrons from Au NPs at GNG photoelectrode.

Keywords:

Photoelectrochemical, water splitting, Au NPs, GaN, photoanode

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.02

Spin orbit coupling induced high thermoelectric performance in two dimensional chalcogenides systems: GaSe and GaTe

MARFOUA Brahim [1], HONG Ji Sang [*1]
[1]Physics, Pukyong National University
hongj@pknu.ac.kr

Abstract:

Since the energy conversion from heat to electricity is considered as a promising renewable and sustainable source, the study on the thermoelectric effect is attracting extensive research interest. Among the group-III chalcogenides, the two-dimensional (2D) GaSe and GaTe materials have been synthesized[1-4], but recent theoretical studies have raised controversial results regarding their thermoelectric (TE) properties[5, 6]. Hereby, we have systematically investigated the temperature and carrier concentration dependent TE properties of 2D GaSe and GaTe. We have found that the GaSe has an indirect band gap of 2.94 eV while the GaTe has an indirect band gap of 1.88 eV. Both materials have almost the same Seebeck coefficients and show non-directional dependence. The hole doped GaTe monolayer showed the largest electrical conductivity and electron thermal conductivity. Finally, we found that the GaTe exhibited the highest thermoelectric performance and ZT ~ 0.91 with non-significant carrier concentration and temperature dependence (300K~700K) in the hole doped system. Unlike the previous TE investigations, here we estimated the carrier relaxation in the ZT calculation. We have also investigated the SOC and exchange correlation functional dependency of the TE properties. Mainly we found that the carrier relaxation time and SOC effect may have a crucial role in the determination of the ZT performance. Our findings may provoke further experimental verification.

Keywords:

thermoelectric, 2D GaSe, 2D GaTe

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.03

GaN/Al_2O_3 Core-shell Nanowire based Flexible and Stable Piezoelectric Energy Harvester

WASEEM Aadil [1], RYU Sang Wan *[1]
[1]Department of Physics, Chonnam National University
sangwan@chonnam.ac.kr

Abstract:

Flexible and stable piezoelectric energy harvesters (PEHs) are fabricated based on polydimethylsiloxane-embedded m-axis gallium nitride/aluminium oxide (GaN/Al_2O_3) core-shell nanowires (NWs) transferred to indium (In)-deposited flexible polyethylene terephthalate substrates. The piezoelectric performance was optimized by controlling the Al_2O_3 shell thickness on GaN NWs. The huge barrier height of Al_2O_3 suppresses the junction current screening effect, and the remnant piezopotential in the GaN region at the $GaN-Al_2O_3$ interface modulates the transportation of carriers. Because of the significant suppression of the junction current screening and reduction in the leakage current, the PEHs could effectively harvest mechanical energy, even from static strain. The PEH based on core-shell NWs with a controlled Al_2O_3 thickness of 6 nm exhibited the maximum piezoelectric performance. Reduced piezoelectric performance was observed by increasing and decreasing the thickness of the Al_2O_3 shell from 6 nm. For higher thickness, the performance was reduced because of the significant voltage drop across the $GaN-Al_2O_3$ interface. However, for lower thickness the performance was reduced due to the direct tunnelling of the current from the $GaN-Al_2O_3$ interface. The optimized PEH also worked as an energy supplier to demonstrate the light emitting diode operation.

Keywords:

GaN, piezoelectric, energy harvester, nanowire

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.04

슈퍼커패시터 응용을 위해 전기화학적 성능 개선된 구리망간산화물 나노입자 연구

KRISHNA B. N. Vamsi [2], YU Jae Su *[1,2]
[1]Department of Electronic Engineering, Kyung Hee University
[2]Department of Electronics and Information Convergence Engineering, Kyung Hee University
jsyu@khu.ac.kr

Abstract:

다공성 특성을 가진 다양한 마이크로/나노 구조 재료를 설계하는 것은 에너지 저장 분야에서 인상적인 전기화학적 특성을 허용하는 중요한 관심사이다. 본 발표에서는, 우리는 손쉬운 실리콘 오일 배스 (oil-bath) 방법으로 제작된 흑연탄소질화물 시트에 의해 지지되는 구리망간산화물 나노입자에 대해 연구하였다. 또한 구리망간산화물-흑연탄소질화물 물질의 형성은 X-선 회절법, 전자주사현미경 및 투과전자현미경에 의해 분석되었다. 또한, 합성된 구리망간산화물-흑연탄소질화물 전극 재료의 전기화학적 특성이 측정되었다. 구리망간산화물 나노입자는 흑연탄소질화물 시트기반 전극과 결합되어 구리망간산화물 나노입자만에 비해 비용량이 향상되었다. 합성된 물질을 전극으로 사용하여 파우치형 비대칭 슈퍼커패시터소자가 제작되었고, 향상된 속도 성능, 에너지 밀도 및 전력 밀도는 물론 매우 안정적인 사이클링 성능을 보여주었다. 따라서, 얻어진 결과는 구리망간산화물-흑연탄소질화물 기반 전극 재료가 에너지 저장 분야에서 우수한 특성을 가지고 있음을 강력히 시사한다.

Keywords:

구리망간산화물, 슈퍼커패시터, 전기화학적 특성

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.05

GaP photoanodes coated with nickel oxyhydroxide cocatalyst for stable photoelectrochemical water splitting reactions

BAGAL Indrajit V.[1], ARUNACHALAM Maheswari [2], KANG Soon Hyung [2], RYU Sang Wan [*1]
[1]Department of Physics, Chonnam National University
[2]Department of Chemistry Education, Chonnam National University
sangwan@chonnam.ac.kr

Abstract:

GaP is a promising material for photoelectrochemical (PEC) water splitting due to its appropriate bandgap and straddling band alignment with the water redox level. However, it suffers from poor charge transport and sluggish reaction kinetics. To mitigate these limitations and improve the PEC water splitting efficiency, simple photodeposition followed by electrodeposition of nickel oxyhydroxide (NiOOH) as a cocatalyst on GaP was carried out. As a result, the NiOOH-deposited GaP photoanodes exhibit much-improved PEC water splitting performance compared to that of a bare GaP photoanode. The optimally deposited NiOOH cocatalyst on GaP enhanced the PEC activity of the photoanode with a photocurrent density of 1.15 mA/cm^2, giving rise to a 10-fold enhancement compared to that of bare GaP (0.114 mA/cm^2. The best photoanode showed a 1.38 % photoconversion efficiency at 0 V vs Ag/AgCl, which was 10 times higher than that of the bare GaP photoanodes (0.142 %). Furthermore, all the NiOOH-deposited GaP photoanodes manifested long-term stability over 40000 s under one-sun illumination. The enhancement is attributed to the reduced onset potential and enhanced reaction kinetics by efficiently transporting the photogenerated holes and preventing the corrosion of GaP surface upon deposition of NiOOH cocatalyst.

Keywords:

GaP, NiOOH, photoelectrochemical, water splitting

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.06

고성능 슈퍼커패시터용 배터리형 전극 소재로 금속 인산염기반 복합물질 합성

BHIMANABOINA Ramulu [2], S. Chandra Sekhar [1], S. Junide Arbaz [1], YU Jae Su *[1,2]
[1]Department of Electronic Engineering, Kyung Hee University
[2]Department of Electronics and Information Convergence Engineering, Kyung Hee University
jsyu@khu.ac.kr

Abstract:

최근 연구 커뮤니티는 증가하는 에너지 요구 사항으로 인해 녹색 에너지저장 시스템의 발전에 초점을 맞추고 있다. 이중 슈퍼 커패시터 는 빠른 충방 전성, 장수명, 고전력 밀도, 친환경 성 등이 두드러진 특성으로 인해 신재생 에너지 저장 장치로 많은 관심을 받고 있다. 현재 $NiMoO_4$, NiCoP, Ni $(OH)_2$, Co_3O_4 등은 전지형 전극 소재로 널리 연구되고 있으며, 더 높은 산화 환원 반응과 원소의 다가 상태 로 인해 기존의 슈퍼커패시터 소재보다 상대적으로 큰 비용량/용량 및 에너지 밀도를 제공할 수 있다. 단독 또는 이원에 비해 삼원 금속 산화물은 산화 환원 화학 및 전자 전도도가 증가하여 우수한 에너지 저장 성능을 보여준다. 더욱이, 금속 인산염은 화학적 안정성, 저렴한 비용 및 향상된 전기 화학적 특성으로 인해 효과적인 전극 재료이다. 본 발표에서는 금속 인산염 복합체와 통합된 바인더가 없는 삼원 금속 산화물은 손쉬운 수열합성법 공정을 통해 합성되었다. 합성된 합성물은 금속 산화물/인산염에 비해 지배적인 산화 환원 화학과 더 높은 용량을 나타냈다. 얻어진 전기 화학적 특성에 기초하여 금속 산화물/인산염의 조합은 슈퍼커패시터의 잠재적인 전극 역할을 할 수 있다.

Keywords:

슈퍼커패시터, 배터리형 전극 소재, 전기화학적 특성

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G19.07

Phase boundary engineering for active hydrogen evolution reaction at large-scale $MoTe_2$

YANG Heejun [*1], LEE Yongjoon [2], LING Ning [2], KIM Dohyun [2], ZHAO Mali [2], ESHETE Yonas Assefa[2], KIM Eunah [2], CHO Suyeon [3]
[1]Department of Physics, KAIST
[2]Department of energy science, Sungkyunkwan University
[3]Department of chemical engineering & material science, Ewha Womans University
h.yang@kaist.ac.kr

Abstract:

Material structure engineering is a promising way for catalysts. Beyond conventional microscopic structures, polymorphism in transition metal dichalcogenides (TMDs) provide a new category of active sites, phase boundaries. In particular, sctructural phase in molybdenium based layered TMDs have shown enhanced hydrogen evolution reaction (HER) performances compared with platinum-based catalysts. While theoretical studies have revealed atomically-resolved active sites for HER with certain TMDs, electrochemical measurements have been done so far with macroscopic devices containing phase boundaries, limiting the rigorous study of the role of local heterophase interfaces for HER. Here, we report local HER study of activated basal plane via phase boundary in CVD grown $MoTe_2$. Local activity of HER near phase boundaries full film $MoTe_2$ samples were systematically investigated by using microreactor for HER. This unique 2H-1T' phase boundary clearly act as a activated basal plane compared with 1T' one. To clarify the origin for highly active HER at phase boundaries of the CVD-grown $MoTe_2$, kelvin probe force microscopy (KPFM) has been conducted, which demonstrates band bending as a major origin for the active HER at heterophase interfaces. The unique phase boundary engineering with large-scale $MoTe_2$ allows a new direction for catalytic engineering for HER.

Keywords:

Transition metal dichalcogenides, Hydrogen evolution reaction, Phase engineering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

G21.01

오창 다목적 방사광 가속기 사업(안) 경과 보고

이민규*[1]
[1] 과학기술정보통신부 원자력연구개발과 사무관
office@kps.or.kr

Abstract:

- 11:10 - 11:15 인사말 (한국물리학회장, 정책위원장)
- 11:15 - 11:40 오창 다목적 방사광 가속기 사업(안) 경과 보고, 과학기술정보통신부
- 11:40 - 12:05 패널 의견 제시

권기석 과장 (과학기술정보통신부 원자력개발과)
김진형 단장 (충북방사광가속기추진지원단)
정진석 교수 (숭실대)
문봉진 교수 (GIST)
이성호 박사 (SK Hynix)
류혜진 박사 (KIST),
김현정 교수 (서강대, 정책위원장)

- 12:05 - 12:20 질의 및 응답
- 12:20 폐회사

Keywords:

방사광 가속기

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.01

Search for Long-Lived Particle Using Delayed Photons with CMS

MOON Chang-Seong *[1], SEO YeongDeok [1], PEñA Cristián Herrera[3], NGUYEN Thong [2], XIE Si [2]
[1]Department of Physics, Kyungpook National University
[2]Department of Physics, Caltech
[3]Particle Physics Division, Fermi National Accelerator Laboratory
csmoon@knu.ac.kr

Abstract:

We explore long-lived neutral particles predicted by many physical models in a gauge-mediated SUSY breaking scenario called the SPS8 benchmark model. In the SPS8 benchmark model, pair-produced squarks and gluinos decay, via neutralino, into gravitino and photons, where large MET (Missing Transverse Energy) and delayed photon arrival time to the ECAL calorimeter observed. Based on this, we explore the presence of supersymmetric particles under certain conditions using the ABCD method in four intervals: large or small MET and delayed or not delayed incident time of photons.
In this talk, the results of the study conducted with data of 59.83 fb^{-1} recorded in the 2018 CMS experiment will be presented

Keywords:

LHC, delayed photon

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.02

Search for new physics in dilepton events using asymmetry

YANG Un-ki *[1], SEO HyonSan [1], LEE Sang Eun [1], JEON Si Hyun [1], JUN Won [1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

We report a noble way to search for new physics in dilepton events using asymmetry at the LHC. Since the discovery of the Higgs particle, we have not observed any new physics signal yet in bump hunting. A tantalizing new physics signature can be hidden in the corners of kinematic phase space of the dilepton events. We measure differential asymmetry as functions of various kinematic variables to search for hints of new physics.

Keywords:

LHC, CMS, 13TeV, asymmetry, AFB

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.03

Search for heavy neutrinos in di-lepton events at 13 TeV using the CMS detector

YANG Un-ki *[1], LEE Haneol [1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

The observation of neutrino oscillations established that the standard model neutrinos have non-zero masses. One of the theories to best explain the mass of the standard model neutrinos predicts the existence of a heavy Majorana neutrino at the LHC energy scale. We report sensitivity studies for these heavy Majorana neutrinos in di-lepton events using the full Run 2 data collected by the CMS detector.

Keywords:

CMS, heavy neutrino

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.04

Search for pair production of heavy Majorana neutrinos using Full Run2 proton-proton collision data of the LHC at 13 TeV collected by the CMS detector

YANG Un-ki *[1], OH SungBin [1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

We present a result of search for pair production of heavy Majorana neutrinos (N) via Z' based on the left-right symmetric (LRS) extension of the Standard Model (SM). Not only opened question about source and mechanism of neutrinos masses, the see-saw mechanism and the LRS extension of the SM can also provide answers to matter/anti-matter asymmetry and left handedness of the universe.
The analysis targets to search for pair production of N via Z' where each N decays into a lepton and two jets.
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 search 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, 2017, and 2018 from proton-proton collision of the LHC at 13 TeV of center of mass energy which is corresponding to 137 /fb of data.

Keywords:

Heavy Neutrino, LHC, CMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.05

Search for high mass spin-0 resonances in semileptonic WW to lvqq final state at √s=13TeV in CMS experiment

CHOI Junho [1], LEE Sangeun [1], YANG Un-ki [*1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

We present a study of search for high mass scalar particle in the semileptonic WW to lvqq final state at LHC with CMS p-p collision data at the center of mass energy 13 TeV. The mass range of the renonances is extended from 200 GeV/c2 to 5000GeV/c2. In this mass region hadronically decaying W-boson is boosted enough to produce a merge jet. A technique to tag the merge jet from the W boson decay is used. Also, events with hadronic W decay to resolved jets are investigated.

Keywords:

CMS, LHC

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.07

Search for new physics using non-isolated leptons at the LHC

LEE Joon-Bin [1], YANG Un-ki *[1]
[1]Department of physics and astronomy, Seoul National University
ukyang@snu.ac.kr

Abstract:

Many different types of new physics have been studied using isolated leptons, which are presented in no jet or outside jet environment, at the LHC. However, we have not found any strong evidence for new physics yet. In contrast, leptons inside a jet ("non-isolated lepton") have been ignored in new physics search since they are mostly from QCD events. We thus investigate new physics signature inside a jet using non-isolated leptons. This is a new domain for new physics search. In this report, we will present a preliminary result of anomalous dimuon production inside a jet.

Keywords:

non-isolated lepton, LHC, CMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H1.08

Search for Z' bosons decaying into tau pairs in bottom fermion fusion process

PARK Inkyu *[1], LEE Jason Sang Hun[1], ROH Youn Jung [1], WATSON Ian James[1], KANG Dayoung [1]
[1]University of Seoul
icpark@uos.ac.kr

Abstract:

Anomalies in the B-meson decays reported by the b physics experiments could be explained by a heavy neutral gauge boson, Z', with flavor changing bs coupling and a nonuniversal coupling to leptons. In this study, we investigate the Z' decaying to tau tau in association with at least one b-jet. The analysis is performed in the tau mu channel in pp collisions at center-of-mass energy of 13 TeV using data corresponding to an integrated luminosity of 35.9/fb collected by CMS detector.

Keywords:

Zprime, CMS, Tau, BSM

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.01

The Clockwork Standard Model

LEE Hyun Min *[1], KANG Yoo-Jin [1]
[1]Department of Physics, Chung-Ang University
hminlee@cau.ac.kr

Abstract:

We consider bulk fields with arbitrary spins in the linear dilaton background in 5 dimensions of the continuum clockwork models. We show that the localization of the zero modes of bulk files and the Kaluza-Klein(KK) mass spectrum depends on not only the bulk dilaton coupling and bulk mass parameter in the case of a bulk fermion. The consistency from universality and perturbativity of gauge couplings constrain the dilaton couplings to the brane-localized matter field as well as the bulk gauge bosons. Constructing the Clockwork Standard Model(SM) in the linear dilaton background, we provide the necessary conditions for the bulk mass parameters explaining the mass hierarchy and mixing for the SM fermions using different size of expansion parameters between quark and lepton sector. We found that massive KK gauge bosons and gravitons couple more strongly to light and heavy fermions, respectively. So searching for those KK modes at the LHC is expected in resonance researches.

Keywords:

extra-dimension, Clockwork models, linear dilaton, flavor hierarchy

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.02

Selection rules for the decay of a particle into two identical massless particles of any spin

JEONG Jae Hoon *[1], CHOI SeongYoul [1]
[1]physics, Chonbuk National University
jaehoonjeong229@gmail.com

Abstract:

The well-known Landau-Yang (LY) theorem on the decay of a neutral particle into two photons is generalized for analyzing the decay of a neutral or charged particle into two identical massless particles of any spin. Selection rules categorized by discrete parity invariance and Bose/Fermi symmetry are worked out in the helicity formulation. The general form of the Lorentz-covariant triple vertices are derived and the corresponding decay helicity amplitudes are explicitly calculated in the Jacob-Wick convention. After checking the consistency of all the analytic results obtained by two complementary approaches, we extract out the key aspects of the generalized LY theorem.

Keywords:

Generalized Landau-Yang theorem, Covariant formulation, Selection rules

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.03

Higgs to dimuon discovery using quark/gluon tagging of ISR

CHO Won Sang [1], HAN Subin [1], KIM Hyung-do [*1], LEE Dongsub [1]
[1]Department of Physics and Astronomy, Seoul National University
hdkim@phya.snu.ac.kr

Abstract:

In 2020, CMS collaboration reported the significance of 3.0σ for the Higgs boson decay to dimuon process. We propose that by using quark/gluon tagging of the initial state radiation(ISR) jets, the significance can be considerably enhanced. We exploit the difference in the fraction of quark/gluon ISR jets of gluon-fusion Higgs signal and its background, Drell-Yan. By conducting multivariate analysis with jet-substructure variables, which have distinct distributions for each quark and gluon jets, we obtain significantly improved significance compared to the result of CMS collaboration.

Keywords:

Higgs dimuon decay, quark/gluon tagging, jet substructure, CMS

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.04

A study of in-medium property of quarkonium using NRQCD on a anisotropic quenched lattices

KIM Se Yong *1
[1]Department of Physics, Sejong University
skim@sejong.ac.kr

Abstract:

In-medium property of quarkonium is heralded as a thermometer of quark-gluon plasma (QGP). In contrast to potential model approaches to the problem, lattie NRQCD method which calculates in-medium quarkonium spectral function by applying Bayesian method (such as MEM) on NRQCD quarkonium correlators is superior, in that the computation is based on first principles of quantum field theory and is thus systematically improvable. On the other hand, small number of the time-directional lattice sites in the finte temperature formulation introduces limited accuracy in Bayesian method. Here, we simulate quenched lattices with larger anisotropy (and thus increase the number of the time-directional lattice sites) and test the future improvement avenue in Bayesian method before full, larger scale dynamical lattice QCD simulations.

Keywords:

lattice gauge theory, quarkonium, quark-gluon plasma, anisotropic lattice, quenched lattice

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.05

Decay Constant Analysis of $B_{(s)}$ and $D_{(s)}$ meson using the Oktay-Kronfeld Action

LEE Weonjong *[1], JANG Yong-Chull [2], PARK Sungwoo [3], CHOI Benjamin Jaedon [1], LEE Sunkyu [1], JWA Seungyeob [1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Physics, Columbia University
[3]Center for Nonlinear Studies/T-2, Los Alamos National Laboratory
wlee@snu.ac.kr

Abstract:

We present current progress on the data analysis of decay constants for $B_{(s)}$ and $D_{(s)}$ mesons in the lattice QCD. Here, for charm and bottom valence quarks, the Oktay-Kronfeld (OK) action is used. Here, the masses of charm and bottom quarks are nonperturbatively tuned. The calculations are done with HISQ ensembles generated by the MILC collaboration with N_f=2+1+1 flavors. We also use the HISQ action for the light spectator quarks. Results are presented for the ratios f_{Bs}/f_B and f_{Ds}/f_D, which reflect SU(3) flavor symmetry breaking, and are independent of the renormalization constants of the axial currents.

Keywords:

Lattice QCD, Phenomenology, Quantum Chromodynamics, Lattice Gauge Theory, Heavy Quark Effective Theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.06

Machine learning study on the Dirac eigenvalue spectrum of staggered quarks

LEE Sunkyu [1], JEONG Hwancheol [2], JUNG Chulwoo [3], JWA Seungyeob [1], KIM Jangho [4], KIM Jeehun [1], KIM Nam Soo [5], KIM Sunghee [1], LEE Weonjong [*1], LEE Youngjo [6], PAK Jeonghwan [1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Physics, Indiana University Bloomington
[3]Physics Department, Brookhaven National Laboratory
[4]Institut fur Theoretische Physik, Goethe University
[5]Department of Electrical and Computer Engineering and the Institute of New Media and Communications, Seoul National University
[6]Department of Statistics, Seoul National University
wlee@snu.ac.kr

Abstract:

We study chirality of staggered quarks on the Dirac eigenvalue spectrum using machine learning technique. As a result of theoretical research, we expect a characteristic pattern, we call leakage pattern, in the matrix elements of the chirality operator sandwiched between two eigenstates of staggered Dirac operator. Machine learning analysis gives 98.7(34)% accuracy per a single normal gauge configuration for classifying non-zero mode quartets in Dirac eigenvalue spectrum. It confirms that the leakage pattern is universal on normal gauge configurations. We choose the multi-layer perceptron (MLP) method which is one of the deep learning models. It happens to give the best performance in our study. Numerical study is done using HYP staggered quarks on the 20^4 lattice in quenched QCD.

Keywords:

Staggered quark, Dirac eigenvalue spectrum, Leakage pattern, Machine learning, Lattice gauge theory

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H2.07

Data analysis of staggered meson spectrum in lattice QCD

PAK JEONGHWAN [1], LEE Weonjong *[1]
[1]Department of Physics and Astronomy, Seoul National University
wlee@snu.ac.kr

Abstract:

Staggered fermion formalism have an advantage in cost of computation than other fermion formalism in lattice QCD. It make possible to calculate more simulation. But It suffer from the taste symmetry breaking. This complicates the analysis and error of results. Hence, reducing the taste symmetry breaking is important to using the staggered fermion formalism. The first goal is to calculate the spectrum of meson masses by each tastes.
There are some improved staggered fermion formalisms. HYP, asqtad and HISQ are parts of them. They are expected to reduce the taste symmetry breaking. Hence, the next goal is to compare the splitting from spectrum of meson mass of these improved formalism.
In this research, we focus on to calculate meson masses and accurate analysis of data using staggered fermion formalism.

Keywords:

lattce QCD, staggered, meson spectrum, fitting

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.01

Research and Development of LAMPS starting counter

KWEON Min Jung *[1], LEE Hyungjun [1]
[1]Inha University
minjung@inha.ac.kr

Abstract:

LAMPS is a large acceptance multi-purpose spectrometer that will be installed in RAON. in the LAMPS, a starting counter acts as a trigger detector. To acts as a good trigger detector, the starting counter should have a good timing resolution. Moreover, the energy deposition has to be small at the starting counter because an incident beam energy loss must be small until the beam hits a target. we are making the starting counter that meets two conditions. And americium source test and KOMAC(Korean proton accelerator in Gyeongju) beam test were conducted. we are analyzing the result of each test and improving the performance of the starting counter.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.02

Status Report of the Prototype Beam Drift Chamber (BDC) for the LAMPS Experiment at RAON

SEO Junhu *[1], MOON Dongho [1], KIM Hyunchul [1], HWANG Jaein [2], LEE Jongwon [2], HWANG Sanghoon [3]

[1]Department of Physics, Chonnam National University
[2]Department of Physics, Korea University
[3]KRISS
zhwkzm85@gmail.com

Abstract:

The Large Acceptance Multi-Purpose Spectrometer (LAMPS) is a detector system for studying rare isotope collisions and the nuclear symmetry energy at supra-saturation densities. A new type of accelerator is under construction by using a combined method of In-flight Fragmentation (IF) and Isotope Separation On-Line (ISOL), named RAON accelerator. For this experiment, the beam trajectory is one of the important information for data analysis. The Beam Drift Chamber (BDC) is designed for tracking Rare Isotope beam trajectories produced by RAON using thin wires with gas ionization. Now, the prototype BDC is being tested and the status of the test result will be presented.

Keywords:

nuclear symmetry energy, RAON, LAMPS, wire chamber, beam drift chamber

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.03

High-precision mass measurement of exotic neutron-rich nuclei

KORKULU Zeren *1
[1]Center for Exotic Nuclear Studies (CENS), Institute for Basic Science (IBS)
korkulu@ibs.re.kr

Abstract:

Binding energy is a vital property of the atomic nucleus. It provides important nuclear information such as separation energies and shell structure [1]. This information is highly desired in the area of nuclear astrophysics. Especially the masses of exotic neutron-rich nuclei are important for understanding nuclear structure far from the valley of β-stability, and as direct inputs into astrophysical models. To measure the masses of nuclei located far from stability, a storage ring called Rare-RI Ring (R3) [2] was constructed at the RI Beam Factory in RIKEN, Japan. It employs the isochronous mass spectrometry technique [3], with the goal of determining masses with a precision of 10^{-6} in less than 1-ms measurement time. The Rare-RI Ring has already been commissioned and studied experimentally.

In order to improve measurement efficiency, beam diagnostics are required to tune the R3's magnetic optics. Advanced position sensitive detectors enable this fine tuning as they give an accurate depiction of the beam profile which displays the beam behavior. Therefore, we have started the construction of a new position-sensitive detector with an intelligent, digital-readout-based data acquisition system. This unique combination of detection and read-out method will enable us to achieve high timing resolution and high position sensitivity necessary for mass measurements with high-precision.

In this talk our new experimental program aiming to measure, for the first time, the masses of exotic neutron-rich nuclei around N= 50 with precision of ~50 keV will be discussed. Furthermore, the details and status of our detector development will be presented. This work is conducted in the frame of RIKEN R3 collaboration.

[1] K. S. Crane, Introductory Nuclear Physics, Wiley, 2nd edition, 1955.
[2] A. Ozawa et al., Prog. Theor. Exp. Phys 03C009, 2012.
[3] M. Hausmann et al., Nucl. Instr. Meth. A 446, 569–580, 2000.

Keywords:

mass measurements, high-precision, position sensitive detector, digital read out

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.04

Exploration of next generation heavy ion collision experiment at LHC

JUNGEOL Kim *[1,2], YOUNGIL Kwon [2]
[1]DuDu IT.
[2]Dep. of Physics, Yonsei University
entfrise@naver.com

Abstract:

The heavy ion collision experiment is one of the main category in experimental nuclear physics, and focuses on the studies of the interaction dictating extreme nuclear matter. Perturbative-QCD is the first principle theory for the relevant phenomena and predicts production of the heavy flavor (c/b) quarks as a promising example. Several experimental programs including PHENIX, STAR, and ALICE were completed with great success or are under continuation while extending their capabilities.

In this work we consider a new detector concept assuming the possibility of the LHC fixed target experiment and the probable innovations in the silicon sensor technology. It has near 4π acceptance for the produced tracks and superior momentum and decay vertex resolution even for very high multiplicity, which might make a breakthrough. We investigated the potential of this new concept detector utilizing full detector simulation based on GEANT4 and the following tracking program development for the specific example of the heavy flavor production.

Keywords:

Heavy ion collision, Fixed target experiment, Detector

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.05

Production test of ALPIDE chips at Yonsei University

KIM Taejun *[1,2]
[1]ALICE Collaboration, ALICE Collaboration
[2]Yonsei University
taejun_kim@yonsei.ac.kr

Abstract:

Production test of ALPIDE, the monolithic pixel sensors fabricated in the 180 nm CMOS Imaging Sensor process of TowerJazz, was recently completed for the ALICE ITS upgrade under installation. Deep p-well process by foundry enables the continuously active low-power front-end and 3 memory cells to keep discriminated hit information within each pixel. Zero suppression by the priority encoder logic is also implemented between pixel matrix and the memory block inside the sensor. Recorded hits in the memory block can be read out up to 1.2 Gbps through a serial link. In addition, sensor operation is configured using the registers inside the sensor. More than 60,000 sensors were tested by an automated test system. We will describe construction of the test system including its prober and the tests performed to ensure the proper operation of the fabricated sensors.

Keywords:

CMOS, ALICE

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.06

Alignment and Correction for Deformation of a Precision Tracker by Artificial Intelligence

KIM Jaehyun *[1], JEONG Jae Young [2], KIM Yong Kyun [2], KWON Youngil [1]
[1]Physics, Yonsei University
[2]Department of Nuclear Engineering, Hanyang University
xhaxha@yonsei.ac.kr

Abstract:

Precision trackers are used for the high energy and nuclear physics. The trackers measure precise positions of the hits produced by the particles and associate hits to a trajectory when the associated positions are consistent. Any small misalignment or deformation of detector caused by various factors significantly affects the precise position measurements and its correction frequently appears as a major issue in the tracker operation.

Usual correction method is to introduce parameter set relevant to likely deformation models and adjust this parameter set so that the associated hits yield ideal particle trajectory. This approach however works to the validity of the chosen deformation model while reality is always beyond the modeling.

A small but non-trivial correction function has to be associated to each position measurement for unknown deformations. Regression using neural network or artificial intelligence can approximate any multi variable functions and we performed regression fit to extract deformations taking inner barrel of the ALICE ITS upgrade at CERN LHC as a test bed and simulating simple deformations to it. We observed a certain level of success in this effort and will present results so far while discussing the next step.

Keywords:

Alignment, AI, ITS2, Regression Method, Neural Network

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.07

ALICE FoCal 용 PIN 실리콘 센서 디자인

KIM DONG GEON [2], KIM YOONSEOK [1], KWON YOUNGIL [1], HAN YOUNGHOON [*1]
[1]Department of physics, Yonsei University
[2]Department of nuclear physics, Hanyang university
yeou951753@gmail.com

Abstract:

CERN LHC 의 ALICE 실험은 LS3(Long shutdown 3)기간 FoCal(Forward Calorimeter) 검출기 추가를 통한 성능향상을 준비하고 있다. 충돌지점에서 7(m)의 거리에 위치할 FoCal 은 EM(ElectroMagnetic) 열량계 FoCal-E 와 H(Hadronic) 열량계 FoCal-H 로 나뉜다. 이중 Silicon sensor 와 Tungsten converter 가 교대로 놓여있는 Si-W 샌드위치 구조의 FoCal-E 가 중심적인 역할을 수행한다. ɣ (광자), e(전자)γ (광자), e(전자) 와 같은 입자들이 Tungsten converter 를 수직에 가깝게 지나면서 EM shower 를 발생시키며 2,000 여 개의 PIN 구조를 갖는 Si 센서가 변환된 에너지를 측정하는데 사용된다. 언급된 Si 센서는 고저항의 진성 Si 기판 양면에 B(붕소)및 P(인)를 도핑한 구조를 갖으며 비대칭 접합을 갖는 다이오드 구조이다. 사용되는 다이오드 패턴은 FoCal-E 검출기의 Moliere 반경인 1 (cm)의 크기를 갖는 패드들의 8 x 9 평면 배열로 형성되는데 이는 6 인치 웨이퍼를 활용하여 제작하는 것을 전제한다. 500 (m)에 상당하는 웨이퍼 두께 전부가 공핍되는 전압 이상에서 동작해야 하며 이의 두배에 상당하는 수백 볼트에서 무리없이 동작할 수 있도록 설계해야 한다. 이를 위해 TCAD(Technology Computer-Aided Design)에 기반한 전산 모사를 활용하여 Guardrings, Channel stop, 그리고 패턴과 금속 전극의 배치를 최적화 하였다. 각각의 요소가 갖는 의미와 최적화 방식에 대해 설명하고 제작된 센서에 대한 기초적인 특성을 보고하고 토론할 것이다.

Keywords:

실리콘 센서

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.08

ALICE 실험 FoCal 검출기에 사용할 PIN 구조를 갖는 실리콘 센서 공정

KIM Yoonseok *[1], KIM Donggeon [2], JEONG Jaeyoung [2], HAN Younghoon [1], KIM Yongkyun [2], KWON Youngil [1]
[1]Physics, Yonsei University
[2]Nuclear Engineering, Hanyang University
antares1103@gmail.com

Abstract:

CERN LHC 의 ALICE 실험은 LS3(Long shutdown 3)기간 FoCal(Forward Calorimeter) 추가를 통한 성능향상을 준비하고 있다. 충돌지점에서 7(m)의 거리에 위치할 FoCal 은 EM(ElectroMagnetic) 열량계 FoCal-E 와 H(Hadronic) 열량계 FoCal-H 로 나뉜다. FoCal-E 는 Si-W 샌드위치 구조를 갖으며 2,000 여 개의 PIN 구조를 갖는 Si 센서가 에너지를 측정하는 핵심 센서가 된다.
PIN 구조는 고저항의 진성 Si 기판의 양면에 B(붕소)및 P(인)를 도핑한 구조를 말하는데 해당 센서의 경우 공정이 그 성능을 결정한다. 일본 그룹들과 Hamamasu(주), 인도 그룹들과 인도의 센서 회사, 그리고 한국 그룹들과 ETRI(전자 통신 연구소)가 PIN 형 실리콘 제작 가능성을 검토하고 있다.
본 연구는 TCAD(Technology Computer-Aided Design)에 기반한 전산 모사를 활용하여 FoCal 의 요구 사항을 만족하도록 Si 센서 공정을 최적화하였다. 주요 공정 단계들은 순서에 따라 후면 도핑, Channel stop 도핑, 패턴 도핑, Metalization, Passivation 으로 이루어지는데 개별 단계는 다수의 세부 공정들로 이루어진다. 작성된 공정으로 제작된 센서의 기초적인 특성 분석 결과를 보고하고 센서 성능에 중요한 영향을 미치는 공정 요소들에 대한 토론이 이루어질 것이다.

Keywords:

Si PIN sensor, Semi-conductor fabrication process

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H3.09

Design of a RPC Detection System for Monitoring Nuclear Reactors

LEE Kyong Sei *[1], KANG Minho [1], JO Youngmin [1]
[1]Korea University
kslee0421@korea.ac.kr

Abstract:

We report on a feasibility study of a RPC detector system to be applied to cosmic-ray muon radiography for imaging nuclear reactors. In this research, we propose a tracking system composed of RPC detectors with a two-dimensional readout scheme. We performed Monte-Carlo simulations for Coulomb scattering of typical cosmic muons with momenta ranging from 300 MeV/c to 10 GeV and for the track reconstructions with cases of various RPC detector resolutions. From the simulations, a position resolution of the tracking detectors of a few mm is expected to be fairly adequate to reproducing the images of a nuclear reactor core by using the data of the muon tracks. In this presentation, we also report the design of the dedicated RPC detectors and the electronics for the digitization of detector signals and for the triggers. The expected angular resolution obtained by the proposed multi-layered-RPC system with 6-mm strip pitches is about 2 mrad, which is amply enough to differentiate the typical uranium-oxide fuel core and surrounding shielding materials composed of water and iron.

Keywords:

Muon radiography, Resistive Plate Chambers, Nuclear reactors , Coulomb scattering

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H14.01

학령 인구 감소에 따른 물리 교사 양성 과정의 변화

JO Kwang Hee *[1]
[1]Chosun University
khjo@chosun.ac.kr

Abstract:

학령 인구의 급감에 따른 교육 여건의 변화는 이미 오래전부터 예견되었다. 특히 올해는 대학 입학 자원의 축소로 인해, 대규모 미충원 사태가 발생하였다. 물리교육과를 포함한 교원양성대학의 입시경쟁률은 지속적으로 하락하고 있으며, 국가교육회의에서는 중등교원 양성 규모의 축소를 권고하였다. 인구 감소에 따라 소규모 학교 통폐합이 진행 중이며, 이제는 대도시에서도 이러한 현상이 발생하고 있다. 이는 다만 올해에 국한된 일시적 사건이 아니며, 앞으로 더욱 심화될 전망이다. 이와 함께 2022 학년도부터 대학수학능력시험에서 물리학 I 과 II 를 포함한 과학탐구 영역이 사회탐구 영역 및 직업탐구 영역과 합쳐지고, 이 중에서 2 과목만 선택하는 방식으로 바뀌었다. 새 교육과정이 2022 년 개정을 목표로 사전 작업이 진행되고 있으며, 학생의 선택권을 확대하는 고교학점제는 2022 년부터 점차 도입되고 2025 년에 전면 시행될 계획이다. 또 중등교사 전국시도교육감협의회에서는 지속적으로 교육감의 선발권을 강화하는 방안을 추진하고 있다. 이러한 일련의 변화들은 직간접적으로 학령 인구 감소와 관련이 있으며, 예비 물리 교사 양성에 크고 작은 영향을 끼칠 것이다. 본 발표에서는 인구 감소에 따른 교육 정책의 변화, 이와 관련한 물리 교사 양성 과정의 개선 방향 등을 논의하고자 한다.

Keywords:

인구 감소, 물리 교사 양성, 교육 정책

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H14.02

인구절벽으로 인한 미래형 학교 모델의 도입에 따른 물리교사 역량의 변화

JI Young rae *[1]
[1]Department of Physics education, Sunchon National University
yrji@scnu.ac.kr

Abstract:

인구절벽 문제로 인해 우리 사회의 지속가능성에 대한 우려가 깊어지고 있다.
지속가능성에 대한 위기는 인구감소가 심각한 지방에서는 통폐합 정책을 통해 대응되곤 했으나 집약화를 통해서는 소외된 지역의 지속가능성의 문제가 해결되지 않는다. 따라서 물리적 학교의 통폐합 정책은 작은 거점 중심의 네트워크를 온라인으로 구축하여 지역 사회의 자원을 활용하는 방향으로 제안되고 있다. 온오프라인을 겸한 학교 네트워크의 구축은 작은학교의 운영을 통한 교육적 가치 실현을 지향한다. 기존 표준화된 학교 체제 및 교육과정의 유연화가 요구되고 새로운 시도를 통한 지역 거점 네트워크의 운영이 필요할 수 있다. 학령 인구 감소로 인한 미래형 학교 모델의 도입은 교과 교사로서의 물리 교사의 새로운 역량에 대한 요구로 이어질 것이므로 교사양성기관에서의 예비교사 양성 방향의 변화를 가져올 것이다.

Keywords:

인구절벽, 미래형 학교 모델, 물리교사 역량

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H14.03

누구를 위한 물리교육인가: 지역기반 물리교육의 필요성

KIM Heekyong *[1]
[1]Division of Science Education, Kangwon National University
heekyong@kangwon.ac.kr

Abstract:

인구절벽과 지방소멸의 문제는 더 이상 미래의 문제가 아니다. 서울대의 한국인구 추계 예측 결과에 따르면, 2038 년을 기점으로 위기가 가속화되 매년 20 만명 이상 인구가 감소할 것으로 예측되고 있다(세계일보, 2021. 02.07). 더 심각한 문제는 인구절벽의 비대칭성에 있다. 인구감소의 영향이 지역적으로 대칭적이지 않다는 것은 여러 통계수치를 통해 심각성을 드러내고 있다. 한국고용정보원의 '한국의 지방소멸위험지수 2019 및 국가의 대응전략'에 따르면, 전국 228 개 시군구 가운데 소멸위험지역은 97 곳으로 전체의 42.5%를 차지하였다(한국고용정보원, 2019). 지방소멸문제는 교육계에서 이미 가시화되어, 강원, 충북, 전남, 전북, 경북 등 5 개 지역 교육청의 경우 학교당 평균 교원 수가 24 명 이내(일반계 고교 기준)로 고교 단계까지 소규모화가 가속되고 있다. 지방소멸은 지역의 지속가능성, 생존의 문제와 직결되면서 큰 파장을 낳고 있으며, 이에 대한 대응책을 다방면에서 시도하고 있으나 실효성은 아직 미지수이다.
문제의 심각성을 고려할 때 지방소멸의 문제는 정부의 여러 정책적 투입으로만 해결할 수 있는 시점을 지났으며, 지역의 모든 주체들이 지역공동체를 살리기 위한 다양한 노력을 협력적으로 수행해야 하며, 적극적으로 대응해야 할 단계이다.
사람이 없으면 마을도 없으며, 교육도 없다. 이러한 측면에서 물리교육에서도 지역공동체와 연계하여 지역의 지속가능성을 높일 수 있는 방안을 찾고 실행전략을 모색해야 한다. 물리교육은 물리학을 전공할 학생들을 위한 물리교육 뿐만 아니라 일반인을 위한 물리교육의 지향점을 꾸준히 추구해왔다. 연구자는 일반인을 위한 물리교육이 인구절벽 시대에 찾아가야 할 방향의 하나로 학습자가 속한 지역의 특성을 살리고 지역의 문제를 해결할 수 있는 지역재생에 기여하는 물리교육의 필요성을 제안하고자 한다.

Keywords:

지방소멸, 일반인을 위한 물리교육, 지역기반 물리교육

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H14.04

물리교육의 위기에 대한 역사적 교훈: 20 년 전의 정책 연구를 중심으로

IM Sung Min *1
[1]Department of Physics Education, Daegu University
ismphs@daegu.ac.kr

Abstract:

학령인구 감소에 따른 대학 입학자원 고갈은 이미 예견된 일이었으나, 기초과학 분야 특히 물리학 분야에서는 학생들이 물리학에 대한 이탈과 맞물려 예상보다 빨리 심각한 위기 상황에 이르렀다. 물리교육의 위기는 인구절벽 사태로 빚어진 최근의 일만은 아니다. 1960 년대 스푸트니크 충격 이후 서방 사회를 중심으로 우수 과학기술 인력양성에 대한 위기가 고조된 시기가 있었고, 그보다 가깝게 우리나라에서는 IMF 사태 이후 2000 년대에 확산된 이공계 기피 현상으로 인한 기초과학교육에 대한 위기감이 국가사회적인 이슈가 되기도 있었다. 그러나 물리교육의 시대적 위기는 곧 그 시대 물리교육의 혁신을 유도하는 또는 독려하는 동력이 되기도 했다. 이 발표에서는 지금부터 약 20 년 전 이공계 기피 현상이 위기로 인식되던 시기에 정부 차원의 노력과 과학기술계를 중심으로 제안된 몇 가지 주요 정책연구를 살펴보고, 이를 바탕으로 현재의 물리교육 위기에 대한 시사점을 논의하고자 한다.

Keywords:

물리교육, 정책연구, 위기, 혁신

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H17.01

Benchmarking near-term quantum devices based on quantum chaos

CHOI Joonhee [1], SHAW Adam L.[1], MADJAROV Ivaylo S.[1], XIE Xin [1], CONVEY Jacob P.[1], COTLER Jordan [2], MARK Daniel K.[3], HUANG Hsin-Yuan [1], KALE Anant [2], PICHLER Hannes [4], BRANDAO Fernando [1], CHOI Soonwon [*5], ENDRES Manuel [*1]
[1]Caltech
[2]Harvard
[3]MIT
[4]University of Innsbruck
[5]UC Berkeley
soonwon@berkeley.edu, mendres@caltech.edu

Abstract:

The proof-of-principle demonstrations of quantum simulation have been performed using a number of different programmable quantum devices and led to the unexpected discoveries of novel phenomena such as discrete time-crystalline order or quantum many-body scars. However, the verification of a many-body quantum system, which quantifies how well a quantum device produces a desired target state, is both theoretically and experimentally challenging since existing methods such as tomographic techniques often require fine-tuned spatiotemporal controls and substantial experimental resources that scale exponentially with system size. In this talk, we introduce a simple, efficient protocol to estimate the many-body fidelity between a quantum state produced from experiment and the target state from ideal noise-free evolution. Our protocol does not require advanced controls or large number of measurements, but only rely on the ability to time evolve a quantum state under a time-independent Hamiltonian, followed by the projection measurement of all qubits in a fixed basis. Such a remarkable simplification in verification stems from an unprecedented universal phenomenon: the emergence of local random state ensembles from chaotic quantum many-body dynamics. We demonstrate our verification protocol using a Rydberg quantum simulator. Besides quantum device verification, the observed phenomenon has broad theoretical implications for the study of many-body quantum chaos.

Keywords:

quantum information science, quantum simulation, quantum device verification, quantum device benchmarking, quantum chaos

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H17.02

Quantum simulation of nonidentical SU(N) fermions interacting identically

JO Gyu Boong *[1]
[1]Department of Physics, HKUST
gbjo@ust.hk

Abstract:

Ultracold fermions with an enlarged SU(N) spin symmetry are now offering unique possibilities for exploring novel quantum magnetism and correlated quantum many-body systems. In such a fermionic system, multi-component fermions interact identically with others due to the SU(N) symmetry. On the one hand, the SU(2) Hubbard model, with one goal being a better understanding of the possibility of exotic superconductivity, can be extended to the exotic SU(N>2) Hubbard model. On the other hand, the Fermi liquid description of interacting fermions can also be generalized to the SU(N)-symmetric Fermi liquid. In this talk, I will describe our progress at the frontiers of SU(N) physics, including experiments on thermodynamics, bosonization and collective excitations in bulk SU(N)-symmetric Fermi liquid. These developments, together with recent experiments from other groups, set the stage for exploring SU(N) spin symmetry in the context of magnetic correlations both in bulk and lattices.

Keywords:

Quantum simulation, Interacting fermions, SU(N) symmetry, Ultracold atoms

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H17.03

Quantum many-body physics studied with QAOA

MOON Eun-Gook *[1]
[1]physics, KAIST
egmoon@kaist.ac.kr

Abstract:

Entanglement of quantum many-body systems is one of the key concepts for future science and technology. One issue is how to control and realize the entanglement. In this talk, we discuss the recent developments in quantum many-body physics in connection with the hybrid quantum classical algorithm such as quantum approximate optimization algorithm (QAOA). We propose a new way to capture quantum entanglement overcoming limitations of traditional descriptions of quantum many-body systems such as mean-field theory in which quantum entanglement is not well captured. We also discuss how quantum simulations with AMO systems are connected with condensed matter systems.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H17.04

Quantum Simulation using ultracold atoms at KRISS

MUN Jongchul *[1]
[1]Quantum Technology Institute, KRISS
jcmun@kriss.re.kr

Abstract:

In this talk, we present brief introduction to quantum simulations using ultracold atoms in optical lattices. Our proposed quantum platform – ultracold atomic system and optical lattice technique will be reviewed. Ultracold atomic systems represent an ideal platform for simulations of complex quantum many-body problems in wide range physics from condensed matter physics, statistical physics, quantum chemistry, and high-energy physics. In addition, the high degree of controllability, system purity, and wide range of particle correlation parameters provides unique quantum engineering tool box.
We also discuss the target quantum problem that we propose to simulate: Hubbard type model. Hubbard type model is experimentally realized, and “encoded” in our quantum simulator by engineering optical lattices and physical parameters such as interaction strengths. Our proposed experimental implementation for Hubbard type model simulations will be described.

Keywords:

quantum simulation, quantum gas, optical lattice, single atom microscopy, many-body problem

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.01

InP 계 리지 도파로 구조에서 활성층-수동층 버트 조인트의 광결합 효율 최적화 연구

송연수[1], 명기환[2], 김인[2], 유준상[2], RYU Sang Wan *[1]
[1]Department of Physics, Chonnam National University
[2]연구개발부, (주)오이솔루션
sangwan@chonnam.ac.kr

Abstract:

활성 도파로와 수동 도파로의 집적을 구현하기 위한 기술들 중에 버트 조인트는 상당한 장점을 가지고 있다. 그러나 버트 조인트 접합은 높은 광손실을 야기하며, 두 도파로 간의 정렬에 있어서 정확한 공정 제어가 요구되는 구조이다. 본 연구에서는 레이저 다이오드와 spot size converter (SSC)로 구성된 집적 소자를 시뮬레이션하기 위해 beam propagation method 을 이용하였다. 상이한 모드 특성을 갖는 두 SSC 를 레이저 도파로와 접합한 후 광결합 효율을 시뮬레이션 하였다. 큰 근접장 모드를 가지는 SSC 는 좁고 대칭적인 원거리 발산각 패턴을 얻을 수 있으나 낮은 광결합 효율을 보였다. 테이퍼 구조의 수동 도파로는 원거리 발산각 패턴을 열화시키지 않고 버트 조인트에서 도파로 오프셋의 무의존성과 광결합 효율을 향상시키기 위해 이용되었다. 이를 바탕으로 89.6%의 높은 광결합 효율과 16°×16°의 좁은 원거리장 발산각을 얻을 수 있었다.

Keywords:

waveguide, butt joint, spot size converter, photonic integrated circuit

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.02

Relaxation process of exciton-polariton vortex in non-resonant Laguerre-Gaussian pumping

CHOI Daegwang [1], PARK Min [1], OH Byoung Yong [1], KWON Min-Sik [1], PARK Suk In [2], KANG Sooseok [2], SONG Jin Dong [2], CHOI Hyoung Soon [1], CHO Yong Hoon [*1]
[1]KAIST
[2]Center for Opto-Electronic Convergence Systems, KIST
yhc@kaist.ac.kr

Abstract:

In a semiconductor microcavity, strong coupling between a quantum well exciton and a cavity photon creates a new eigenstate, called exciton-polariton (polariton). Above the threshold density, Polariton exhibits bosonic phenomena such as superfluidity, quantized vortices. Particularly, a polariton vortex can be generated even in non-resonant Laguerre-Gaussian (LG) pumping. Here, we found that the polariton vortex shows a relaxation process with loss of angular momentum in time evolution. In LG beam pumping, polaritons show multi-state condensates with different angular momentum state. Time-resolved PL spectroscopy reveals the relaxation process between the multi-states condensates. Moreover, we show that the population ratio of multi-states and relaxation process depend on the LG beam size. Thus, we confirmed that the polariton vortex is sensitively affected by the potential induced from non-resonant LG beam and this experimental result will be key to solve a mechanism of vortex creation in non-resonant LG pumping

Keywords:

Exciton-polariton, Strong coupling, superfluidity, quantized vortex

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.03

Improvement of optical properties of III-nitride quantum dot based single photon source using quasi-resonant excitation

JUN Seongmoon [1], CHOI Minho [1], CHO Yong Hoon *[1]
[1]KAIST
yhc@kaist.ac.kr

Abstract:

Single photon sources are indispensable elements for quantum information processing such as linear optical quantum computing, quantum key distribution. There are various platforms for implementing single photon sources such as atoms, defects in diamond and semiconductor-based quantum dots (QDs). In particular, III-nitride semiconductor-based QDs have attracted much attention owing to their scalability and possibility to electrically-driven and room temperature operation.

In considerable previous studies, the non-resonant excitation scheme has been exploited by exciting the barriers near the QDs. In non-resonant excitation, it causes not only inhomogeneous broadening due to the carriers in the barriers but also background emission from the barriers. Background emission from the barriers aggravates the single photon purity of QDs. To overcome these hurdles, a quasi-resonant excitation scheme can be an alternative. In quasi-resonant excitation, we could reduce the linewidth broadening and background emission due to direct excitation of excited states of QDs.

In this work, we performed the quasi-resonant excitation to single GaN/InGaN QDs. To probe the excited states of single QDs, micro-photoluminescence excitation (PLE) is operated. In micro-PLE experiment, we measured the intensity of single QDs during tuning the wavelength of the excitation laser. Then, we confirmed the curtailed linewidth and improved single photon purity by exploiting the quasi-resonant excitation.

Keywords:

Quasi-resonant excitation, Quantum dot, Quantum emitter

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.04

Tunable Rabi splitting of Exciton-Polaritons in Phase-changing Lead Halide Perovskites

CHO Chang-Hee *[1], LEE Taejin [1], KO Minjee [1], JUNG Jin-Woo [1], LEE Young-Jun [1], HEO Jin-Hee [2]
[1]Department of Emerging Materials Science, DGIST
[2]Materials Analysis and Evaluation Department, Korea Institute of Materials Science
chcho@dgist.ac.kr

Abstract:

Lead halide perovskites are emerging platforms for exciton-polaritons due to their high oscillator strength and large binding energy of excitons. Yet, the phase-dependency of Rabi splitting in the perovskite has not been reported. In this work, we measured the angle-resolved photoluminescence and reflectivity in $CH_3NH_3PbBr_3$ perovskite microcavities in three structural phases of orthorhombic ($T < 155$ K), tetragonal ($247 \text{ K} > T > 155$ K), and cubic ($T > 247$ K) to estimate exciton-polariton coupling strength. Also, we confirmed the ferroelectric domains which only appear in the tetragonal phase via piezoelectric force microscopy measurements. Very interestingly, the coupling strength was minimized in the tetragonal phase due to the ferroelectricity. These results strongly suggest the potential for active tuning of the exciton-polaritons by making use of the ferroelectricity in the perovskite materials.

Keywords:

Exciton-polariton, Rabi splitting, Halide perovskite, Ferroelectricity

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.05

나노 양자링 구조의 미세 에너지 구조의 자기의존성 및 비선형성 연구

KYHM Kwangseuk *[1], YANG Hanyi [1]
[1]Optomechatronics, Pusan National University
kskyhm@pusan.ac.kr

Abstract:

GaAs 양자링의 미세 에너지 준위를 계산하고, Pump-probe 실험을 통해 얻을 수 있는 펄스 세기에 따른 흡수 스펙트럼을 계산하였다. 양자링 속의 전자와 홀의 에너지 준위를 얻기 위해 루프 모델을 가정하였으며 전자와 홀의 쿨롱 상호작용도 고려하였다. 링의 단면에 수직으로 자기장을 걸었을 때 측정된 micro-PL 신호와 비교하여 전자와 홀의 반지름을 각각 28nm, 10nm 로 추정하였다.
반도체 Bloch 방정식을 적용하여 여기광의 세기에 따라 변화하는 각 미세 준위의 광학적 비선형성을 계산하였다. 레이저의 에너지 스펙트럼을 L=-3 준위에 맞추고 펄스 면적이 0 부터 1.3π 가 될 때까지 증가시킨 경우 나타나는 흡수 스펙트럼의 비선형적 변화를 예측하였고 펄스의 세기가 π 가 될 때부터는 gain 이 나타남을 확인하였다.

Keywords:

양자링, Pump-probe, 반도체 Bloch 방정식

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.06

Engineering the spatial and temporal modes of singled photons from solid-state quantum emitters

KIM Kyu Young [1], KIM Je Hyung [*1]
[1]Department of Physics, UNIST
jehyungkim@unist.ac.kr

Abstract:

Most photonic quantum information technologies require photonic qubits. As a single-photon source, the solid-state quantum dots can deterministically generate single photons with fast generation rate, high purity and indistinguishability, and the possibility to be integrated with cavities or photonic circuits. However, their asymmetric temporal and spatial single-photon mode profiles limit optimal efficiency and fidelity of quantum interaction. Here, we demonstrate the single-photon pulses at telecom wavelength with Gaussian-like waveforms in both temporal and spatial domains using InAs/GaAs quantum dots coupled with *L*3 photonic crystal cavity mode. Coupling the quantum dots into a cavity mode leads to a Gaussian-like far-field spatial mode profile, which brings a high collection efficiency. Additionally, engineering the exciton dynamics via multi-exciton cascade recombination and cavity detuning enables us to modify the rise and decay dynamics of single excitons. Furthermore, the cascade recombination process of multi-excitons temporally separates single photons from background emission, and therefore, the $g^{(2)}(0)$ value remains low below 0.5 even at 40 times greater power than the saturation power of the single exciton. This approach paves the way toward producing single photons with optimized temporal and spatial waveforms, which are essential for efficient quantum states transfer in quantum systems involving multiple photons and nodes.

Keywords:

semiconductor quantum dot, quantum information, quantum optics, photonic crystal cavity, cavity QED

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H18.07

Bright and fast single photon source from defect in point defect-stacking fault complex in silicon carbide nanowires

KIM Je Hyung *[1], LEE Jin Hee [1]
[1]Department of Physics, UNIST
jehyungkim@unist.ac.kr

Abstract:

Defects in crystals have the ability to engineer the band structures at the atomic level. Point defects, for example, behave as trapped atoms and serve photonic and spin qubits. Planar defects such as stacking faults form two-dimensional quantum wells or barriers. Combining these point and planar defects can generate a new type of defect complex system. Here, we investigate silicon carbide (SiC) nanowires that host a silicon vacancy coupled to a few-layered stacking fault. These defect complexes in the nanowire exhibit distinct optical properties from the silicon vacancy in bulk SiC. We observe unusually strong zero-phonon transition at room temperature. The structural advantages of nanowires lead to record brightness (>360 kHz) with a fast recombination time of 0.92 ns. Together with such outstanding optical properties, the self-grown nanowires are beneficial to be integrated into various hybrid platforms and thus will extend the potential use of quantum defects for the future integrated, scalable quantum photonic system.

Keywords:

solid state quantum emitter, color center, silicon carbide nanowire, stacking fault, hybrid integration

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.01

Quasiparticle interference in twisted bilayer graphene

HWANG Euy Heon *[1], LI Jinshu [1]
[1]Sungkyunkwan University
euyheon@skku.edu

Abstract:

We use both the joint-density-of-states (JDOS) and T-matrix approximations to analyze the quasiparticle interference (QPI) in twisted-bilayer graphene (TBG). A number of characteristic behaviors of the interference process are identified, which are distinct from those of monolayer or AB-stacked bilayer graphene. Especially for $\theta \sim 1.05°$, the magic angle, the high intensity regions in the QPI spectra become quite intricate owing to its nearly-flat band nature near the Dirac points. It reveals that the scattering between quasiparticles with small wave vector q differences dominates the final interference spectra in TBG. Combining the powerful technique, STM, these QPI results could be analyzed to reveal information about the electronic states of twisted bilayer graphene in momentum space.

Keywords:

Twisted bilayer graphene, Magic angle, Quasiparticle interference

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.02

무아레 초격자의 전자구조

MOON Pilkyung *[1]
[1]Arts and Sciences, New York University Shanghai
pilkyung.moon@nyu.edu

Abstract:

그래핀을 비롯한 2 차원 원자층들은 다양한 물질의 조합과 적층을 통해 새로운 물성을 디자인할 수 있는 가능성을 제공한다. 특히 이 구조들은 층간 결합이 약하여 (반데르발스 결합), 일반적인 반도체 재료의 에피택셜 성장과는 달리, 원자층들간에 격자 정합을 필요로 하지 않는다. 이는 두 원자층들의 주기가 임의의 회전각만큼 틀어진 구조를 가능케하고, 그런 구조는 원자층들의 주기의 차이에 의한 무아레 (moiré) 간섭 무늬의 주기를 갖는다. 이번 발표에서는 이런 무아레 초격자의 전자구조를 기술할 수 있는 유효이론[1]을 간략하게 설명한 후, 대표적인 몇가지 구조들의 전자구조와 물성을 소개하고자 한다. 구체적으로, 동일한 원자층 조합에서도 층간 회전각에 따라 광흡수 스펙트럼이 크게 바뀌고[2], 그래핀의 반전 대칭성을 깨뜨림으로써 밴드갭을 열거나[3] 열전효과[4]를 일으킬 수 있음을 보일 것이다.

[1] J. Lopes dos Santos et al., Phys. Rev. Lett. 99, 256802 (2007); R. Bistritzer and A. Macdonald, PNAS 108, 12233 (2011); P. Moon and M. Koshino, Phys. Rev. B 87, 205404 (2013).
[2] P. Moon and M. Koshino, Phys. Rev. B 87, 205404 (2013); K. Yu et al., Phys. Rev. B 99, 241405(R) (2019); S. Zhao et al., Phys. Rev. Lett. 124, 106101 (2020).
[3] P. Moon and M. Koshino, Phys. Rev. B 90, 155406 (2014).
[4] R. Moriya et al., Nat. Commun. 11, 5380 (2020).

Keywords:

무아레 초격자, Moire, superlattice

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.03

Infrared absorption of gate-tuned twisted bilayer graphene

CHOI E. J. *[1], YU Kwangnam [1], LUAN Nguyen Van[2], KIM Taesoo [2], JEON Jiwon [2], KIM Jiho [1], MOON Pilkyung [1], LEE Young Hee[2]
[1]University of Seoul
[2]Center for Integrated Nanostructure Physics, Institute for Basic Science (IBS), Sungkyunkwan University
[3]NYU-ECNU Institute of Physics at NYU Shanghai, New York University Shanghai
[4]Department of Physics, New York University
[5]State key Laboratory of Precision Spectroscopy, East China Normal University
echoi@uos.ac.kr

Abstract:

Optical property of 2d materials can be widely tuned by stacking order, twist angle, electrical gating, and so on. Here we measured optical absorptions of Moire-patterned twisted bilayer graphene using a microscopic FTIR. A prominent transition peak is found at mid-IR range, where peak position is linearly dependent on twist angle θ. As TBG is gated, this peak red-shifts and its intensity is reduced. When the gating voltage exceeds a certain value, another peak is activated at $\hbar\omega$=0.2eV and grows rapidly with Vg. I will discuss underlying mechanisms for these θ- and gate-dependent absorption behaviors. I also propose that gate-tuned optical changes can occur in other 2d Moire materials based on TMDC and h-BN, which may be exploited in electro-optical device applications.

Keywords:

TBG , Optical Transition, Gate tuning

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.04

Doping and electric-field dependences of electronic structures in twisted graphene layers

CHOI Hyoung Joon *[1]
[1]Department of Physics, Yonsei University
h.j.choi@yonsei.ac.kr

Abstract:

Twisted graphene layers started to draw a lot of attention since the report of superconducting and insulating phases in magic-angle twisted bilayer graphene. Then research topics have been extended to magnetic and topological properties, and also extended to twisted double bilayer graphene and alternating-twist trilayer graphene. These twisted graphene layers show large-scale moire patterns in their atomic structures and have almost flat bands in their electronic structures. In this talk, we present electronic structures near the Fermi energy of twisted graphene layers obtained from atomistic tight-binding calculations and density functional theory calculations [1-4]. We discuss low-energy band dispersions of almost flat bands as a function of doping, electric field, twist angle, and the number of layers. In addition, we also discuss doping and temperature dependences of Stoner-type ferromagnetic phase, and layer-number dependence of electron-phonon coupling strength. This work was supported by NRF of Korea (Grant No. 2020R1A2C3013673) and KISTI supercomputing center (Project No. KSC-2020-CRE-0335). [1] Young Woo Choi and Hyoung Joon Choi, Phys. Rev. B 98, 241412 (2018). [2] Young Woo Choi and Hyoung Joon Choi, Phys. Rev. B 100, 201402 (2019). [3] Young Woo Choi and Hyoung Joon Choi, in preparation. [4] Yosep Cho, Young Woo Choi, and Hyoung Joon Choi, in preparation.

Keywords:

twisted graphene layers, electronic structure, doping, electric field

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.05

Recent transport experiments in twisted bilayer-bilayer graphene

JEONG Hyeon-Woo [1], JEONG Gyouil [2], KIM Jiho [3], KIM Zee Hwan [2], LEE Gil-Ho [*1]
[1]Department of Physics, POSTECH
[2]Pohang Accelerator Laboratory, Pohang Accelerator Laboratory
[3]Department of Chemistry, Seoul National University
lghman@postech.ac.kr

Abstract:

Twisted bilayer-bilayer graphene (TBBG) has shown correlated electronic phases including ferromagnetism and Mott insulator at so-called magic twist angle of 1.1 degree. Especially, TBBG offers additional displacement field controllability compared to twisted bilayer graphene. In our magic angle TBBG devices, we observed interaction-driven Mott insulating state at half fillings. We also investigated the signature of superconducting phase near Mott insulating phase.
When TBBG is marginally twisted with angle close to zero, topological edge states are expected to arise in ABAB/ABCA domain network. After reviewing previous works on such system, we discuss our efforts to reduce twist angle inhomogeneity, the bottleneck in twistronics research. We used near-field scanning optical microscopy (NSOM) to directly observe ABAB/ABCA triangular superlattice, with which we select an area of uniform twist angle. With help of pre-cut method by atomic force microscope, we can get more uniform triangular superlattice by avoiding the mechanical strain applied to bilayer graphene during the tearing process.

Keywords:

twisted bilayer graphene

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

H19.06

Odd integer quantum Hall states with interlayer coherence in twisted bilayer graphene

KIM Youngwook *1
[1]Department of Emerging Materials Science, DGIST
y.kim@dgist.ac.kr

Abstract:

The study of two dimensional electron systems with extraordinarily low levels of disorder was for a long time the exclusive privilege of the epitaxial thin film research community. The successful isolation of graphene by mechanical exfoliation has however been truly disruptive. Furthermore, the assembly of heterostructures consisting of several layers of different 2D materials with precise control of twist angle by exploiting van der Waals forces has been a game changer in the field of low dimensional physics. By now they have reached a extrmely flat band and a level of cleanness where the most fragile of all correlated ground states in 2D electron systems can be anticipated.

Twisted bilayer graphene is the most exotic outcome of this van der Waals heterostucture. As a result of the twist, the Dirac cones from each layer are displaced in momentum space, which can strongly suppress the interlayer coupling. Different regimes must be distinguished. Near the so-called magic angle of 1.05°, the band dispersion becomes extremely flat and both layers are always strongly coupled. This gives rise to a rich phase diagram with ferromagnetic, correlated insulating and superconducting ground states. At larger twist angle, the energy dispersion of the miniband that forms due to zone folding around zero energy, closely resembles that of graphene. A Van Hove singularity forms when the states belonging to the displaced Dirac cones come close and hybridize. This merger occurs at an energy no longer set by the hopping parameter of graphene (about 3eV), but instead at lower energy controlled by the angle induced displacement of the Dirac cones. At small angles above the magic angle, the chemical potential can easily be lifted up to this energy with conventional gating techniques.

In this talk, we will briefly review the state-of-the-art device fabrication method and show inter- and intralayer transport properties of twisted bilayer graphene with weakly coupled regime. We found interlayer coherence is broken even with atomic layer separation. In this regime, odd-integer quantum Hall physics is not anticipated in the weak coupling regime when the layer densities are balanced, yet it is observed. We interpret this as a signature of interlayer Coulomb interaction induced interlayer coherence and Bose Einstein condensation of excitons formed by holes and electrons at half filling of each layer.

Keywords:

van der Waals Heterostructure, Quantum Hall Effect, Twisted Bilayer Graphene

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.01

Dynamical screening effects on nuclear astrophysics

HWANG EUNSEOK [1], CHEOUN Myung Ki *[1], PARK KIWAN *[1], JANG DUKJAE [2]
[1]Department of Physics, Soongsil University
[2]Center for Relativistic Laser Science, IBS
cheoun@ssu.ac.kr, pkiwan@gmail.com

Abstract:

We study dynamical screening effects of nuclear charge on big bang nucleosynthesis (BBN). A moving ion in plasma creates a distorted electric potential leading to a screening effect which is different from the standard static Salpeter formula. We consider the electric potential for a moving test charge, taking into account dielectric permittivity in the unmagnetized Maxwellian plasma during the BBN epoch. Based on the permittivity in a BBN plasma condition, we present the Coulomb potential for a moving nucleus, and show that enhancement factor for the screening of the potential increases the thermonuclear reaction rates by a factor order of 10−7 . In the Gamow energy region for nuclear collisions, we find that the contribution of the dynamical screening is less than that of the static screening case, consequently which primordial abundances hardly change. Based on the effects of dynamical screening under various possible astrophysical conditions, we discuss related plasma properties required for possible changes of the thermal nuclear reactions.

Keywords:

BBN, Dynamical screening, reaction rate

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.02

INVESTIGATION OF MULTI-REFLECTION TIME-OF-FLIGHT MASS ANALYZER OPERATING

NGUYEN Uyen Kim*[1], CHAE KyungYuk [1], NGUYEN NgocDuy [1], JUN YoungMoon [2]
[1]Department of Physics, Sungkyunkwan University
[2]Daejeon, Institute for Basic Science
kimuyendlu@nuclearemail.org

Abstract:

With the advantages of single-ion sensitivity, large mass range, short measurement time, and less expensive construction cost, the multi-reflection time-of-flight mass spectrometer (MRTOF-MS) is considered as a modern technique for precise mass measurements of exotic nuclei and molecules. The mass analyzer is designed and optimized to achieve the highest mass resolving power by extending the flight time through a folded trajectory. This is accomplished by using two electrostatic mirrors in a coaxial arrangement to reflect the ions axially and focus them transversally to achieve a stable trajectory. In this work, we optimized the potentials on the electrodes in the mini-MRTOF mass analyzer. We combined the mirror-switching and in-trap-lift mode to trap ions and release them with the kinetic energy of 1.5 keV. The maximal mass resolving power has been achieved to be 2.86 x 10^4 corresponding to 500 ions of $^{65}As^+$, for instance, with the time spread around 20 ns. The dependence of resolving power on the bias of electrodes was investigated. We found that the resolving power varies by a factor of two when the bias of electrodes was simultaneously reduced by 10%. The effect of operating conditions, i.e., numbers of reflections, statistics, and beam size, were also investigated. It shows that the resolving power changes by a few factors due to a deviation of 10% in the beam size. The results in the present study are useful for operating MR-TOF spectrometers at RI beam facilities, i.e., RAON, in the future.

Keywords:

precise mass, exotic nuclei, multiple-reflection time-of-flight (MR-TOF)

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.03

Variations in predicted β⁻-decay half-lives and isotopic abundance in the r-process

NGUYEN Duy Ngoc*[1], CHAE KyungYuk [1], NGUYEN KimUyen [1]
[1]Department of Physics, Sungkyunkwan University
ngocduydl@gmail.com

Abstract:

We report on the variations in estimations of the β^--decay and (ɣ,n) photodisintegration rates due to mass uncertainties of neutron-rich nuclei beyond Fe, which are possible waiting points (i.e., ^{74}Fe, ^{84}Zn, ^{88,90}Ge, ^{89,91}As, ^{92,94}Se, ^{95,97}Br, ^{106}Sr, ^{141}Sb, ^{145}I, ^{148}Xe, etc.) in the rapid neutron-capture process (r-process). The impact of the variations on the isotopic abundance of r-process was investigated. The β^--decay half-lives and the photodisintegration rates, which are key inputs in r-process calculations, were analyzed based on the updated mass database, AME2016. It was found that the half-lives of the possible waiting points are ranging from 20 to 161 ms. Besides, the β^--decay rates of possible waiting points vary by up to a factor of 6 due to mass uncertainties, leading to a large change in the r-process abundance. Because of uncertainties in the half-lives, variations in the estimated n_n-T_9 conditions for the dominant between neutron captures and β decays, which is important for the shift of reaction flows toward stability, was also observed. The results indicate that precise masses of the considered neutron-rich nuclei are necessary to be measured for better understanding the β-decay half-lives and nucleonsynthesis via r-process. With the estimated half-lives from tens to hundreds of milliseconds, Multiple-Reflection Time-of-Flight technique, which will be installed at RAON facility, is sufficient for the precise mass measurements of the concerned isotopes.

Keywords:

mass spectrometer, MR-TOF, neutron-rich isotopes, neutron capture, photodisintegration

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.04

Generation of the primordial magnetic field due to neutrino interaction

PARK Kiwan *[1], CHEOUN Myung-Ki [1]
[1]Physics, Soongsil University
pkiwan@gmail.com

Abstract:

The movement of the plasma in the Universe creates a magnetic filament, which again confines the plasma motion. And the nuclear reaction takes place in this magnetized plasma environment. However, the process of generation of the primordial magnetic field is not yet well known. After Big Bang, quantum fluctuation such as QCD or phase transition followed by plasma fluctuation (Biermann battery effect) is known to generate the seed magnetic field. However, the magnitudes of these seed fields are too weak (10^{-62} – 10^{-19} G) compared to the current average magnetic field (10^{-5}G). Dynamo theory infers that it would take a much longer time than the age of the Universe for the weak seed fields to grow up to the currently observed magnetic filaments.

As one of the possible physical processes, we are paying more attention to magnetic helicity yielded by the interaction of the neutrinos with leptons. Magnetic field helicity <A.B> refers to the number of knotted magnetic fields. Magnetic helicity is a basic physical quantity that is better preserved than magnetic field energy. The magnitude and scale of magnetic helicity grow of themselves using the fluctuations of the plasma. We analyze this nonlinear process represented as electromotive force (EMF) VXB. We show how EMF can be linearized by the alpha, beta effect analytically and phenomenologically.

Keywords:

Primordial magnetic field, Neutrino, Dynamo, Plasma

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.06

Collective neutrino oscillation including the sterile neutrino in the core-collapse supernovae neutrino process

KO Heamin [1], JANG Dukjae [2], CHEOUN Myung Ki *[1]
[1]Department of Physics, Soongsil University
[2]Center for Relativistic Laser Science, Institute for Basic Science
cheoun@ssu.ac.kr

Abstract:

Neutrino anomalies reported by shortbase line experiments imply the possibility for the existence of the sterile neutrino, which is one of the open questions in neutrino physics. If the sterile neutrino exists in nature, the behavior of neutrino oscillation would be different from the three favor model. For the core-collapse supernova (CCSN) neutrino process, considering the Hamiltonian composed of vacuum and matter terms for the globally fitted 3+1 neutrino model, we showed that the resonance in neutrino oscillation remarkably differs from the three favor model. However, since neutrinos are densely trapped by the gravitational collapse near the neutrino sphere, it is widely accepted that the collective neutrino oscillation caused by the neutrino-neutrino interaction is significant in CCSN physics as well as the neutrino process. As a subsequent study, we present the effects of collective neutrino oscillation including the sterile neutrino on the CCSN neutrino process in this meeting.

Keywords:

neutrino process, sterile neutrino, collective neutrino oscillation

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.07

Production of a hidden-strangeness pentaquark-molecular bound state

NAM Seung-il *[1]
[1]Department of Physics, Pukyong National University
sinam@pknu.ac.kr

Abstract:

In this talk, we present a recent research on the $K^*\Sigma$ bound state as a hidden-strangeness pentaquark molecular via $K^+p \to K^+\phi p$, by considering the hidden-charm pentaquark molecular state was reported in the LHCb experiment. For this purpose, we employ the effective Lagrangian approach at the tree-level Born approximation. We also investigate the effect from $K^*(1680, 1^-)$ and pentaquark Θ^{++}_{27}. We observe that the signal-to-background ratio is about 1.7% and the cross-section is enhanced in the backward-scattering region in the c.m. frame. The target-recoil spin asymmetry is also studied to reduce the background contributions. The present theoretical observations will be a informative guidance for future experiments as in J-PARC.

Keywords:

Bound state, Pentaquark, Molecular state, Effective Lagrangian

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.08

Near-threshold photoproduction of J/ψ mesons off the proton

KIM Sangho *[1], NAM Seung-il [1]
[1]Physics Department, Pukyong National University
sanghokim28@gmail.com

Abstract:

The photoproduction of J/ψ mesons off protons is studied in an effective Lagrangian approach,
focusing on the low energy region. Due to the Okubo-Zwieg-Iizuka (OZI) rule, the hadron
exchange process is known to be highly suppressed. We consider the exchanges of the ground-state
mesons and of the tetraquark mesons as well. The two exchanges produce differentl results, each
revealing specific features. The relevant experimental data will be measured in Hall C with CLAS12 at Jefferson Lab.

Keywords:

J/ψ photoproduction, effective Lagrangians, tetraquark mesons

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I3.09

Quark matter in a rotating frame via instanton vacuum

NAM Seung-il *[1]
[1]Department of Physics, Pukyong National University
sinam@pknu.ac.kr

Abstract:

In this talk, we investigate quark matter in a rotating frame via instanton vacuum. In addition to that, we consider strong constant magnetic fields, which are parallel to the angular momentum of the rotating frame. First, we obtain a gap equation of the instanton model in which quarks and nonperturbative gluons as instantons and anti-instantons are interacting each other nonlocally. In addition, we employ the parity-violating quark mass, indicating the finite number difference between the instantons and anti-instantons. We confirm that the chiral magnetic effect (CME) due to the local chiral chemical potential is modified by the rotation. We also note that the chiral vortical effect (CVE) is derived from the model naturally. The magnetic catalysis is observed then reduced according to the rotation since it plays a similar role to the quark chemical potential.

Keywords:

Chiral magnetic effect, Chiral vortical effect, Instanton vacuum, Rotating QGP, Extermal magnetic field

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I17.01

Topological Floquet engineering of a 1D optical lattice via resonantly shaking with two harmonic frequencies

SHIN Yong-il *[2,1], KANG Jin Hyoun[2,1]
[1]Center for Correlated Electron Systems, Institute for Basic Science
[2]Department of Physics and Astonomy, Seoul National University
yishin@snu.ac.kr

Abstract:

Floquet engineering concerns generating new properties out of a system via periodically driving it with its external or internal parameters. In line with increasing interest in topological insulators and related physics, Floquet engineering of band structures has been actively investigated with many lattice systems, establishing a novel direction for creating topological states. In this talk, we will present our experimental and numerical investigation on the topological properties of a resonantly shaken one-dimensional optical lattice system, where the lattice position is periodically driven with two harmonic frequencies to generate one- and two-photon couplings between the two lowest orbitals. In a two-band approximation, we showed that degenerate edge states appear under a certain driving condition and that the corresponding topological phase is protected by the chiral symmetry of the periodically driven system. Furthermore, we found that a topological charge pumping effect can arise when the driving parameters are slowly modulated around a critical point and that a flat band structure can emerge with topologically nontrivial character in a certain driving condition. We will discuss the experimental realizations of the topological phenomena in the tunable Floquet lattice system.

Keywords:

Quantum simulation, Floquet engineering, Optical lattices, Quantum gases

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

I17.02

Quantum annealing with Rydberg atoms

AHN Jaewook *[1]
[1]Physics, KAIST
jwahn@kaist.ac.kr

Abstract:

Significant efforts are being directed towards developing a quantum annealer to solve combinatorial optimization problems. The challenges are Hamiltonian programming and large-scale implementations. Lately there has been rapid progress in Rydberg-atom quantum simulators, which have advantages, compared to most other qubit platforms, regarding the both challenges. Here we report our quantum annealing experiments of Rydberg atoms, which include three-dimensional qubit arrangements for continuous Hamiltonian tuning, Cayley-tree Ising Hamiltonians, and quantum wires for maxmimal indepednent set problems.

Keywords:

quantum simulation, Rydberg atom, quantum computing

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

PL1.01

Chiral magnetic effect in a Weyl superconductor

BEENAKKER Carlo *[1]
[1]Lorentz Institute for Theoretical Physics, Leiden University
beenakker@lorentz.leidenuniv.nl

Abstract:

The chiral magnetic effect is the appearance of a current along the lines of magnetic flux, due to an imbalance between Weyl fermions of opposite chirality. In a Weyl semimetal this is a dissipative, non-equilibrium current. We will discuss how this current can flow in equilibrium, without dissipation, in the vortex lattice of a Weyl superconductor. The chirality imbalance appears when one of the two chiralities is confined to vortex cores. The confined states are charge-neutral Majorana fermions.

Keywords:

Weyl superconductor

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T1.01

Unconventional Spin Transport in Quantum Materials

KIM Se Kwon *[1]
[1]Physics, KAIST
sekwonkim@kaist.ac.kr

Abstract:

Recent advancements in spintronic techniques originally developed for spin-based devices now enable us to study fundamental spin physics of various quantum materials with unprecedented spin-current control and measurement, opening a new area of theoretical and experimental investigation of quantum systems. In this talk, we will introduce this emerging research area of spin transport in quantum materials which is fueled by the global interest in quantum information science. As examples, we will discuss our discovery of magnonic topological insulators realized by 2D magnets [1-3], which shows how spintronic techniques can be used for probing elusive quantum materials, and our prediction of long-range spin transport mediated by a vortex liquid in superconductors [4], which shows that quantum materials can provide novel platforms for efficient spin-transport devices. We will conclude the talk by offering a future outlook on quantum spintronics.

[1] S. K. Kim, H. Ochoa, R. Zarzuela, and Y. Tserkovnyak, “Realization of the Haldane-Kane-Mele Model in a System of Localized Spins,” Phys. Rev. Lett. 117, 227201 (2016)
[2] G. Go, S. K. Kim, and K.-J. Lee, "Topological Magnon-Phonon Hybrid Excitations in Two-Dimensional Ferromagnets with Tunable Chern Numbers," Phys. Rev. Lett. 123, 237207 (2019)
[3] S. Zhang, G. Go, K.-J. Lee, S. K. Kim, "SU(3) Topology of Magnon-Phonon Hybridization in 2D Antiferromagnets," Phys. Rev. Lett. 124, 147204 (2020)
[4] S. K. Kim, R. Myers, and Y. Tserkovnyak, "Nonlocal Spin Transport Mediated by a Vortex Liquid in Superconductors," Phys. Rev. Lett. 121, 187203 (2018)

Keywords:

spintronics, quantum materials, spin transport, 2d magnets

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T2.01

Surface Photovoltage Characterization using Kelvin Probe Force Microscopy

KIM Dong-Wook *[1]
[1]Department of Physics, Ewha Womans University
dwkim@ewha.ac.kr

Abstract:

Atomic force microscopy (AFM)는 가장 주목 받는 nanometrology tool 중 하나이다. 특히, 표면 전위를 측정하는 Kelvin probe force microscopy (KPFM)는 광원을 이용하면 높은 공간분해능으로 광생성 잉여 전하에 의한 surface photovoltage (SPV) 측정이 가능하다. 본 튜토리얼에서는 KPFM 기반 SPV 측정 원리와 연구사례를 살펴봄으로써 나노 소재 및 소자 연구에 있어서 다양한 활용 가능성을 고찰해보고자 한다.

Keywords:

surfaced photovoltage, Kelvin probe force microscopy, nanostructures

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T3.01

물리교육과 내용학 수업의 전문성 기반에 의한 방향성

KIM Sung Won *[1]
[1]Science Education, Ewha Womans University
sungwon@ewha.ac.kr

Abstract:

이 발표에서는 사범대학 물리교육과에서 이루어지는 물리내용학 교육과 자연대학의 물리학과 또는 관련학과의 그것과의 차별화에 대한 논의를 다룬다. 이때 학과의 설립 목적에 따른 전문성 배양에 기반한 과목 개설과 수업에 대해 방향성을 실례와 함께 제시한다.

Keywords:

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T4.01

3D Field Physics in Tokamak Plasmas

PARK J.-K. *[1], HU Q. M. [1], LOGAN N. C. [1,2], YANG S. M. [1], KIM S. K. [1,3], KOLEMEN E. [3], PAZ-SOLDAN C. [4], JEON Y. M. [5], KIM K. [5], PARK G. [5], LEE H. H. [5], LEE J. H. [5], IN Y. [6], LEE Y.-S. [7], NA Y.-S. [7]
[1]Princeton Plasma Physics Laboratory
[2]Lawrence Livermore National Laboratory
[3]Princeton University
[4]Columbia University
[5]Korean Institute of Fusion Energy
[6]Ulsan National Institute of Science and Technology
[7]Seoul National University
jpark@pppl.gov

Abstract:

Massive fusion burning plasmas will be tested first in a tokamak, a toroidally axisymmetric device for magnetic confinement. It is the symmetry in the magnetic field that enables a toka- mak to confine hot and charged particles more efficiently than other confinement concepts, and thus any unexpected departure from the symmetry, i.e. 3D error field (EF), must be properly compensated. Surprisingly great utilities of 3D fields have also been discovered in tokamak operations as highlighted by 3D control of instabilities such as edge-localized-mode (ELM). These two opposing examples of 3D fields in a tokamak are in fact both related to the resonant bifurcation of local magnetic topology from nested magnetic surfaces to magnetic island chains, and even potentially to stochastic volumes, through the magnetohydrodynamic (MHD) evolu- tions with plasma fluids. Fundamental particle motions and transport are also changed in any such form of the 3D magnetic topologies, in particular promoting the toroidal drag of stabiliz- ing rotation due to the loss of toroidal symmetry. It is a major challenge for tokamak science to optimize 3D fields to leave only the beneficial part of the changes in magnetic topologies, MHD dynamics, and kinetic transport, through virtually unlimited choice of 3D fields and multi-scale tokamak profiles. Nonetheless recent linear and non-linear physics studies and validations have successfully resolved the key aspects such as major MHD and transport coupling optimizations, bifurcation thresholds and resonant windows, and adaptive control - which all shed light on the predictive use of 3D fields for tokamaks. As will also be introduced in the talk, KSTAR has been a major contributor in this area with its unique capabilities on 3D control coils, advanced imaging diagnostics, and long-pulse operation of high performance scenarios. This work was supported by US DOE Contract DE-AC02-09CH11466, and also by the Korean Ministry of Science, ICT and Future Planning.

Keywords:

Tokamak, 3D fields, EF, RMP, NTV

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T5.01

광시계와 SI 초의 재정의 (Optical Clocks and Redefinition of SI Second)

이원규*[1]
[1] 한국표준과학연구원
oneqlee@kriss.re.kr

Abstract:

현재 국제단위계(SI)에서 초(second)는 세슘 원자의 마이크로파 전이선을 이용해 정의된다. 최근 들어 광시계의 비약적인 발전으로 기존 세슘 원자시계보다 100 배 이상 정확한 결과들이 속속 보고되고 있어서, 2026 년 ~ 2030 년 경에 광시계를 이용하여 SI 초가 재정의될 것으로 예상된다. 이 강의에서는 광시계의 기본 원리, 발전 상황, 응용 분야 및 초 재정의의 파급효과에 대해 다룰 것이다.

Keywords:

Optical Clocks

2021 KPS Spring Meeting
2021-04-21 ~ 2021-04-23

T6.01

저차원 반도체 소재의 전자 구조 및 밴드갭 분석 기술 (Characterizing Electric Bandgaps of Low-dimensional Semiconductors)

YANG Heejun *[1]
[1]Department of Physics, KAIST
h.yang@kaist.ac.kr

Abstract:

트랜지스터, 다이오드 등 중요한 반도체 소자의 기본이 되는 전자 구조 및 밴드갭 특성은 지금까지 3 차원 반도체 소재를 대상으로, 광학적/전기적 방법으로, 다양하게 연구되어 왔다. 최근 새롭게 연구되고 있는 2 차원 반도체 및 저차원 반도체 구조에서는 낮은 수준의 screening, 높은 exciton 결합 에너지 등 기존에 고려되지 않은 물리 현상이 발현되어, 반도체 특성 분석에 새로운 분석법을 요구하고 있다. 본 강연에서는 저차원 반도체 소재가 갖는 특이한 물성 측정 및 이를 활용하여 새로운 반도체 소자를 개발하려는 노력 및 결과를 소개한다.

Keywords:

Semiconductor, Bandgap, Low-dimension

포스터발표논문

Poster session abstract

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.101

Ultrasensitive MoS_2 Avalanche Phototransistors

SEO Junseok [1], PAK Jinsu [1], KIM Jae-Keun [1], LEE Jin Hee [2], CHO Kyungjune [3], KIM Jaeyoung [1], JANG Juntae [1], LIM Seong Chu [2], CHUNG Seungjun [4], KANG Keehoon [5], LEE Takhee [*1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Department of Energy Science, Sungkyunkwan University
[3]-, Max-Planck Institute of Microstructure Physics
[4]Soft Hybrid Materials Research Center, KIST
[5]Department of Materials Science and Engineering, Yonsei University
tlee@snu.ac.kr

Abstract:

In contrast to graphene, two-dimensional (2D) transition metal dichalcogenides (TMDCs) possess a plethora of alluring characteristics such as a nonzero bandgap and strong light-matter interactions, which make them as a promising candidate for next-generation electronics and optoelectronics [1]. For the past decade, there have been diverse studies on improving the optoelecronic properties of phototransistors based on 2D TMDCs by utilizing chemical treatments or photosensitizing layers [2,3]. In this work, we took a new approach to capitalize on the avalanche breakdown process in order to enhance the photoresponsivity and detectivity of MoS_2 phototransistors. We achieved the photoresponsivity of ~3.4×10^7 A W^{-1} and the detectivity of ~4.3×10^{16} Jones under a low dark current (~100 nA) by making use of the photo-initiated avalanche carrier multiplication. Our work grants a simple and promising method to realize atomically thin ultrasensitive photodetectors.

References
[1] Q. H. Wang et al., Nat. Nanotechnol. **7**, 699 (2012).
[2] D.-H. Kang et al., Adv. Mater. **28**, 7799 (2016).
[3] Z.-Y. Peng et al., Adv. Mater. **5**, 1800505 (2018).

Keywords:

MoS2, field-effect transistor, avalanche photodetector

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.102

Interlayer modes in 2H-$MoTe_2$/hBN heterostructure

NGUYEN Manh Hong [1], LIM Soo Yeon [1], CHEONG Hyeonsik [*1]
[1]Department of Physics, Sogang University
hcheong@sogang.ac.kr

Abstract:

2H-$MoTe_2$ is a semiconductor belonging to group VI – transition metal dichalcogenides with an indirect (~1 eV) and a direct (1.1 eV) bandgap in bulk and monolayer, respectively. Hexagonal BN (hBN) is an insulator with a large bandgap (~6 eV). Heterostructures based on van der Waals materials have been studied intensely because of their new physical properties which cannot be observed in a single material such as interlayer excitons and the moire pattern [1]. Through the phenomena, the origin of interlayer interactions in heterostructure is revealed and understood. Raman spectroscopy is an effective technique to study Van der Waals materials, because the low-frequency Raman spectrum directly reflects the interlayer interactions. Recently, the unusual low-frequency Raman peaks have been reported in hBN/WS_2 heterostructures due to cross-dimensional electron-phonon coupling [2]. In this work, we fabricated heterostructures based on 2H-$MoTe_2$ and hBN by mechanical exfoliation and the dry transfer method. The thicknesses of 2H-$MoTe_2$ and hBN are from 1 to 4 layers and several nanometers, respectively. The low-frequency Raman measurements were performed to observe interlayer vibrational modes in the heterostructures. New modes in the low-frequency region appeared, and the peak positions of the interlayer vibrational modes in 2H-$MoTe_2$ were changed. These behaviors of the Raman modes in the heterostructures suggest that interlayer interactions depend on the thickness of samples and the contribution of the twist angle between 2H-$MoTe_2$ and hBN is negligible. The peak positions of the interlayer vibrational modes can be explained by the linear chain model.

References
[1] Pasqual Rivera et al., Nature nanotechnology **13**, 1004–1015(2018).
[2] Miao-Ling Lin et al., Nature communications **10**, 2419(2019).

Keywords:

Interlayer modes, 2H-MoTe2, hBN, Heterostructure , Raman spectroscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.103

Study of multi-bit floating gate memory characteristics

GWON Oh Hun [1], KIM Jong Yun [1], KANG Seok-Ju [1], YU Young-Jun *[1]
[1]Department of Physics, Chungnam National University
yjyu@cnu.ac.kr

Abstract:

Currently, as digital technology is rapidly developing, next-generation computing technologies are required. However, new materials are needed to complement existing Si-based materials. In particular, the two-dimensional material is a material that is very strong in terms of integration and is suitable for supplementing the limitations of existing materials. In addition, research on multi-bit is actively underway to increase the degree of integration. Multi-bit means having several current levels in one memory element, and has the same effect as combining several elements into one. Therefore, we have implemented a multi-bit memory device. The sturcture of devices is MoS_2(Molybdenum disulfide)/hBN(hexagonal boron nitride)/graphene/SiO_2/Si. Following those layers stacking, the electrode was deposited with Cr / Au. We confirmed on/off ratio, and retention time from our floating gate memory devices. Additionally, we checked multi-bit characteristics.

Keywords:

multi-bit, floating gate memory, two-dimensional materials

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.104

Electrically Controllable Neuromodulation Emulated by 2D Weight-Tunable Memristor for Neuromorphic Electronics

HUH Woong [1], JANG Seonghoon [1], SO Jae-Pil [2], KIM Jong Chan [3], LEE Donghun [1], KIM Yeon Ho [1], PARK Hong-Gyu [2], JEONG Hu Young [4], WANG Gunuk [1,5], LEE Chul-Ho *[1,5]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]Department of Physics, Korea University
[3]School of Materials Science and Engineering, UNIST
[4]UNIST Central Research Facilities , UNIST
[5]Department of Integrative Energy Engineering, Korea University
chlee80@korea.ac.kr

Abstract:

Two-dimensional (2D) semiconductors have emerged as a promising material for low-power and high-performance electronics because of the intrinsic atomic thickness and the exceptional properties maintaining even with ultimate scaling. Besides, the competitive ability to electrostatically control the electrochemical potential allows us to design band-modulated 2D heterostructures for implementing a variety of gate-tunable electronic devices. Such a unique capability of 2D materials can also offer great potential for realizing an energy-efficient artificial synapse with high controllability. Nevertheless, the artificial synapse utilizing functionally unique properties has rarely been demonstrated, as appropriate materials and structures with robust memristive switching characteristics and an adequately integrated device architecture are not available.

Here, we report a 2D weight-tunable memristor using the defect-controlled molybdenum disulfide (MoS_2) as a switching layer, working in a three-terminal FET geometry. Through the precise control of defect states in the MoS_2 channel, the memristive devices with low-power switching were achieved due to the voltage-dependent space charge limited current (SCLC), which is distinct from previously reported memtransistors. In addition, owing to the gate-controlled trapping of defect states and consequent modulation of SCLC in the atomically thin channel, the device exhibited electrostatically tunable memristive switching characteristics. Basically, the device could implement essential synaptic characteristics, such as short-term plasticity and long-term plasticity. Notably, by electrostatic tuning with a gate terminal, we can also regulate the degree and tuning rate of the synaptic weight independent of the programming impulses from source and drain terminals, with sub-1 FJ pulse input. These capabilities eventually enable the accelerated consolidation and conversion of synaptic plasticity, functionally analogous to the synapse with an additional neuromodulator in biological neural networks. Furthermore, such acceleration improves the recognition accuracy and reduces the learning step in MNIST pattern recognition, with considerable power-saving benefits. Our demonstration represents an important step toward highly networked and energy-efficient neuromorphic electronics.

Keywords:

2D Materials, Memristor, Neuromorphic application

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.105

Chemical Vapor Deposition of Graphene on Metal-Coated Carbon Micro Fiber Filament

KIM Minjae [1], KO Yong-il [1], LEE Gilyong [1], LEE Bumjin [1], KIM Keun Soo *[1]
[1]Department of Physics & Astronomy, Sejong University
kskim2676@sejong.ac.kr

Abstract:

본 연구에서는 진공 게이지에 이용할 금속 코팅된 필라멘트를 산화로부터 보호하기 위하여 그래핀을 합성하기 위한 기초 연구이다. 이전의 확보한 Chemical Vapor Deposition(CVD) 공법을 이용한 다양한 금속 포일 위에서 그래핀을 합성하는 조건을 응용하여 여러 금속 와이어 위에서 그래핀을 합성하는 조건에 대하여 연구하였다. 이후 실험 조건에 따른 그래핀의 품질 변화를 라만 분광기를 이용하여 특성을 확인하였고, 주사전자현미경을 이용하여 그래핀이 균일하게 합성되었음을 확인하였다.
금속의 종류, 와이어의 두께에 따른 그래핀의 특성 변화를 확인하였고, 금속을 도금한 마이크로 탄소 필라멘트 위에서도 그래핀을 합성하여 합성된 그래핀의 품질을 확인하였다. 고온의 합성 과정 동안 도금한 금속의 증발을 방지하기 위해 낮은 온도에서 액체 소스를 이용한 Rapid CVD Growth를 진행하였다.
이후 그래핀이 합성된 와이어가 산화로부터 보호받는지를 확인하기 위하여 섭씨 85도, 습도 85%에서 전류를 흘려 시간에 따른 전류변화를 측정하며 내산화성 테스트를 진행하였다.
자세한 연구 내용은 본 포스터 발표에서 설명할 예정이다.

Keywords:

CVD, Graphene, CarbonMicroFiber

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.106

Van der Waals metal-semiconductor field-effect transistor with the Fermi-level pinning-free Schottky gate approaching the intrinsic Boltzmann switching limit

KIM Yeon Ho [1], LEE Donghun [1], KIM Jong Chan [2], HUH Woong [1], KIM Tae Soo [3], SO Jae-Pil [4], PARK Hong-Gyu [1,4], KANG Kibum [3], JEONG Hu Young [2], LEE Chul-Ho [*1,5]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]UNIST Central Research Facilities (UCRF) and Department of Materials Science and Engineering, UNIST
[3]Department of Materials Science and Engineering, KAIST
[4]Department of Physics, Korea University
[5]Department of Integrative Energy Engineering, Korea University
chlee80@korea.ac.kr

Abstract:

Van der Waals (vdW) semiconductors such as transition metal dichalcogenides (TMDs) have emerged as a promising material for next-generation electronics due to excellent gate coupling and immunity to short channel effects even at the ultimate scaling. To achieve high-performance electronic device, the gate stack that enables the effective electrostatic control of the TMD channel is necessary. In this regard, the metal-semiconductor junction can be a promising alternative considering that appropriate gate dielectrics are not available except hexagonal boron nitride. Nevertheless, control of the metal-vdW semiconductor junction is still challenging because of unavoidable Fermi-level (E_F) pinning originated from either metal-induced gap states (MIGS) or disorder-induced gap states (DIGS). Here, we propose a new device architecture of vdW metal-semiconductor field-effect transistors (MESFETs) with the E_F pinning-free Schottky gate. The E_F depinning is achieved by forming the vdW metal-semiconductor junction between the TMDs and the surface-oxidized metals due to the suppression of both DIGS and MIGS. Utilizing such a Schottky gate, the vdW MESFETs with low-power and stable operation were demonstrated. The ON/OFF switching via the E_F modulation of the TMD channel occurred at V_g < 0.7 V owing to effective gate coupling. More importantly, the devices exhibited excellent transfer characteristics with the subthreshold swing of 60 mV/dec and negligible hysteresis, approaching the nearly intrinsic Boltzmann limit. In addition, the E_F depinning effects were verified in various vdW junctions with different metals through Kelvin probe force microscopy and temperature-dependent transport measurements. Furthermore, scalability of the device concept has been proven by fabricating the wafer-scale array of MoS_2 MESFETs.

Keywords:

Transition Metal Dichalcogenides, Metal-semiconductor field-effect transistor, Fermi-level depinning, Van der Waals Schottky gate

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.107

Ferroelectric behavior of In_2Se_3 Nanomaterials for 2D Synaptic Devices

KANG Seok-Ju [1,2], KIM Jong Yun [1,2], GWON Oh Hun [1], YU Young-Jun *[1]
[1]Department of Physics, Chungnam National University
[2]Institute of Quantum Systems (IQS), Chungnam National University
yjyu@cnu.ac.kr

Abstract:

Atomically thin two-dimensional transition-metal dichalcogenides (TMDCs) have attracted tremendous attentions due to its significant potential for novel memory, optoelectronics devices, and chemical gas sensors. Among them, specific atoms composition ferroelectric materials have spontaneous polarizations that can be switched by applying an electric field, thus rendering them highly useful in nonvolatile memory and computing applications. So far, most of the three-terminal synaptic transistors use the dielectric layer to change the state of the channel and mimic the synaptic behavior. For this purpose, special dielectric layers are needed, such as ionic liquids, solid electrolytes, or ferroelectric insulators, which are difficult for miniaturization and integration. Moreover, the ferroelectricity of insulating oxide materials, such as HfO_2, $BaTiO_3$, depends sensitivity on its growth history and the nature of dopants. To solve the problems, we used 2D ferroelectric semiconductors, which has an intrinsic 2D structure compatible with vertical scaling and high carrier mobility, for channel materials as an alternative platform.
Therefore, we report a novel type of synaptic transistors using a two-dimensional ferroelectric semiconductor, i.e., α-In2Se3, as the channel material to mimic the synaptic behavior. This 2D ferroelectrics can be classified as in-plane, out-of-plane, and intercorrelated ferroelectric semiconductors. In addition, this semiconducting material is a promising candidate for realizing synaptic weight elements in neural network hardware because of their nonvolatile multilevel memory effect. Normally, α-In_2Se_3 flakes exhibit only n-type behavior when they were used as a channel material of field-effect transistors (FETs) due to its low-lying conduction band minimum level. Here, we fabricated the n-type ferroelectric semiconductor transistor by stacking α-In_2Se_3 on hBN flakes. Subsequently, the α-In_2Se_3 ferroelectric semiconductor channel device was characterized by measuring the electrical memory signals including STP, STD, LTP, LTD. At the same time, we investigated the thickness of various 2D materials flakes using AFM and Raman spectra systems for comparing the atomic layer thickness dependent ferroelectric behaviors.

Keywords:

ferroelectric materials, memory effect, field-effect transistors, synaptic device, transition metal dichalcogenides

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.108

Chirality of Fingerprint

LEE Jaebeom *[1], HWANG Siyeong [2]
[1]Chemistry, Chungnam National University
[2]Chemical Engineering and Applied Chemistry, Chungnam National University
nanoleelab@gmail.com

Abstract:

The study of chirality in 2D materials had little attention to date. A fingerprint is one of the most notable chiral surfaces in real life. Inspired by fingerprints, a universal strategy to impart chirality on 2D materials has been suggested. Surface pattern and curvature can both break the symmetry except the mirror planes of the component parallel and perpendicular to the direction of those. If surface pattern and curvature are applied simultaneously, symmetry can be break completely. Elastomeric grating meta-skin (EGMS), which is the polydimethylsiloxane (PDMS) with a uniform surface pattern from diffraction grating and gold coating has been used. Patterns of diffraction grating divided of different ridge distances, d. The EGMS showed no CD signals without curvature. The chirality was decided by angle **θ** which is the skew angle between the pattern direction **P** and tangent vector **T**, the size of **P** which is related to the density of ridges, and the size of **T** which is related to the size of curvature. The relation can be expressed by Chirality $\propto$ $|\mathbf{P}||\mathbf{T}|\sin 2\theta$. Also, a computational simulation study has proceeded. In actual fingerprints that might have chiral surfaces, the CD signals were detected using fabricated fingerprint EGMS. Impartment of chirality with two factors can be applied to the analysis, sensor, metasurface, and biometrics.

Keywords:

bio-inspired, fingerprint, chirality, surface pattern, symmetry breaking

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.109

Ab initio study of electronic properties of defects in monolayer GeS

CHOI Hyeongkyu [1], CHA Janghwan [1], HONG SukLyun *[1]
[1]Sejong University
hong@sejong.ac.kr

Abstract:

Two dimensional (2D) materials have recently attracted great attention in the fields of electronic devices due to their unique electrical and optical properties. Among 2D materials, graphene, black phosphorus (BP), and transition metal dichalcogenides (TMDs) have been actively studied in various ways. Along with such attention, germanium sulfide (GeS) has also received attention as it has a similar structure to BP. Furthermore, it is worthwhile to note that defects in 2D materials play a fundamental role in variation of their material properties because they can be donor or acceptor.
In this study, the effects of vacancies and substitutional atoms in monolayer GeS are investigated using density function theory calculations. We choose group IV or chalcogen atoms as substitutional ones which substitute for Ge or S in GeS. It is found that the band gap of GeS with substitutional atoms is close to that of pristine GeS, while the band gap of GeS with Ge or S vacancies is smaller than that of pristine GeS. In terms of formation energy, monolayer GeS with Ge vacancies is more stable than that with S vacancies. Details are analyzed using the orbital projected band structure, partial density of states, and charge density difference.

Keywords:

2D, GeS, vacancy, defects

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.110

Enhanced Raman mode in WS_2/ReS_2 heterostructure

NA Woongki [1], KWON Yongjae [1], CHEONG Hyeonsik *[1]
[1]Department of Physics, Sogang University
hcheong@sogang.ac.kr

Abstract:

Transition-metal dichalcogenides (TMDs) are known as layered materials and have been studied actively because of their novel properties such as strong light-matter interactions [1]. Tungsten disulfide (WS_2) and Rhenium disulfide (ReS_2) are two types of layered materials showing different dependence on the polarization angle of the incident light due to the different structure. The interactions between the two monolayers of WS_2 and ReS_2 and the polarization dependence of the heterostructure are not understood fully.

We stacked a monolayer WS_2 on another monolayer ReS_2 to fabricate heterostructures using the dry-transfer method [2]. Atomic force microscopy (AFM) and low-frequency polarized Raman measurements are conducted to inspect the quality of the heterostructure. Then, we compared the polarization dependence of the Raman modes from the heterostructure to those of the monolayers of WS_2 and ReS_2. The interlayer vibration mode shows weak anisotropy which may be induced from the anisotropy of ReS_2. Moreover, excitation energy-dependent Raman measurements were conducted for several samples which have different stacking angle between the armchair direction of WS_2 and the b-axis (Re-chain) of ReS_2, and the enhancement of Raman modes of WS_2 and ReS_2 are analyzed.

References
[1] C. Schneider et al., Nat. Comm. **9**, 2695 (2015₩).
[2] A. Castellanos-Gomez et al., 2D Mater. **1**, 011002 (2014).

Keywords:

two-dimensional materials, transition-metal dichalcogenides, TMDs, Raman spectroscopy, heterostructure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.111

In-situ microscopy studies of electromechanical response of ZnO microwires

TRAN Thi Hue [1], JE Yugyeong [1], JEONG Hyunjeong [1], LEE Sang-Wook *[1]
[1]Department of Physics, Ewha Womans University
nicesw@gmail.com

Abstract:

In this study, we observed electromechanical response of individual ZnO microwires using optical and electro microscopes. ZnO microwires were transferred from their growth substrate to an electrical leads attached to home-made micromanipulators. Electric field induced mechanical resonance of ZnO microwires were studied by in-situ measurements on optical and electron microscopes. The experimental set-up and future plan for in-situ electromechanical measurements based on our result will be presented.

Keywords:

Electromechanical response, In-situ measurements, ZnO microwires

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.112

Electronic properties of Y_2C/graphene/Y_2C van der Waals heterostructures

CHOI Chang-Gyu [1], KIM Junghwan [1], CHA Janghwan [1], HONG SukLyun *[1]
[1]Sejong University
hong@sejong.ac.kr

Abstract:

Due to the characteristics of Dirac cone in the reciprocal space, graphene has received enormous attention from the world's scientific communities. Moreover, as two-dimensional (2D) material, graphene has the benefit of making heterostructures by stacking with other materials. On the other hand, the 2D electrides such as Y_2C and Ca_2N have an uncommon electric charge distribution called the anionic electron, which is composed of electrons located between two electride layers. The anionic electrons are very loosely bound, causing them to act as an electron gas. In the viewpoint of future devices applications, it is important to investigate the electronic properties of graphene/electride van der Waals heterostructure by focusing on unique properties of graphene and electrides.
In this study, we have performed density functional theory calculations to calculate the electronic structure of Y_2C/graphene/Y_2C heterostructures built by sandwiching graphene between Y_2C electride layers. Especially, we focus on the change in charge distribution occurring in electron cloud of Y_2C/graphene/Y_2C heterostructures, and correspondingly the change of Fermi level in graphene surrounded by anionic electrons causing doping in graphene. The orbital projected band structure, partial density of states, charge density difference, and band alignment are investigated for analysis.

Keywords:

graphene, Y2C, anoinic electron

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.113

Interlayer Vibration Modes of Bilayer-Monolayer MoS_2/WSe_2 Heterostructure

OH Siwon [1], CHEONG Hyeonsik *[1], KIM Jungcheol [1]
[1]Department of Physics, Sogang University
hcheong@sogang.ac.kr

Abstract:

Two-dimensional-material-based heterostructures produce novel phenomena due to distinctive interactions between the stacked layers. For MoS_2 and WSe_2, several studies have been done for their monolayer-monolayer heterostructures [1]. However, there are only few studies on monolayer-multilayer or multilayer-multilayer structures. As a first step, we tried to investigate bilayer - monolayer heterostructure.
We fabricated 1L-WSe_2/2L-MoS_2 heterostructure using the dry-transfer method [2]. The twist angles of these heterostructures were determined using polarization dependent second harmonic generation. When the interlayer interaction between the constituent layers existed, we found that new low-frequency Raman modes appeared in addition to the breathing and shear modes of bilayer MoS_2. Using circularly polarized Raman spectroscopy, we assigned the peaks as breathing- and shear-like interlayer vibrational modes. For breathing-like modes, 3 or more peaks were observed only in the samples with relatively small angles (< 9 °), although only 2 normal modes can exist in a material with 3 layers. We also observed that these new modes vary with the twist angle of the samples. Two breathing-like modes were observed in samples with relatively big angles (< 9 °), with little angle-dependent peak shifts.

[1] Ming-Hui Chiu, ACS Nano. 8, 9649–9656 (2014)
[2] A. Castellanos-Gomez et al., 2D Mater. 1, 011002 (2014).

Keywords:

Raman spectroscopy, heterostructure, interlayer vibration mode, MoS2, WSe2

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.114

Artificial ultrasensitive synapses based on 2D material $CrPS_4$

PARK Bae Ho *[1], LEE Mi Jung [1], YOON Chansoo [1], AHN Jae-Pyoung [2], KIM Sung-Hoon [2]
[1]Department of Physics, Konkuk University
[2]Advanced Analysis Center, KIST
baehpark@konkuk.ac.kr

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. This memory device has analog resistive switching and good reproducibility, exhibits unilateral connection, long-term potentiation/depression characteristics, which are the main characteristics of artificial biological synapses, and is similar to ultra-low power consumption. In addition, even under the bending condition, the synapse device can still stably achieve a variety of synaptic functions. This work shows that memory devices made of two-dimensional materials can pave a promising path for the realization of synaptic systems and the future development of wearable electronic devices.

Keywords:

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.115

Surface Charge Transfer Doping of MoS_2 by AlO_x Overlayer

PARK Beomjin [1,2], GU Minseon [1], HAN Moonsup [*1]
[1]Department of Physics, University of Seoul
[2]Department of Smart Cities, University of Seoul
mhan@uos.ac.kr

Abstract:

The low on-current density resulting from substantial contact resistance has been a main obstacle for the realization of 2D layered material based low-power devices. Recently, as a solution to the problem, surface charge transfer doping methods of MoS_2 are reported by depositing AlO_x thin films, and the doping techniques are considered promising for their thermal stability and compatibility with current CMOS processes.[1, 2] In this work, we fabricated multi-layer MoS_2 back-gate field effect transistors and observed the n-type doping behavior of AlO_x. The MoS_2 samples are prepared by mechanical exfoliation and analyzed by atomic force microscopy and Raman spectroscopy. Source and drain contact are defined by using a photolithography and lift-off process. Next, we deposit an ultra-thin Al seed layer by DC magnetron sputtering, forming AlO_x by exposure in the air. We performed I-V measurements and observed a strong threshold voltage shift and improved current density by the n-type doping of AlO_x. In addition, we perform XPS spectroscopy to analyze charge transfer at the MoS_2/AlO_x interface. Through this work, we note that the charge transfer is very promising to improve the contact resistance problem and enlighten the charge transfer mechanism.

References:

[1] C. McClellan et al., ACS Nano 2021, 15, 1, 1587–1596
[2] A. Leonhardt et al., ACS Appl. Mater. Interfaces 2019, 11, 42697−42707

[Acknowledgements: NRF-2020R1F1A1048651, UOS-BSIRDF2019]

Keywords:

MoS2, Surface charge transfer doping, I-V measurement, Raman Spectroscopy, XPS

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.116

Fabrication and characterization of p-WSe_2/n-WS_2 heterojunction diode on SiO_2 and h-BN substrates

SHARMA Pradeep Raj[1], GAUTAM Praveen [1], AFZAL Amir Muhammad[2], PARK Byoungchoo [2], NOH Hwayong *[1]
[1]Sejong University
[2]Department of Electrical and Biological Physics, Kwangwoon University
hnoh@sejong.ac.kr

Abstract:

We have studied the electrical and opto-electrical properties of p-WSe_2/n-WS_2 heterojunction diode on SiO_2 and h-BN substrates. We have observed a significant enhancement of the diode rectification ratio and photovoltaic characteristics on the h-BN substrate. More than an order-of-magnitude enhancement is obtained on the diode rectification ratio ($>10^6$), whereas about two-fold increments in the overall opto-electronics behavior is observed on the h-BN substrate compared with those on the SiO_2 substrate. The excellent self-powered photo responsivity and external quantum efficiency we have obtained are 3 A/W and 588% respectively on the h-BN substrate at 10 mW/cm^2 photo-power density and 633 nm wavelength, whereas they reduce to about one-half on the SiO_2 substrate. Similarly dynamic response characteristic shows faster photo-response on the h-BN substrate compared to that on the SiO_2 substrate.

Keywords:

2D materials, heterojunction, photo-diode

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.118

WS2 Photo-Luminance Polarization Control using Microcavity Coupling

LEE Sanghoon [1], PARK Q-Han *[1]
[1]Korea University
qpark@korea.ac.kr

Abstract:

2D TMD(Transitional Metal Dichalcogenide) materials such as WS2, MoS2, WSe2 are well-known for having a band-gap valley structure, unlike graphene. Since their bands have a valley-dependent optical selection rule, the photo-luminance(PL) of TMD materials is polarized as right-hand-circular(RHC) or left-hand-circular(LHC) depending on the polarization of a pumping light source. Also, many researchers have studied TMD materials with micro-disk to make use of resonance, such as an excitonic laser. In contrast to these studies, however, a polarization of TMD applied with micro-disk is not yet studied enough. In this work, we introduce PL polarization control using WS2-microcavity coupling. We transferred CVD-grown monolayer WS2 to a Silicon Nitride disk on a quartz substrate. As pumping 594 nm laser to the center of Silicon Nitride disk, we could easily observe PL along the edge of the disk, and analyzed a polarization of the PL, comparing to a bare WS2. Our works make a major step toward controlling the polarization of PL when it comes to expecting and inducing polarization of PL using the coupling effect of TMD and microcavity.

Keywords:

TMD, WS2, Exciton, Photoluminance

Electrical and Photo-responsive Characteristics of FPS-K coated WS_2- and $MoSe_2$-Based Field-Effect Transistors with treatment of conjugated polymers

JOO Jinsoo *[1], KWON Dayeong [1]
[1]Depsrtment of Physics, Korea University
jjoo@korea.ac.kr

Abstract:

전이금속 칼코겐화합물 (transition metal dichalcogenide, TMD) 중 몰리브덴 다이셀레나이드 ($MoSe_2$)와 텅스텐 다이설파이드 (WS_2)는 다양한 광전자 소자에 응용되고 있는 2차원 반도체 물질이다. 공액 고분자 전해질 (conjugated polymer electrolyte, CPE) 재료는 기존의 금속 산화물 소자들의 전하 수집능력 저하 및 광전자 소자 활성층 계면에서의 결함을 극복하기 위해 사용되고 있다. 본 연구에서는 $MoSe_2$와 WS_2로 전계효과트랜지스터 (FET)를 제작하였다. 스핀 코팅 방식을 이용해 CPE의 일종인 Poly(9,9-bis(4′-sulfonatobutyl)fluorene-alt-1,4-phenylene) potassium (FPS-K)를 $MoSe_2$와 WS_2 표면에 하이브리드하여 전류 전달 특성 (transfer characteristics)과 광전류 (photocurrent) 및 광응답도 (photoresponsivity)의 증가를 관찰하였다. $MoSe_2$와 WS_2에 FPS-K 처리 전과 후의 레이저 공초점 현미경 (laser confocal microscope)를 이용해 측정한 각 물질의 광발광 (photoluminescence), XPS (X-ray photoelectron spectroscopy) 및 흡수 스펙트럼을 측정하여서 나노광학 특성을 비교, 분석하였다. 제작된 $MoSe_2$/FPS-K, WS_2/FPS-K의 나노광학 특성을 기반으로 광전자소자 성능 향상의 원인을 분석하였다. FPS-K가 $MoSe_2$와 WS_2 표면 결함을 치유하고 도핑효과를 유도한 것으로 해석하였다.

Keywords:

transition-metal dichalcogenide, field effect transistor, photoresponsivity, conjugated polyelectrolyte, passivation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.120

Optical axis and domain structure in sub-domain ReS_2 samples

PARK Je Myoung [1], NA Woongki [1], CHOI Yun [1], LEE Sol [2], KIM Kwanpyo [2], CHEONG Hyeonsik *[1]
[1]Department of Physics, Sogang University
[2]Department of Physics, Yonsei University
hcheong@sogang.ac.kr

Abstract:

Rhenium disulfide (ReS_2), one of the transition metal dichalcogenides (TMDs), is a semiconducting material which has a direct bandgap from monolayer to bulk. ReS_2 has an anisotropic crystal structure (1T', distorted tetragonal) unlike hexagonal MoS_2 or WS_2 because Re has one more electron, which makes a Re-chain. Furthermore, opposite vertical orientations of ReS_2 are not equivalent. Due to the in-plane anisotropic structure, its physical properties such as electrical transport and optical response are anisotropic [1]. The direction of the Re-chain and the direction of the c-axis of ReS_2 can be determined by polarized Raman spectroscopy [2, 3].
We made a few-layer ReS_2 sample by mechanical exfoliation and found that some samples have several domains in a flake. Polarized Raman spectroscopy is used to identify opposite vertical orientations [3, 4]. The direction of the Re-chain in each domain is also determined by polarization dependence of the Raman mode at 212 cm^{-1} [2, 3] and selected area electron diffraction (SAED) patterns. The high-resolution scanning transmission electron microscopy (HR-STEM) image shows the atomic structure in the grain boundary between the two domains. Furthermore, the grain boundary can be observed by Raman mapping, the dark-field images of TEM, and the angle-resolved polarized optical microscopy (ARPOM) [5]. We found that the directions of the Re-chain in neighboring domains are exactly aligned. Moreover, we studied the birefringence in the ReS_2 samples with several domains by the cross-polarized optical images and the angular dependence of the optical contrast [6]. We found that the optical axis is not exactly aligned with the Re-chain of the ReS_2 samples.

References

[1] E. Liu et al., Nature comm. **6** 6991 (2015).
[2] D. A. Chenet et al., Nano Lett. **15** 5667 (2015).
[3] Y. Choi et al., Nanoscale Horiz. **5** 308-315 (2020).
[4] S. Zhang et al., ACS Nano. **11** 10366-10372 (2017).
[5] X. Li et al., Adv. Funct. Mater. **29** 1906385 (2019).
[6] J. Kim et al., Nanoscale. **7** 18708 (2015).

Keywords:

2D materials, TMD, ReS2, domain structure, optical axis

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.201

Ionic and electronic transport in lead halide perovskites by optimizing contact area and thickness of SnO_2 charge transport layers

YOUN Sarah Su-O[1,2], GO Un [2], JO William *[1], KIM Gee Yeong [2]
[1]Department of Physics, Ewha Womans University
[2]Advanced Photovoltaics Research Center, KIST
wmjo@ewha.ac.kr

Abstract:

In the photovoltaic community, perovskite materials are one of the main research topics due to their high conversion efficiency which reached 25%, easy fabrication method, and interesting physical-chemical features. Methylammonium lead iodide (MAPI) is a mixed electronic and ionic conductor and iodine vacancies are responsible for ion conduction [1]. Therefore, investigating both electronic and ionic transport properties is needed. From previous study of the interface effect between MAPI and oxide layers (TiO_2 and Al_2O_3), ions are responsible for the equilibrium space charge potential due to ion adsorption [2]. While the electron transport material from the perovskite solar cell structure is being replaced from TiO_2 to SnO_2, the interfacial effect on charge transport between MAPI and SnO_2 is not surely identified. In this study, the interaction between MAPI and SnO_2 was investigated by observing the adsorption behavior of SnO_2 nanoparticles in MAPI and SnO_2 composite layers and compared to TiO_2. The electrical conductivity through MAPI and SnO_2 composite layers beholding different contact areas was measured with conductive atomic force microscopy (C-AFM) to understand the charge transport properties. The contact area of MAPI and SnO_2 interface was controlled by changing the concentration of SnO_2 nanoparticles in MAPI solution. Additionally, different film thicknesses of MAPI were deposited on SnO_2 layers to determine the charge accumulation and depletion effects at the interface of MAPI/SnO_2 thin films. The conductivity in MAPI/SnO_2 thin films by adjusting the thicknesses of SnO_2 layers were also investigated. This gave us evidence on how the interface effect and film thickness contributes to charge extraction and recombination. Our work will offer a remarkable physical understanding of the perovskite solar cell system.

[1] A. Senocrate, I. Moudrakovski, G.Y. Kim, T.-Y. Yang, G. Gregori, M. Graetzel, and J. Maier, Angew, Chem.Int. Ed, 56 (2017) 7755.
[2] G.Y. Kim, A. Senocrate, D. Moia, and J. Maier, Adv. Funct. Mater, 30 (2020) 2002426.

Keywords:

lead halide perovskite, charge transport, interface, tin oxide

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.202

Electronic structure of tantalum oxide depending on oxygen vacancies

CHANG Seo Hyoung *[1], HEO Jin Eun [1], HONG Seungbum [2], LEE Myoung-Jae [3], CHATTOPADHYAY Soma [4], SHIBATA Tomohiro [5], MAGYARI-KOPE Blanka [6], KADUK James A. [7], KIM Young-Bae [8], KIM Jungho [9]
[1]Department of Physics, Chung-ang University
[2]Department of Materials science and Engineering, KAIST
[3]Department of Nanotechnology, DGIST
[4]Department of Engineering and Astronomy, Elgin Community College
[5]Materials Science, Kennametal Inc.
[6]Department of Electric Engineering, Stanford University
[7]Department of Chemistry, Illinois Institute of Technology
[8]Semiconductor Device Laboratory, Samsung Advanced Institute of Technology
[9]Advanced Photon Source, Argonne National Laboratory
cshyoung@cau.ac.kr

Abstract:

RRAM has been considered as next-generation memory devices and artificial synaptic devices in neuromorphic computing systems. The resistive switching phenomenon has observed in various materials, but especially transition metal oxides. Among them, tantalum oxide has attracted great interests because of their high endurance and fast switching when they are used as insulator material in RRAM[1,2]. It has been found that the resistive switching mechanism of the TaOx-based RRAM is caused by the migration of oxygen vacancies in the filament. However, there is little research about specific physical properties of tantalum oxide depending on oxygen vacancies. In this study, we verified electronic structure by using RIXS (resonant inelastic x-ray scattering) measurements and observed that their bandgap related to resistivity reduces as increasing oxygen vacancies. Moreover, we measured EXAFS and confirmed that the local distance between Ta-O stretches due to oxygen vacancies. Therefore, the correlation between the bandgap and configuration of oxygen vacancies could provide the atomic-level design rule of the tantalum-based neuromorphic computing circuits.

1. M. J. Lee, C. B. Lee, D. Lee, S. R. Lee, M. Chang, J. H. Hur, Y. B. Kim, C. J. Kim, D. H. Seo, S. Seo, U. I. Chung, I. K. Yoo and K. Kim, Nat Mater 10 (8), 625-630 (2011).
2. A. C. Torrezan, J. P. Strachan, G. Medeiros-Ribeiro and R. S. Williams, Nanotechnology 22 (48), 485203 (2011).

Keywords:

RRAM, Neuromorphic computing, RIXS, Tantalum oxide

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.203

Deterministic and stable single-photon emission in phase-patterned in-plane WSe_2/WO_x quantum wells

KIM Yoon Seok [1], SO Jae-Pil [2], YANG Seunghoon [1], PARK Hong-Gyu [1,2], LEE Chul-Ho [*1,3]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]Department of Physics, Korea University
[3]Department of Integrative Energy Engineering, Korea University
chlee80@korea.ac.kr

Abstract:

Single-photon emitters (SPEs) in solid-state systems are a crucial building block for quantum information technologies. The emergence of SPEs in 2D transition metal dichalcogenides (TMDs) can provide new opportunities because TMDs have large exciton binding energy and potential qubit operation due to the reduced dimensionality and symmetry. In the previous studies, SPEs in TMDs have been engineered via the artificial creation of defects or strain fields. However, it remains a challenge to integrate the deterministic and stable SPEs for realizing the quantum photonic circuits. Here, we demonstrate the novel approach to implement site-controlled and band-structure-engineered SPEs based on in-plane WSe_2/WO_x quantum well (QW) structures. Through the lithographic patterning and the following oxidation, the phase-patterned WSe_2/WO_x lateral heterostructures were site-specifically fabricated. It thus creates the in-plane QWs with type-I band alignment, enabling extreme localization of excitons. In the in-plane QWs, we observed the single-photon emission with the zero-phonon-line width of 284 □eV and the estimated value of $g^{(2)}(0) = 0.25$ at 4 K. In addition, the emission was maintained for > 150 seconds without spectral wandering and blinking. This work paves the way toward scalable integration of 2D SPEs for novel quantum communication and information.

Keywords:

Single-photon emitters, Deterministic, Transition Metal Dichalcogenides, Quantum wells

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.204

Laser Scribed Carbon Nanomaterials for Gas Sensor based on Polyacrylonitrile-Copper composite

KO Yong-il [1], KIM Min Jae [1], JANG A-Rang [2], KIM Keun Soo [*1]
[1]Department of Physics & Astronomy, Sejong University
[2]Department of Electrical Engineering, Semyung University
kskim2676@sejong.ac.kr

Abstract:

Carbon nanomaterials have excellent physicochemical properties and are attracting attention as a core material applied to various industries. Especially, due to their excellent molecular adsorption behavior resulting from high specific surface area and conductivity, application in the gas sensor field can also be expected. However, in general, the synthesis of carbon nanomaterials has disadvantage in that it takes a lot of process time and cost by using a high-temperature heat treatment furnace. On the other hand, the laser scribing method has an advantage of being able to localize carbonization in a very short time (seconds) with a pattern of a desired shape. PAN (polyacrylonitrile) is a well-known precursor of carbon materials, and forms an intermediate in which nitrile groups are cyclized through stabilization pretreatment. Therefore, by applying a laser scribing method that carbonizes only cyclic polymers, carbon nanomaterials with a desired pattern can be patterned on the stabilized PAN.

In this study, the PAN thin film formed by spin coating is cyclized through stabilization, and then carbon nanomaterials are synthesized through LASER-assisted CVD to reduce process time and energy consumption with a desired pattern. In addition, by complexation with copper (Cu) particles, it was possible to obtain carbon nanomaterials having enhanced properties by improving laser absorption and acting as a carbonization catalyst. The chemical and morphological properties of the synthesized material were evaluated through Raman spectroscopy, XPS and SEM analysis. The sensor performance for nitrogen dioxide and ammonia was evaluated through LabVIEW programming interfacing with the gas sensing chamber. As a result, the synthesized carbon nanomaterial has a three-dimensional structure which is advantageous to absorb the gas molecule, thereby exhibiting excellent performance as a gas sensor.

Keywords:

Carbon nanomaterials, Laser scribing, Gas sensor, Polyacrylonitrile, Copper particle

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.205

Fluorocarbon과 접촉하는 그래핀의 홀도핑 전하수송 특성

YI Yoonhyuck [1], YUN Yoojoo [1], LEE Sangjin [2], JEON Jinho [1], KIM Byeongwan [1], LEE Hyunkyung [1], OH Jinseok [1], KANG Haeyong [*1]
[1]Department of Physics, Pusan National University
[2]화학소재솔루션센터, KRICT
haeyong.kang@pusan.ac.kr

Abstract:

우리는 이 연구를 통해 불소(Fluorine)원자의 큰 전자 친화도를 활용하여 불화물 기판과 접촉하는 그래핀의 전하 도핑 및 전하수송 특성을 연구하고 이를 응용한 다양한 전하수송 소자를 구현하는 것을 제안한다. 그래핀을 불화물 기반의 기판에 직접 전사하여 기판과 반데르발스 상호작용 접촉하는 구조를 만들고 홀바 전극을 만들었다. 실험에서 사용된 불화물 기판은 SiO_2/Si(SiO_2 300nm) 기판위에 Polytetrafluoroethylene(PTFE)과 Carbon nanotube(CNT)를 혼합하여 만든 타겟을 Mid-Frequency Sputtering 방법을 통해 약 50nm 두께의 Fluorocarbon(CF)을 증착하였다. 3단자 측정을 통해 gate에 대한 의존도를 측정해본 결과 CF기판에서 그래핀의 CNP(Charge Neutral points)가 오른쪽으로 이동한 것을 통해 P-doping된 것을 확인하였다. 이는 불소 원자의 큰 전자친화도에 의하여 2차원 물질내 전자가 다수 불소층으로 넘어갔다는 것을 의미한다. 아직은 금속불화물과 2차원 물질간의 전기적인 특성에 대한 연구가 활발히 진행되고 있지 않지만 이번 실험을 통해 우리는 기판과의 상호작용을 적극적으로 활용하여 2차원 물질의 특성을 제어할 수 있는 가능성을 기대한다.

Keywords:

금속불화물, Fluoro Carbon (CFx), P-doping, 반데르발스 상호작용, Graphene

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.206

X-ray 분광법에 의한 마그네슘 합금 표면에 대한 화학반응

LEE Youn Seoung *[1], RHA Sa Kyun [2]
[1]Hanbat National University
[2]신소재공학과, Hanbat National University
yslee@hanbat.ac.kr

Abstract:

최근 과학, 기술 및 의료 산업 분야 등에 미래의 환경 친화적인 소재로 알려져 있는 마그네슘 합금은 뛰어난 가벼움과 고강도로 인해 자동차, 항공 우주, 전자 및 통신 산업에서 점점 더 많이 사용되고 있습니다. 그러나 마그네슘은 화학적으로 활성도가 매우 크므로 대기중에서 빠르게 산화되는 특징이 있어 제품으로 실용화 하기 위해서는 표면처리가 우선시 되어야 한다. 본 연구에서는 마그네슘 합금 표면의 유기 불순물을 제거하고 표면을 활성화 하기 위해, 알카리 및 산 세척을 진행하였다. 알카리 및 산 세척은 가장 기초적인 세정 공정임에도 불구하고 이들에 의한 마그네슘 합금 표면의 특성변화에 대한 연구는 아주 부족하다 할 수 있다. 산성 및 알카리성 용액을 이용하여 마그네슘 기반 합금의 표면 변화에 의한 특성을 XPS (X-ray Photoelectron Spectroscopy), XAS (X-ray Absorption Spectroscopy)등의 X-선 분광법을 이용하여 조사 분석하였다.

Keywords:

Mg alloy, Surface, XPS, XAS

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.207

Bragg Coherent X-ray imaging of chiral photonics nanocrystal

CHOI Sungwook [1], IM Sang won [2], KIM Sungwon [1], KIM Jaeseung [1], SPRUNG M. [3], LEE Su Yong [4], CHA Wonsuk [5], NAM Ki Tae [2,5], KIM Hyunjung [*1]
[1]Physics, Sogang University
[2]Department of Materials Science and Engineering, Seoul National University
[3]P10 beamline, Deutsches Elektronen-Synchrotron
[4]9C beamline, Pohang Accelerator Laboratory
[5]34ID-C beamline, Advanced Photon Source, Argonne National Laboratory
hkim@sogang.ac.kr

Abstract:

Crystallographic orientation is a key property of facets of nanocrystal. Miller-index of the facet determines surface structure of the crystal that consisted of terraces, steps, and kinks. Determining this crystallographic structure becomes more important for the nanocrystal with high-Miller-index facet because low-coordinated atoms on the edges and kinks play important role in biochemistry, medicine, catalysis, and crystal growth. In this study, we introduce a new method of identifying the orientation of facets of nanocrystal in three dimensions using Bragg coherent X-ray diffraction imaging technique [1,2]. We imaged 432 Helicoid III chiral nanoparticle that is highlighted for applications in photonics nanoparticle. Because its chirality is developed at the high-Miller-index facet [3,4], 432 Helicoid III has a concave gap with complex orientation distribution that is main obstacle for imaging using other techniques. We observed orientation distribution along depth from chiral gap and relation between facet orientation and strain in chiral gap that considers the implication of chirality development. We expect that this three-dimensional mapping of facet orientation may be applied to other nanocrystals such as in-situ studies of high-miller index nano-catalysis and photonics nanocrystals.

This research was supported by the National Research Foundation of Korea (Nos. NRF-2015R1A5A100996 and NRF-2019R1A6B2A02100883).

References

[1] Choi, S. et al. In Situ Strain Evolution on Pt Nanoparticles during Hydrogen Peroxide Decomposition. Nano Lett. 20, 8541–8548 (2020).
[2] Cha, W. et al. Core–shell strain structure of zeolite microcrystals. Nature Materials 12, 729 (2013)
[3] H.-E. Lee, H.-Y. Ahn, J. Mun, Y. Y. Lee, M. Kim, N. H. Cho, K. Chang, W. S. Kim, J. Rho, and K. T. Nam, Nature 556, 360 (2018).
[4] S. W. Im, H. Ahn, R. M. Kim, N. H. Cho, H. Kim, Y. Lim, H. Lee, and K. T. Nam, Adv. Mater. 1905758 (2019).

Keywords:

Facet Orientation Identification, Bragg Coherent X-ray Imaging, Chiral nanoparticle

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.208

Energy and charge transfer between MoS_2 monolayers and luminescent organic molecules

KWON Soyeong [1], SONG Jungeun [1], NGUYEN Anh Thi[1], LEE Jinjoo [1], JEONG Dong Yeun [2], CHOI Soo Ho [3], WON Yo Seb [3], KIM Ki Kang [3], CHAE Weon-Sik [4], YOO Youngmin [2], CHOI Taeyoung [1], KIM Dong-Wook *[1]
[1]Department of Physics, Ewha Womans University
[2]Division of Chemical Engineering and Materials Science, Ewha Womans University
[3]3Center for Integrated Nanostructure Physics (CINAP), Institute of Basic Science (IBS), Sungkyunkwan University
[4]Analysis Research Division, Daegu Center, Korea Basic Science Institute (KBSI)
dwkim@ewha.ac.kr

Abstract:

2D transition metal dichalcogenides (TMDs), with bandgap energies corresponding to near-infrared and visible light ranges, are promising materials for photodetectors, light emitting diodes, and solar cells. When integrating organic molecular semiconductors with 2D TMDs, the light-matter interaction can be enhanced. In this work, we investigated physical properties of hybrid systems consisting of CVD-grown MoS_2 monolayers and newly developed luminescent organic molecules, DY1. DY1 molecules were evaporated on quartz substrates with MoS_2 monolayers in high vacuum. Atomic force and optical microscopy images showed that nanostructures as well as thin films of DY1 were formed on the MoS_2 and quartz surfaces. Wide-field fluorescence microscopy revealed that the light emission from the DY1 nanostructures was stronger than that from the thin films. Confocal laser scanning and fluorescence lifetime imaging microscopy images suggested that the MoS_2 flakes modified the emission spectra and lifetime of the DY1 molecules. Kelvin probe force microscopy measurements under illumination helped us to visualize the light-induced contact potential difference at the DY1/MoS_2 interface. All the experimental results will be discussed based on the electron and energy transfer in the organic/TMD hybrid systems.

Keywords:

MoS2, organic, luminescent, electron transfer

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.209

Interface study on lead halide perovskite and hole transport layer

GO Un *1, KIM Gee Yeong 2
1Advanced Photovoltaics Research Center, KIST
2Advanced Photovoltaics Research Center, KIST
rhdns025@hanmail.net

Abstract:

Hybrid lead halide perovskite solar cells are promising candidates for thin-film solar cells because they have many advantages such as high conversion efficiency and a simple fabrication process. However, in terms of stability, they still have limitations with respect to light, oxygen, and water and this issue is the biggest challenge to be solved. In perovskite solar cells, interfaces between the hole transport layer and the perovskite layer have a significant impact on stability and efficiency. In order to investigate the important characteristics of its performance, we have to consider the interaction of hole transport and the perovskite layer. In this work, we investigate the surface interaction of PTAA (as well as Spiro-OMeTAD) and lead halide perovskite interfaces. Here, we show strong interactions in the Spiro-OMeTAD/perovskite interface compared to PTAA/perovskite provided by XPS, KPFM, and conductive AFM results. In a previous study, ions gathered at the perovskite/Spiro-OMeTAD interface and not at the perovskite/PTAA interface[1]. Ionic effects might affect charge transfer, altering device performance and stability. These physical and electrical properties have been extended to perovskite solar cells, providing evidence for charge transfer, hysteresis, and stability. This study may provide a better physical understanding of perovskite stability improvements.

[1] A. G. Boldyreva, I. S. Zhidkov, S. Tsarev, A. F. Akbulatov, M. M. Tepliakova, Y. S. Fedotov, S. I. Brebikhin, E. Y. Postnova, S. Y. Luchkin, E. Z. Kurmaev, K. J. Stevenson, P. A. Troshin, ACS Appl. Mater. Interfaces, 12 (2020) 19161-19173.

Keywords:

Hole transport layer, interface effect, perovskite solar cell

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.210

Study on friction force of 2D materaials with Lateral Force Microscopy

KIM Min Jeong [1], CHOI Inchul [1], JEONG Nae bong [1], LEE Jun-ho [1], CHUNG Hyun-Jong *[1]
[1]Department of Physics, Konkuk University
hjchung@konkuk.ac.kr

Abstract:

In this poster, we have investigated the frictional force of various 2D materials, e.g. graphene, tungsten disulfide(WS2), and hexagonal boron nitride(hBN) on SiO2 substrate, by varying their thicknesses. First, we measured the lateral force of the AFM cantilever using lateral force microscopy (LFM), and then the force is converted to the frictional force. We also analyzed the effect of rapid thermal annealing (RTA).

1-nm-thick thin films exhibit friction similar to the SiO2 substrate, whereas the thicker films greater than 2 nm exhibit lower friction. Also, for the former, we observed that the friction increases through the annealing process. It is because the gap between the sheets and the substrate reduces after the annealing process. Through this study, we observed that the frictional force of the substrates significantly affects the two-dimensional materials, and the effect was significantly reduced for the 2D materials with more than two layers.

[1] Changgu Lee et al., Science. vol328, 76-80 (2010)

Keywords:

lateral force microscopy, friction force, roughness

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.211

Synthesis of gold nanoparticles by citrate reduction and their optical sensing properties

YEWALE Manesh A. [1], NGUYEN Linh Nhat [1], PANERU Ramhari [1], LAMICHHANE Pradeep [1], CHOI Eun Ha [1], LEE GeonJoon *[1]

[1]Kwangwoon University

gjlee1978@gmail.com

Abstract:

Gold nanoparticles were prepared using different reducing agents (trisodium citrate and sodium borohydride) with different molar concentrations. The morphology and average diameter of gold nanoaprticles were obtained by scanning electron microscopy. The gold nanoparticles with different reducing agents and different molar concentrations of gold precursor have specific absorption spectra. The absorption spectra of the gold nanoparticles exhibited plasmon resonance effects in the green-yellow wavelength region. The crystallinity of gold nanoparticle was examined by XRD and the wettability of gold nanoparticle film was studied using water contact angle measurement. The plasmon resonance absorption wavelength and absorption peak height were changed by different reducing agents and different molar concentrations of gold precursor. Next, we investigated optical sensing of biomaterials based on plasmon resonance effects of gold nanoparticles.

Keywords:

Gold nanoparticles, Plasmon resonance effects, Optical sensing

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.212

Study on spatially resolved transconductance of the graphene-WS_2 junction using scanning gate microscopy.

CHOI Inchul [1], LEE Jun-ho [1], JEONG Nae bong [1], KIM Min Jeong [1], CHUNG Hyun-Jong *[1]
[1]Department of Physics, Konkuk University
hjchung@konkuk.ac.kr

Abstract:

Scanning gate microscopy (SGM), a derivative of atomic force microscopy (AFM), measures spatially resolved transconductance-modulation of drain current of transistor by modulating gate voltage in a few tens of nm. The local gate voltage is applied by the PtIr-coated cantilever of the SGM [1]. Lock-in amplifier, installed to commercial AFM, is applied to measure the transconductance rather than drain current. It also detects weak modulation of the drain current. In addition, graphene barristor with a vertical graphene-semiconductor junction exhibits a much greater I_{ON}/I_{OFF} ratio of 10^5, while the graphene field-effect-transistor (FET) does no more than 100 [2]. This property makes the barristor device a good candidate for the SGM experiment.

In this experiment, we measured simultaneously the spatially resolved transconductance and the topography of the vertical graphene-WS_2-metal junction using the SGM. It could provide the unique opportunity to study the substantial carrier transfer through the vertical graphene-TMDC junction. In this poster, the early stage of the experiment will be discussed.

Keywords:

Scanning gate microscopy, Graphene, Barristor, van der Waals heterostructures

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.213

Heterojunction structure of p-CuO/n-TiO2 for high performance gas sensor

LEE Gunhee [1], UMESH NAKATE [1], HONG Chang-Hee [1], SUH Eunkyung *[1]
[1]School of semiconductor and Chemical Engineering, Jeonbuk National University
eksuh@jbnu.ac.kr

Abstract:

일산화탄소 가스는 자동차, 산업 발전소에서 불완전 연소 된 화석 연료에서 대규모로 생성되는 독성 가스 중 하나이다. CO 가스를 흡입하면 신체에 심각한 건강 문제가 발생하며, 무색 무취의 유독 가스로 인간이 탐지해 낼 수 없다. CO 가스를 단기간에 고농도로 흡입하면 사망에 이를수도 있으며 이를 방지하기 위해 높은 선택성을 가지는 고 응답의 가스 센서의 개발이 필수적이다.
본 연구에서는 p-CuO / n-TiO2 이종 접합 센서를 CuO 및 TiO2 나노 입자를 사용하여 제작하였다. 센서 재료의 물리 화학적 특성은 X- 선 회절 (XRD), 전계 방출 주사 전자 현미경 (FE-SEM), 투과 전자 현미경 (TEM), 원소 매핑 및 에너지 분산 분광법 (EDS)으로 조사되었다. 제조 된 이종 접합 센서는 50-800ppm 농도 범위에서 일산화탄소 (CO)를 감지하기 위해 조사되었으며 250 ° C에서 800ppm 농도의 CO에 대해 854 %의 가장 높은 응답을 보인 반면 50ppm CO에 대해 177 % 응답을 나타 냈다. 센서의 선택성은 CO, 이산화탄소 (CO2), 이산화질소 (NO2), 에탄올 (C2H5OH), 수소 (H2) 및 메탄 (CH4)과 같은 가스에 대해 테스트되었으며 제작된 센서는 CO에 대한 탁월한 선택성을 보여주었다. 응답, 반복성 및 안정성을 설명하기 위한 작동 온도 및 가스 농도와 p-CuO / n-TiO2 이종 접합 소자의 감지 메커니즘을 연구하였다.

Keywords:

Heterojunction, p-CuO, n-TiO2, Gas sensor

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.214

Interface Change of AZ31-CFRP by Thermal Laser Joining : NEXAFS and XPS investigation

LEE Youn Seoung *[1], ASHONG Andrews Nsiah [2], KIM Jeoung Han [2]
[1]Department of Information & Communication Engineering, Hanbat National University
[2]Department of Materials Science & Engineering, Hanbat National University
yslee@hanbat.ac.kr

Abstract:

금속-고분자 접합기술은 5G 통신망에 사용되는 DLP-Cu 연성회로 기판을 구성하기 위한 요소 기술이기도 하고, 자동차용 리튬전지 알루미늄 파우치 백의 핵심기술이기도 하다. 최근에는 에너지절감을 위하여 경량화 소재의 개발에 관심을 가지면서, 이들 금속에 대해 경량소재인 마그네슘 (또는 합금)으로 대체하는 것에 대한 연구가 활발하게 진행되고 있다.
본 연구에서는 일체형 AZ31(금속)-CFRP(고분자) 복합체 형성을 위해 열 레이저 접합 기술을 이용하였다. 금속-고분자 접합력 향상을 위해, AZ31 마그네슘합금 표면에 대해 HF 표면처리를 시도하였다. CFRP와의 화학적 상호작용을 촉진시키기 위해 AZ31 마그네슘합금 표면의 불순물을 제거하고, HF를 이용하여 반응성 표면을 형성하였다. AZ31 표면의 변화는 접합강도에 영향을 준다. 레이저 접합기술에 의한 AZ31(금속)-CFRP (고분자) 복합체에 대해, AZ31의 표면 및 계면(파단면)에 대해 XPS와NEXAFS를 이용하여 비교 분석함으로서 계면에서의 접합 메카니즘을 규명하였다.

Keywords:

XPS, NEXAFS, AZ31 Mg alloy, CFRP, thermal laser joining

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.215

Hybrid Structure of MoS_2-Si Quantum Dots for Photoconductors

GU Minseon [1], LEE Keun Wook[1,2], PARK Beomjin [1,2], HAN Moonsup *[1]
[1]Department of Physics, University of Seoul
[2]Department of Smart Cities, University of Seoul
mhan@uos.ac.kr

Abstract:

Molybdenum disulfide (MoS_2) is one of the promising materials for optoelectronic applications due to its tunable bandgap and high mobility. However, its photodetector performance is limited since the thickness of MoS_2 is not enough to create photo-excited carriers. Recently, a hybrid structure of MoS_2 and quantum dots have been studied to enhance the creation of photo-excited carriers. In this study, the hybrid structure of MoS_2 and silicon quantum dots (SiQDs) is presented for photodetector. MoS_2 was prepared using mechanical exfoliation with tape. Silicon quantum dots were synthesized using HSQ powder. The silicon quantum dots were spin-coated on the MoS_2 to make the hybrid structure. Photodetector characteristics were measured under white light and laser illuminations with the optical power measured. The responsivity was enhanced in the hybrid structure of MoS_2-SiQDs compared to the MoS_2-only device. Additionally, time-resolved photocurrent dynamics were also measured. The hybrid structure of MoS_2-SiQDs will be a new combination of materials for optoelectronic application.

Acknowledgement: NRF-2020R1F1A1048651, UOS-BSIRDF2019

Keywords:

MoS2, Silicon quantum dots, Photodetectors, Hybrid structure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.301

Stacking faults and anti-site domain boundaries in chalcopyrites: a density functional theory calculation study

PARK Kanghyeon [1], JEONG Byeong-Hyeon [1], PARK Ji-Sang *[1]
[1]Physics, Kyungpook National University
jisangparkphys@gmail.com

Abstract:

Extended defects are widely known to inhibit the transport of electrons and holes in semiconductors. Therefore the formation of stacking faults and anti-site domain boundaries are generally expected to lower the number of photogenerated carriers reached to the electrodes, resulting in the lower solar conversion efficiency. In this presentation, we present the results of first-principles density functional theory calculations on the stability of extended defects and their electronic structure in chalcopyrite materials including $CuInS_2$, $CuGaS_2$, $CuAlS_2$, $AgInS_2$, $AgGaS_2$, and $AgAlS_2$. Our calculation shows that the incorporation of Ag, which has received a lot of attention recently, promotes the formation of stacking faults in chalcopyrites while the formation of the anti-site domain boundary becomes less likely. Substitution of In with Ga suppresses the formation of both types of extended defects.

Keywords:

stacking fault, antisite domain boundary, dft, chalcopyrite, polytype

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.302

Doping of alkali elements into Cu(In,Ga)Se_2 solar cells: aggregation of passivated sites for improvement of charge carrier transport

PARK Ha Kyung [1], CHO Yunae [1,2], KIM Kihwan [3], JEONG Inyoung [3], YUN Jae Ho [3], GWAK Jihye [3], JO William *[1,2]
[1]Department of Physics, Ewha Womans University
[2]New and Renewable Energy Research Center (NREC), Ewha Womans University
[3]Photovoltaic Laboratory, KIER
wmjo@ewha.ac.kr

Abstract:

Cu(In,Ga)Se_2 (CIGS) thin film solar cells have been widely studied and technological advances have led to stable and highly efficient cells. For more wide application, CIGS thin film solar cells using flexible substrates have attracted attention. Positive effect of alkali doping in CIGS has been studied so far mainly using rigid glass substrate however, effect of alkali doping in CIGS on the flexible substrate needs further exploration. Herein, four CIGS thin film solar cells on flexible polyimide (PI) substrate with a wide range of alkali fluoride post-deposition treatment (NaF, KF, CsF, and RbF) were prepared. The difference in open-circuit voltage (V_{OC}), short-circuit current (J_{SC}), fill factor (FF) and efficiency was not significant between NaF, CsF and RbF samples, but only the KF sample showed degraded cell characteristics with marginal V_{OC} reduction. First, to investigate the electrical properties of CIGS thin film solar cells, Kelvin probe force microscopy (KPFM) was utilized. Surface potential was obtained through KPFM and all the samples showed upward potential bending at grain boundaries (GBs) and no significant difference in potential barrier size at GBs according to the type of alkali. In the dark state, the carrier transport mechanism showed no substantial difference therefore, surface current map was obtained to determine the cause of current loss of the KF sample. Also, flexible substrate application characteristics were investigated to determine the absorber material properties under bending condition and the suitability of the substrate application.

Keywords:

flexible Cu(In,Ga)Se2 thin-film solar cells, alkali doping, Kelvin probe force microscopy, grain boundaries

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.303

Piezoelectricity and flexoelectricity of randomly aligned ZnO nanorods based flexible nanogenerator

ABEN Dimaral *[1], YAN Yan [1], SHIN Dong-Myeong [2], HWANG Yoon-Hwae [1]
[1]Nano Fusion Technology, Pusan National University
[2]Mechanical Engineering , University of Hong Kong
daben@pusan.ac.kr

Abstract:

Zinc oxide materials have been widely studied due to their unique properties and recently are of increased interest in electromechanical devices. Especially ZnO nanorods are attracting attention as they possess good piezoelectricity and can be tuned depending on the degrees of deformations such as compressing and bending. In this work, the piezoelectricity of randomly aligned ZnO NRs were investigated along with their flexoelectricity. In the presence of inhomogeneous stress, the strain gradient is induced and the polarization along the active layer is formed by coupling of piezoelectric and flexoelectric effects. This electromechanical coupling effect has improved the output performance of nanogenerators by boosting up the piezoelectric modulus values. The ZnO NRs were grown by facile hydrothermal method and drop casted on the surface of indium tin oxide coated polyethylene terephthalate (ITO/PET) substrate which also acts as a bottom electrode. The structural and morphology of grown ZnO NRs were characterized by using a scanning electron microscopy and X-ray diffraction. The sandwich type flexible nanogenerator was constructed and its output performance was measured. It was observed that randomly aligned ZnO NRs show strong bending angle dependency and the strain gradient can be varied. This research provides the study of electromechanical coupling effect of piezoelectric ZnO NRs and promising applications in flexible energy harvesting systems.

Keywords:

Zinc oxide nanorods, electromechanical coupling effect, flexible nanogenerator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.304

Orbital-selective observation of Ir 5d in IrO_2 epitaxial thin films using resonant inelastic x-ray scattering

LEE Kyeong Jun [1], CHO Byeong-Gwan [2], KIM Woo Jin [3], SONG Jeongkeun [3], KIM Chanseok [4], HEO Jin Eun [1], LEE Jun Hee [4], NOH Tae Won [3], KOO Tae Young [2], KIM Jungho [5], CHANG Seo Hyoung [*1]
[1]Department of Physics, Chung-ang University
[2]Pohang Accelerator Laboratory, POSTECH
[3]Department of Physics, Seoul National University
[4]School of Energy and Chemical Engineering, UNIST
[5]Advanced Photon Source, Argonne National Laboratory
cshyoung@cau.ac.kr

Abstract:

Rutile IrO_2 is spin-orbit entangled system and has been important model system in energy conversion material due to activity and stability in reaction. Although IrO_2 has been investigated as the ideal catalysis in oxygen evolution reaction (OER), physical origin of the energy conversion is still obscure due to limits of experimental techniques. We introduce Ir L_3-edge resonant inelastic x-ray scattering (RIXS) experiment about IrO_2 epitaxial thin films grown on TiO_2 (100) and (001) substrates. For unveiling the role of Ir 5d orbitals of IrO_2 in OER, we selectively measured the 5d orbitals by controlling scattering geometries in pristine epitaxial IrO_2 thin films. Concretely, the 5d dx^2-y^2 orbital in the plane of edge-sharing of octahedra along [001] dominantly contributed to ~ 2eV energy loss signal.

Keywords:

Resonant Inelastic x-ray scattering, IrO2, RIXS

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.305

Fabrication of Self-Adhesive Triboelectric Nanogenerator Sensor

LEE Hee Jin [1], HWANG TaeSeung [1], YEO Junyeob *[1]
[1]Department of Physics, Kyungpook National University
junyeob@knu.ac.kr

Abstract:

Since TENG (Triboelectric Nanogenerator) appeared in the early 2010s, it has been developed with various structures, like zig-zag shape, and materials like PTFE (Polytetrafluoroethylene). A number of TENGs were fabricated with polymers, and especially elastomers helped TENGs for being wearable with their properties like flexibility and Stretchability. Nevertheless, additional adhesive was required to fix them on human skin. As a solution, fabrication of 'band-aid' shaped TENG was tried.
In this research, we fabricated self-adhesive TENG only with PU (Polyurethane) and PDMS (Polydimethylsiloxane). By adjusting laser scanning conditions, the photopolymer, PU could be cured as adhesive parts or non-adhesive parts. PDMS contacts with the skin and generates triboelectricity. And silver nanowires were embedded between PU and PDMS to work as a current collector.
A Fabricated TENG sensor was attached to human skin and generated output voltage. Specifically, it generated over 2V with the movement of the human's wrist. The simple structure, 'band-aid shaped' self-adhesive TENG worked as a motion sensor that can detect human movement and also turned the light-emitting diode on so could work as an energy harvester.

Keywords:

Triboelectric Nanogenerator, Polymer, Self-Adhesive, elastomer

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.306

Piezoelectricity and Flexoelectricity Characterizations for Organic Material based Flexible Energy Harvesting Devices

YAN Yan [1], DONG Myeong Shin [2], HWANG Yoon Hwae *[1]
[1]Department of Nanoenergy Engineering, Pusan National University
[2]School of Mechanical Engineering, University of Hong Kong
yhwang@pusan.ac.kr

Abstract:

Flexible and wearable devices are treated as next-generation electronics. Electric polarization in response to mechanical deformation has been employed as a key technology for many flexible electronics. The flexible devices experience multiple degrees of deformation, such as compressing, bending, and stretching so that the electric polarization involves multiple mechanistic origins, but many literature reports confuse charge arising from flexoelectricity with piezoelectric effect. They usually assume only piezoelectricity was measured but ignore the influence of flexoelectricity. With the development and large demands of flexible electronics, it eager a comprehensive and deeper understanding of flexoelectric effect in flexible devices. Here we report the nanogenerator (NG) that facilitated the characterizations for piezoelectricity and flexoelectricity in the device scale. This approach offers a perspective on how to separate the piezoelectric and flexoelectric effects from the electric outputs. Such characterization will not only allow us an understanding of fundamental flexoelectric mechanisms but also help us to establish design rules for flexible electromechanical devices.

Keywords:

Piezoelectricity, Flexoelectricity, Nanogenerator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.307

Biocompatible and Biodegradable Triboelectric generators Based on Hyaluronic Acid Hydrogel Film

KIM Hyunki [1], PARK Sang Hyeok [1], CHOI Jinhyeok [1], LEE Minbaek *[1]
[1]Department of Physics, Inha University
mlee@inha.ac.kr

Abstract:

In tissue engineering and other biomedical applications, there are some key features of materials such as biocompatible, biodegradable, and implantable ones. Especially in a biocompatible, self-powered systems, the use of such materials are most likely desirable factors. Hyaluronic acid (HA) derived from mammals has attracted considerable attention due to its biocompatibility as well as tissue engineering and wound healing abilities. However, there has been least effort to utilize HA as the core material for biocompatible self-powered energy devices. In this study, we fabricated biocompatible, biodegradable triboelectric generators based on the HA hydrogel film (HA-TEGs). Pure and cross-linked HA hydrogel film is prepared by solvent evaporation, which is simple but efficient method. Peak-to-peak open circuit voltage and short-circuit currents of HA-TEGs reached about 20 V and 0.4 mA, respectively. Such power output was sufficient to light up six LEDs connected in series. HA-TEGs showed only minor degradation in long-term use, but significant degradation in high-humidity environment. Moreover, pure and cross-linked HA hydrogel films exhibited no cytotoxicity at least within one day and even stimulated the proliferation of MC3T3-E1 cells. Consequently, HA hydrogel film can be a competitive candidate for biocompatible, biodegradable self-powered energy devices for a range of practical tissue engineering and other biomedical applications in the future.

Keywords:

Hyaluronic Acid, Triboelectric Generator, Biocompatible, Biodegradable, Self-powered

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.308

Temperature dependent triboelectric charge of PVDF ferroelectric polymers

KO Young Joon [1], LEE Dong Woo [1], AHN Hyun Soo [1], JUNG Jong Hoon *[1]
[1]Inha University
jhjung@inha.ac.kr

Abstract:

Recently, research on triboelectric power generation that converting wasted mechanical energy to electrical energy is very active. Compared to these application areas, little is understood about the origin of triboelectric charges and the mechanism of charge transfer. In this study, the temperature dependence of the surface charge was studied using PVDF, a ferroelectric polymer. In both the ferroelectric B-phase and the non-ferroelectric a-phase, it was observed that the frictional charge decreases rapidly with increasing temperature. Particularly, the B-phase sample showed a much larger charge density change, and the frictional charge was continuously observed even above the Curie temperature. Compared with the P(VDF-TrFE) sample, which has a similar structure, the thermionic emission model was discussed.

Keywords:

triboelectric, PVDF, thermionic emission

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.309

Effect of Dielectric Constant of Composite Polymer ZnO Films on Piezoelectric Nanogenerator Applications

AMANGELDINOVA Yerkezhan *[1], ABEN Dimaral [1], SHIN Dong-Myeong [2], HWANG Yoon-Hwae [1]
[1]Nano Fusion Technology, Pusan National University
[2]Mechanical Engineering, University of Hong Kong
yerkezhan.amangeldinova@alumni.nu.edu.kz

Abstract:

The ZnO has been employed as building blocks due to its remarkable physical properties and potential applications, and its properties have been shown to improve by nanostructuring. Especially, composite polymer ZnO film is expected to exhibit the piezoelectric output enhancement and improved mechanical properties. Herein, we present a simple strategy for fabricating the composite ZnO-PDMS film to boost the piezoelectric output. Firstly, the mesoporous ZnO films were fabricated by using polymethylmethacrylate as a sacrificial agent mixed in different ratios with zinc oxide, and the characterization of mesoporous ZnO film by using a scanning electron microscope and energy-dispersive X-ray spectroscopy reveals that our approach successfully provides the mesoporous ZnO structure with increasing porosity with higher polymer content. Afterwards, composite film was prepared by spin coating of PDMS onto porous ZnO allowing to obtain uniformly distributed PDMS without agglomerations. Higher porosity ZnO had higher amounts of PDMS intruded into the pores. Broadband dielectric spectroscopy analysis was performed and dielectric constant was calculated at 1MHz. We found that the dielectric constant and piezoelectric output voltage of composite film could be tuned by varying the porosity and composite ratio. The average dielectric constant decreased with the porosity of the films and, resultantly, a high porosity resulted in the highest output voltage. This study provides highly controlled mesoporous ZnO films and uniformly distributed ZnO-polymer composites that have beneficial piezoelectric properties, which suggests a promising potential application for energy harvesting devices.

Keywords:

dielectric constant, piezoelectricity, zinc oxide

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.310

SiO_x Nanorod-Structured Artificial Neuron for Unconventional Computing Applications

CHOI Sanghyeon [1], KIM Gwang Su [1,3], CHO Haein [1], YANG Jehyeon [1], KANG Chong-Yun [1,3], WANG Gunuk *[1,2]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]Department of Integrative Energy Engineering, Korea University
[3]Center for Electronic Materials, KIST
gunukwang@korea.ac.kr

Abstract:

Memristor, which simply consists of a switching layer inserted between two electrodes, is one of the most strong candidates to become a device-platform for imitating the principal characteristics of the biological neural network due to its nonlinear and dynamic electrical characteristics depending on the history of applied electrical programming [1-3]. In this study, we fabricated a nanorod structured SiO_x memristor using E-beam evaporator with glancing angle deposition at the wafer-scale and utilized the device as an artificial neuron for probabilistic computing applications. The device can exhibit a low forming voltage (< 2 V), a high ON-OFF ratio (> 10^5), reliable switching performances, and fast switching time (~40 ns), where the switching event is attributed to the transition between two Si phases (amorphous Si and Si nanocrystal). Notably, the nanorod structured SiO_x can lead to the considerable reduction of forming voltage and enhancement of stochastic switching characteristics, when compared with the typical SiO_x memristor. Moreover, using voltage pulse trains, the SiO_x nanorod memristor with different glancing angles has successfully mimicked fundamental neuronal dynamics called integrate-and-fire processes and stochastic functionalities for the bayesian network in which each node is probabilistic variables. Then, as a proof of concept, we simulated the probabilistic inference for the correlation between three biological genes. Taken all together, the designed SiO_x memristor neuron could pave the way for stochastic artificial neurons and its based probabilistic computing technology.

References [1] S. Choi, J.-W. Choi, J. C. Kim, H. Y. Jeong, J. Shin, S. Jang, S. Ham, N.-D. Kim, and G. Wang, Nano Energy, accepted (2021)
[2] S. Choi, J. Yang, G. Wang, Adv. Mater., 32, 2004659 (2020)
[2] S. Choi, S. Jang, J.-H. Moon, J. C. Kim, H. Y. Jeong, P. Jang, K.-J. Lee, and G. Wang. NPG Asia Mater. 10, 1097–1106 (2018)

Keywords:

Memristor, Neuromorphic, Artificial Neuron, Unconventional Computing, SiOx

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.311

Conducting states and pathways of flexible HfO_x thin films

KWON Suhyoun [1], KIM Yeon Soo [2], CHUNG Harry [1], KIM Jihyun [1], JO William [*1,2]
[1]Department of Physics, Ewha Womans University
[2]New and Renewable Research Center, Ewha Womans University
wmjo@ewha.ac.kr

Abstract:

Conducting states and pathways of flexible HfO_x thin films

Suhyoun Kwon[1], Yeon Soo Kim[2], Harry Chung[2], Jihyun Kim[1], and William Jo[1,2*]

[1]Department of Physics, Ewha Womans University, Seoul, Korea
[2]New and Renewable Energy Research Center (NREC), Ewha Womans University, Seoul, Korea
*E-mail: wmjo@ewha.ac.kr

Hafnium oxide is emerging as a new prototype for a ferroelectric material with a proper dopant while it is potentially a superb candidate for a gate dielectric in semiconductor industry, replacing SiO_2 with its high k-dielectric constant and great thermodynamic compatibility with silicon. Therefore, intensive research has been carried out on growing and modifying HfO_2. Vexingly, the characteristics of Hf suboxide, which may be a clue to understand its electrical properties, have not been clearly elucidated yet. We deposited silver metal layers on polyethylene naphthalate (PEN) flexible substrates. HfO_x thin films were obtained by sputtering from a HfO_2 ceramic target under an inert gas. Gold top electrodes was deposited to form a cylindrical resistor. The samples were grown with a variety of sputtering power and deposition time, which leads to different oxidation states and film thickness, respectively. X-ray photoelectron spectroscopy confirms the oxidation states of hafnium. Topography, current mapping images, and work functions of the samples were by scanning probe microscopy. From the results, conducting states and pathways are identified at metallic, metastable, and insulating HfO_x samples. A controllable tailoring of conducting capability and locality of conduction paths is keen on developing flexible electronics.

Keywords:

HfOx, Hf suboxide, Atomic Force Microscopy, Kelvin Probe Force Microscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.312

Ferroelectric $Hf_{0.5}Zr_{0.5}O_2$ ultrathin film epitaxially grown on the $SrTiO_3$(001) substrate

RYU Woohyeon [1], YOON Chansoo [1], WOO Yewon [1], PARK Bae Ho *[1]
[1]Department of Physics, Konkuk University
baehpark@konkuk.ac.kr

Abstract:

HZO($Hf_{0.5}Zr_{0.5}O_2$) has been known as a material that shows a ferroelectricity in the thin film under 10nm. In this work, we deposited ferroelectric epitaxial HZO ultrathin film about 1nm on the STO($SrTiO_3$) substrate(001) using laser MBE system. The 25nm of $La_{0.66}Sr_{0.33}MnO_3$ is used as the bottom electrode. The RHEED intensity oscillations are observed while the LSMO is deposited. The ultrathin HZO film preserved pfm phase and amplitude about 10^5 sec after polling. This result shows the possibility of ultrathin HZO film as ferroelectric layer of the nonvolatile ferroelectric field effect transistors.

Keywords:

HZO, ferroelectricity, ultrathin film, RHEED oscillations

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.313

Generalized Equation for Magnetic Domain Wall Chirality with Consideration of Domain Wall Tilting

PARK Jung Hyun [1], KIM Dae Yun [2], NAM Yune Seok1 [1], WHANG Hyun Seok [1], CHOE Sug Bong [*1]
[1]Department of Physics, Seoul National University
[2]department of Electrical and Computer Engineering, National University of Singapore
sugbong@snu.ac.kr

Abstract:

The domain wall chirality is the key parameter in recent experimental schemes to measure the spin-orbit torque and Dyzloshinskii-Moriya interaction. These schemes, so far, are based on a model that the domain wall is placed transversely to magnetic wires without consideration of tilting. Here, we report that, in materials with Dyzloshinskii-Moriya interaction, the domain wall have to be tilted, resulting from energy minimization condition on both the magnetization angle in the domain wall and the domain wall tilting angle. Additionally, we analytically calculated critical value of Bloch wall energy which distinguishes behaviors of the domain wall tilting angle as the in-plane field increases. Therefore, the present generalized equation provides a better realistic model to understand the experimental observations in measurement schemes of the spin-orbit torque and Dyzloshinskii-Moriya interaction.

Keywords:

Domain wall, Dzyaloshinskii-Moriya interaction

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.314

A two-terminal perpendicular spin-transfer-torque based stochastic spiking neuron device

KIM Jichan [1,2], BAEK Jongung [1,3], JUN Hansol [1,3], CHOI Jinyoung [1,2], CHOI Yohan [1,3], PARK Jeagun *[1,2,3]
[1]Hanyang University
[2]MRAM center, Department of Electronic Engineering, Hanyang University
[3]MRAM center, Department of Nanoscale Semiconductor Engineering, Hanyang University
parkjgl@hanyang.ac.kr

Abstract:

The conventional Von-Neumann architecture is now at the limit in artificial neural network (ANN) operation requiring massively parallel processing due to the Von-Neumann bottleneck. One way to construct efficient neuromorphic system is to mimic the biological neural network so called spiking neural network (SNN). Neuron integrates the input spike signal over time by increasing the membrane potential and generate an output spike when the potential exceeds a certain threshold. When adapting perpendicular spin-transfer-torque (p-STT) to neuromorphic device, we can take advantages in lower power consumption (~x1/100 than CMOS based neuron) and high switching speed (~ns) without a capacitor and it also leads to scaling down the memory cell **[1]**. There are a few reports on SNN operational p-STT based neuron but with only simulation or requiring additional circuits with large power consumption due to too small resistance difference (R_{AP-P} ~hundreds of Ω) between anti-parallel (AP) state and parallel (P) state **[2-3]**.
A two-terminal p-STT based neuron with a 300 x 300 nm magnetic tunneling junction (MTJ) cell was fabricated to achieve SNN operation. Due to its small cell size, R_{AP-P}~1kΩ was obtained. Furthermore, it showed the stochastic neuron model nature with the input voltage pulse (spike) cycles. The spiking voltage was repeatedly applied for each amplitude of [-0.61~-0.72V] to switch from P state to AP state with a pulse width of 250μs. The condition for the fully reset (AP to P) was designed at the amplitude of 0.55V and the pulse width of 1ms. As a result, the stochastic characteristic probability was derived for each spiking amplitude and it well fitted in the sigmoid function. The mechanism of it will be demonstrated in further presentation.

Keywords:

p-STT neuron , p-STT MTJ, stochastic, spiking neural network

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.315

The experimental study of helical-type electromagnetic pump using liquid lithium

LEE GeunHyeong *[1], KIM HeeReyoung [1]
[1]Department of Nuclear Engineering, UNIST
studiousgh@unist.ac.kr

Abstract:

An electromagnetic pump is used to transport electrically conducting fluid through vector cross product of magnetic flux density and current. The electromagnetic pump was analyzed by the FEM simulation with a pressure condition of 10 bar, flowrate condition of 6 cc/s for making thin liquid lithium film. It was manufactured through the result of the simulation, and circulation system was also made to verify the operation capability. The electromagnetic pump was successfully operated, and flowrate was measured according to the input current (0~400 A).
This research was supported by the Korea Electric Power Corporation (R18XA06-26) and the Rare Isotope Science Project of the Institute for Basic Science funded by Ministry of Science and ICT and NRF of Republic of Korea (2013M7A1A1075764).

Keywords:

Electromagnetic pump, Experiment, Liquid lithium

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.401

공기 방울 산란입자와 적색 콜로이드 양자점을 활용한 백색 LED 조명의 광특성 시뮬레이션 연구

LEE Gijung [1], KO Jaehyeon *[1], HONG Seungchan [1], LEE Junggyun [1], PARK Tahee [2], KO Youngwook [2]
[1]School of Nano Convergence, Hallym University
[2](주)지엘비젼, (주)지엘비젼
hwangko@hallym.ac.kr

Abstract:

양자점의 크기에 따라 방출 파장이 조절되는 양자점은 고색재현성 디스플레이 혹은 고연색성 조명 기술에 적합하다. 양자점을 활용하는 대표적인 방법은 광원으로부터 나온 여기광을 양자점 구조물에 입사시켜 파장 변환을 하는 것이다. 양자점의 농도를 높일수록 파장 변환 효율이 상승하기 때문에 양자점의 농도에 따라 조명의 색 좌표나 색온도, 그리고 연색지수 등이 변화될 것이다. 그러나 양자점의 농도가 과도하게 증가하면 입사광이나 파장 변환된 빛이 내부에 갇히면서 광효율 및 연색지수가 떨어지는 문제점이 발생한다. 이번 연구에선 공기 방울 형태의 산란입자를 활용하여 입사광을 산란시켜 양자점의 변환 효율 상승을 목표로 시뮬레이션을 진행하였다. 광 추적 기반 시뮬레이션 프로그램인 'Light Tools'를 활용하여 캡 형태의 적색 양자점 구조물을 부착한 백색 LED 조명 모델링을 제작한 후 내부가 비어 있는 공기 방울 형태의 산란입자를 양자점 캡에 적용항 후 시뮬레이션을 진행하였다. 시뮬레이션 결과 청색 LED에 황색 형광체를 도포한 백색 LED가 가진 부족한 적색 파장 영역이 적색 양자점 캡에 의해 형성된 적색 피크로 보완되면서 공기 방울의 농도가 증가할수록 연색지수가 증가하는 것이 확인되었다. 이런 결과는 공기 방울과 같은 적절한 산란 입자의 적용을 통해 더 적은 양의 양자점을 사용해도 비슷한 연색지수 개선을 얻을 수 있음을 보여주는 것이다.
*본 연구는 산업통상자원부와 한국산업기술진흥원의 스마트특성화기반구축사업을 통한 지원을 받았습니다. (No. P0013743)

Keywords:

Quantumdot, Color rendering, Optical tracking based simulation, White LED

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.402

Construction of helical resonator for trapped-ion based quantum computer

LEE Hyein [2], KIM Hyerin [1], HONG Yura [3], CHOI Taeyoung [*1]
[1]Department of Physics, Ewha Womans University
[2]Department of Computer Science and Engineering, Ewha Womans University
[3]Department of Electronic and Electrical Engineering, Ewha Womans University
tchoi@ewha.ac.kr

Abstract:

Quantum parallelism in a quantum computer enable us to calculate specific problems exponentially faster than a conventional computer, which allows us to solve those problems that are intractable on the classical machine. Toward building such a quantum machine, various physical platforms such as superconducting circuits, trapped ion, quantum dots, and so on have been studied and demonstrated important ingredients for the quantum computer. Among them, the trapped-ion based quantum architecture has possessed the highest fidelity of initialization, detection, single qubit and two qubit gate operations with the long quantum coherence time. Here, we are currently developing macro-trap device based on four blade structures to construct trapped ion-based quantum computer. The Yb171+ ions can be trapped in an oscillating electric field formed by four blade electrodes combined with static DC voltages(Paul trap). For the oscillating electric field, we need to apply high radio frequency voltages to the trap device through a RF resonator. In this talk, I will present how to build the resonator and how to characterize the resonance frequency, linewidth, and adsorption power of the RF resonator using simple and home-built RF circuitry.

Keywords:

resonator, trapped ion-based quantum computer

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.403

적색 양자점 필름을 이용한 고연색지수의 조명 연구
High color rendering index lighting using red quantum dot film

KO Jaehyeon *[1], HONG Seungchan [1], LEE Gijung [1], GWAK Sungtae [1], PARK Seri [1], LEE Junggyun [1], KO Youngwook [3], KIM Youngduk [2]
[1]School of Nano Convergence, Hallym University
[2]CPRI(철원플라즈마산업기술연구원), CPRI(철원플라즈마산업기술연구원)
[3](주)지엘비젼, (주)지엘비젼
hwangko@hallym.ac.kr

Abstract:

조명 시장에서 사용되는 많은 백색 LED는 청색광을 내는 InGaN LED 기반에 황색 형광체인 YAG($Y_3Al_5O_{12}$)를 도포해 구현한다. 이 경우, 적색 파장 영역의 세기가 부족하여 연색지수(Color Rendering Index, CRI)가 떨어진다.(1) 이를 개선하기 위해 적록 형광체를 도포하는 방법도 있지만, 열적 안정성이나 비용 등의 문제가 있다. 또 다른 방법으로는, 적색 양자점을 적용, 부족한 적색을 보완하여 LED 조명의 연색지수를 개선하여 고품질의 인간중심 조명을 개발하는 실험들이 진행되고 있다.(2). 이를 검증하기 위해 15W의 소비전력에 72개의 백색 LED가 장착되어 있고 연색지수는 80 이상, 상관 색온도(CCT)는 5,700K인 일반 LED 조명에 양자점을 적용했다. QD film과 QD wall은 CdSe/ZnS Core/Shell로 합성되었으며, QD wall은 반사 필름이 내장되어 있다. 두께 2mm인 Diffuser plate의 위, 아래에 각각 QD film과 QD wall을 조합하여 6가지의 방법으로 실험을 진행하였다. 기존 조명을 none, QD wall을 설치한 것을 wall, Diffuser plate의 위에 QD film을 부착 시 top, 아래에 부착 시 bottom으로 정의하였다. 시야각 특성을 확인하기 위해 −70°부터 70°까지 10°씩 늘려가며 연색지수를 측정하였다. 실험 결과, 기존 조명의 연색지수는 평균 82.9였으며, QD wall을 사용 시 평균 90.8까지 증가하였다. 특히 top과 bottom을 비교하였을 경우 bottom의 연색지수가 더 높았으며, QD wall을 함께 사용하였을 때 연색지수가 더욱 증가하는 것을 [그림 1]을 통하여 확인할 수 있다. 특히 bottom+wall의 경우 연색지수가 평균 95.8까지 도달하는데, 이는 bottom이 QD film으로 인한 적색 여기가 일어난 후에 Diffuser plate를 통과하여 변환되지 않은 청색광을 추가적으로 활용하기 때문으로 해석된다. 또한, top과 top+wall은 각도에 따라 청색광이 한번 통과하고 빠져나가는 광경로 차이가 크기 때문에 시야각에 따른 연색지수의 차이가 크게 나는 것을 확인할 수 있다. 즉, 본 연구는 QD film의 적절한 배치를 통해 연색지수를 90 이상 높일 수 있고, QD wall과 같이 적용함으로써 추가적 개선을 기대할 수 있다는 점을 보였다.
* 본 연구는 산업통상자원부와 한국산업기술진흥원의 스마트특성화기반구축사업을 통한 지원을 받았습니다. (No. P0013743)

Keywords:

양자점(Quantum Dot), 연색지수(CRI), 조명(Lighting)

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.404

산화철-은 나노입자와 인지질 이중층 간의 상호작용 연구

BACK Sung Jin [1], KOTHANDAN Vinoth Kumar[3], HWANG Seung Rim [2,3], JUNG Gyeong Bok *[1]
[1]Physics Education, Chosun University
[2]College of Pharmacy, Chosun University
[3]Department of Biomedical Sciences Graduate School, Chosun University
gbjung@chosun.ac.kr

Abstract:

세포(cell), 엑소좀(exosomes)과 같은 생물학적 막은 화학 구조가 다른 다양한 지질로 구성되어 있다. 이러한 생물학적 막 구조는 일반적으로 인지질 이중층(phospholipid bilayer)으로 되어 있으며, 이는 극성 인산염기를 포함하는 친수성 머리 부분과 소수성 꼬리를 가진 분자로 구성된다. 최근 금속산화물 나노입자와 인지질 이중층간의 상호 작용에 대한 연구는 질병진단, 약물전달시스템 등 생물의학 분야에 큰 주목을 받고 있다.
본 연구에서는 산화철-은 나노입자 (Fe_3O_4@Ag NPs)와 인지질 이중층간의 상호작용과 표면증강라만산란(SERS)에 대한 연구를 보고한다. Fe_3O_4@Ag NPs는 고에너지 볼밀링 방법을 이용하여 합성하였고, XRD, SEM 측정을 통하여 나노입자의 결정구조와 표면형상 및 미세구조를 분석하였다. 합성된 Fe_3O_4@Ag NPs에 생체막의 모델로써 1,2-Dioleoy-sn-glycero-3-phosphocholine (DOPC)와, 형광라벨이 붙은 1-palmitoyl-2-(dipyrrometheneboron difluoride) undecanoyl-sn-glycero-3-phosphocholine (TopFluor® PC)을 결합하였다. FTIR과 Raman 측정을 통해 Fe_3O_4@Ag 나노입자와 인지질과의 상호작용을 분석하였다. 또한 표면증강라만산란(SERS) 현상을 확인할 수 있었다.

Keywords:

인지질(Phospholipid), 고에너지 볼밀링(High-energy ball milling, HEBM), 산화철-은 나노입자(Fe3O4@Ag NPs), 표면증강라만산란 (Surface Enhanced Raman Scattering, SERS)

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.405

Pad design with high permittivity material for B1+ homogenization in 7T MRI

YOON Kyoungsub [1], NOH Hansol [1], PARK Namkyoo *[1]
[1]Electrical and Computer Engineering, Seoul National University
nkpark@gmail.com

Abstract:

Magnetic resonance imaging is widely used in the field of neuroimaging. Recently, applications of the 7T MRI have been adopted to enhance SNR. However, neuroimaging at the high frequency results in transmit RF field inhomogeneity induced by the wavelength comparable to the size of the human brain. To address the inhomogeneity by enhancing local improvement of the transmit RF field, high permittivity material(HPM) pads have been employed. Here, we study the relation between B1+ homogenization and the parameters required to design the HPM pads. A spherical phantom is utilized instead of the human brain. Sweeping dielectric constant and thickness of the HPM pads, we identify the trade-off relation between the whole maximum-to-minimum(Mm) and average value of axial Mm ratio in the region of interest(ROI). We also apply the optimized HPM pads to virtual human model. As a result, the whole Mm ratio and average value of axial Mm ratio in the ROI are improved by 25.56% and 47.37% respectively.

Keywords:

B1+ homogenization, high permittivity material(HPM)

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.406

Frequency Doubler Utilizing the Off-State Leakage Behavior of Organic Field-Effect Transistors

KO Eun-Hye [1], KIM Chang-Hyun [*1]
[1]Department of Electronic Engineering, Gachon University
chang-hyun.kim@gachon.ac.kr

Abstract:

The field of organic field-effect transistors (OFETs) has rapidly progressed from basic science to a wide range of electronics technologies in the displays, sensors, and neuromorphic computing areas. However, still there is a significant lack of dedicated efforts into the circuit-level integration of OFETs, which is otherwise critically important to maximize the unique technological potential of these flexible and printable versatile devices. In this paper, we present a new design of frequency doubling circuits based on flexible p-type high-performance OFET devices. Our novel concept relies on the strategic use of off-state conduction, prevailing in many reported OFET devices. In more detail, several different unipolar digital inverter topologies are systematically compared, each of which has its own characteristic balancing mechanism between the pull-up and pull-down components. Therefore, it was possible to fine-tune the shapes and positions of valley formation in the input-output voltage characteristics of inverters. A series of circuit-level simulation theoretically validates the frequency-doubling behaviors that arise from our original device-circuit co-design approaches, which will eventually enable applications in mobile communications, Internet-of-things (IoTs), and next-generation neuromorphic/artificial intelligent (AI) processors.

Keywords:

Organic field-effect transistors, Flexible electronics, Circuit integration

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.407

Device Simulation on the Mobility Effects in Perovskite Photovoltaics

LEE Hyuna [1], KIM Chang-Hyun *[1]
[1]Department of Electronic Engineering, Gachon University
chang-hyun.kim@gachon.ac.kr

Abstract:

The organic-inorganic hybrid perovskite materials have shown a huge potential as a high-efficiency light absorber in thin-film photovoltaics (PVs). Despite the impressive progress made over the last decade in terms of materials design, solution processing, and device optimization, we still seem to have a limited knowledge on the operating mechanism of perovskite-based PV cells, which may in turn build up a significant performance bottleneck in the risk of slowing down the future research activities. In this paper, we identify the key physical mechanisms behind the systematic open-circuit voltage loss in a high-performance methylammonium lead iodide PV device. The experimental current-voltage data were first reproduced by means of two-dimensional finite-element simulation, to prepare a robust theoretical framework for parametric analyses. Then, we observed both increase and decrease in photo-voltages with respect to the constantly increasing charge-carrier mobility in the active perovskite layer. This intriguing phenomenon was fully rationalized by carrying out a series of simulation and analyses on the internal charge and potential distributions, which were correlated back to the various terminal behaviors. Therefore, our results are expected to further improve our fundamental understanding on how to improve perovskite PV performances.

Keywords:

Perovskite photovoltaics, Device simulation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.408

Improvement of charge transport in organic TIPS semiconductor device by using crystalized eco-friendly plastic cellulose nanowhisker

LIM EunJu *[1], CHO Seongjib [1]
[1]Convergent Systems Engineering, Dankook University
elim@dankook.ac.kr

Abstract:

In this study, the charge transfer characteristics and capacitance of the organic semiconductor device were controlled by changing the crystal characteristics of the organic semiconductor layer. We found a novel way to improve charge transfer characteristics of 6, 13-Bis(triisopropylsilylethynyl)pentacene (TIPS)-field effect transistor (FET) device, by embedding bio-friendly plastic nanoparticles of cellulose nanowhiskers (CNWs) into TIPS. We compared TIPS/CNW layers with pure TIPS layers by using TEM, SEM, X-ray analys, and also compared the charge transfer characteristics of TIPS/CNW and TIPS FET devices. The molecular direction, size, and crystallinity of the substrate surface were found changed by embedding CNW nanoparticles, and lead to the improvement of charge transfer characteristics of TIPS organic semiconductor devices, even though the embedded CNW have electrical insulating properties.

Keywords:

Cellulose nanowhisker, TIPS-Pentacene, Organic semiconductor device

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.409

Vertical energetic analysis of degraded exciplex-based blue phosphorescent OLEDs using gas cluster ion beam

KIM Kiwoong [1], PARK Soohyung [2], CHUNG Wonjae [3], LEE Junyeob [3], YI Yeonjin [*1]
[1]Department of Physics, Yonsei University
[2]Advanced Analysis Center, KIST
[3]School of Chemical Engineering, Sungkyunkwan University
yeonjin@yonsei.ac.kr

Abstract:

Phosphorescent organic light-emitting diodes (PhOLEDs) have been commercialized in past years, delivering significantly enhanced electroluminescence efficiency beyond the limit of fluorescent OLEDs. To circumvent quenching effect of phosphorescent emitter, co-host has been utilized in PhOLEDs due to its better charge balance as well as the high energy transfer efficiency by forming an exciplex with small single-triplet energy splitting. Despite its successful application in red and green PhOLEDs, blue PhOLEDs show extremely short lifetime by the deformation of organic materials, extensive trap, and luminescence quencher formation. However, the stacked structure of organic layers and upper cathode hinders direct measurements of interfacial properties, which are critical information to understand device degradation.

Herein, we investigated the change in electronic structure of exciplex-based PhOLEDs by operational time. Argon gas cluster ion beam enabled damage-free etching to trace the energy level alignment and chemical change of stacked layers. The intrinsic degradation mechanism of exciplex-based blue PhOLEDs such as the mismatch of energy level offsets and aggregation of FIrpic dopant will be discussed.

Keywords:

Exciplex, Phosphorescent OLEDs, gas cluster ion beam, electronic structure, FIrpic

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.411

Identification of ion migration in $MAPbI_3$ films through electronic structure analysis

LEE Hyun Bok *[1,2], PARK Soohyung *[5], CHOI Seungsun [1,2], KIM Wonsik [1,2], SHIN Woojin [1,2], KIM Kitae [3,4]
[1]Department of Physics, Kangwon National University
[2]Accelerator Science, Kangwon National University
[3]Physics and Applied Physics, Yonsei University
[4]van der Waals Materials Research Center, Yonsei University
[5]Advanced Analysis Center, KIST
hyunbok@kangwon.ac.kr, soohyung.park@kist.re.kr

Abstract:

Organometal trihalide perovskites (OTPs) materials with long carrier diffusion length and high absorption coefficient are emerging as attractive photovoltaic materials. The power conversion efficiency (PCE) of OTP solar cells has increased rapidly, recorded 25.5 % in 2020. Although OTP solar cells have such high PCEs, the short-term lifetime due to instability of OTP materials remains a challenge for commercialization. The main factor of the instability of OTP materials is ion migration and chemical change. Therefore, it is important to understand the cause of ion migration through accurate measurements. Therefore, accurate measurement of ion migration in OTP films and understanding of the mechanism are essential.

In this study, we investigated the ion migration in methylammonium lead iodide ($MAPbI_3$) films under 1 sun illumination and bias condition. To analyze the distribution and chemical state of ionic species in $MAPbI_3$ films, the electronic structure of films was studied by using the X-ray photoelectron spectroscopy (XPS).

Keywords:

MAPbI3, Ion migration, Electronic structure, XPS

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.412

Effect of ultraviolet-ozone treatment on solution-processed tetra-tert-butyl copper phthalocyanine film

KIM Wonsik [1,2], CHOI Seungsun [1,2], SHIN Woojin [1,2], OH Jaewon [1,2], JUNG Sehyun [1], OH Hyesung [1], KO Moonseock [1], RYU Mee-Yi [1,2], LEE Hyun Bok *[1,2]
[1]Department of Physics, Kangwon National University
[2]Institute for Accelerator Science, Kangwon National University
hyunbok@kangwon.ac.kr

Abstract:

Ultraviolet-ozone (UVO) treatment etches the surface of an organic thin film and its hydrophobic nature can be changed to be hydrophilic. Thus, UVO treatment is popularly used for the fabrication of the multilayer structure using the solution process. Moreover, UVO treatment oxidizes the organic film, which significantly affects the performance of optoelectronic devices. However, the electronic properties of UVO-treated organic films have not understood sufficiently. In this study, the effects of UVO treatment on the electronic structure of tetra-tert-butyl copper phthalocyanine (ttb-CuPc) films by using UV-vis absorption spectroscopy, X-ray photoelectron spectroscopy (XPS), and density functional theory (DFT) calculation. Significant oxidation is observed in both UV-vis and XPS spectra. The charge redistribution on the ttb-CuPc molecule is discussed using the XPS and DFT results.

Keywords:

X-ray photoelectron spectroscopy, UV-vis absorption spectroscopy, ultraviolet-ozone treatment, oxidation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.413

혼합 용매로 제작된 유기 반도체 소자의 UV-vis 분석

PARK Keon Joo [1], KIM Chae Won [1], SUNG Min Jae [1], KIM Kyoung Hwa [1], AHN Hyung Soo [1], YI Sam Nyung [1], CHUN Young Tea [*1]
[1]Division of Electronics and Electrical Information Engineering, Korea Maritime and Ocean University
ytc24@kmou.ac.kr

Abstract:

유기 반도체는 저렴한 공정 과정과 유연성으로 인해 각광 받는 소재이다. 하지만, 기존의 유기 반도체는 전하의 이동도가 낮아서 유기 반도체를 활용한 전자 소자의 특성에 한계가 있다. 이러한 유기 반도체의 결정성은 유기 반도체로 구성된 전자제품의 성능을 크게 향상시키는데 매우 중요한 요소이다. UV-vis은 자외선을 이용하여 정량, 정성분석에 응용되는 분석 방법으로 UV-vis 분석을 통해 유기 반도체의 결정성 및 구조를 분석 할 수 있다.
본 연구에서는 N-type의 고분자 유기 반도체 물질을 사용하며 혼합 용매로는 Toluene과 1,2-Dichlorobenzene (DCB)을 사용하고 첨가제로 극성을 띠는 Cyclohexanone을 사용하여 0~20%의 다양한 혼합비로 제작된 소자를 전기적으로 분석 하였다.
혼합 용매를 이용한 유기 반도체의 UV-vis 흡수 스펙트럼 분석을 통해 혼합 용매가 소자에 미치는 영향을 분석하였으며 용매의 농도 및 용매의 종류 따라 Intensity 및 peak shift가 발생되는 것을 확인할 수 있었다. 이는 용매에 따라 유기 반도체의 분자 배열 및 결정성이 달라짐을 의미한다.
본 연구를 통해 유기 반도체의 결정성을 향상시키기 위한 방법을 제시할 수 있었으며 최적의 조건을 가진 혼합 용매를 이용해 용해시킨 유기 반도체를 이용하여 특성이 우수한 전자제품을 제작하는데 기여할 것으로 기대한다.

Keywords:

UV-Vis, cosolvent, OTFT, Spectrometry, Polymer Crystal

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.414

Effect of molecular dipole orientations in a molecular heterostructure with two-dimensional semiconductors

WANG Gunuk *[1], EO Jung Sun [1], SHIN Jaeho [1]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
gunukwang@korea.ac.kr

Abstract:

Diverse types of molecules such as a donor-s-acceptor molecules and ferrocenyl alkanethiol have been suggested as potential candidates for the electronic component of a molecular rectifier.[1,2] Recently, we demonstrated a novel strategy and design rule for realizing molecular-scale diode features based on the energy band engineering between simple alkanethiol or conjugated molecules and two-dimensional (2D) semiconductors.[3] Here, we study a effect of molecular dipole orientation in a molecular heterostructure with two-dimensional semiconductors and firstly demonstrate the nonlinearity and suggest it as a molecular-scale (sub-2nm) selector model where is based on a heterojunction structure with a non-functional molecule(1-octanethiol, tridecafluoro-1-octanethiol) and two-dimensional semiconductor(MoS_2, WSe_2), which can be utilized to prevent the crosstalk signal in the crossbar memory array. According to direction of molecular dipole moment, the type of 2D semiconductors (1_L-MoS_2 of n-type), and the metal work function (Au and Pt), we found the nonlinearity at $V_r/2$ scheme can be significantly varied, e.x., 1.2± 10^1 for Au/C8/1_L-MoS_2/Au and 3.5 ± 10^2 for Au/F6H2/1_L-MoS_2/Pt. This phenomenon can be understood based on the interfacial energy band adjustment of 2D semiconductor in molecular heterojunction according to the direction of molecular dipole moment. The maximum non-linearity value is found to be 2.7± 10^3 for the case of Au/F6H2/1_L-MoS_2/Pt. With this non-linearity, the suggested molecular selector enables to extend the array size up to ~ 9Gbit crossbar array.

[1] Díez-Pérez, I. et al. Rectification and stability of a single molecular diode with controlled orientation. Nat. Chem. **1**, 635 (2009).
[2] Chen, X. et al. Molecular diodes with rectification ratios exceeding 10^5 driven by electrostatic interactions. Nat. Nanotechnol. **12**, 797 (2017).
[3] Shin, J. et al. Tunable rectification in a molecular heterojunction with two-dimensional semiconductors. Nat. Commun. **11,** 1412 (2020).

Keywords:

Molecular electronics, 2D semiconductor, molecular dipole moment, molecular selector, molecular heterojunction

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.415

Stamp를 이용해 패터닝한 유기 반도체 소자의 전기적 특성의 비교

KIM Chae Won [1], SUNG Min Jae [1], PARK Keon Joo [1], KIM Kyoung Hwa [1], YI Sam Nyung [1], AHN Hyung Soo [1], CHUN Young Tea [*1]
[1]Division of Electronics and Electrical Information Engineering, Korea Maritime and Ocean University
ytc24@kmou.ac.kr

Abstract:

유기 반도체를 이용하여 전계 효과 트랜지스터를 제작하는 데에 있어서 분자 정렬은 소자 성능에 매우 중요한 요소로 알려져 있다. 잘 정렬된 유기 반도체는 좋은 결정성을 나타내고, 전기적 특성의 향상을 야기한다. 이러한 이유로 한 방향으로 잘 정렬된 유기 반도체를 만들기 위해 전통적인 스핀코팅 방법 보다는 용매증기열처리 (solvent-vapor thermal annealing), 딥코팅 (dip coating), 용액전단 (solution shearing) 등 다양한 코팅 방법이 시도되었다. 하지만 기존의 방법들은 까다로운 공정 조건(높은 박막 형성 온도, 긴 공정 시간 등) 및 결정화 제어에 한계를 나타냈다.
본 연구에서는 일반적인 반도체 공정인 포토리소 기반으로 제작한 elastomer stamp를 이용한 유기 반도체의 패터닝을 제시하였다. 이 방법은 고온과 긴 시간이 필요하지 않고, stamp의 형태를 변경함으로써 유기 반도체의 패턴 형태를 쉽게 변형할 수 있었다. 유기 반도체 P(NDI2OD-T2)와 용매 1,2-Dichlorobenzene (DCB)를 이용하여 유기 반도체 박막을 형성하였다. 유기 반도체 전계 효과 트랜지스터의 경우 Bottom Gate/Bottom Contact (BG/BC) 형태로 제작되었으며, 같은 구조에서 패터닝한 유기 반도체 박막과 spin coating으로 제작한 유기 반도체 박막의 전기적 특성을 분석하였으며 또한 유기 반도체의 패턴 형태에 따른 전기적 특성 변화도 비교하여 전기적 특성을 분석하였다.
본 연구에서 제시한 방법은 상온에서 쉽게 유기 반도체의 정렬을 만들어 낼 수 있으므로 유기 반도체 물질을 이용하여 전자 소자를 제작하는 데에 새로운 길을 열어줄 수 있을 것으로 보인다.

Keywords:

Patterning, Stamp process, Polymer Semiconductor, OTFT

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.416

콘쥬게이션 폴리머의 발광 특성을 이용한 니트로기의 센싱 특성 연구

NOH DaeGwon [1], AMPADU Emmanuel Kwame[1], OH Eunsoon *[1]
[1]Department of Physics, Chungnam National University
esoh@cnu.ac.kr

Abstract:

Conjugated polymer의 일종인 PEE 박막을 스핀코팅하여 주요한 폭발물질 성분의 하나인 니트로 성분에 의한 발광 특성 변화를 관찰하였다. 박막의 SEM 이미지를 측정하여 박막의 두께와 균일성, 표면 상태를 확인하였으며, PEE 박막의 PL(Photoluminescence) 세기가 공기 및 TNT(Trinitrotoluene) 증기와의 반응에 따라 감소하는 PL quenching 현상이 발생하는 것을 관찰하였다. 또한 제조한 박막 시료에 TNT 수용액을 가하여 이에 따른 PL quenching도 확인하였으며, 이를 증기 상태에서의 반응과 비교하였다. 본 연구에서는 공기의 유속 및 여기 광원에 따른 니트로 성분의 반응 효율 차이를 측정하였다.

Keywords:

Conjugated polymer, Photoluminescence, quenching

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.417

Micro-pattern된 고분자 반도체의 AFM 표면 분석

SUNG Min Jae [1], KIM Chae Won [1], PARK Keon Joo [1], KIM Kyoung Hwa [1], AHN Hyung Soo [1], YI Sam Nyung [1], CHUN Young Tea [*1]
[1]Division of Electronics and Electrical Information Engineering, Korea Maritime and Ocean University
ytc24@kmou.ac.kr

Abstract:

유기 반도체 소재는 저렴한 가격, 손쉬운 제작 공정, 유연성, 가벼운 무게 등의 이유로 많은 관심을 받아왔다. 특히, 용액 공정이 가능한 고분자 반도체는 spin-coating, bar-coating, drop-casting 등의 간단한 방법으로 반도체 소자를 제작하여 그 특성을 극대화하기 위해 오랫동안 연구가 진행되었다. 유기 반도체를 이용한 논리 회로, 트랜지스터, 가스 센서 등 정보, 전자 분야에 걸쳐 다양하게 진행된 연구들을 통해 고분자 반도체의 성능을 향상시키기 위해서 분자 정렬을 통해 전자 소송 현상을 극대화할 필요하다는 연구들이 보고되고 있다.
본 연구에서는 마이크로 스케일로 정렬된 고분자 반도체 소자를 제작하고, AFM 표면 분석으로 마이크로 스케일로 패턴 되는 동안 발생되는 고분자 반도체 솔루션의 거동을 분석하고 고분자 반도체가 패턴 형성 시 발생되는 결정화가 소자에 미치는 영향을 분석한다. 본 연구에서 제안하는 최적의 조건으로 제작된 마이크로 스케일 고분자 반도체 소자는 향후 다양한 전자제품에 적용할 수 있는 기회를 창출 할 것이라 기대한다.

Keywords:

Micro-pattern, AFM, OTFT, Polymer semiconductor crystals, Molecular alignment

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.418

A Study on the Correlation between the Morphology and Device Characteristics by Small Molecular Hole Material Doping in Quantum Dot Emission Layer

KIM Jaeseung [1], HYEON Min Woo [2], SUH Min Chul [2], KIM Hyunjung *[1]
[1]Physics, Sogang University
[2]Information Display, Kyung Hee University
hkim@sogang.ac.kr

Abstract:

In this work, correlation between the change in the morphology and the efficiency of the device with small molecular hole transporting material was investigated. Previous studies have also been conducted to enhance device characteristics by adding small molecular hole transporting material into emission layer. The increase in the efficiency of quantum dot emission layers is identified using Tris(4-carbazoyl-9-ylphenyl)amine (TCTA), a representative small molecular hole transporting layer material. However, efficiency has decreased since a certain ratio of additions. This is the result of showing that current did not flow efficiently into quantum dots. This study shows that the reduction in device characteristics shown by other studies is also related to structural problems, not just due to current characteristics alone. By matching the cross point of the topological property with the reduction point of the efficiency of the device, we have identified that not only charge balance, but also structural changes are factors that affect the efficiency of the device.

Keywords:

quantum dot LED, mixture, Hole transporting material, morphology change

A novel cyan phosphor of Eu^{2+} ion doped magnesium cordierite, $Mg_2Al_4Si_5O_{18}$ for WLED applications

PARK Jin Young [1], HONG Woo Tae [2], CHUNG Jong Won [1], YANG Hyun Kyoung *[1]
[1]Department of Electrical, Electronics and Software Engineering, Pukyong National University
[2]Marine-bionics convergence technology center, Pukyong National University
hkyang@pknu.ac.kr

Abstract:

Phosphor-converted white light emitting-diodes (pc-WLEDs) have received great attention to be a next-generation light source due to their high luminous efficiency, low power consumption, and environment-friendly characteristics in comparison with traditional incandescent and currently implemented fluorescent lamps. Currently, commercial WLEDs employ a blue InGaN LED chip with a yellow phosphor of Ce^{3+}-doped yttrium aluminum garnet (YAG:Ce), and are very poor in the color rendering index (CRI) because of the color deficiency in the red region. Consequently, WLEDs fabricated with near ultraviolet (NUV) LEDs chip and three primary color emissions mixed (red, green and blue) phosphors have been widely investigated.

The luminescent properties of Eu^{2+} ions in various matrix compounds and the reduction processes of Eu^{3+} to Eu^{2+} in phosphor have attracted signifcant attention in the past decades. Normally, the photoluminescence of Eu^{2+} in most silicates host is associated with the 4f - 5d transitions. Compared with 4f orbitals of Eu^{2+}, those of 5d orbitals are sensitive to the changes of the crystal feld strength due to its existing in the outer shell. The peak positions in the emission spectra depend strongly on the nature of the Eu^{2+} surroundings. Therefore Eu^{2+} can be efficiently excited in a broad spectral range depending on the host lattices in which it is incorporated.spectral range depending on the host lattices in which it is incorporated.

Here, we report on the synthesis and characterizations of $Mg_2Al_4Si_5O_{18}:Eu^{2+}$ phosphors for WLEDs application, and a systematic study on the structural and luminescent properties of these phosphors has been carried out in detail.

Keywords:

Luminescence, Eu2+, magnesium cordierite

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.502

Air-processable and Stable Perovskite Planar Solar Cells with Organic Seeding Layer Induced 2D/3D Heterointerface

SHIN Insoo [1], HANGOMA Pesi Mwitumwa[1], SON Semo [2], PARK Sung Heum *[1]
[1]Department of Physics, Pukyong National University
[2]2Department of Graphic Arts Information Engineering, Pukyong National University
spark@pknu.ac.kr

Abstract:

Despite having record power conversion efficiencies, moisture instability still presents a challenge for the commercialization of inverted planar perovskite solar cells. We work on overcoming the moisture instability of the perovskite solar cells by introducing extra ethylenediamine cations at the base of the 3-dimensional (3D) perovskite active layer. A 2-dimensional /3-dimensional (2D/3D) hybrid active layer is formed when the cations induce thin 2-dimensional (2D) perovskite growth beneath the 3D perovskite. This 2D layer in turn acts as a template for the growth of relatively large grains compared to that of pure 3D perovskite films. This stems from the merging of grain boundaries. The hydrophobicity of the 2D/3D perovskite film consequently improves, as evidenced by a larger contact angle of 93.1°, compared to 68.9° for the 3D perovskite film. Because there are fewer defects sourced from grain boundaries, the air-processed 2D/3D perovskite devices yield a higher power-conversion efficiency of 15.02%, compared to 13.10% from 3D perovskite devices. When stored in moderately humid environment of 55% RH, the 2D/3D devices exhibit longer stabilities, with 75% of their power conversion efficiencies maintained after 150 hours, compared to a total loss in efficiency for 3D device in the same time frame.

Keywords:

Perovskite, Solar Cell, Stability

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.503

Spatiotemporally modulated coupled mechanical resonators for synthetic frequency dimension

MIN Bumki *[1], KYUNG Minwook [1], PARK Jagang [1], KIM Yung [1], LEE Kyungmin [1]
[1]KAIST
bmin@kaist.ac.kr

Abstract:

The concept of synthetic dimension opens up new possibilities in various disciplines by exploring higher dimensional physics in a lower dimensional physical system. Generally, synthetic dimension can be created by forming a lattice with a set of coupled states. Recently, photonic platforms are emerging as a powerful platform that can be utilized to investigate interesting behaviors such as Bloch oscillation and topological edge states along the synthetic dimension. However, the formation of synthetic dimension has not been explored in mechanical or phononic domains. Here, we show numerically the realization of synthetic frequency dimension by employing spatiotemporally modulated coupled mechanical resonators in a ring-shaped geometry. The proposed platform is analyzed based on a mass-spring chain model and a coupled mode formalism. The construction of mechanical synthetic dimension is verified by the observation of Bloch oscillation along the synthetic frequency dimension and probed by its effective band structure. Our results show that higher dimensional physics can be tested in classical mechanical systems.

Keywords:

Synthetic dimension, Bloch oscillation, Mass-spring chain model

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.504

Grain Boundary Passivation and Faster Hole Extraction by Polymer Permeation Strategy for Highly Efficient and Stable Perovskite Solar Cell

KIM Danbi [1], PARK Woon Ik [2], SEO Hyo Jin [1], PARK Sung Heum *[1]
[1]Department of Physics, Pukyong National University
[2]Department of Materials Engineering, Pukyong National University
spark@pknu.ac.kr

Abstract:

Organic-inorganic hybrid perovskites are attracting significant attention due to their numerous advantages such as superior optical/electrical properties and solution processability. However, the efficiency of perovskite solar cells and device stability are still limited by the defects which originate from the inevitable formation of perovskite grain boundary and sensitive dependency of perovskite grain growth. To solve these issues, here we present a simple, efficient polymer-permeating grain boundary (PPGB) method that hydrophobic p-type materials are introduced into the perovskite grain boundary down to bottom after fabricating dense, single-like perovskite grain. This approach of passivated perovskite grain boundary from p-type material lead to defect passivation and enhancement of hole extraction with improved highly solar cell efficiency and stability. It was achieved that the modified device has decreasing leakage current, 3.8 times enhancement of hole mobility, as well as reduced trap state density comparing pristine device due to less nonradiative recombination losses. Consequently, modified perovskite solar cells performance are significantly enhanced from 16.5 % to 18.6 % and the stability also increase under the ambient environment due to covering perovskite grain.

Keywords:

Grain boundary passivation, Perovskite solar cell, Polymer permeation strategy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.505

Phenylethylammonium Iodide Induced Bilateral Interface Engineering for Efficient and Stable Perovskite Solar Cells

ZHANG Yuanyuan [1], LEE Bo Ram [1], PARK Sung Heum [*1]
[1]Department of Physics, Pukyong National University
spark@pknu.ac.kr

Abstract:

Achieving high efficiency and long-term device stability is a vital issue for the commercialization of organic-inorganic hybrid perovskite solar cells (PeSCs). In this paper, phenyl ethyl−ammonium iodide (PEAI) induced bilateral interface engineering was developed via incorporation of its activated bottom and top ways, which would inherit the high PCE from bottom way and the superior stability from top way. As for bottom way, PEAI solution is spin−coated on the top of hole transfer layer (HTL) then active film is deposited. As a result, high−quality perovskite film with enlarged grain sizes can be obtained. Moreover, PEA^+ could realize superior energy level match between HTL and active layer, largely decreasing energy loss during charge transfer. These variations are contributed to high efficiency of device. With regard to top way, PEAI solution is deposited on the top of perovskite film to construct 2D/3D stacked structure for active layer. Because the 2D top layer acts as a capping layer to prevent water penetration, the stability of the perovskite active layer is significantly enhanced. A PeSC device fabricated based on this combination exhibits enhanced power conversion efficiency and extended device lifetime compared to a pristine PeSC. Under high-humidity conditions (75 ± 5%), the PEAI-treated PeSC retains 88% of its initial PCE after 100 h. In contrast, a pristine PeSC device loses over 99% of its initial PCE after only 25 h under the same conditions.

Keywords:

Phenylethylammonium Iodide, Perovskite Solar Cell, stability

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.506

The Fabrication of Cesium Based Perovskite through Thermal Evaporation and its Application on Green Light Emitting Diode

KIM Junho [1], KANG Donghee [1], JUNG Na Eun [1], LEE Hyunbok [*2], PARK Soohyung [*3], YI Yeonjin [*1]
[1]Department of Physics, Yonsei University
[2]Department of Physics, Kangwon National University
[3]Advanced Analysis Center, KIST
hyunbok@kangwon.ac.kr, soohyung.park@kist.re.kr, yeonjin@yonsei.ac.kr

Abstract:

Organic-inorganic halide perovskites dragged huge research interest with their attractive optical and electronic properties. Among the most interesting characteristics is their bandgap tunability, achieved by varying the composition of precursor or the amount of them. The total range of visible ray spectrum could be covered with just only a few sources. Along with their bandgap tunability, their intrinsically narrow emission spectrum (~20 nm) lead perovskite as one of the most promising materials for display industry. The most unfavorable characteristic of perovskite is the degradation induced by environment. (moisture, temperature, oxygen, etc.) For the growth of more resistible film, the necessity of vacuum deposition and all-inorganic perovskite has been emphasized.

Here, we investigated the vacuum deposition of Cs^+-containing perovskite for the application on light emitting diode. The co-evaporation of cesium bromide (CsBr) and lead bromide ($PbBr_2$) lead to mixed phase perovskite film ($CsPbBr_3$/Cs_4PbBr_6). To improve emission efficiency, we tried on promoting the formation of Cs_4PbBr_6, which was reported to aid emission property, just by adding excess amount of CsBr. However, the deposition rate of CsBr could not exceed a certain point because of control issue and high material consumption. We instead fabricated Cs_4PbBr_6 through solution process and directly evaporated it for the formation of highly emissive perovskite film. We confirmed morphology, crystallinity and photoluminescence of films and applied them for light emitting diode.

Keywords:

Perovskite, Light emitting diode, Vacuum deposition, CsPbBr3, Cs4PbBr6

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.507

Synthesis and Characterization of Carbon Dots using Fine Dust in Hepa Filter

CHUNG Jong Won [1], PARK Jin Young [1], YANG Hyun Kyoung [*1]
[1]Department of Electrical, Electronics and Software Engineering, Pukyong National University
hkyang@pknu.ac.kr

Abstract:

Fine dust pollution is of great concern worldwide due to the high demands of modern lifestyles. Most of these fine dust pollutions are artificially generated, and these are mainly composed the sulfate, nitrate, and organic carbon, etc.. Exposure to fine dust causes symptoms such as asthma, acute-bronchitis, and arrhythmia in the short term, and it persists for a long time the risk increases disease such as cardiovascular disease, respiratory disease, and lung cancer. When fine dust enters the body, it supplies active oxygen to the body organs promotes cell aging, and affects the whole body through blood flow. So, the air-purifiers using has become essential in home or industrial areas. Sensitive group such as pregnant, infants, children and the elderly are particular at risk for exposure to fine dust, so the air-purifiers using is essential. The high efficiency particulate air (HEPA) filters are used as core component of these air purifiers. Which is generally used the HEPA filters has a collection capacity of 99.975% or more of fine dust, and these made glass fiber. However, the wasted HEPA filters are not recycled and being discarded. In this work, we synthesized carbon dots with using wased fine dust in HEPA filters by solvothermal method according to various solvents such as DI-water, EtOH, and 2-ProH. Their structures, luminescence, and morphology characterization synthesized carbon dots were investigated by using X-ray photoelectron spectroscopy (XPS), raman spectroscopy, Fourier-transform infrared spectroscopy (FT-IR), photoluminescence (PL) and high-resolution transmission electron microscopy (HR-TEM), respectively.

Keywords:

Carbon dots, Hepa filter, Luminescence

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.508

Characteristics of chase of principal states of polarization using two ports of polarization beam splitter in optical fiber communications

HAN Ki Ho *1
[1]Department of Optical Engineering, Kongju National University
khhankr@kongju.ac.kr

Abstract:

Principal states of polarization (PSP) and differential group delay emerge in fiber optic link due to imperfect fiber symmetry and ambient factors such as weather variation, pressure and vibration, which may vary over time. Therefore, real time PSP chasing is needed to compensate for polarization mode dispersion, which limits capacity of optical fiber transmission systems. In this work, two output ports of a polarization beam splitter are used to generate monitoring signal, which enables PSP tracing by means of recursive process. The tracing performance and characteristics are investigated via theoretical simulation pursuant to electronic band pass filter and fiber system parameters. The simulation results are analyzed and discussed.

Keywords:

Principal states of polarization, polarization mode dispersion, optical fiber communication

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.510

Enhanced photodetection characteristics of solution-processed ZnO phototransistor via Li doping

JEONG Jun Hyung [1], PARK Sung Ho [1], KIM Byung Jun [1], HEO Su Been [1], KIM Tae Yeon [1], SHIN Jae Seung [1], MA JinHyun [1], KANG Seong Jun *[1]
[1]정보전자신소재공학과, Kyung Hee University
junkang@khu.ac.kr

Abstract:

Zinc oxide (ZnO) have been widely studied due to their wide band gap of 3.3 eV and improved electrical properties than amorphous-Si, and various methods were studied to improve the optoelectronic properties. In this study, we fabricated Li doped ZnO thin film transistors (TFTs) to enhance the optoelectronic properties of ZnO TFTs. Since zinc oxide (ZnO) is an n-type semiconductor due to its intrinsic defects, the interstitial site doped Li acts as an electron donor resulting in enhancement of electrical performances. The optimized doping concentration of Li was found to be 5 mol%. Photoresponsivity of 5 mol% Li doped ZnO under 405 nm wavelength illumination at the gate bias of -4.8 V was 92.94 A/W, which was higher than that of 0.28 A/W of undoped ZnO. The maximum photosensitivity of 5 mol% Li doped ZnO under 405 nm wavelength illumination was 6.8×10^7, which is also higher than that of 6.16×10^5 of undoped ZnO. Also, electrical properties such as electron mobility of 11.34 cm^2/Vs, on-off current ratio of 1.15×10^7 were obtained. Our results demonstrate that the optical and electrical performances of ZnO TFTs can be highly improved by doping Li in ZnO.

Keywords:

Oxide semiconductor, Li doped ZnO, Phototransistor, Solution process, Photoresponsivity

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.511

Color alteration of carbon dots via solvent changes

PARK Sung Jun [1], MOON Byung Kee [2], YANG Hyun Kyoung *[3]
[1]Interdisciplinary Graduate Program of Artificial Inteligence on Computer, Electronic and Mechanical Engineering, Pukyong National University
[2]Department of Physics, Pukyong National University
[3]Department of Electrical, Electronics and Software Engineering, Pukyong National University
hkyang@pknu.ac.kr

Abstract:

Carbon dots have unique properties such as ease of modification, biocompatibility, low cost, high stability, etc. Therefore, carbon dots can be applied for several fields such as light emitting diodes (LEDs), lighting, displays, bio imaging, optical device, photocatalysis, sensor, and solar cell. The developed fluorescent materials are organic fluorescent dyes, inorganic quantum dots, inorganic phosphors. However, they have susceptibility to photobleaching, low emission quantum yields, complicated synthesis.

In this work, the carbon dots were synthesized by using facile solvothermal method with different solvents (DI-water, ethanol, acetone, 2-propanol, And DMF). The prepared carbon dots have good emission intensity, several color and photo and chemical stability. Therefore, we present the characterization with using the prepared carbon dots. The results show that the prepared carbon dots can be effectively applied to several applications.

Keywords:

Carbon dots, solvent, Luminescence

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.512

Investigation of circuit noise influence on optical signal to noise ratio acquisition in optical communication systems

HAN Ki Ho *[1]
[1]Department of Optical Engineering, Kongju National University
khhankr@kongju.ac.kr

Abstract:

Optical signal to noise ratio (OSNR) is one of criteria to assess performance of fiber optic transmission systems. OSNR can be measured in a signal band from photocurrent noises, which arise from light detection at optical receivers. Excluding the photocurrent noises, there may be other circuit noises at the receiver, which may obstruct exact OSNR measurement. In this study, the effect of the circuit noise on OSNR acquisition is theoretically and computationally investigated. OSNR is obtained by way of simulation for respective case where the circuit noise is disregarded and considered. The OSNR difference between the two cases is analyzed and discussed.

Keywords:

Optical signal to noise ratio, circuit noise, optical fiber communication

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.513

Efficient and Air-Stable Halide Perovskite Solar Cells via Surface Structural Modification

KIM Tae hyun [1], JU Byeong Kwon [1], KWAK Joon Young [3], KIM Junghwan *[2]
[1]School of Electrical Engineering, Korea University
[2]Department of Materials System Engineering, Pukyong National University
[3]Center for Neuromorphic Engineering, KIST
junghwan.kim@pknu.ac.kr

Abstract:

Organic/inorganic halide perovskite solar cells (PSCs), which are in the spotlight as the next-generation energy source, are now stepping closer to commercialization by achieving the highest efficiency of 25.5%. However, low stability in the air remains the most important challenge to be solved and the instability of the organic cation methylammonium (MA) is known to be the main cause. Here, we report efficient and air-stable PSCs based on the MA-free perovskite with a combination of rubidium (Rb), cesium (Cs), and formamidinium (FA) cations. It is found that the RbCsFA perovskite exhibits many surface defects during the crystal formation, which in turn deteriorates performance and stability. To suppress the defect formation, we judiciously choose bulky organic cations and introduce a dimensional modulation at the surface of the perovskite. As a result, the multi-dimensional MA-free perovskite with a 3D bulk/2D surface structure shows remarkably enhanced device efficiency and air-stability. We expect that these results pave the way for realizing more efficient and stable MA-free PSCs and provide great contributes to commercialization in the field.

Keywords:

Halide perovskites, Solar Cells, Stability, Defects

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.514

Study on efficient quantum-dot light-emitting diodes using metal-doped inorganic hole injection layer

SHIN Jae Seung [1], KANG Seong Jun *[1]
[1]정보전자신소재공학과, Kyung Hee University
junkang@khu.ac.kr

Abstract:

The hole injection characteristics of hole injection layer (HIL) play an important role in the electroluminescence performance of quantum-dot light-emitting diodes (QLEDs). We demonstrated a hole injection material for a low temperature, solution processable QLED by doping Li into vanadium oxide. As a result, the QLED with Li-doped V_2O_5 (10 mol%) exhibited a turn-on voltage of 3.1 V, a maximum luminance of 146,820 cd/m^2, and a current efficiency of 20.6 cd/A, respectively. Compared to QLEDs with V_2O_5, both luminance and current efficiency outperformed more than twice. The effect of Li doping led to the improvement of hole injection and was confirmed by fabricating hole-only devices (HODs). These results suggest that Li-doped V_2O_5 HIL will be promising for achieving high-performance QLEDs.

Keywords:

Hole injection layer, Li doped vanadium oxide, Quantum-dot light-emitting diodes

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-ap.515

Bandgap engineering of nitrogen doped carbon dots

HONG Woo Tae [1], MOON Byung Kee [2], YANG Hyun Kyoung *[3]
[1]Marine-Bionics convergence technology center, Pukyong National University
[2]Department of Physics, Pukyong National University
[3]Department of Electrical, Electronics and Software Engineering, Pukyong National University
hkyang@pknu.ac.kr

Abstract:

Carbon dots (CDs) have been paid attention as favorable luminescent materials in next generation, due to their low toxicity, cheap price, high quantum yield, high photo-stability. In order to apply the CDs, control of their bandgap is one of important issue. The bandgap of the CDs has been modulated by using a quantum confinement effect, surface modification and adding a fluorophore. Nevertheless, these modulation methods can suffer poor chemical stability and luminescent quenching by aggregation. In order to solve these problem, substitution of heteroatom is suggested as an alternative of bandgap modulation.

Among various heteroatoms, nitrogen is favorable dopant of CDs due to the similar atomic radius. The nitrogen can be existed as graphitic, pyrridinic, pyrrolic and amine bondings. Based on these bondings and their concentration, luminescent properties of CDs was modulated. The nitrogen doped surface state can occur high yield of radiative recombination. To optimize the bandgap, selecting the suitable synthesis conditions can be solution.

In this study, CDs were synthesized by using a solvothermal method. The bandgap of the CDs was modulated by changing a synthesis temperature and time. The structural, morphological and luminescent properties of the CDs were analyzed.

Keywords:

Carbon dot, Luminescence

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-as.001

Detecting signature of fast radio burst associated with soft gamma repeater by using machine learning

SONG Hyung Seon [1], HUR Min Sup *[1]
[1]Physics, UNIST
minshur@daum.net

Abstract:

Soft Gamma Repeater (SGR) is considered to be one of the candidate sources of Fast Radio Burst (FRB). However, only one SRG 1935+2154 out of 30 SGR's has been reported to emit FRB. Due to the lack of data, it is still unclear if the other SGRs are FRB sources with radio emission suppressed by Compton scattering. More detection of FRB-associated SGRs is required to resolve these issues. Recently, people are trying to discover the signatures of FRB in the SGR data using machine learning technique; with the aid of machine learning, the subtle difference in the signals or images can be perceived. We let the algorithm learn primarily various patterns of SGR1935+2154 and then analyze the other 30 candidates of SGRs to find FRBs. The trained algorithm also traces the signature of Compton scattering to catch indirect evidence of energy loss of radio emissions.

Keywords:

Soft Gamma Repeater, Fast Radio Burst, Machine Learning

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-as.002

Extending the search for neutrinos from cosmic ray interactions in the Sun to the Solar minimum with IceCube

ROELLINGHOFF Gerrit Leon*[1]
[1]Department of Physics, Sungkyunkwan University
gerritr@skku.edu

Abstract:

Interactions between cosmic rays and the solar atmosphere are expected to result in the generation of particle showers producing gamma rays and neutrinos. While there has been evidence for high-energy gamma rays originating from the solar disk, a search for high-energy neutrinos from the Sun with 7 years (2010-2017) of IceCube data has not observed any evidence of a signal, resulting in the first ever experimental bound on the high-energy neutrino flux from the Sun. Gamma-ray data collected during past solar cycles suggests an anti-correlation between solar activity and high-energy gamma-ray flux from the direction of the Sun. This indicates an enhancement in the high-energy neutrino flux during the solar minimum of 2018-2020. We present sensitivities of a new solar atmospheric neutrino search that improves upon the previous analysis and extends it to cover periods of the solar minimum.

Keywords:

Solar physics, IceCube, Solar minimum, Solar Atmospheric Neutrinos, Neutrino physics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.001

The influence of the optical pump beam on the transverse spin relaxation of ^{129}Xe

LEE Deok-Young [1], KIM Minwoo Moca[1], YIM Sin Hyuk [1], SHIM Kyu Min [1], LEE Sangkyung *[1]
[1]Agency for Defense Development
sklee82@add.re.kr

Abstract:

We investigate the influence of the optical pump beam on the transverse spin relaxation of ^{129}Xe and demonstrate the pulsed pump beam technique to measure the transverse spin relaxation without the effect of the magnetic field gradient originating from the optically pumped alkali polarization.
We observe that the transverse spin relaxation time of ^{129}Xe in the pulsed pump configuration is longer than that in the continuous pump configuration and it approaches close to the longitudinal spin relaxation time.

Keywords:

Transverse spin relaxation, Optical pump beam, Pulsed pump beam, Alkali polarization

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.002

Total photoionization cross-section of the collinear eZe model with Z>2

LEE Min-Ho *1, CHOI Nark Nyul 1
1School of Liberal Arts and Teacher Training, Kumoh National Institute of Technology
minho.lee.kr@gmail.com

Abstract:

Based on the semiclassical theory of chaotic scattering to the helium, Byun et al [1] predicted that the fluctuation in the total photoionization cross-section (TPICS) of two-electron atom below the double ionization threshold shows that the Fourier spectrum of the fluctuation reveals peaks at the classical actions of closed triple collision orbits and the amplitude of the fluctuation decreases algebraically in thems of a threshold law $|E|^\mu$ as $E \to 0^-$where the exponent μ is

$$\mu = \frac{1}{4}\mathrm{Re}\left[\sqrt{\frac{100Z-9}{4Z-1}} + 2\sqrt{\frac{4Z-9}{4Z-1}}\right]$$

with Z, the charge of the nucleus. For Z=2, the predictions were confirmed by numerically calculating the TPICSs of eze collinear model and planar helium. By calculating the TPICS of the collinear eze model with Z > 2 up to I_{30}
we show that the predictions are indeed valid even for Z > 2.
[1] Byun et al Phys. Rev. Lett. 98, 113001 (2007)

Keywords:

total photoionization cross section, chaotic scattering, helium

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.003

주기적 온도 변화에 의한 편광 유지 광섬유의 편광 안정화

LEE Sanglok [1], JEONG Jeongyoun [1], HWANG Sungi [1], BAEK Jaeuk [1], MOON Geol [*1]
[1]Department of Physics, Chonnam National University
cnuapi@jnu.ac.kr

Abstract:

레이저 시스템에 광섬유를 사용할 때 시스템의 성능은 광섬유를 진행하는 빛의 편광 변화에 크게 영향을 받는다. 이러한 편광 변화를 방지하기 위해 일반적으로 편광 유지 광섬유(Polarization maintaining fiber)를 사용한다. 그러나 입사되는 빛의 편광이 광섬유의 편광 축에 정렬되지 않을 경우, 외부 응력 및 온도변화가 가해 질 때 편광 회전이 일어나게 된다. 우리는 광섬유에 입사되는 레이저 빔의 편광이 편광 축에 정렬된 정도를 판단하기 위해 열을 직접 클래딩에 가하여 열응력에 의한 편광변화를 관찰하였다. 열응력이 유지 되도록하기 위해 광섬유 피복 안에 에나멜 코팅된 구리선을 삽입하고, MOSFET을 이용해 전류를 주기적으로 ON OFF 할 수 있는 간단한 장치를 만들어 수 초 영역의 연속적인 편광변화의 주기성을 확인하였다. 이러한 연속적인 주기적 편광 변화 관측을 통해 상대적으로 쉽게 편광이 정렬된 정도를 판단하고 정밀하게 편광을 정렬시킬 수 있는 방법에 대해 자세히 논의하고자한다.

Keywords:

편광 유지 광섬유, 주기적 온도변화, 편광 안정화

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.004

고출력 레이저 개발을 위한 아르곤 플라즈마 내의 준안정 준위 밀도 측정

SHIM Sungyong [1], LEE Wonwook [1,2], OH Cha-Hwan *[1]
[1]Hanyang University
[2]Research Institute for Natural Sciences, Hanyang University
choh@hanyang.ac.kr

Abstract:

최근 국방과 재료가공 분야에의 응용을 위해 고품위 고출력 레이저기술이 요구되고 있으며, 최근 연속발진 다이오드 펌핑 불활성기체 레이저(diode pumped rare gas laser, DPRGL)가 차세대 기술로 제안되었다. 아르곤 가스를 이용한 DPRGL 개발의 성공을 위해서는 불활성 기체 전기방전에서 $10^{12}cm^{-3}$ 이상의 아르곤 $1s_5$ 준안정 준위 밀도를 유지하는 것이 요구된다. 본 연구에서는 아르곤 펄스방전 플라즈마 발생 시스템을 구축하였으며, 레이저 흡수 분광법을 이용한 아르곤 준안정 준위 밀도 측정 시스템을 구성하였다. 레이저 흡수 분광법에 사용한 광원으로는 $1s_5$à$2p_{10}$ 전이에 해당하는 912.3nm의 파장 가변 레이저를 이용하였으며, 측정된 $1s_5$ 준안정 준위 밀도는 플라즈마 발생 조건에 따라서 어떻게 변화하는지 분석하였다. 그리고 최적화된 조건에서 시간에 따른 $1s_5$ 준안정 준위 밀도 변화를 측정하였다.

Keywords:

High power laser, Metastable state, Laser absorption spectroscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.005

유도 결합 플라즈마에서의 He $2^3S \rightarrow 2^3P$ 전이선의 미세 준위 측정

SHIM Sungyong [1], LEE Wonwook [1,2], OH Cha-Hwan *[1]
[1]Hanyang University
[2]Research Institute for Natural Sciences, Hanyang University
choh@hanyang.ac.kr

Abstract:

유도 결합 플라즈마는 낮은 기체압력에서 고밀도 플라즈마를 생성할 수 있으며, 여러 산업분야에서 활용되고 있다. 본 연구에서는 포화흡수 분광법을 이용하여 유도결합 플라즈마에서 He $2^3S \rightarrow 2^3P$ 미세전이선을 측정하고, 자기장의 영향을 분석했다. 유도결합 플라즈마를 생성하기 위해 Right-helical 타입의 RF 안테나를 이용하였으며, 전원으로는 13.56MHz RF 전원을 사용하였다. 생성된 플라즈마의 전자 밀도는 $10^{11}cm^{-3}$~$10^{12}cm^{-3}$ 이었다. 1083 nm 파장의 레이저를 이용하여 포화흡수 스펙트럼 측정 시스템을 구성하였으며, 다양한 플라즈마 생성조건, 위치에서 포화흡수 스펙트럼을 측정하였다. RF 안테나 근처에서 자기장의 영향에 의한 Zeeman spitting을 확인하였으며, RF 안테나와 거리에 따른 자기장의 영향을 분석하였다.

Keywords:

Inductively coupled plasma, Saturation spectroscopy, Helium plasma

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.006

Origin of the asymmetries in the pump-probe EIA spectra of ^{85}Rb atoms

KIM Jin-Tae *[4], JADOON Zeeshan Ali Safdar [1], HASSAN Aisar Ul [2], NOH Heung-Ryoul [3]
[1]Dept. of Photonic Eng., Chosun University
[2]Dept. of Photonic Eng., Chosun University
[3]Dept. of Physics, Chonnam National University
[4]Dept. of Photonic Eng., Chosun University
kimjt@chosun.ac.kr

Abstract:

We study the origin of asymmetries in the pump-probe EIA spectra of ^{85}Rb atoms with respect to static magnetic field applied in the longitudinal direction theoretically and experimentally. Strong pump and weak probe fields with orthogonal linear polarizations are generated utilizing single laser combined with two AOMs. The influence of the neighboring hyperfine sub-levels on the resonant $\boldsymbol{F_g} = \mathbf{3} \rightarrow \boldsymbol{F_e} = \mathbf{4}$ transition is calculated utilizing time-dependent density-matrix equations considering the off-resonant transitions of the ^{85}Rb D_2 lines. We realize that the off-resonant transitions mainly contribute to the asymmetrical experimental spectra.

Keywords:

EIA, Rb, AOM

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.007

Measuring the ratio between the enhancement factors for Rb-129Xe and Rb-131Xe

KIM Minwoo Moca[1], LEE Sangkyung *[1], LEE Deok Young [1], YIM Sin Hyuk [1]
[1]Advanced Defense Technology Research Institute, Agency for Defense Development
sklee82@add.re.kr

Abstract:

We investigate the ratio between the enhancement factors for Rb-129Xe and Rb-131Xe based on measurements of NMR frequency shifts in each Xenon isotope. In the dilute regime, the interactions between Rb-129Xe and Rb-131Xe are dominated by formations of Van der Waals molecules, rather than random collisions. Since in general a molecule comprising a heavier isotopic atom is more stable than its lighter counterpart due to its lower interatomic vibrational frequencies, we may expect a larger enhancement factor for the latter pair. We present an experimental scheme to verify this conjecture. Here, the bias magnetic field alternates between B_0 and $-B_0$, and also the polarization of the optical pumping beam switches between σ^+ and σ^- during the experiment for determining the NMR frequency shifts. Finally, temperature dependence of this isotopologue effect is investigated experimentally.

Keywords:

SEOP, Hyperpolarized noble gas, Van der Waals molecule, Enhancement factor, Isotopologue

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.008

Scattering of matter waves from various optical reflection gratings under grazing incident conditions

KIM LeeYeong [1], LEE JuHyeon [2], KIM Yun-Tae [3], LEE Chang Young [4], SCHOLLKOPF Wieland [5], ZHAO Bum Suk [*6]
[1]Department of Physics, UNIST
[2]Department of Chemistry, Fritz-Haber-Institut der Max-Planck-Gesellschaft
[3]Department of Biomedical Engineering, UNIST
[4]Department of Chemical Engineering, UNIST
[5]., Fritz-Haber-Institut der Max-Planck-Gesellschaft
[6]Department of Chemistry, Department of Physics, UNIST
zhao@unist.ac.kr

Abstract:

Handy mirrors and gratings for atoms and molecules would open new frontiers in matter-wave optics with neutral particles. The realization of such components for atoms and molecules, however, has required sophisticated electromagnetic fields, nano-fabrication, or particle cooling, because of their inherently short wavelength and strong interaction with a surface. We demonstrate that reflective gratings designed for photons can work as a grating or a mirror for atoms and molecules of a thermal energy when used under grazing incidence conditions. The matter-waves of He atoms and D_2 molecules are reflected from various gratings that are easily fabricated or commercially available. We find out the critical factors affecting diffraction peak widths and efficiencies. Our analyses imply that quantum and multiple-diffraction reflections occurring at the grazing incidence conditions are the underlying physics allowing optical square-wave and blazed gratings to function as a grating or a mirror for those particles.

Keywords:

Quantum reflection, Matter-wave, Reflection grating

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.009

Spin transport in ferromagnetic spinor Bose-Einstein condensates

HUH SeungJung [1], KIM Kyungtae [1], CHOI Jae Yoon *[1]
[1]Physics Department, KAIST
jaeyoon.choi@kaist.ac.kr

Abstract:

Motivated by the recent experiment of spin transport in Heisenberg spin ½ Hamiltonian [P. N. Jepsen et al., Nature (London) 588, 403 (2020)], we study spin transport in a spin-1 superfluid system. After preparing two-dimensional spinor condensates of Lithium-7 atoms in m_F=1 state, the longitudinal spin spiral states are imprinted within 10 ms. Then, its temporal dynamics are investigated using spin-separated absorption imaging after time-of-flight. The contrast of the spin spiral state is exponentially decreased over the hold time, and we could identify the nature of spin dynamics from the dependence of the decay constant on the wavenumber of the initial state.

Keywords:

spin transport, spin-1 superfluid

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.010

Clock spectroscopy of Yb-174 BEC in a crossed optical dipole trap

JUNG Haejun [2], HAN Jeong Ho [1], LEE Jae Hoon [3], LEE Won-kyu [3], CHOI Jae-yoon [2], MUN Jongchul [*1]
[1]Quantum Technology Institute, KRISS
[2]Department of Physics, KAIST
[3]Physical Metrology, KRISS
jcmun@kriss.re.kr

Abstract:

We report on the spectroscopy of ultranarrow clock transition (1S0-3P0) in Yb-174 Bose-Einstein condensates (BEC). The Yb BEC is prepared in the crossed dipole trap generated by 532 nm laser beams with the typical atom number of 8×10^4 and temperature of few tens of nK. An external magnetic field of about 100 G is applied to the atoms to open strictly-forbidden channel of the clock transition line. An atom loss is observed when we interrogate the BEC with resonant clock laser pulse at the wavelength of 578 nm. We compare our results based on the knowledge of the frequency standards from Yb-171 atomic clock. We characterize our clock laser system for different trapping potentials and pulse types. Our work lays the starting point of our future goal toward quantum simulation using metastable states such as Kondo effects.

Keywords:

Quantum Simulator, Quantum Gases, Bose-Einstein Condensate, Spectroscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.011

Quantifying non-Gaussianity of a quantum state by the negentropy of quadrature distributions

PARK Jiyong *[1], LEE Jaehak [2], BAEK Kyunghyun [2], NHA Hyunchul [3]
[1]School of Basic Sciences, Hanbat National University
[2]School of Computational Sciences, Korea Institute for Advanced Study
[3]Department of Physics, Texas A&M University at Qatar
jiyong.park@hanbat.ac.kr

Abstract:

We here propose a non-Gaussianity measure of a quantum state using the negentropy of quadrature distributions. Our measure is faithful, invariant under Gaussian unitary operations, and non-increasing under Gaussian channels. We find a quantitative relation between our measure and the previously proposed ones based on quantum relative entropy and quantum Hilbert-Schmidt distance, which allows us to estimate the non-Gaussianity measures by homodyne detection without prior information on the state under examination.

Keywords:

non-Gaussianity, relative entropy, homodyne detection

P1-at.012

A photonic engine fueled by an atomic beam

KIM Jinuk [1], AN Kyungwon *[1]
[1]Department of Physics and Astronomy, Seoul National University
kwan@phya.snu.ac.kr

Abstract:

A Fabry-Perot cavity consists of two highly reflective mirrors which are pushed outward by the radiation pressure of contained photons. It can be interpreted as a piston or engine whose working fluid is photon gas. If excited atoms pass through the cavity, they provide energy to the cavity like fuel. This kind of engine is not practical in daily life but a versatile platform for fundamental studies especially quantum phenomena in thermodynamics. There are numerous proposals based on the photonic engine: tailoring the thermalization time, an engine based on a single reservoir, nonlinear work output brought on by quantum coherence, and so on. We demonstrate a photonic engine fueled by an atomic beam. The atoms are coherently excited by a pump laser. However, due to the randomized phase between atomic coherence and atom-cavity interaction, generated photonic state is the thermal state which is confirmed by second-order correlation measurement. Atomic injection rate dependence of engine power is investigated. Temperature dependence and efficiency of the photonic engine will be also presented.

Keywords:

Fabry-Perot cavity, heat engine, thermodynamics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.013

안정된 이온 포획을 위한 나선형 RF 공진기의 제작 및 특성 조사

LEE Hyegoo *1, KIM Myunghun 1, HONG Jungsoo 1, LEE Wonchan 1, SHIN Yongha 1, LEE Moonjoo 1
1Electrical Engineering, POSTECH
sunnine12@postech.ac.kr

Abstract:

본 연구에서는 이온 큐빗 포획을 위한 RF 대역에서 작동하는 나선형 공진기를 제작하고 특성 조사를 수행하였다. 고순도 구리로 제작된 나선형 공진기는 공진 주파수 25 MHz 근처에서 100 이상의 품위값을 가진다. 또한 축전 용량을 바꾸어줌에 따라 공진 주파수가 이론적으로 예측한 대로 변화하였다. 전산 시늉을 통해 공진기 내부에 생기는 전자기장의 주파수와 모드의 3차원 모양을 이해하였다. 향상된 에너지 전달과 품위값의 개선을 위한 안테나 코일 구조의 최적화, 공진기 표면의 금 도금 계획에 대해 논의한다.

Keywords:

Ion trap, helical resonator

이터븀과 칼슘을 동시에 포획할 수 있는 이온 트랩 기반의 양자컴퓨터

KIM Myunghun *[1], HONG Jungsoo [1], LEE Hyegoo [1], SHIN Yongha [1], LEE Wonchan [1], LEE Moonjoo [1]
[1]Department of Electrical Engineering, POSTECH
myunghunk@postech.ac.kr

Abstract:

본 발표에서는 분할된 날(segmented blade) 전극을 이용하여 이터븀과 칼슘을 동시에 포획할 수 있는 이온 트랩 장치 개발 진행 상황에 대하여 보고한다. 초극고진공(XHV)을 얻기 위하여 진공 챔버를 강한 산 용액으로 세척 후 챔버 내부 벽면의 산화 처리를 통해 수소 기체 분압을 최소화하였다. 또한, 포획 장치에 사용될 알루미나를 수 마이크로미터의 분해능으로 레이저 미세 가공하였으며, 금 증착 및 전기 도금 수행 후 4개의 날을 정렬 하였다. 이러한 제작 과정 중에는 필연적으로 날들 사이 배치의 어긋남이 발생하게 되는데, 이는 포텐셜의 왜곡 및 미세운동을 야기한다. 이 어긋남 정도를 실험적으로 정량화하였고, 전산 시뮬레이션을 통해 얻게 된 보상 방법에 대해 논의한다.

Keywords:

Ion trap, Quantum Computing

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.015

광자의 도달 시간 정보를 이용한 이온의 양자 상태 측정 신뢰도 향상

JEONG Junho [1], KIM Jaeun [2], JUNG Changhyun [1], KIM Taehyun [2], CHO Dongil Dan[*1]
[1]Dept. of Electrical and Computer Engineering, ASRI/ISRC, Seoul National University
[2]Dept. of Computer Science and Engineering, ICT/ASRI/ISRC, Seoul National University
dicho@snu.ac.kr

Abstract:

양자 정보 기술에서 빠르고 높은 신뢰도를 갖는 양자 상태 측정 방법의 확보는 양자 정보 처리 단계에 선행되어야 할 중요한 요소이다. 이온 트랩 기반 큐빗의 상태 측정은 양자 상태 의존적인 광자의 측정을 통해 이루어진다. 이 때 양자 상태 측정 도중 비대각전이가 발생하거나 측정 장비의 낮은 양자 효율 혹은 암수(dark counts)등의 한계로 인하여 실험적으로 100 % 신뢰도의 상태 측정을 달성할 수 없다. 일반적으로 이온트랩에서의 상태 측정은 특정 시간 동안 검출된 광자의 개수를 기록하여 특정 광자 개수 이상이 검출되었으면 $|1\rangle$, 그 미만이 검출되었으면 $|0\rangle$ 상태로 결정하는 역치법 (threshold method)를 사용하는데, 시간 정보가 없으므로 측정 장비에서 발생한 오류 신호와 광자로 인해 발생한 신호를 구분할 수 없다. 본 논문에서는 양자 상태 측정시에 광자가 도달하는 시간도 함께 측정하여 광자의 도달 시간 정보를 활용하면 측정 장비에서 발생한 오류를 제외하는 데에 도움을 주어 기존의 역치법보다 개선된 신뢰도를 달성할 수 있음을 보인다. 또한 심층 학습을 이용하면 검출 시간들(time bins)에서의 정보 중요성에 대한 가중치를 활용할 수 있기 때문에 더 개선된 신뢰도를 달성할 수 있음을 보인다.

Acknowledgments:

본 논문은 삼성전자 미래기술육성센터의 지원을 받아 수행된 연구임 (과제번호 SRFC-IT1901-09)

Keywords:

Ion trap, Quantum Information, State discrimination

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.016

Analytic treatment of quantum search on complete graphs using interpolated quantum walks

LEE Min-Ho [1], TANNER Gregor [2], CHOI Nark Nyul [*1]
[1]School of Liberal Arts and Teacher Training, Kumoh National Institute of Technology
[2]School of Mathematical Sciences, University of Nottingham
nnchoi2001@gmail.com

Abstract:

Krovi et al. [Algorithmica 74, 851 (2016)] suggested a quantum walk algorithm for the purpose of finding a marked vertex in any graph quadratically faster than the corresponding classical random walk. The authors succeeded in constructing an algorithm that can achieve a quadratic speedup for the special case when the marked set consists of just a single vertex. Recently, Ambainis et al. [arXiv:1903.07493v1 (2019)] conjectured a simple algorithm that is valid even for the marked set consisting of many vertices. Furthermore, Apers et al. [arXiv:1912.04233v1 (2019)] proved the conjecture by using a technique called quantum fast-forwarding. Although their proof is robust, it is worthwhile understanding the underlying mechanism in the context of quantum dynamics thus giving an alternative viewpoint to the somewhat more technical framework of classical random walks and electrical network systems used by the authors cited above. As a first step, we present an analytic treatment of quantum search on complete graphs using the interpolated quantum walk.

Keywords:

quantum walk, quantum search, complete graph, interpolated quantum walk

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.017

Classified graph-entanglements of interacting Rydberg atoms

KIM Kangjin [1], AHN Jaewook *[1]
[1]Physics, KAIST
jwahn@kaist.ac.kr

Abstract:

We investigate the nature of many-body entanglements of Rydberg atoms which interact with transverse Ising Hamiltonians of various graph-mapped connections. When Rydberg atoms and blockade couplings are mapped to vertices and edges, respectively, of an N-vertex graph, we find that the resulting many-body entangled states and eigenenergies can be specified in terms of the number of maximally connected vetices and the number of independent clusters. First, we use the given analysis to explain the 6-vertex (two cluster) Rydberg-atom experiment [1] and then consider all possible nonisomorphic 6-vertex graphs, which are $\mathrm{K6}, \overline{\mathrm{3C2}}, \overline{\mathrm{C6}}, \mathrm{2C3}, \mathrm{C6}$ and $\mathrm{3C2}$ [2], to analyze the all possible interactions of two clusters of atom trios.

[1] M. Kim, Y. Song, J. Kim, and J. Ahn, "Quantum Ising Hamiltonian Programming in Trio, Quartet, and Sextet Qubit Systems," PRX Quantum 1, 020323 (2020).
[2] H. N. de Ridder et al., Information System on Graph Classes and their Inclusions (ISGCI), https://www.graphclasses.org

Keywords:

Rydberg atom, entanglement

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-at.018

Novel characterization of an optical cavity with small mode volume.
작은 모드 볼륨을 가진 광학 공진기의 새로운 특성 조사.

LEE Dowon *[1], KIM Myunghun [1], HONG Jungsoo [1], KIM Junwoo [1], KIM Keumhyun [1], BAE Seunghun [1], LEE Moonjoo [1]
[1]Electrical Engineering, POSTECH
dowonlee@postech.ac.kr

Abstract:

다양한 양자네트워크 플랫폼 중 원자-공진기 기반의 양자노드는 많은 발전을 보여왔다. 본 연구에서는 효율적인 양자인터페이스를 위한 공진기 특성 조사에 대해 보고한다 [1]. 여기서 사용된 공진기는 780 nm 근처에서 25,000 이상의 휘도(finesse)를 가지고, 두 개의 비대칭적인 반사율을 가진 거울로 구성되어 한 쪽 거울로만 90% 이상의 광자가 빠져나가는 효율적인 광자 추출이 가능하다. 780 nm 다이오드 레이저를 이용하여 휘도, 복굴절(birefringence) 정도, 기계 진동수(mechanical resonance)를 측정하였고, 795 nm에서 공진기 특성 역시 조사되었다. 고 분해능 파장 측정기를 통해 780 nm와 782nm 두 개의 다이오드 레이저를 이용한 자유 스펙트럼 범위를 측정하는 방법으로, 작은 모드 볼륨을 가진 공진기의 기하학적 매개 변수들을 높은 해상도로 추출하였다. 본 공진기에 단일 루비듐 원자를 결합하여 양자광학, 양자네트워크 실험을 진행할 계획이다.

[1] D. Lee et al., arXiv:2102.05853(2021)

Keywords:

Cavity QED, High Finesse Fabry-Perot Optical Cavity, Atom-photon Quantum Interface

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.001

An exact theory for the transverse force-extension relation of stiff polymers

LIM Chan [1], JEON Jae-Hyung *[1]
[1]Department of Physics, POSTECH
jeonjh@gmail.com

Abstract:

The Euler-Kirchhoff theory is a classical elasticity theory that describes the shape of an elastic rod. This theory has been successfully described the elasticity of stiff biopolymers such as DNA, actin filament, and microtubules. Based on the Euler-Kirchhoff theory, we construct an exact analytic theory describing the elastic response of a stiff polymer subject to a force transverse to the longitudinal axis. More precisely, when such a transverse force is applied to the mid-point of a polymer whose both ends are tethered, we obtain the extension toward the force direction. We also show that the limiting case of our theory reduces to other classical theories. Our findings are supported by polymer simulations.

Keywords:

Worm-like chain, Force-extension relation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.002

AP_1 structure predictions in CASP14

KIM Hyung-Rae *[1]
[1]School of Basic Sciences, Hannam University
k52hr01@gmail.com

Abstract:

AP in AP_1 stands for “Allied Protocols in protein science program suite”, which is being prepared for publication. AP_1 is the first ever developed AP program package. Thus, it was named AP_1. The goal of AP_1 is single chain protein structure scoring. AP_1 inherits several characteristics of our previous method : PRESCO, database search and structure retrieval without calculating pair-wise potentials and without building a fixed form potential.
Methods: The goal of AP_1 is to accurately score not only the topology of a protein structure, but also the side-chain positions of the high-accuracy template-based models. The newly incorporated assumption of AP_1 was that “amino acids might contribute differentially to the formation steps of a protein structure”. Thus, each contribution of amino acids in structure scoring was employed differentially and implemented. Moreover, we found and employed three new scoring matrices, which had not been used before. AP_1 was used on CASP12 for the first time. However, owing to the difficulty in balancing between the high accuracy scoring and topology scoring, AP_1 did not perform well for CASP12. We changed the weighting-scheme in CASP14 and tested our AP_refine protocol, which is currently under development. Thus, our structure prediction pipeline consists of the following points. 1. Five of the best models were picked using AP_1 from all submitted server models of CASP13. 2. Five of the best models were picked and used as the seed model for our refinement protocol. 3. Subsequently, five generated models were added to the seed models. 4. We applied AP_1 again to the above candidate models and selected the five best models to submit. In CASP14 (2020), we submitted 390 models for 78 TS (3D structure) regular targets.
Results : In the main category of CASP14, Free Modeling (FM) category, AP_1 achieved rank 31 among 196 participated human expert groups and server groups from all over the world. Among the participated domestic (South Korean) groups, we were 2nd in FM category.

Keywords:

Protein Structure Prediction, Scoring Function, CASP

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.003

FAST AND ACCURATE MICROBIAL SPECIES IDENTIFICATION BY FLUORESCENCE IN SITU HYBRIDIZATION WITH PEPTIDE NUCLEIC ACID

KIM Hajin *[1], KIM Sungho [1], IM Jae-Kyung [1], HYUN Hwi [1], LEE Min Seok [1], KANG Joo H. [1], KWON Taejoon [1]
[1]UNIST
hajinkim@unist.ac.kr

Abstract:

Early detection of pathogenic microbial from a biological mixture is the vital factor to developing treatments for acute infectious diseases such as sepsis. Fluorescence in situ hybridization (FISH) technique allows to detect and identify microbes based on the variation in their genome sequence without the need for time-consuming culturing or sequencing. However, this approach is restricted by crosstalk between species due to non-specific binding of FISH probes. We developed a novel set of PNA-FISH probes through large-scale analysis of 16S sequence variation in microbiome and minimize crosstalk between species. Since Peptide nucleic acid (PNA) is an oligonucleotide analogous to (deoxy)ribose nucleic acid that sugar-phosphate backbone is replaced by a pseudo peptide backbone typically formed in N- (2-amino-ethyl)-glycine unit and is a nearly neutral charged molecule,
It allows to use of shorter probe length, small sequence variation between close species could be maximally utilized to produce large contrast. Using these techniques, we verified that 7 microbial species (Klebsiella pneumonia, Proteus mirabilis, Bacillus subtilis, Enterococcus faecalis, Escherichia coli, Pseudomonas aeruginosa, Salmonella enterica, Staphylococcus aureus) could be successfully distinguished. Next, we showed Sequential FISH method by utilizing disulfide linker PNA probes. These chemically cleavable FISH probes dramatically reduce turnover times between each FISH round. Also, we demonstrate a fluorescence resonance energy transfer (FRET)-based FISH technique to overcome crosstalk between bacterial species.

Keywords:

Fluorescence in situ hybridization (FISH), Microbial identification, Peptide Nucleic Acid (PNA)

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.004

Application of Ago-FISH to general RNA quantification

KANG Chanshin [1], HOHNG Sungchul *[1]
[1]Seoul National University
shohng@snu.ac.kr

Abstract:

Previous Ago-FISH(Argonaute-based Fluorescence In Situ Hybridization) technique provides quantification of microRNAs(miRNAs) without amplification. The non-amplification method eliminates uncertainty from template to amplified product ratio conversion, so it gives us reliable concentration information with high sensitivity. It, however, has practical limitations to apply Ago-FISH on general application such as quantification of mRNA for medical purpose. Most of mRNAs compose secondary structure so that Ago-binded imager could not apporach to target sequence. Even Ago-FISH, futhermore, shows high sensitivity, it takes much longer time than other quantification method to guarantee enough limit of detection for pathology target RNA. In this study, we introduce acceleration method of Ago-FISH and apply not only miRNA but also mRNA using modified experiment design.

Keywords:

Ago-FISH, RNA Quantification, single-molecule Experiment

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.005

Comparing Various Background Noise Suppression Techniques in STED Optical Nanoscopy

JEONG Sejoo [1], KIM Jaeyong [1], LEE Jong-Chan *[1]
[1]Department of New Biology, DGIST
jclee@dgist.ac.kr

Abstract:

Super-resolution microscopy or optical nanoscopy has enabled all-optical observation of nanoscopic objects with resolution beyond the Abbe’s diffraction limit. Especially, STimulated Emission Depletion (STED) nanoscopy achieves diffraction-unlimited resolution by employing a doughnut shaped de-excitation laser in addition to the conventional excitation laser in confocal microscopy. One of the strong unexpected adverse effects in resolution improvement in STED nanoscopy is a structured, systematic background noise, which deteriorates the desired super-resolved image. Suppressing background noise, therefore, has been an major challenge in STED nanoscopy. Here, we introduce the characteristics of the background noise in STED nanoscopy and review several recent techniques that tackle this problem. The methods will be examined in comparison to one another and the advantages and disadvantages of each method will be highlighted.

Keywords:

Super-resolution, STED, Background noise

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.006

Study of transparent flexible photosynthetic microbial fuel cell

LIM EunJu *[1], CHO Seongjib [1], KIM Seonghyun [1]
[1]Dankook University
elim@dankook.ac.kr

Abstract:

The study is to develop a previously unreported eco-friendly, self-sufficient transparent flexible microbial fuel cell. In order to realize a transparent and flexible microbial fuel cell, a polymer-based electrode with a transparent metal deposited, an electrolyte system in the form of a hydrogel, and a transparent proton exchange membrane were introduced. The transparent cell multi-layer structure allows the light source to pass through and realizes a new type of cell that can be flexibly bent or folded. By combining a transparent and flexible microbial fuel cell with an organic semiconductor device, we can develop innovative energy production/drive devices capable of self-driving through photosynthesis.

Keywords:

Transparent, Flexible, Eco-friendly energy source

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.007

Condensation of PCNA-Associating Factor 15 in cells

BU Gayun [1], SEOL Jincheol [2], KIM Daehyung [1], LEE Jong-Bong *[1,2]
[1]Physics, POSTECH
[2]School of Interdisci plinary Bioscience and Bioengineering, POSTECH
jblee@postech.ac.kr

Abstract:

PCNA-associating factor 15 (PAF15) is an intrinsically disordered protein that is included in many cellular processes such as DNA methylation, DNA translesion synthesis, cell cycle regulation, and DNA replication. In the previous in vitro study, we found that PAF15 regulated the ring-shaped DNA polymerase processivity factor, PCNA. Interestingly, replication factor C (RFC), a PCNA loading and unloading protein, could not load PCNA onto DNA at a high concentration of PAF15, which does not correspond to a cellular condition with ~ uM concentration of PAF15. An additional mechanism to regulate PAF15 local concentration is needed to load PCNA onto DNA via RFC.

Recently we observed that fluorescently tagged PAF15 formed condensations in mammalian cells using live cell fluorescence microscopy. PAF15 condensations changed after UV irradiation or in different cell cycles. When PAF15 is condensed, it was completely co-localized with PCNA condensation. However, unlike other liquid-liquid phase separation proteins, we could not see considerable movement or fission/fusion of PAF15 condensates. The in vitro and in vivo PAF15 condensation observation proposes that PAF15 condensation can provide the local concentration regulation of PAF15 to control related cellular processes.

Keywords:

PAF15, PCNA, Condensation, Cell

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.008

Transcription of Arc mRNA induced by electrical burst stimulation

KIM Dong Wook [1], MOON Hyungseok C.[1], LEE Byung Hun [1], SHIM Jae Youn [1], PARK Hyeyoon [*1]
[1]Department of Physics and Astronomy, Seoul National University
hyeyoon.park@gmail.com

Abstract:

Immediate early genes (IEGs) are genes that are rapidly induced by neural activity. The expression of IEGs such as Arc, c-fos, and Egr1 has been used to investigate the relation among external stimuli, neural activity, and memory formation. Inside cells, there exist signaling pathways where the chain reaction of enzymes leads to gene expression and regulation. These pathways can be driven by external stimuli such as heat, chemicals, growth factors, and electrical stimulation. In this research, we investigated the effect of electrical stimulation on the expression of Arc in hippocampal neurons cultured from the Arc-PBS x PCP-GFP mice. Among various frequency ranges of brain waves, 4~8 Hz (5~10 Hz for rodents) is called theta frequency. The theta frequency wave is observed during rapid eye movement (REM) sleep and known to be involved in memory formation. Particularly, the theta burst stimulation (series of high-frequency bursts given at theta frequency) is known to induce long-term potentiation (long-lasting increase in synaptic responses). We focused on the effect of the burst stimulation and tested various time intervals between the bursts to find the optimal burst frequency for induction of Arc transcription. Live-cell imaging of Arc-PBS x PCP-GFP neurons allowed us to observe the real-time response of Arc transcription. We found that theta burst stimulation induced Arc transcription in ~45% of neurons, which were significantly higher than the percentage of neurons activated by other frequency ranges. We also investigated how Arc transcription is related to calcium activity and pCREB expression level. These results will shed light on the relation between Arc transcription and LTP-inducing electrical stimulation.

Keywords:

immediate early gene, Arc, electrical stimulation, theta burst stimulation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.009

Biophysical principles regarding the formation and the regulation of biomolecular condensates

KIM Jinkwang *[1], GWAK Eunha [1], LEE Jong-Chan [1]
[1]Department of New Biology, DGIST
akfls2870@dgist.ac.kr

Abstract:

To effectively orchestrate biochemical reactions and to optimize reactions in different physicochemical environments, cells are evolved to carry diverse non-membranous biomolecular condensates in addition to canonical membrane-bound organelles. Recently, these biomolecular condensates are shown to be comprised of proteins and RNAs with a specific character that can drive liquid-liquid phase separation. Here, we review recent theoretical studies trying to understand the biophysical principles underlying the formation and regulation of these intriguing phenomena. Comprehension of the biophysical underpinnings regarding the occurrence and the behavior of biomolecular condensates will provide deeper insights into their biological functions.

Keywords:

Biomolecular condensate, Liquid-liquid phase separation, Biophysical principles

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.010

1-Dimensional Diffusion of RNA Polymersae in the Cell.

SONG Minseok [1], HOHNG Sungchul *[1]
[1]Seoul National University
shohng@snu.ac.kr

Abstract:

Recent studies on the behavior of RNA polymerase(RNAP) after transcription termination maintain that RNA transcript is released from DNA and most RNAP remains on DNA. RNAP diffuses along DNA, searches promoter and restart transcription initiation. It is called recycling of RNAP. The goal of this new study is observing the recycling of RNAP in E.coli cell. First, insert the transcription sequence with two adjacent gene in the E.coli plasmid. Then, compare the difference of expression of adjacent gene by RT-qPCR. We anticipate that we can apply the result on genetic engineering.

Keywords:

E.coli. RNA Polymerase, RNA recycling, Transctiption termination, 1-D diffusion

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.011

MRI compatible multi-site fiber photometry to record neural activities in living animal brain

LEE Ga-Young [1], JOO Bitna [2,3], KOO Ja Wook [2,3], KIM Kipom [*1]
[1]Brain Research Core Facilities, Korea Brain Research Institute
[2]Emotion, Cognitive, & Behavior Research Group, Korea Brain Research Institute
[3]Department of Brain and Cognitive Sciences, DGIST
kpkim@kbri.re.kr

Abstract:

Fiber photometry has been increasingly popular in neuroscience research in a behaving animal. In combination with genetically encoded calcium indicators, neural activity can be measured in deep brain structures, which translate neural activity into an optical signal. We have been developing a multi-site fiber photometry system to monitor neural activities in several brain regions of a behaving animal. Since this device operates on a magnetic resonance imaging (MRI) system, it can simultaneously measure the structure, function, and neural activities of living animal brains. Here, we present the operating principles of the photometry system, some preliminary results, and future applications.

Keywords:

Fiber photometry, MRI, Neural activity

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.012

DNA base pair is more stable in heavy water.

KIM Sung Eun [1,2], MOON Hyeon-Min [1], LEE Il-Buem [1], HONG Seok-Cheol [*1,2,3]
[1]Center for Molecular Spectroscopy and Dynamics, Institute for Basic Science (IBS)
[2]Physics, Korea University
[3]School of Computational Sciences, Korea Institute for Advanced Study (KIAS)
hongsc@korea.ac.kr

Abstract:

Heavy water (D_2O) is a form of water whose hydrogen atoms are replaced by deuterium (D). Given the same electronic configuration, chemical properties of heavy water are thought to be almost identical to those of normal water. From quantum mechanics, the hydrogen bond by deuterium is slightly stronger than by hydrogen. To date, few experiments regarding the stability of nucleic acids in heavy water have been performed except for a few melting temperature measurements. Thus, the effect of heavy water on nucleic acids has not been explored well and remains unclear. Here, we examined the effect of heavy water on nucleic acids, that is, the stability of various DNA structures in heavy water with a range of different experimental methods (from single-molecule force spectroscopy to biochemical assay). All the experimental results clearly indicate that DNA structures are more stable in heavy water than in normal water. Interestingly, the unzipping force of a short DNA hairpin in heavy water is notably larger, which was not directly measured before. Our finding provides quantitative insights into the biological, harmful effect of heavy water.

※ This work was supported by the Institute for Basic Science (IBS-R023-D1)

Keywords:

DNA stability, Magnetic tweezers, DNA hairpin, Hydrogen bond strength, Heavy water

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.013

Single-molecule studies on co-transcriptional formation mechansim of R-loop

LIM Gunhyoung [1], HOHNG Sungchul *[1]
[1]Seoul National University
shohng@snu.ac.kr

Abstract:

R-loop, one of the non-canonical nucleic acid structures, consists of a DNA:RNA hybrid and a single-stranded DNA. Since R-loop is known to be related with gene regulation and genonme instability, its formation should be exquisitely regulated. This structure can be formed during transcription, but its co-transcriptional formation mechanism is not well defined. Here, we monitor the R-loop formation during transcription using single-molecule fluorescence technique. We observed co-transcriptional formation of R-loop at the single-molecule level. From this information, we studied the effect of R-loop structure on the next-round transcription and the fate of RNA polymerase after creating R-loop.

Keywords:

R-loop, single-molecule, FRET

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.014

Single-molecule Studies on Rho-dependent Transcription Termination

SONG Eunho [1,2], UHM Heesoo [1,2,3], HOHNG Sungchul [*1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]Institute of Applied Physics, Seoul National University
[3]Department of Physics, University of Oxford
shohng@snu.ac.kr

Abstract:

Rho-dependent transcription termination, involving 20~50% of Escherichia coli termination sites, is induced by a hexameric helicase Rho. It's still remain elusive what the role of the Rho-RNAP interaction is in termination. In recent, there are progress in elucidating the role of Rho-RNAP interaction. Zhitai Hao et al. (2020) and Nelly Said et al. (2021) reported cryo-EM images showing the Rho-RNAP interaction during termination, which support the necessity of Rho-RNAP interaction in RNA release. We thought that just observing the Rho-RNAP interaction is not enough, but the full movie from Rho-RNAP binding to RNA release need to be made up for. Moreover, the other pathway of Rho-dependent termination is need to be studied. To solve these problems, we designed single-molecule fluorescence assay to monitor the Rho-dependent termination. Our assay reproduced the past results of gel-shift assay. We designed assay to distinguish two pathways depending on the presence of Rho-RNAP interaction using single-molecule assay's easiness in controlling chamber condition. We observed that both of the pathway with and without Rho-RNAP interaction, and different property of them. Especially, the pathway with Rho-RNAP interaction is more sensitive to pausing time, and this property seemed to be key role in ion sensing in specific riboswitch. We suggested that there are two different two pathways in Rho-dependent termination, and this diversity in pathway support the fine tuning in gene expression.

1. Said, Nelly, et al. "Steps toward translocation-independent RNA polymerase inactivation by terminator ATPase ρ." Science 371.6524 (2021).
2. Hao, Zhitai, et al. "Pre-termination Transcription Complex: Structure and Function." Molecular Cell (2020).

Keywords:

Single Molecule, Rho-dependent termination, Rho-RNAP interaction

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.015

Mechanistic basis for human DNA polymerase θ-directed microhomology-mediated end-joining

KIM Chanwoo [1], SUNG Yubin [1], TAKATA Kei-ichi [1], KIM Hajin *[1]
[1]UNIST
hajinkim@unist.ac.kr

Abstract:

DNA polymerase Polθ is a unique polymerase that effects a microhomology-mediated, error-prone, double strand break repair, also referred to as Microhomology-Mediated End Joining (MMEJ). The molecular mechanism whereby Polθ processes microhomology to perform MMEJ is unknown. Previous crystal studies suggest that Polθ can form a homodimer whose function is still not clear. Using a combination of single molecule FRET (smFRET) technique and denaturing PAGE gel assay, we find that polymerization processivity is higher for a subtrate that has two 3' overhangs than for a subtrate with only one 3' overhang, suggesting that the dimer formation might be responsible for improved processivity in the bidirection fashion. We further find that polθ binding to either ssDNA or dsDNA alters DNA conformation and microhomology stability and negative charges on the DNA end govern synapsis formation essential for MMEJ.

Keywords:

smFRET, DNA Polymerase, Polθ

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-bp.016

A hierarchical folding pathway of a human glucose transporter facilitated by ER membrane protein complex and lipids

CHOI Hyun-Kyu [2], KANG Hyunook [1], LEE Chanwoo [1], KIM Hyun Gyu [1], PARK Soohyung [3], HONG Heedeok [4], IM Wonpil [3], MILLER Elizabeth A.[5], CHOI Hee-Jung [1], YOON Tae-Young *[1]
[1]Seoul National University
[2]Coulter Department of Biomedical Engineering, Georgia Institute of Technology
[3]Departments of Biological Sciences and Chemistry, Lehigh University
[4]Department of Chemistry and Department of Biochemistry & Molecular Biology, Michigan State University
[5]Medical Research Council (MRC) Laboratory of Molecular Biology, Cambridge Biomedical Campus
tyyoon@snu.ac.kr

Abstract:

Multi-pass membrane proteins control flow of information and materials across the membrane. Due to their structural complexity, cells invest a significant amount of resource to help their folding and maintain their quality. If this quality control system fails, it may result in aging and lead to various types of diseases. Although detailed structures of many multi-pass membrane proteins are being resolved with cryo-electron microscopy, the detailed process of membrane protein folding in the endoplasmic reticulum (ER) remains elusive. In previous study, our group observed the native folding pathway of E.coli GlpG and human beta 2-adrenergic receptor using single-molecule magnetic tweezers. We extended this approach to more complex multi-pass membrane proteins. We observed the detailed folding pathway of human glucose transporter 3 (GLUT3), which is composed of two structurally similar domains (N-domain and C-domain). We saw that N-domain folds first and acts as a template for complete folding. Moreover, we found residues that makes a membrane-embedded conduit acts as a main barrier for the entire folding process. We observed that ER membrane complex (EMC) helps insertion of all transmembrane helices (TMH) beyond first TMH, accelerating folding. Furthermore, we saw that specific lipid species facilitate final assembly between N- and C- domain by easing desolvation energy of lipid shells. Our results show an evolutionary tradeoff between functionality and foldability, reveal critical bottlenecks along the pathway and understand how cells mitigate with these obstacles to promote membrane protein biogenesis.

Keywords:

Mulri-pass membrane protein, Single-Molecule Magnetic tweezers, GLUT3, ER membrane complex, Membrane protein folding

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.101

A Detailed Numerical Analysis for High-Temperature Superconductivity Phase Diagrams Based on U(1) and SU(2) Slave-Boson Approaches to the t-J Hamiltonian

AHN Sul-Ah *[1], CHO Hyeyoung [1], SALK Sung-Ho S.[2]
[1]National Supercomputing Center, Korea Institute of Science and Technology Information
[2]Department of Physics, Pohang University of Science and Technology
snowy@kisti.re.kr

Abstract:

The generic phase diagrams of high-temperature superconductors invariably display a monotonously decreasing pseudogap temperature and a dome-shaped superconducting transition temperature in the plane of temperature vs. hole concentration. One of the major theoretical challenges in high-temperature superconductivity is to reproduce the observed phase diagrams. Earlier Lee and Salk [Phys. Rev. B **64,** 052501 (2001); ibid. **71**, 134518 (2005)] reproduced successfully the phase diagrams by introducing a feasible slave-boson approach to the Heisenberg exchange interaction term in the t-J Hamiltonian. Recently, Shin et al. [J. Supercond. Nov. Magn. **23**, 637 (2010)] reported both the temperature and the doping dependencies of magnetic susceptibility and spin pairing correlations involved with spin dynamics in high-temperature superconductivity. Further optical conductivity is reproduced in agreement with observations, thus revealing critically important success of our proposed theory in fitting both spin and charge dynamics. More recently, Salk [Quantum Studies: Mathematics and Foundations **5**, 149 (2018)] presented a detailed study with emphasis on the physics of high temperature superconductors. In addition, highly reasonable room temperature superconductivity was proposed by demonstrating that the higher, the antiferromagnetic coupling strength J, the higher, the superconducting transition temperature T_c. Most recently, Ahn et al. [J. Korean Phys. Soc. **76**, 1020 (2020)] discussed hitherto-less-reported detailed numerical analysis of the phase diagrams by varying the values of J by following the U(1) slave-boson approach to the t-J Hamiltonian. Here we present a detailed numerical analysis of the phase diagrams, specially focusing on the comparison of the U(1) slave-boson approach with the SU(2) slave-boson approach to the t-J Hamiltonian in which case the role of phase fluctuations of order parameters is clearly exhibited.

Keywords:

Numerical Analysis, High-Temperature Superconductivity, Phase Diagram, U(1) and SU(2) Slave-Boson Approaches, t-J Hamiltonian

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.102

Numerical modeling of high-temperature superconducting tapes with the critical state model

KIM Mu Yong *1
1Optics, InLC Technology
my712@naver.com

Abstract:

High-temperature superconductors(HTS) have reached the stage of skilled commercialization. For its application, the development of simulation tools to understand and predict the behavior of superconductors in various environments is also becoming important. In the verification of many simulation results, the critical state model (CSM) has been used to understand the electromagnetic properties of HTS. In this study, several results for various situations of HTS tapes were presented by simulation based on CSM and magnetic energy minimization (MEM). From these results, an example of application to the analysis of the local magnetic field was shown.

Keywords:

high-temperature superconducting tape, critical state model, HTS thin film, HTS numerical modeling

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.103

Effect of the sample work function on alkali metal dosing induced electronic structure change

JUNG Saegyeol [1,2], HUH Soonsang [1,2], KIM Changyoung *[1,2]
[1]CCES, CCES (IBS)
[2]Department of Physics and Astronomy, Seoul National University
changyoung@snu.ac.kr

Abstract:

Alkali metal dosing (AMD) has been widely used as a way to control doping without chemical substitution. This technique, in combination with angle resolved photoemission spectroscopy (ARPES), often provides an opportunity to observe unexpected phenomena. However, the amount of transferred charge and the corresponding change in the electronic structure vary significantly depending on the material. Here, we report study on the correlation between the sample work function and alkali metal induced electronic structure change for three iron-based superconductors: FeSe, $Ba(Fe_{0.94}Co_{0.06})_2As_2$ and NaFeAs which share a similar Fermi surface topology. Electronic structure change upon monolayer of alkali metal dosing and the sample work function were measured by ARPES. Our results show that the degree of electronic structure change is proportional to the difference between the work function of the sample and Mulliken's absolute electronegativity of the dosed alkali metal. This finding provides a possible way to estimate the AMD induced electronic structure change.

Keywords:

Work function, , Alkali metal dosing, ARPES, Iron-based superconductors

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.104

Temperature dependence of superconducting gap in Nb thin films

LEE Ji Eun [1], CHOI Joonyoung [2], SIM Kyung Ik [1], JO Younjung [2], KIM Jae Hoon [*1]
[1]Department of Physics, Yonsei University
[2]Department of Physics, Kyungpook National University
super@yonsei.ac.kr

Abstract:

We studied the electrodynamics of superconducting niobium thin films by using terahertz spectroscopy in the range of 0.3 – 3 THz at 2 - 295 K. The complex conductivity is obtained from the transmission spectra in the terahertz region without a Kramers-Kronig analysis. The temperature-dependent superconducting gap was determined from the real part of the conductivity below T_c = 8 K. Our results are consistent with the weak coupling BCS theory.

Keywords:

terahertz spectroscopy, Nb, BCS superconductor

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.105

B_{1g} phonon anomaly above superconducting transition temperature in $YBa_2Cu_3O_{7-\delta}$

OH Dongjin [1,2], SONG Dongjoon [1,2], MIYASAKA Shigeki [3], TAJIMA Setsuko [3], PARK Seung Ryong [4], KIM Changyoung *[1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]Center for Correlated Electron Systems, IBS
[3]Department of Physics, Osaka University
[4]Department of Physics, Incheon National University
changyoung@snu.ac.kr

Abstract:

In conventional superconductors, it has been known that the electron-phonon coupling can mediate Cooper pairs. However, the relationship between superconductivity and electron-phonon coupling in copper oxide high-Tc superconductors is still controversial. In addition, the electron-phonon coupling in various exotic phases such as pseudogap and CDW is not well understood. Here, we have used Raman spectroscopy to observe the temperature dependence of oxygen buckling phonon (B1g) in YBa2Cu3O7-δ. We found that the anomalous behavior of B1g phonon appears above superconducting transition temperature (Tc) and doesnt appear in overdoped region. These observation suggest that B1g phonon may be closely related to pseudogap or precursor pairing in copper oxide high-Tc superconductors.

Keywords:

unconventional superconductivity, Cuprates, Raman spectroscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.106

Momentum dependent $d_{xz/yz}$ band splitting in LaFeAsO

HUH Soonsang [1], KIM Younsik [1], KIM Changyoung *[1]
[1]Department of Physics and Astronomy, Seoul National University
changyoung@snu.ac.kr

Abstract:

The nematic phase in iron based superconductors (IBSs) has attracted attention with a notion that it may provide important clue to the superconductivity. A series of angle-resolved photoemission spectroscopy (ARPES) studies were performed to understand the origin of the nematic phase. However, there is lack of ARPES study on LaFeAsO nematic phase. Here, we report the results of ARPES studies of the nematic phase in LaFeAsO. Degeneracy breaking between the d_{xz} and d_{yz} hole bands near the Γ and M point is observed in the nematic phase. Different temperature dependent band splitting behaviors are observed at the Γ and M points. The energy of the band splitting near the M point decreases as the temperature decreases while it has little temperature dependence near the Γ point. The nematic nature of the band shift near the M point is confirmed through a detwin experiment using a piezo device. Since a momentum dependent splitting behavior has been observed in other iron based superconductors, our observation confirms that the behavior is a universal one among iron based superconductors.

Keywords:

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.107

$La_{1.85}Sr_{0.15}CuO_4$ thin film growth and in-situ ARPES

KIM Youngdo [1,2], KIM Changyoung *[1,2]
[1]Center for Correlated Electron Systems, IBS
[2]Department of Physics and Astronomy, Seoul National University
changyoung@snu.ac.kr

Abstract:

Cuprate thin films are showing novel physical properties that are different from bulk, such as strain effects from substrate or proximity effects of heterostructure. And their electronic structures can be directly probed by Angle-resolved photoemission spectroscopy(ARPES). Since ARPES is highly surface sensitive, it requires a flat and clean surface of sample and UHV transfer process to carry out thin film ARPES. We have grown $La_{1.85}Sr_{0.15}CuO_4$ (LSCO) thin film On LaSrAlO4(LSAO) Substrate with 20 Unit cell(UC) thickness by pulsed laser deposition(PLD). The thickness of the film was monitored with in-situ reflection high energy electron diffraction(RHEED), and the film was characterized with atomic force microscopy(AFM) and physical property measurement system(PPMS). With our UHV transfer system connected with PLD and ARPES chamber, we performed in-situ ARPES and obtained Fermi surface map data of the LSCO thin film.

Keywords:

La1.85Sr0.15CuO4 , Cuprate, Thin film, ARPES, PLD

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.108

Pt/(Co/Pt)$_3$/FeMn 박막에서 FeMn 두께와 온도에 따른 보자력과 수직 교환바이어스

JUN Minsuk [1], PARK Yeonjung [1], KIM Jungbea [1], DHO Joonghoe [*1]
[1]Kyungpook National University
jhdho@knu.ac.kr

Abstract:

반강자성 FeMn과 접합시킨 수직 자기이방성 [Co/Pt]$_3$ 강자성 박막에서 온도에 따른 보자력과 수직 교환바이어스의 변화를 연구하였다. FeMn과 Co사이 Pt의 존재 유무에 따라 샘플이 수직 자기이방성 또는 수평 자기이방성을 보였는데, 이는 Pt층이 수직 자기이방성을 갖는데 중요한 역할을 한다는 사실을 의미한다. 그리고 FeMn의 두께를 5 nm ~ 20 nm까지 변화시킴에 따라 [Co/Pt]$_3$ 층의 보자력과 수직 교환바이어스의 크기를 연구하였다. 5 kOe 자기장 하에서 냉각 후 25 K에서 Co/Pt의 자기이력곡선을 측정하였을 때, 보자력은 약 600 Oe, 수직 교환바이어스는 약 20 Oe 였다. 온도가 증가함에 따라 보자력은 단조롭게 감소하는 경향을 보였고 수직 교환바이어스는 약 400 K에서 거의 사라졌다. 또한 자기장 하에서 냉각하는 경우와 자기장 하에서 증착한 경우 보자력과 수직 교환바이어스의 크기를 비교하였다. 평면 내에서 수평하게 정렬된 강자성/반강자성 시스템과 비교해서 수직으로 정렬된 강자성/반강자성 시스템의 교환바이어스는 조절하기에 다소 어려운 것으로 생각된다.

Keywords:

thin film, magnetism, Exchange bias, Perpendicular exchange bias, Co/Pt

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.109

자기 이중층에서 자기장에 의한 자구벽 운동

MOON Joon [1], YOON Jaesung [1], KIM Kitae [1], LEE Seong-Hyub [1], CHOE Sug Bong *[1]
[1]Department of Physics, Seoul National University
sugbong@snu.ac.kr

Abstract:

자기 메모리 소자를 위하여 자기박막에서의 자구벽 운동은 많은 연구[1]가 진행되어 왔다. 특히 다층 자기박막을 이용한 소자에서 DMI등을 이용해 자구벽을 효과적으로 구동하려는 연구[2]가 진행되고 있고, 이를 위하여 다층 자기박막의 자구벽 구조와 운동에 대한 이해를 하는 것이 필요하다. 우리는 자기 이중층에서 수평/수직방향의 외부자기장을 인가한 자구벽 운동이 단일 자기 박막[3]과는 다른 자구벽 거동을 하는 것을 발견하였으며, 이를 해석하고자 시뮬레이션을 진행하였다. 본 연구를 위하여 DC 마그네트론 스퍼터링을 이용하여 Ta(5 nm) / Pt (2.5 nm) / Co (X nm) / Pt (Y nm) / Co (Z nm) / Pt (1.5 nm)의 이중 자성박막을 제작 하였고, 광자기 커 효과 (MOKE) 현미경을 통해 자기장을 인가하였을 때의 자구벽 운동을 측정하였다. 실험 결과를 설명하기 위해 마이크로 시뮬레이션을 진행하였으며, 이를 통해 이중박막에서 자구벽의 구조 변화와 이로 인한 자구벽 운동 변화를 설명하였다.

참고문헌
[1] Metaxas, P. J. (2009). Domain wall dynamics in ultrathin ferromagnetic film structures : disorder, coupling and periodic pinning. Sciences-New York.
[2] Hrabec, A., KřiŽáková, V., Pizzini, S., Sampaio, J., Thiaville, A., Rohart, S., & Vogel, J. (2018). Velocity Enhancement by Synchronization of Magnetic Domain Walls. Physical Review Letters, 120(22), 1–5.
[3] Je, S. G., Kim, D. H., Yoo, S. C., Min, B. C., Lee, K. J., & Choe, S. B. (2013). Asymmetric magnetic domain-wall motion by the Dzyaloshinskii-Moriya interaction. Physical Review B - Condensed Matter and Materials Physics, 88(21), 1–5.

Keywords:

다층 자기박막, 자구벽, MOKE

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.110

중금속/강자성체 이종접합 구조에서 발현되는 단방향 스핀 홀 자기저항에서 마그논의 기여도에 관한 연구

JANG Heechan [1,2], PARK Eunkang [1], LEE Ki-Seung [3], JEONG Seyeop [1], LEE Donghyeon [1], KIM Jisu [1], KIM Kwangsu [1,4], THAN Vu Minh[1], LEE Soogil [5], PARK Byong Guk [5], KIM Kyoung-Whan [4], YOU Chun-Yeol [3], LEE Nyun Jong *[1], KIM Sanghoon [1], ONO Teruo [2]
[1]Department of Physics and EHSRC, University of Ulsan
[2]Institute for Chemical Research, Kyoto University
[3]Department of Emerging Materials Science, DGIST
[4]Center for Spintronics, KIST
[5]Department of Materials Science and Engineering, KAIST
leenj829@ulsan.ac.kr

Abstract:

단방향 스핀 홀 자기저항(unidirectional spin Hall magnetoresistance, USMR)은 최근 밝혀진 자기저항(magnetoresistance, MR)으로 heavy-metal(HM)/ferromagnet(FM) bilayer에서 발생하는 현상이다.[1] USMR은 GMR, SMR 등의 다른 자기저항과 달리 전류 및 자화 방향에 대해 비대칭적인 거동을 보이는 non-linear MR로 two terminal을 이용한 새로운 magnetization switching 소자에 활용 가능성을 가지고 있다.[1, 2, 3]
USMR을 관찰하기 위해서는 전하-스핀 전환현상을 이용한다. HM/FM 구조에서 in-plane 전류를 흘려주었을 때 HM 층에서 스핀 홀 효과에 의해 스핀 전류 생성된다.[4, 5] 이때 HM 층에서 FM 층으로 주입된 스핀 전류가 FM층의 스핀과 상호작용하고 이로 인하여 발생하는 non-linear 자기저항이 바로 USMR이다.[6] USMR은 발표된 이후로 이에 대해 다양한 연구가 진행되었다.[7, 8, 9, 10] 이처럼 스핀 홀 효과에 의한 스핀 전류가 USMR의 원인임은 알려져 있으나 USMR이 일어나는 메커니즘에 관해서는 아직 연구의 여지가 있다.
현재까지 밝혀진 USMR의 대표적인 메커니즘으로는 스핀 축적에 의한 메커니즘과 마그논에 의한 메커니즘이 있다. USMR이 처음 발표될 당시에는 중금속층의 스핀 축적에서 기인한 chemical potential에 의한 현상으로만 설명되었으나[1, 6] 여러 연구를 통해 electron-magnon scattering또한 고려되어야 할 메커니즘임이 확인되었다.[7, 8] 그러나 마그논에 의한 USMR의 기여에 대한 정량적인 분석 모델은 아직 보고되지 않았다.
본 연구에서는 중금속(Pt 또는 Ta)/Co 이중층 구조에서 Co 층의 두께와 온도에 따른 USMR을 측정하고, 변형된 형태의 two current 모델을 유도하고 적용함으로써 USMR에서 마그논의 기여도를 살펴보았다. 분석 결과 Pt/Co에서는 마그논에 의한 USMR 기여가 지배적이며, Ta/Co에서는 자성층의 두께가 얇은 곳에서는 스핀 축적에 의한 USMR이 자성층의 두께가 두꺼운 곳에서는 마그논에 의한 USMR이 지배적임을 확인하였다. 더하여, 본 연구에서 제안된 변형 two current 분석 모델이 마그논과 관련된 USMR의 정량화에 사용가능하다는 것을 확인하였다.

Acknowledgements
This work was supported by the Brain Korea 21 Plus Program (Human Resource Center for Novel Materials Research Experts) through the National Research Foundation of Korea (No. F19SR21D1101) and the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2018R1A4A1020696, 2017R1A2B3002621, 2019R1C1C1010345, and 2019R1A6A1A11053838).

References
[1] C. O. Avci et al., Nature Physics **11** 570–575 (2015).
[2] G. Binasch et al., Physical Review B **39** (1989)
[3] H. Nakayama et al.,, Physical Review Letters **110** (2013)

[4] J. E. Hirsch, “Spin Hall Effect”, Physical Review Letters **83** (1999)
[5] Jairo Sinova, et al., Physical Review Letters **92** (2004)
[6] S. S. -L. Zhang and G. Vignale, Physical Review B **94** (2016).
[7] K-J Kim et al., Applied Physics Express **12** 063001 (2019).
[8] K. Yasuda, et al., Physical Review Letters **117** 127202 (2016).
[9] Yuxiang Yin et al., Applied Physics Letters **111** (2017)
[10] C. O. Avci et al.,, Physical Review Letters **121** (2018).

Keywords:

USMR, electron-magnon scattering, spin accumulation, charge-spin conversion, spin Hall effect

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.111

Volume dependence of anomalous Hall effect in compensated ferrimagnet Mn_3Al

RHIM Sonny *[1,3], HAN Guihyun [1], PARK Minkyu [2], HONG Soon Cheol [1,3]
[1]Department of Physics, University of Ulsan
[2]Research Institute of Basic Sciences, University of Ulsan
[3]Energy Harvest-Storage Research Center, University of Ulsan
sonny@ulsan.ac.kr

Abstract:

The emergence of anomalous Hall effect (AHE) even with zero magnetization has been elucidated with symmetry analysis [1,2,3]. In this context, anomalous Hall conductivity (AHC) of a compensated ferrimagnet, Mn_3Al has been investigated using ab initio calculations. AHC under volume change while retaining the cubic symmetry, reaches up to 1000 (S/cm). The change of AHC by volume is further analyzed, where band occupancy plays an important role.
More specifically, low dispersive bands near Fermi level are affected. Possibility of van Hove singularity of those bands is studied.

[1] Hua Chen, Qian Niu and A. H. MacDonald, Phys. Rev. Lett. **112**, 017205 (2014).
[2] Yang Zhang, Yan Sun, Hao Yang, Jakub Zelezný, Stuart P. P. Parkin, Claudia Felser, and Binghai Yan, Phys. Rev. B **95**, 075128 (2017).
[3] Libor Šmejkal, Rafael González-Hernández, T. Jungwirth, J. Sinova, Sci. Adv. **6** eaaz8809 (2020).

Keywords:

anomalous Hall effect, magnetism, DFT, electronic structure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.112

Strain effect on magnetic properties of monolayer Fe_3GeTe_2

RHIM Sonny *[1], KIM G Hye [1], AIN Qurat Ul[1], HONG SoonCheol [1]
[1]Department of Physics, University of Ulsan
sonny@ulsan.ac.kr

Abstract:

In recent years, two-dimensional (2D) magnetic materials [1][2] are intensively studied for many fascinating physics. Fe_3GeTe_2 (FGT) is one of this class with relatively high Curie temperature (~130K) [3]. Using density-functional theory, we studied monolayer FGT, strain effect on magneto-crystalline anisotropy (MCA) in ferromagnetic (FM) state. FM state monolayer FGT prefers perpendicular MCA for all strains (η), E_{MCA} from 0.85 to 4.72 meV for η = -5 and 0 %, respectively. According to band analysis, occupation change of some bands by strain is responsible E_{MCA}. Furthermore, strain dependent anomalous Hall conductivity of FGT is investigated using Kubo formula.

[1] Kenneth S. Burch, David Mandrus and Je-Geun Park, Nat. **563**, 47 (2018).
[2] M. Giberini, M. Koperski, A. F. Morpurgo and K. S. Novoselov, Nat. Nanotechnol. **14**, 408 (2019).
[3] Zaiyao Fei, Jiun-Haw Chu and Xiaodong Xu et al, Nat. Mater. **17**, 778 (2018).

Keywords:

2D magnetic material, density-functional theory, magneto-crystalline anisotropy, strain, anomalous hall conductivity

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.113

(110) NiCo2O4 에피탁시 박막의 결정구조와 자기적 특성

KIM Jungbea [1], JUN Minsuk [1], PARK Yeonjung [1], DHO Joonghoe *[1]
[1]Kyungpook National University
jhdho@knu.ac.kr

Abstract:

AB204 화학식의 역 스피넬 구조를 가진 $NiCo_2O_4$는 준강자성과 함께 금속성을 가진 산화물로서 자기소자, 슈터 캐패시터 전극 등으로 활용될 수 있어 많은 주목을 받고 있다. 펄스 레이저 증착법 (PLD)을 이용하여 100 ~ 500 ℃ 사이의 온도, 1 mTorr ~ 200 mTorr 산소분압에서 (110) MgAl2O4 기판 위에 에피탁시 (110) $NiCo_2O_4$ 박막을 증착하였다. 20 nm ~ 80 nm의 두께의 (110) NiCo2O4 에피탁시 박막의 표면특성, 결정성, 평면내 자기적 특성, 전기적 특성을 비교 분석하였다. X-선 회절 측정법으로 산소분압을 100 mTorr까지 높일 수록 박막의 결정성이 좋아지는 경향을 관찰하였으며, 자기 광 커 효과(MOKE) 방법을 이용하여 평면내 결정방향에 따라 뚜렷한 자기이방성과 온도에 따른 보자력 및 상전이 온도를 분석하였다. 또한 기판에 따른 결정성이 $NiCo_2O_4$의 전기적 저항 값을 반도체성 또는 금속성으로 나뉘며, 산소분압과 온도에 따라 달라지는 특성을 보였다.

Keywords:

film, NiCo2O4, PMA, half-metal

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.114

Multistage development of anisotropic magnetic correlations in the Co-based honeycomb lattice Na2Co2TeO6

LEE Chan Hyeon [1], LEE Suheon [1], CHOI Youngsu [1], JANG Z. H. [2], KALAIVANAN R. [3], SANKA R. [3], CHOI Kwang Yong [*4]
[1]Department of Physics, Chung-Ang University
[2]Department of Physics, Kookmin University
[3]Institute of physics, Academia Sinica
[4]Department of Physics, Sungkyunkwan University
choisky99@skku.edu

Abstract:

We report the magnetic properties of the Co-based honeycomb lattice $Na_2Co_2TeO_6$, where the Co^{2+} magnetic ions form a j_{eff} = 1/2 Kramers doublet ground state. Our static susceptibility and ^{23}Na nuclear magnetic resonance measurements show three-dimensional long-range magnetic ordering at T_N = 26 K. In a high-temperature paramagnetic regime (T>110 K), the Curie-Weiss analysis yields anisotropic magnetism with the Curie-Weiss temperature Θ_{CW}=-104.5 K for H // a* and Θ_{CW}=-13.2 K for H // c. In the intermediate–temperature regime (26 K < T < 110 K), the nuclear spin-lattice relaxation rate $1/T_1$ shows a power-law dependence whose exponent relies on a magnetic field direction. This signifies anisotropic spin-spin correlations of a two-dimensional renormalized classical character. In a magnetically ordered state (T < 26 K), we observe four consecutive transitions or crossovers at T_N = 26 K , T_{N1} = 16 K , T_{N2} = 7 K, and T_{N3} = 3.5 K. Our anisotropic and complex magnetic behaviors highlight a significant role of Kitaev and Γ-type interactions in the Co-based honeycomb compound with a high-spin d^7 configuration.

Keywords:

Kitaev spin model, Co-based honeycomb lattice, NMR

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.115

Random singlet magnetism in the Kitaev honeycomb iridate K_2IrO_3

LEE Suheon *[1,2], LEE Chan Hyeon [2], CHEN Wei-Tin [3], CHOI Kwang Yong *[2,4]
[1]IBS CINAP, Sungkyunkwan University
[2]Department of Physics, Chung-Ang University
[3]Center for Condensed Matter Sciences, National Taiwan University
[4]Department of Physics, Sungkyunkwan University
leesuheon9@gmail.com, choisky99@skku.edu

Abstract:

We present the dc magnetic susceptibility, magnetization, and muon spin relaxation (muSR) results of the Kitaev honeycomb iridate K_2IrO_3. The dc magnetic susceptibility $x_{dc}(T)$ results display a sub-Curie law behavior (n=0.65) below 20 K, implying the presence of abundant low-energy excitations. The isothermal magnetization M(H) data at 2 K exhibit a power-law increment (1-n=0.35). Remarkably, both $x_{dc}(T)$ and M(H) results are well collapsed onto a single scaling curve with the exponent n=0.65, which is reminiscent of universal scaling behavior observed in a certain class of frustrated quantum magnets, such as quantum spin liquids and quenched disorders. The zero-field muSR experiments show the absence of long-range magnetic ordering down to 120 mK with persistent spin dynamics. On the other hand, the longitudinal-field muSR measurements reveal the presence of weakly fluctuating moments at low temperatures. Taken together, our findings suggest the weak dynamical magnetism in the random singlet background, which will be compared to the prototypical random Kitaev honeycomb antiferromagnet Cu_2IrO_3.

Keywords:

Honeycomb lattice, Iridate, Kitaev model, Muon spin relaxation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.116

Magnetic compensation state in new phase of metal tellurate $(Mn,Ni)_3TeO_6$

WON Choong Jae *[1], KIM Jungkyu [1], PARK Jaehoon [1], CHEONG Sangwook [2]
[1]Max Planck POSTECH/Korea Research Initiative
[2]Department of physic and astronomy, Rutgers University
msagem@hanmail.net

Abstract:

The transition metal tellurate M_3TeO_6 have rhombohedral lattice (M =Ni, R3, M = Mn, R-3), and monoclinic latice (M = Co, C2/c). Recently we grown $(Mn,Ni)_3TeO_6$ single crystal, and found monoclinc structure, such as Co_3TeO_6. From magnetic susceptibility, and specific heat measurements, we discover ferrimagnetic transition and magnetic compensation state. These results significantly different from both end-member Ni_3TeO_6 and Mn_3TeO_6 and require further investigations of its magnetic structure.

Keywords:

magnetic compensation, multifunction oxide, ferrimagnetic

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.117

표적 지향적 약물전달시스템 기술에 적용되는 초상자성 나노입자 제조 및 물성연구

YANG Chan Woo [1], CHOI Ye Ji [1], HEO Jin Yong [1], CHOI Hyeon Kyung [2], KIM Chul Sung [2], KIM Sung Baek [*1]
[1]Department of Biomedical materials, Konyang University
[2]Department of Physics, Kookmin University
physics@konyang.ac.kr

Abstract:

본 연구에서는 표적 지향적 약물전달시스템(DDS) 기술에 적용되는 초상자성(superparamagnetic) 나노입자를 제조하고 그 물성에 대한 연구를 수행하고자 한다. 이를 위하여 높은 포화자화 및 자화율 값을 나타내는 것으로 알려진 Fe_3O_4 나노입자를 합성하였다. Fe_3O_4 나노입자는 고온 열분해법을 이용하여 합성하였고, Benzyl ether를 용매로 oleic acid, oleylamine을 계면활성제로 첨가하였다. 합성된 Fe_3O_4 나노입자의 결정구조 분석을 위하여 X-선 회절 실험을 수행하였으며, 격자상수 a_0 = 8.3831 Å을 갖는 Fd-3m 공간군의 Cubic Spinel 구조임을 알 수 있었다. 입자의 크기는 X-선 회절 패턴을 이용한 Scherer 식으로 계산하였으며 평균 12.8 nm임을 알 수 있었다. 진동시료형 자화율 측정기(VSM)로 측정된 포화자화 값은 71.47 emu/g, 보자력은 10.25 Oe 인 것을 확인하였다. 미시적인 자성과 명확한 나노입자의 상을 판별하기 위하여 Mössbauer 분광실험을 수행하였다. 상온에서 Mössbauer 스펙트럼은 Fe_3O_4 물질의 전형적인 Lorentzian 6 line 3 Set으로 분석되었다. 분석된 Mössbauer 초미세매개변수로부터 Spinel 구조의 A-자리에는 Fe^{3+} 이온이 위치하고 있으며, B-자리에는 Fe^{3+} 이온과 Fe^{2+} 이온이 2:1로 점유되어 있음을 확인할 수 있었다.

Keywords:

초상자성, Mössbauer, Fe3O4

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.118

온열치료용 초상자성 나노입자의 제조 및 물성연구

YANG Yoon Hee [1], CHA Min Gyeong [1], AN Hyeon Ho [1], CHOI Hyeon Kyung [2], KIM Chul Sung [2], KIM Sung Baek [*1]

[1]Department of Biomedical materials, Konyang University
[2]Department of Physics, Kookmin University
physics@konyang.ac.kr

Abstract:

본 연구는 최근 암 치료를 위한 온열치료(Hyperthermia) 물질로 응용 가능성을 보이는 초상자성 나노입자를 제조하고 그 미시 자성을 연구하는데 목적이 있다. 이를 위하여 강자성 물질 중 높은 포화자화 및 자화율 값을 나타내는 것으로 알려진 $CoFe_2O_4$ 나노입자를 고온 열분해법으로 제조하였다. 나노입자의 분리 단계에서 Hexane을 사용하면, 나노 입자의 표면에서 발생하기 쉬운 불완전한 자기 구조의 형성을 방지할 수 있으며, 계면활성제를 사용하지 않고 효과적인 분산이 가능하다. 이로 인해 자성 나노입자의 결정성이 높아지며 비자성 표면층의 형성이 억제되어 자기적 성질을 크게 향상시킬 수 있을 것으로 기대된다.
X-선 회절 실험결과 결정구조는 Cubic Spinel 구조의 Fd-3m 공간군을 형성하고 있음을 확인하였으며, 격자상수는 a_0=8.3960 Å로 분석되었다. X-선 회절 패턴으로 계산된 입자의 크기는 9.80 nm이다.
진동시료형 자화율 측정기 (VSM)를 이용하여 1.5 T 의 외부자기장 하에서 측정한 자기적 특성 실험 결과 포화자화 값은 65.78 emu/g, 보자력은 57.46 Oe 임을 보였다. 또한 미시적인 자성과 명확한 나노입자의 상을 판별하기 위하여 Mössbauer 분광실험을 수행하였다. 상온에서 Mössbauer 스펙트럼은 Lorentzian 2 set으로 분석되었으며, Fe^{3+} 이온이 spinel 구조의 A-site와 B-site에 모두 위치하고 있음을 알 수 있었다.
온열치료를 위한 발열반응 실험은 109.8 kHz, 250 Oe의 외부 인가 자기장하에서 0, 50, 100, 200, 400, 600, 800 sec 일 때 각각 21.1, 47.3, 60.2, 70.5, 75.7, 77.0, 77.5 ℃로 나타났다. 대략 시간이 200 sec에서 발열 온도가 포화 상태에 도달함을 알 수 있었으며 50 sec 일 때 47.3 ℃로, 온열치료에 적용되기 위해서는 50 sec보다 조금 적은 시간에서 발열반응이 제어되어야 함을 예측할 수 있다.

Keywords:

초상자성, Mössbauer, CoFe2O4

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.201

The Effect of Gamma-Ray Irradiation on Ferroelectric Characteristics of $Hf_{0.5}Zr_{0.5}O_2$

NAMKUNG Jin [1], CHAE Seung Chul *[1]
[1]Dept. of Physics Education, Seoul National University
scchae@snu.ac.kr

Abstract:

The unprecedented discovery of ferroelectricity in hafnium oxide in 2011 has shed renewed light on the feasibility of ferroelectric based non-volatile future memory device due to its remarkable compatibility with contemporary complementary metal-oxide-semiconductor technologies. Considering the diverse requirements of memory applications such as power plant and outer space, stability of the ferroelectric properties even in harsh conditions should be confirmed. Therefore, the detailed study of stability issues of hafnium based ferroelectrics under the gamma-ray irradiation is urgently required.

Here, we demonstrated 60-Co gamma-ray irradiation effects on the ferroelectric properties of $Hf_{0.5}Zr_{0.5}O_2$ thin films. The ferroelectricity of HZO was confirmed via grazing incidence X-ray diffraction (GIXRD), ferroelectric hysteresis measurement (P-E measurement), and capacitance-voltage measurement (C-V measurement). Corresponding measurements of electrical properties were followed after the exposure of radiation to the films with various energy. The endurance and resistance characteristics of HZO will be discussed under varied gamma-ray radiation energy.

Keywords:

Gamma-Ray, Ferroelectric, Hf0.5Zr0.5O2, Polarization, Capacitance

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.202

Structural analysis of deuterium-substituted hydrogen bonded systems using high-resolution NMR

KIM Se Hun *1
1Jeju National University
spinjj@jejunu.ac.kr

Abstract:

In this study, we obtained experimental results similar to the isotope substitution effect by using the proton irradiation of K(H0.47D0.53)2PO4 (DKDP) ferroelectric single crystals. Temperature dependence of dielectric constants showed that the ferroelectric phase to paraelectric phase transition temperature increased from 175 K to 195 K of approximately 20 K after the proton beam irradiation. It was observed that the vibration mode P(OD)2 was changed from 893 to 884 cm-1 in Raman spectroscopy. In 1H Magic Angle Spinning (MAS) Nuclear Magnetic Resonance (NMR) experiments, the isotropic chemical shift after proton irradiation decreased from 14.46 to 14.32 ppm, which is indicative of the change of the O-H...O the equilibrium distance of hydrogen bonds estimated as 1.60066 Å and 1.62228 Å before and after the proton irradiation, respectively. It was observed that the Full width at half maximum (FWHM) line width also decreased from 563 to 244 Hz in 1H MAS spectral line shape, which is indicative of obeying the displacive phase transition model.

Keywords:

hydrogen-bonded system, High-resolution nuclear magnetic resonance (NMR), phase transition, Isotropic chemical shift

Thickness-dependent dielectric properties of polymorphic Ga_2O_3 epitaxial thin films

KWAK Seungyeop [1], EOM Tae Hwa [1], KIM Ki Seok [1], LEE Sang A *[1], HWANG Jae-Yeol *[1]
[1]Department of Physics, Pukyong National University
sangalee@gmail.com, jyhwang@pknu.ac.kr

Abstract:

Thermally stable Ga_2O_3 with ultra-wide bandgap and high breakdown electric field characteristics has recently attracted much attention as a promising candidate for UV applications and power electronics. Ga_2O_3 is a polymorph with five phases (α, β, γ, δ, ε), each has a unique characteristic. Among them, many researches have been focused on β-Ga_2O_3 due to the thermal and chemical stabilities. However, for the thin film growth, β-Ga_2O_3 has fundamental issues, such as poor crystal quality and the formation of twin due to the low symmetry of monoclinic structure (C2/m). On the other hand, α-Ga_2O_3 thin film with the bandgap of 5.3 eV is known as a structurally stable rhombohedral (R-3c). In this study, α-Ga_2O_3 thin films were grown on Al_2O_3 substrate by pulsed laser deposition (PLD) with varying thicknesses. To confirm the growth parameters for α-phase, we investigated Ga_2O_3 thin film by changing growth temperature (T_g) and oxygen partial pressure ($P(O_2)$) during PLD process. At 500℃ ≤ T_g < 700℃, we obtained the β-Ga_2O_3 thin films (strain 6.12%) with twinned epitaxial structures. At T_g = 700°C and $P(O_2)$ = 100 mTorr, the α-Ga_2O_3 thin films were achieved and showed a high-quality single phase with Pendellösung fringes. In principle, as-grown α-Ga_2O_3/Al_2O_3 epitaxial thin film can have a considerable lattice mismatch (strain 4.46%). For the verification of strain effect, the dielectric properties of the Ga_2O_3 thin films for the various thickness were investigated.

Keywords:

Ga2O3, PLD, Thickness-dependent, Dielectric properties, Thin film

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.204

Attempt to chemically reduce barium oxide and barium carbonate with hydrogen

OH Ju Hyun [1], KANG Mijeong [2], JEONG Jung Hyun [1], LEE Seunghun *[1]
[1]Department of Physics, Pukyong National University
[2]Department of Optics and Mechatronics Engineering, Pusan National University
seunghun@pknu.ac.kr

Abstract:

Barium is an alkaline earth metal belonging to group 2 in the periodic table. Barium metal is known to be extremely difficult to be purified because of its high chemical instability. In this study, we attempted to chemically reduce barium oxide (BaO) and barium carbonate ($BaCO_3$) to barium metal by a thermal treatment with either carbon or Ar:H mixed gas as feasible reducing agents. X-ray diffraction and IR absorption measurements were employed to investigate the change in structural properties of BaO and $BaCO_3$ after the post-treatments. We here point out that special care should be taken when reducing highly reactive elements using gases even with high purity (99.999%).

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2020R1F1A1070421 and 2020R1A6A3A01100374).

Keywords:

barium oxide, chemical reduction, thermal treatments, hydrogen gas, carbon

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.205

Temperature dependent Raman spectroscopic study of Methylammonium Lead Bromide ($MAPbBr_3$)

KANG Dong hoon [1], KO Jaehyeon *[1], AHN Changwon [2], KIM Taeheon [2]
[1]School of Nano Convergence, Hallym University
[2]Department of Physics and Energy Harvest-Storage Research Center, University of Ulsan
hwangko@hallym.ac.kr

Abstract:

Organic-inorganic halide perovskites (OIHP) have emerged as a fascinating material for photovoltaic applications [1], [2]. Over the last decade, a remarkable increase has been seen in the solar cell efficiency of the perovskite based solar cells up to 25.5% as of early 2021 [3]. OIHPs have a low-cost synthesis route, high charge carrier lifetime and tunable bandgaps which makes them an attractive material for photovoltaic applications [4], [5]. In this study, single crystals of OIHPs $MAPbBr_3$ were synthesized and investigated by Raman spectroscopy. The laser wavelength used was 633nm to avoid any degradation effect and the frequency range was 200-3500 cm^{-1}. Raman spectra were recorded in a wide temperature range from room temperature to -190°C. The Raman shifts were plotted as a function of temperature in the intensity plot as shown in figure 1. $MAPbBr_3$ undergoes three phase transitions that are from cubic to tetragonal I at -37°C, tetragonal I to tetragonal II at -119°C and tetragonal II to orthorhombic at -125°C. In our results, noticeable anomalies were seen only for the tetragonal II to orthorhombic transition. The tetragonal phase needs to be investigated in more detail as it was stable for a short temperature range.

Keywords:

Organic-inorganic halide perovskites, solar cell, Raman spectroscopic, single crystals, MAPbBr3

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.206

Synthesis and Raman spectroscopic investigation of mixed hybrid halides $MAPbBr_{3-x}Cl_x$ with x=0, 2, 2.5, 3

NAQVI Furqanul Hassan [1], KO Jaehyeon *[1], AHN Changwon [2], KIM Taeheon [2]
[1]School of Nano Convergence, Hallym University
[2]Department of Physics and Energy Harvest-Storage Research Center, University of Ulsan
hwangko@hallym.ac.kr

Abstract:

Halide perovskites (HP) are known to be the rising stars of photovoltaic world due to their excellent optoelectronic and photovoltaic applications [1], [2]. HPs have a great compositional flexibility [3] and can be formed by choosing different organic/inorganic cations and anions for example $CH_3NH_3PbX_3$ ($MAPbX_3$) with X=Cl, Br or I. In this study, single crystals of mixed HPs $MAPbBr_{3-x}Cl_x$ with x=0, 2, 2.5, 3 were synthesized and Raman spectroscopy was employed to investigate the effect of the composition of halide anions on vibrational behaviors. The probing wavelength and the frequency range were 633 nm and 80-3500 cm^{-1}, respectively. Raman spectra were recorded at both the room-temperature cubic phase as well as the low-temperature orthorhombic phase. All the observed vibrational modes were assigned according to the well-reported mode assignment for HP. Figure 1 shows the Raman shifts of different vibrational modes as a function of halide composition. The MA torsional mode is affected most substantially by the substitution of halides showing a shift from 485cm^{-1} in $MAPbCl_3$ to 325cm^{-1} in $MAPbBr_3$. The C-N stretching mode ν(C-N) and the MA rocking mode ρ(MA) show a blue shift from cubic to orthorhombic phase which is linked to change in hydrogen bonding from NH_3 to CH_3 as the temperature is decreased. Upon substituting a heavier halide, Raman shifts of most vibrational modes decreased. Taken together, these outcomes highlight the significant role of halides in altering several properties of perovskites linked to the chemical interplay.
Acknowledgment: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Government (MSIT) (No. 2020R1A2C101083111).

Keywords:

Halide perovskites, MAPbCl3, Raman spectroscopic, hybrid halides

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.207

Growth optimization and atomically resolved ferroelectricity mapping of ferroelectric Bi_2WO_6 thin film

JEONG Jihwan [1,2], MUN Junsik [2,3], DAS Saikat [1,2], KIM Jinkwon [1,2], KIM Jeong Rae [1,2], PENG Wei [1,2], KIM Miyoung [2,3], NOH Tae Won [*1,2]
[1]Department of Physics and Astronomy, Seoul National University
[2]Center for Correlated Electron System, IBS
[3]3Department of Materials Science and Engineering and Research Institute of Advanced Materials, Seoul National University
twnoh@snu.ac.kr

Abstract:

Aurivillius family is known to display excellent ferroelectric properties like high Curie temperature and strong spontaneous polarization.[1] Bi_2WO_6 (BWO) is the simplest member of the Aurivillius family, with each Bi_2O_2 layer and WO_6 octahedron layer are sandwiching each other. The most interesting property about this material is that its ferroelectric domains are aligned along only the in-plane (IP) direction and it has a total of 4 directions with 90 degrees with a low energy barrier. This means we can expect there will be no depolarizing field and critical thickness will be decreased or disappear. Also, the ferroelectric domains of BWO can be switched with much lower energy than other typical ferroelectrics like $PbTiO_3$. So, BWO can be an attractive candidate for an electric device with low energy demand [2]. Although BWO has such advantages, a detailed study focusing on growth condition optimization and direct experimental proof ferroelectric origin is missing.
We have grown epitaxial BWO thin films on (001)-oriented $SrTiO_3$ substrates and $SrRuO_3$ buffer layers with the pulsed laser deposition (PLD) technique. The crystalline quality of BWO thin film is confirmed by X-ray diffraction, atomic force microscopy, and transmission electron microscopy. With those varying crystalline quality by PLD growth conditions, we show the optimized condition for depositing BWO thin film. We also show the origin of ferroelectricity by Scanning Transmission Electron Microscopy technique and ferroelectric property by Piezoresponse Force Microscope technique.

[1] H. Djani, et al., Phys. Rev. B 86, 054107 (2012).
[2] C. Wang, et al., Nature Communications 7, 10636 (2015).

Keywords:

Ferroelectricity, Scanning Transmission Electron Microscopy (STEM), Aurivillius compounds, Oxide thin films, Piezoresponse force microscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.208

Epitaxial growth control of oxygen vacancies in Co_3O_4 thin films for two-dimensional topological superconductivity

NOH Tae Won *[1], SHIN Min Soo [1], LEE Han-Gyeol [1]
[1]Department of Physics and Astronomy, Seoul National University
[2]Institute for Basic Science, Center for Correlated Electron Systems
twnoh@snu.ac.kr

Abstract:

Two-dimensional topological superconductivity has attracted much attention from condensed matter physicists. Since it rarely appears in nature, realizations and observations through experimental methods depend upon delicate atomic-scale engineering. Recently, Lado et al. made a theoretical prediction on the realization of 2D topological superconducting state utilizing a class of 3D antiferromagnets as an alternative way to build a 2D topological superconducting phase [1]. According to its theoretical prediction, the 2D superconducting state appears at the interface between a conventional superconductor and a topologically trivial antiferromagnet. Even though $CoAl_2O_4$ was suggested in the above-mentioned paper as a candidate for the topologically trivial antiferromagnet, this material has some issue about showing spin frustration, so disturb its antiferromagnetic ordering at low temperature [2]. Here we suggest an alternative antiferromagnetic material; Co_3O_4 which shows less spin frustration [3] and introduce a way of delicate epitaxial growth control of Co_3O_4 thin films which is an essential step for further study on topological superconductivity at the interface of the heterostructure. Though the topological superconductivity of Co_3O_4 in a two-dimensional area has yet not been confirmed, this material may open a new playground for topological superconductivity in oxide thin films.

For the experimental realization of the research, fabricating this material into high-quality thin film form is crucial. According to a recent report by Matsuda et al., the assertion that Co_3O_4 films can be grown in high epitaxial quality at room temperature was given [4]. However, we found that Co_3O_4 films grown at room temperature have oxygen vacancies when the film is grown without delicate control of oxygen partial pressure using pulsed laser deposition technique. To confirm the existence of oxygen vacancies of the films, we measured the core-level spectrum of Co_3O_4 films by X-ray photoemission spectroscopy. Co^{3+} over Co^{2+} ratios in Room-T grown films is decreased, compared to Co_3O_4 films without oxygen vacancies. Tough higher oxygen partial pressure or higher growth temperature seems like a reasonable way to get rid of oxygen vacancies, it turned out that film growth without discreet control of growth temperature and oxygen partial pressure can easily exacerbate the epitaxial quality of Co_3O_4 films. To settle this issue, we will report the results of detailed tuning of oxygen partial pressure and growth temperature using pulsed laser deposition technique and will report the optimized growth condition for high-quality Co_3O_4 thin films.

Keywords:

Pulsed laser deposition, Oxygen vacancy, Cobalt oxide thin film, Phase diagram, Antiferromagnetic insulator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.209

$Nd_{0.8}Sr_{0.2}NiO_2$ thin films synthesized by physical oxygen reduction method

MAENG Jin Young [2], SONG Jong Hyun *[1,2]
[1]Chungnam National University
[2]Department of Physics, Chungnam National University
songjonghyun@cnu.ac.kr

Abstract:

When $Nd_{0.8}Sr_{0.2}NiO_3$ thin film exposures under an oxygen reduction configuration using chemical method using CaH_2 gas, the composition of the film changes to $Nd_{0.8}Sr_{0.2}NiO_2$ with superconductivity accompanying structural transition. Herein, we tried to find a physical oxygen reduction method through a procedure in PLD (Pulsed Laser Deposition) instead of chemical method using a toxic CaH_2 gas. The $Nd_{0.8}Sr_{0.2}NiO_3$ thin film was grown on the $SrTiO_3$ substrate by using the PLD method. The stoichiometric $Nd_{0.8}Sr_{0.2}NiO_3$ film was confirmed through XRD (X-Ray Diffraction) and electrical-transport measurements. After the growth, the film surface was capped by $SrTiO_3$ layer which was grown in-situ using the same PLD procedure. In this process, the physical oxygen reduction was attempted by changing the PLD growth condition variously for the $SrTiO_3$ capping layer.

Keywords:

Nd0.8Sr0.2NiO2, Nd0.8Sr0.2NiO3, thin film, physical oxygen reduction, Pulsed Laser Deposition

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.210

Studies in critical thickness of $SrTiO_3$/$LaAlO_3$/$SrTiO_3$ and superconducvity

KWAK Yongsu [1], HAN Woojoo [2], LEE Jonn Sung [3], KIM Jinhee [4], SONG Jong Hyun [*1]
[1]Chungnam National University
[2]Department of Nanoscience, UST
[3]Display and Semiconductor Physics, Korea University
[4]플랑크상수질량팀, KRISS
songjonghyun@cnu.ac.kr

Abstract:

A two dimensional electron gas is formed at the interface between $LaAlO_3$(LAO) and $SrTiO_3$(STO). According to Polar catastrophe scenario, 4 unit cells of LAO well known for critical thickness is necessary condition for metallic conduction. Here, we found that the critical thickness of LAO was reduced when depositing capping STO on the LAO/STO heterostructure. The metallic conduction was induced at $(LAO)_1$/STO interface if 3 or more uc of capping STO was deposited on $(LAO)_1$/STO. We obtained consistent results from calculation of density functional theory. Additionally, we found that the trilayer exhibits superconductivity at temperature below 180 mK and found that the superconductivity showed suppressed superconducting gap which imply a non BCS-type superconductivity.

Keywords:

two-dimensional electron gas, Superconducvitiy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.211

Evolution of electronic structure in the bilayered perovskite $Sr_3(Ir_{1-x}Mn_x)_2O_7$

KIM Dong Wook *1, AHN G. 1, SCHMEHR J. 2, WILSON S. D.2, MOON S.J. *1
1Physics department, Hanyang University
2Materials Department, UCSB
ghtkkim45@naver.com, soonjmoon@hanyang.ac.kr

Abstract:

A 5d transition metal oxide $Sr_3Ir_2O_7$ has the J_{eff} = 1/2 Mott insulating state, which are due to the strong spin-orbit coupling and comparably weak coulomb interaction. We investigate temperature and doping evolutions of the optical response in the layered perovskite $Sr_3(Ir_{1-x}Mn_x)_2O_7$ in the range of $0 \le x \le 0.33$ using infrared spectroscopy. The notable changes in the optical spectra weight (SW) are observed near 0.41 eV and 0.83 eV upon Mn-doping, which belong to the optical transitions in the J_{eff} = 1/2 and Jeff = 3/2 bands. While the former is suppressed upon Mn-doping, the latter is enhanced. In addition, we find appearance of new novel optical transitions at about near 0.17 and 1.2 eV upon Mn-doping. The SW near 1.2 eV shows gradual decreases in accordance with increasing Mn-doping ($0.09 \le x \le 0.33$). On the other hand, the optical transitions near 0.17 eV have a peculiar tendency in which the SW is increased for lower Mn-concentration ($0.09 \le x \le 0.18$), while reduced for higher Mn-concentration ($0.18 \le x \le 0.33$). We discuss the effects of the interplays between Ir and Mn ions on the evolution of the electronic structure of $Sr_3(Ir_{1-x}Mn_x)_2O_7$.

Keywords:

Infrared Spectroscopy, Sr3Ir2O7, Mn-doping, optical response, Jeff = 1/2, 3/2 Mott state

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.212

Fabrication of fully-strained 5d Pyrochlore iridate thin films

SONG Jeongkeun [1,2], NOH Tae Won *[1,2], KIM Woo Jin [1,2], MUN Junsik [1,2], KO Eunkyo [1,2], KIM Jinkwon [1,2], LI Yangyang [1], KIM Miyoung [3], KIM Tae Heon [4]
[1]Department of Physics and Astronomy, Seoul National University
[2]Center for Correlated Electron systems, IBS
[3]Department of materials science and engineering, Seoul National University
[4]Department of Physics, University of Ulsan
twnoh@snu.ac.kr

Abstract:

The lack of control of volatile elements has been long-standing challenges for synthesizing high-quality 4d/5d transition metal oxides and tailoring the novel quantum phases. Recently, the in-situ synthesis method called “Repeated rapid High-T synthesis epitaxy (RRHSE)” has reported to fabricate one of volatile compound, $Nd_2Ir_2O_7$ (NIO-227) as the thin film. While the method was introduced, the guideline to fully utilize such method to fabricate high-quality NIO-227 thin films still challenging. In this work, we show that ratio of IrO_2, other than conventional growth paramters such as temperature and oxgyen pressure, is the key parameter to control the crystal structure and magneto-trasnport of NIO-227 thin films. Our work will provide cornerstone to extend the further studies on strain-engineered novel topological phases in $Nd_2Ir_2O_7$ thin films.

Keywords:

Pyrochlore iridate thin film, Growth technique, 5d transition metal oxide

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.213

Temperature dependence of crystal structure for epitaxial perovskite ruthenates ($ARuO_3$, A = Ca, Sr, and Ba)

EOM Tae Hwa [1], LEE Sang A *[1], HWANG Jae-Yeol *[1]
[1]Department of Physics, Pukyong National University
sangalee@gmail.com, jyhwang@pknu.ac.kr

Abstract:

ABO_3-type ruthenate family (A = Ca, Ba, and Sr) is widely used as a fundamental block for oxide electronics due to various physical properties, such as conductive oxide, ferromagnetism, behavior. Among them, $CaRuO_3$(CRO) and $SrRuO_3$ (SRO), which has been widely reported as epitaxial thin films, have the same orthorhombic structure (Pbnm, 62) including RuO_6 octahedral distortion, and can be considered as pseudocubic with the lattice constant of 3.84 and 3.93 Å, respectively. On the other hand, $BaRuO_3$ (BRO) bulk has four polymorph phases. Particularly, cubic BRO structure (3C-BRO, Pm-3m , 221) can be obtained by crystal growth under high temperature and pressure. So far, temperature dependence of structural characteristics for CRO and BRO has not been studied, whereas SRO is well known that the structural phase transition of the strained thin film is occurred from orthorhombic to cubic structure according to the transition temperature.
In this study, we investigated the temperature dependence of crystal structure for the ruthenate thin films to understand the thermal expansion and the deformation of the crystal structure. The epitaxial ruthenate thin films were grown on $SrTiO_3$ (001) substrates by pulsed laser deposition. X-ray diffraction (XRD) results of the ruthenates thin films show clear distinctive structural phases, such as tetragonal structure for CRO (1.7%, tensile) and 3C-BRO (2.46%, compressive) and orthorhombic SRO (0.64%, compressive) at room temperature. To determine the temperature dependence of crystal structure, in-plane and out-of-plane ω-2θ scans of ruthenate thin films were analyzed with varying temperatures under atmospheric and vacuum conditions. We suggest that these results provide a fundamental understanding of crystal structure as well as deformation depending on the temperature in the perovskite ruthenate thin films.

Keywords:

temperature dependent, crystal structure, ARuO3, thin film

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.214

Signature of Kondo hybridization with an orbital-selective Mott phase in 4d $Ca_{2-x}Sr_xRuO_4$

KIM Minsoo [1,2], KWON Junyoung [1,2], KIM Choong H [1,2], KIM Younsik [1,2], CHUNG Daun [3], RYU Hanyoung [1,2], JUNG Jongkeun [1,2], KIM Beom Seo [1,2], SONG Dongjoon [1,2], DELINGER Jonathan D[4], HAN Moonsup [5], YOSHIDA Yoshiyuki [6], MIZOKAWA Takashi [7], KYUNG Wonshik [1,2], KIM Changyoung [*1,2]
[1]Center for Correlated Electron Systems, Institute for Basic Science
[2]Department of Physics and Astronomy, Seoul National University
[3]College of Liberal Studies, Seoul National University
[4]Advanced Light Source, Lawrence Berkeley National Laboratory
[5]Department of Physics, University of Seoul
[6]-, National Institute of Advanced Industrial Science and Technology
[7]Department of Applied Physics, Waseda University
changyoung@snu.ac.kr

Abstract:

The heavy fermion state with Kondo-hybridization (KH), usually manifested in f-electron systems with lanthanide or actinide elements, was recently discovered in several 3d transition metal compounds without f-electrons. However, KH has not yet been observed in 4d/5d transition metal compounds, since more extended 4d/5d orbitals do not usually form flat bands that supply localized electrons appropriate for Kondo pairing. Here, we report a doping- and temperature-dependent angle-resolved photoemission study on 4d $Ca_{2-x}Sr_xRuO_4$, which shows the signature of KH. We observed a spectral weight transfer in the γ-band, reminiscent of an orbital-selective Mott phase (OSMP). The Mott localized γ-band induces KH with the itinerant β-band, resulting in spectral weight suppression around the Fermi level. Our work is the first to demonstrate the evolution of the OSMP with possible KH among 4d electrons, and thereby expands the material boundary of Kondo physics to 4d multi-orbital systems.

Keywords:

Kondo hybridization, Perovoskite oxides

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.215

Capping & gating control of anomalous Hall effect and hump structure in ultra-thin $SrRuO_3$ film

KIM Donghan [1,2,3], SOHN Byungmin [1,2,3], KIM Minsoo [1,2,3], HAHN Sungsoo [1,2,3], KIM Youngdo [1,2,3], KIM Jong Hyuk[3], CHOI Young Jai[3], KIM Changyoung [*1,2]
[1]CCES (IBS), CCES (IBS)
[2]Department of Physics and Astronomy, Seoul National University
[3]Department of Physics, Yonsei University
changyoung@snu.ac.kr

Abstract:

Ferromagnetism and exotic topological structures in $SrRuO_3$ (SRO) induce sign-changing anomalous Hall effect (AHE). Recently, hump structures have been reported in the Hall resistivity of SRO thin films, especially in the ultra-thin regime. We investigate the AHE and hump structure in the Hall resistivity of SRO ultra-thin films with an $SrTiO_3$ (STO) capping layer and ionic liquid gating. STO capping results in sign changes in the AHE and modulation of the hump structure. In particular, the hump structure in the Hall resistivity is strongly modulated and even vanishes in STO-capped 4 unit cell (uc) films. In addition, the conductivity of STO-capped SRO ultra-thin films is greatly enhanced with restored ferromagnetism. We also performed ionic liquid gating to modulate the electric field at SRO/STO interface. Drastic changes in the AHE and hump structure are observed with different gate voltages. Our study shows that the hump structure as well as the AHE can be controlled by tuning inversion symmetry and the electric field at the interface.

Keywords:

Hall effect, hump structure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.216

Observation of Kondo lattice behavior in an antiferromagnetic metal FeTe

KIM Younsik [1,2], HUH Soonsang [1,2], JUNG Saegyeol [1,2], KIM Jong Hyuk [3], CHOI Young Jai [3], KIM Changyoung [*1,2]

[1]Center for Correlated Electron Systems, Institute for Basic Science
[2]Department of Physics and Astronomy, Seoul National University
[3]Department of Physics, Yonsei University
changyoung@snu.ac.kr

Abstract:

In a classical picture, Kondo lattice and antiferromagnetism competes each other, making them barely overlap in the phase diagram since localized moments are screened by itinerant electrons upon forming Kondo singlet. This classical picture assumes the Kondo interaction is on-site. If the Kondo interaction is off-site, itinerant electrons are not able to screen localized moments. As a result, Kondo lattice and magnetism can coexist if the Kondo interaction if off-site. Here, we report the emergence of Kondo lattice behavior in an antiferromagnetic metal, FeTe. We observed Kondo hybridization between localized Fe 3dxy and Te 5pz bands by using angle-resolved photoemission spectroscopy (ARPES) below Néel temperature. Our work shows the first observation of Kondo p-d hybridization, and cooperation of Kondo lattice and antiferromagnetism.

Keywords:

Kondo lattice, Iron-based superconductors

P1-co.217

Visible-UV Optical spectra of Cu_3TeO_6

KIM Jae Ha [1], SIM Kyung Ik [2], CHAKRABORTY Tirthankar [3], PARK Je Geun [4,5,6], KIM Jae Hoon [*1]
[1]Department of Physics, Yonsei University
[2]Center for Integrated Nanostructure, Institute for Basic Science
[3]Chemical Physics of Solids, Max Planck
[4]Center for Quantum Materials, Seoul National University
[5]Department of Physics and Astronomy, Seoul National University
[6]Institute of Applied Physics, Seoul National University
super@yonsei.ac.kr

Abstract:

Cu_3TeO_6 has an antiferromagnetic spin-web lattice structure. Using visible-UV spectroscopy, we obtained transmission and reflection spectra of Cu_3TeO_6 and studied the temperature dependence in the 0.5 – 3 eV energy range. Around 2 eV range, there is a specific transmission peak and a temporal fluctuation of reflectance. From the measured optical spectra, we derived spectral functions of Cu_3TeO_6 and studied its band structure.

Keywords:

Cu3TeO6, Spectroscopy, Antiferromagnet

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.301

Coherent acoustic phonon in van der Waals heterostructure

PARK Tae Gwan [2], JEON Jae Ho [1], CHUN Seung-Hyun [1], LEE Sunghun *[1], ROTERMUND Fabian [2]
[1]Department of Physics and Astronomy, Sejong University
[2]Department of Physics, KAIST
kshlee@sejong.ac.kr

Abstract:

Well-defined contact between a metal and a semiconductor is imperative to scrutinize the esoteric characteristics of peculiar materials. However, identification of the intrinsic nature of intriguing materials through ongoing attempts has remained elusive owing to the large Schottky barrier caused by inevitable defects and strong Fermi level pinning (FLP). Most recent theoretical studies have suggested possible solutions to overcome FLP issues, but experimental clues and in-depth interpretation are still lacking. Here, the interfacial dipoles formed in the junction between a van der Waals metal (VSe_2) and semiconductor (Bi_2Se_3) is identified through time-resolved ultrafast spectroscopy. The excellent interfacial contact in the MSJs was verified by precise STEM images. Furthermore, thickness-dependent coherent acoustic phonons are indicative of the sound velocity of VSe_2, reflecting defect-free contacts without additional gap states. Our findings provide new insights into the interfacial dynamics in metal-semiconductor junctions, triggering endeavours towards an ideal junction close to the Schottky-Mott limit.

Keywords:

VSe2, Bi2Se3, Heterostructure, Pump-probe laser, Coherent acoustic phonon

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.302

Effects of Magnetically Ordered Atoms on the Properties of Edge States in Two-Dimensional Topological Insulators

LEE Teresa [1], JEON Gun Sang *[1]
[1]Ewha Womans University
gsjeon@ewha.ac.kr

Abstract:

Engineering edge states of two-dimensional(2D) topological insulators(Tis) has been attracting much attention in the past decade[1-3]. We consider the 2D TIs when the electrons at the edge of nanoribbons are exposed to an exchange field due to the nearby ferromagnetically ordered atoms. Particularly, we investigate the energy dispersion of the edge states by the numerical computation. No energy gap is present when the magnetic atoms are ordered in the direction perpendicular to the plane of the nanoribbon. In contrast, an energy gap shows up in the edge-state dispersion when the magnetic ordering is parallel to the plane. We find the monotonic dependence of the size of the energy gap on the direction of the exchange field. We also discuss the effects of the other type of magnetic ordering.

[1] H. Ishida and A. Liebsch, Phys. Rev. Res. **2**, 023242 (2020).
[2] X.-R. Chen, W. Chen, L. B. Shao, and D. Y. Xing, Phys. Rev. B **99**, 085417 (2019).
[3] C.-X. Liu, X.-L. Qi, X. Dai, Z. Fang, and S.-C. Zhang, Phys. Rev. Lett. **101**, 146802 (2008).

Keywords:

topological insulator, edge state, exchange field

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.304

Observation of the back-donation π-bonding states near Fermi level with ARPES

KIM Changyoung *[1], JUNG Jongkeun [1]
[1]Department of Physics and Astronomy, Seoul National University
changyoung@snu.ac.kr

Abstract:

In molecular orbital theory, the chemisorption of CO molecules onto metals is described as a combination of pi- and sigma-bonding interactions, in which the electronic properties of the metal play a critical role. Using state-of-art angle-resolved photoemission spectroscopy (ARPES), we report the direct visualization of the pi-bonding of metal substrate back-donation states of frontier molecular orbitals near the Fermi level as CO molecules are adsorbed on Pt(111) and Pt-Sn/Pt(111) 2 × 2 surfaces. The estimated carrier concentrations near Fermi level show the difference in amount of charge transferred between the Pt and Pt-Sn/Pt surfaces. Spectral features near the Fermi level show that only selected bands participate in chemical bonding. Our results provide important insight into how the delocalized electronic band structure of metals interacts with localized surface molecular orbitals.

Keywords:

angle resolved photoelectron spectroscopy, CO adsorption, Pt, Pt-alloy surfaces, pi backdonation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.305

The influence of defect states in ZnO quantum dot on the energy level alignment

KIM Ahyoung [1], KIM HongHee [2], KIM Kitae [1,3], KANG Heekyung [1], YI Yeonjun [3], CHOI Wonkook [2], PARK Soohyung *[1]
[1]KIST
[2]Center for Optoelectronic Materials and Devices, KIST
[3]Institute of Physics and Applied Physics, Yonsei University
soohyung.park@kist.re.kr

Abstract:

Controlling the energy level alignment (ELA), such as heterojunction for p-n junction and electrode contact for carrier injection/extraction, is critical for optimizing the optoelectronic application. With the assumption of a vacuum level alignment and based on the Schottky-Mott rule, these ELA have been correctly predicted for conventional bulk materials. When the dimension and size of the materials become smaller to be comparable to the Broglie wavelength of an electron, it is known that strong quantum confinement resulting in the electronic structure renormalization (i.e. widen bandgap and many body effect) will occur. This effect implies that the above assumption is no longer valid; in other words, the conventional Schottky-Mott rule should be revised for nano-scale materials.

ZnO nanoparticles (NP) exhibit advantageous properties for quantum dot based electronic applications such as widely tunable bandgap and high enough conductivity to be used for an electron transport layer.Since ZnO NP is small enough, quantum confinement should be considered in the determination of ELA. However, recent previous works reported that the consideration of size-induced-quantum confinement mostly fails to predict the ELA due to interaction by the atomic point defect (or interstitials) that are frequently observed in nanomaterials.

In this contribution, we demonstrate a comprehensive understanding of the impact of defect states in ZnO-NPs on their energy level alignments by using photoluminescence and photoelectron spectroscopy. Furthermore, the difference of photoluminescence (PL) and absorption spectra between ZnO-NPs manufactured by pH regulation and Hydrothermal synthesis methods provide theevidence of the presence of defects. The ZnO-NPs produced by pH regulation methods turned out to retain plenty of defects, and corresponding films did not follow the traditional energy level alignment model. This result indicates that carrier transport between ZnO-NPs and nearby layers can be impeded by defect states. Our study not only suggests the significance of the energetic and spatial location of ZnO-NPs' defect states which have not been considered so far, but also provides a promising approach to optimized nanoparticle-based electronic applications.

Keywords:

2D material, Thin film, Energy level alignment, Quantum Dot, ZnO

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.306

A Photoelectron spectroscopy study on the electronic structure of 2-dimensional perovskites

KIM Kitae [1,2], KIM Ahyoung [2], KWON Namhee [2], PARK Soohyung [*2], LEE Hyunbok [*3], YI Yeonjin [*1]
[1]Department of Physics, Yonsei University
[2]Advanced Analysis Center, KIST
[3]Department of Physics, Kangwon National University
soohyung.park@kist.re.kr, hyunbok@kangwon.ac.kr, yeonjin@yonsei.ac.kr

Abstract:

Organometal halide perovskites are currently considered as potential candidates for the next generation of optoelectronic materials thanks to their prominent photonic absorption and emission properties and high carrier mobilities. In recent years, especially, the attention has been extended to Ruddlesden-Popper type halide perovskites (2D-RPs) which are 2-dimenstional perovskites in which each layer is separated by organic cations with van der Waals type interlayer interactions. 2D-RPs not only retain all of the excellent properties of their traditional 3D counterparts, but they also overcome weak thermal and atmospheric stabilities which have been problematic in 3D perovskites and therefore became prime strategic materials for designing (opto) electronic devices. However, the lack of fundamental understanding of their electronic structures is believed to be the missing link between the superior electronical/optical properties of 2D-RPs and industrial applications. Therefore, in this study, we present the electronic structures of $(PEA)_2PbI_4$ which is a prototypical 2D-RP as well as its charge transfer characteristics investigated via photoelectron spectroscopy. The $(PEA)_2PbI_4$ has been prepared in the forms of (i) thin films and (ii) single crystals and their results were compared with each other. Furthermore, we derived negatively charged $(PEA)_2PbI_4$ by surface doping of alkali metals and deeply examined the changes of photoemission features to reveal the charge transfer mechanism between $(PEA)_2PbI_4$ and its surroundings. These results would not only alleviate the shortage of fundamental understanding of 2D perovskites and but is also expected to boost up the performance of perovskite-based applications.

Keywords:

Perovskite , 2D, Photoelectron spectroscopy, Interface, Optoelectronics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.307

Correlation between crystal structure and electronic properties of $SrRuO_3/CaRuO_3$ superlattices

KIM Ki Seok [1], LEE Sang A *[1], HWANG Jae-Yeol *[1]
[1]Department of Physics, Pukyong National University
sangalee@gmail.com, jyhwang@pknu.ac.kr

Abstract:

Transition metal oxides thin films, strongly coupled charge, spin, lattice, and orbital degrees of freedom, give rise to various functionalities associated with their structural, electrical, magnetic, and chemical properties. In principle, tuning of physical properties is possible by inducing epitaxial strain and perturbing dimensionality. In ABO_3 perovskite materials, ruthenates ($ARuO_3$, A = Ca and Sr) with RuO_6 octahedral distortion, is widely used as an electrode for oxide electronics. They have the same orthorhombic structure with Pbnm space group (62) and representative pseudocubic lattice parameters. Interestingly, these materials have been known that physical properties can be changed depending on a degree of octahedral distortion.
In this study, we suggest that the electronic properties can be tailored by controlling the octahedral distortion in the artificial $SrRuO_3/CaRuO_3$ heterostructure. To verify this concept, $SrRuO_3/CaRuO_3$ superlattices films on $SrTiO_3$ (001) substrate were grown by pulsed laser deposition. The structure of superlattice was controlled by altering the stacking of $[(SrRuO_3)_n/(CaRuO_3)_m]$ (n or m is the number of unit cell layer) and were characterized by high-resolution 6-circle X-ray diffractometer. The electronic transport properties as a function of temperature for these superlattices were systematically analyzed with varying the periodicity of the superlattice. To confirm the correlation between transport properties and electronic structure, spectroscopic ellipsometry was also introduced to elucidate the electronic structures of the superlattices.

Keywords:

thin film, superlattice, SRO, CRO, electronic property

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.308

Wettability of Cu thin films depending on surface morphology and oxidation

NAM Kideuk [1], CHEON Miyeon [2], KIM Young-Hoon [3], OH Ju Hyun [1], PARK Sung Heum [1], KIM Young-Min [3], JEONG Se-Young [4], LEE Seunghun *[1]
[1]Department of Physics, Pukyong National University
[2]Crystal Bank Research Institute, Pusan National University
[3]Department of Energy Science, Sungkyunkwan University
[4]Department of Optics and Mechatronics Engineering, Pusan National University
seunghun@pknu.ac.kr

Abstract:

Wettability, which determines the interaction between a material surface and external particles, has technical importance for a myriad of applications, such as surface protective coatings, sensing, and drug delivery devices. Metals in general are known to hydrophilic because of their relatively high surface energy. However, several studies on the wettability of copper (Cu) have given different numbers of contact angles. In this study, we thus investigate the change in the wettability of Cu thin films depending on crystallinity, surface morphology, and surface oxidation. The Cu thin films were prepared through atomic epitaxy sputtering (AES), and contact angle measurements were employed for wettability analysis. Pristine Cu thin films show the contact angle close to hydrophilic but become hydrophobic as the surface oxidizes. The change of contact angles depending on the surface morphology can be explained by Wenzel model, based on effective surface areas. The conversion of the wettability of Cu thin films by UV irradiation suggests that the hydrophobicity of the Cu thin films is likely due to surface absorbed oxygen or surface oxidation. These results provide a physical understanding on the intrinsic wettability of Cu and suggest its high applicability for various fields.

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the MSIT (Grant Numbers. NRF-2020R1A4A4078780)

Keywords:

Copper, Surface wettability, Contact angle, Oxidation, Surface morphology

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.309

Beating effect in Aharonov-Bohm oscillations in topological insulator

SONG Jong Hyun *[1], KWON Du Hyuk [1,2], BAE Myung-Ho [2], DOH Yong-Joo [3]
[1]Chungnam National University
[2]Electromagnetic Standard Group, KRISS
[3]Department of Physics and Photon Science, GIST
songjonghyun@cnu.ac.kr

Abstract:

Topological insulator (TI) represents an unusual phase of quantum matters with an insulating bulk gap and gapless surface state, indicating that electrons can only transport along the surface of the material. For TI nanowires, the observation of the Aharonov–Bohm (AB) oscillation in magnetoconductance (MC) with axial magnetic fields at a cryogenic temperature has been used as an evidence of the topologically protected surface state. In this study, we observed beating patterns of the AB oscillations in Sb doped Bi_2Se_3 NWs. As the origin of the beating effect, we consider the spin-orbit effect occurring in the two-dimensional electron gas region existing at the surface of the nanowire.

Keywords:

Bi2Se3, Topological Insulator, Aharonov–Bohm oscillation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.310

Characterization of a GaAs/AlGaAs heterojunction-based single-electron-transistor as a charge sensor

GHEE Young-Seok [1], KIM Bum-Kyu [1], PARK Suk-In [2], SONG Jindong [2], KIM Wan-Seop [1], BAE Myung-Ho [1], KIM NAM *[1]
[1]KRISS
[2]Center for Electronic Materails, KIST
namkim@kriss.re.kr

Abstract:

We report the characterization of a charge sensor made of a single-electron-transistor (SET) that is capacitively coupled to a 2-dimensional (2D) electron node. The SET is designed to sense the node's charge population which is controlled by the electron tunneling rate of a quantum dot (QD) adjacent to the node. The sample device is fabricated using a 2D electron system of GaAs/AlGaAs heterojunction whose carrier density and mobility are estimated to be approximately 4×10^{11} cm^{-2} and 5×10^{4} $cm^{2}V^{-1}s^{-1}$, respectively. We confirmed the correlation between the SET signal and the electron tunneling rate from the QD to the node. The estimated charge sensitivity of the SET at optimum condition ranges between 3×10^{-3} $eHz^{-1/2}$ and 3×10^{-4} $eHz^{-1/2}$ at 10 Hz.

Keywords:

single electron transistor, single electron tunneling, quantum dot, charge sensor, electron counter

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.401

Ab initio study of electronic structure of metal monochalcogenides GaX and janus GaXY (X, Y = S, Se, Te)

HONG SukLyun *[1], KIM Junghwan [1]
[1]Sejong University
hong@sejong.ac.kr

Abstract:

Since the discovery of graphene, various two-dimensional (2D) materials have received a lot of attention from the scientific community because of their excellent atomic and electronic properties. Until now, 2D materials have shown outstanding potential for new devices based on their interesting electrical properties beyond conventional 3D materials. In recent years, a new concept of 'valleytronics' based on valley degree of freedom has been suggested in hexagonal 2D materials and a lot of 2D materials like transition metal dichalcogenides (TMDs) and janus TMDs have been proposed as candidates for spintronics and valleytronics. In this study, among various 2D materials, we focus on metal monochalcogenides (MMCs) and janus MMCs showing good physical and electrical properties for device applications. Specifically, we consider GaX and janus GaXY (X, Y = S, Se, Te) of which electronic structure are investigated for future spintronic and valleytronic device applications using density functional theory calculations. Details in electronic structure are studied using orbital projected band structure and Berry curvature.

Keywords:

two-dimensional materials, electronic structure, valley degree of freedom, density functional theory

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.402

High mobility two-dimensional electron gas in $PbZr_{0.5}Ti_{0.5}O_3/BaSnO_3$ heterostructure

HWANG Jaejin [1], BYUN Jinho [1], LEE Jaekwang [*1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

The two-dimensional electron gas (2DEG) formed at oxide heterointerface between $LaAlO_3$ and $SrTiO_3$ has been attracting fundamental and practical attention due to its novel quantum properties and interfacial conductivity. However, these 2DEGs reside in weakly dispersive Ti-d bands, and the mobility of 2DEG is relatively low at room temperature, which limit its future application. Here, in order to enhance 2DEG mobility, we consider a novel $BaSnO_3$ with highly dispersive conduction Sn-5s band. Using the first-principles calculations, we find that the n-type 2DEG can be formed at $PbZr_{0.5}Ti_{0.5}O_3/BaSnO_3$ heterostructure. Our results show that the 2DEG produced by polar field resides within the highly dispersive Sn-5s band and its mobility is expected to be several times higher than that in LAO/STO.

Keywords:

2DEG, PZT, BSO, heterostructure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.403

Circular dichroism in high-order harmonic generation: Heralding topological phases and transitions in Chern insulators

CHACON Alexis *[1,2,3], KIM Dasol [1,2], ZHU Wei [3], KELLY Shane Patrick[3,4], DAUPHIN Alexandre [5], PISANTY Emilio [5], MAXWELL Andrew S.[5,6], PICóN Antonio [5,7], CIAPPINA Marcelo F.[5,8], KIM Dong Eon [1,2], TICKNOR Christopher [3], SAXENA Avadh [3], LEWENSTEIN Maciej [5]

[1]MPC-AS, Max Planck Center for Attosecond Science
[2]Physics Department, POSTECH
[3]Center for Nonlinear Studies and Theoretical Division, Los Alamos National Laboratory
[4]Physics and Astronomy Department, University of California Riverside
[5]ICFO, The Barcelona Institute of Science and Technology
[6]Department of Physics & Astronomy, University College London
[7]Departamento de Quımica, Universidad Autonoma de Madrid
[8]Institute of Physics of the ASCR, ELI-Beamlines project
achacon@postech.ac.kr

Abstract:

Topological materials are of interest to both fundamental science and advanced technologies, because topological states are robust with respect to perturbations and dissipation. Experimental detection of topological invariants is thus in great demand, but it remains extremely challenging. Ultrafast laser-matter interactions, and in particular high-harmonic generation (HHG), meanwhile, were proposed several years ago as tools to explore the structural and dynamical properties of various matter targets. Here we show that the high-harmonic emission signal produced by a circularly-polarized laser contains signatures of the topological phase transition in the paradigmatic Haldane model. In addition to clear shifts of the overall emissivity and harmonic cutoff, the high-harmonic emission shows a unique circular dichroism, which exhibits clear changes in behavior at the topological phase boundary. Our findings pave the way to understand fundamental questions about the ultrafast electron-hole pair dynamics in topological materials via non-linear high-harmonic generation spectroscopy.

Keywords:

Chern insulator, Circular dichroism

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.404

First-principles studies of doped SnO_2 for photocatalytic applications

JIN Yeongrok [1], LEE Jaekwang *[1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

SnO_2 has been identified as one of the promising and suitable oxide-based photocatalytic semiconductors. However, the large bandgap limits its application in the visible region. Doping is an efficient way of optimizing the materials properties and improving the photocatalytic performance. Here, using the first-principles density functional theory calculations, we considered the substitutional and interstitial doping of SnO_2 with Fe and Cr atoms. We find that Fe atoms tend to occupy interstitial sites while Cr atoms prefer to occupy substitutional sites with the different amount of oxygen vacancies. Bandgap narrowing, O-K edge electron energy loss spectra due to the oxygen vacancy, and resulting enhanced photocatalytic behavior of visible light will be discussed and associated underlying mechanism will be introduced along with scanning transmitted electron microscopy measurements.

Keywords:

Tin oxide, TM doping, photocatalyst, xanes simulation, formation energy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.406

Interface engineered TER optimization in HfO_2-based FTJ

LEE Jaekwang *[1], BYUN Jinho [1], LEE Joonbong [2], CHOI Taekjib [2]
[1]Department of Physics, Pusan National University
[2]Hybrid Materials Research Center and Department of Nanotechnology and Advanced Materials Engineering, Sejong University
jaekwangl@pusan.ac.kr

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 ultrathin oxides-based ferroelectric tunneling junctions (FTJs) useful for the next generation switchable diode. Among various ferroelectric oxides, HfO_2 is the most promising material for FTJ devices since it has the great advantage of complementary metal-oxide-semiconductor (CMOS) process compatibility. Here, using the numerical tunneling current simulations, we propose that the tunneling electroresistance (TER) can be maximized by inserting dielectric layer at one of the interfaces in a FTJ, which will be an essential guideline to design HfO_2-based FTJ devices.

Keywords:

Ferroelectricity, HfO2, FTJ

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.407

Strain induced topological phase transition of Si_2Bi_2 : First-Principles Study

JEONG Dameul [1], YOO Seungwoo [1], JEON Junyeop [1], LEE Seungjun [1], KWON Young-Kyun *[1]
[1]Department of Physics, Kyung Hee University
ykkwon@khu.ac.kr

Abstract:

Si_2Bi_2, which is a van der Waals layered material, possesses several unique symmetry-dependent characteristics. Its in-plane C_3 rotational symmetry together with the inversion and time-reversal symmetries determines its special symmetry-induced properties. It was, interestingly, found that there are Dirac cones near the Fermi level in the electronic band structure of Si_2Bi_2. We found that Si_2Bi_2 experiences a phase transition from its metallic to topological insulating phases, which is induced by small in-plane compressive strain, either uniaxial or biaxial. Especially, the compressive strain along the zigzag direction induces band structure evolution which discloses band inversion occurred. Using hybrid Wannier charge center calculation, we confirmed that this material becomes a topological insulator. To figure out how to control in-plane strain to realize the topologically different phases of Si_2Bi_2, its topological phase diagram was constructed in the parameter space of the in-plane strain fields.

Keywords:

Layered materials, Density functional theory, Electronic structures, Topological phase transition, In-plane strain

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.408

First-principles studies of Novel 2D Intrinsic Ferromagnetic Materials with High Curie Temperature

KANG Mingi [1], JIN Yeongrok [1], LEE Jaekwang [*1]
[1]Department of Physics, Pusan National University
jaekwangl@pusan.ac.kr

Abstract:

Low-dimensional ferromagnetic semiconductors have attracted significant interest due to their technological importance and promising applications for the information storage, communication, sensors and spintronics. However, the basic mechanism of robust ferromagnetic couplings that can survive at high temperature has rarely been investigated. Here, by combining first-principles density functional theory calculations and Monte Carlo simulation of anisotropic Heisenberg models, we found that CrSeX (X=Cl, Br, I) monolayers are thermally stable and have high Curie temperature. In order to uncover the origin of the strong ferromagnetic coupling in low-dimensional CrSeX (X=Cl, Br, I) monolayers, spin-orbit coupling, magnetic anisotropy and ferromagnetic exchange couplings will be discussed in detail.

Keywords:

2D Intrinsic ferromagnetic material, High curie temperature, Density functional theory calculation, Monte Carlo simulation

P1-co.409

A Simulation Web Platform for Analyzing Electronic Structures of Semiconductors

KIM Sowon [1,2], KEMBAY Assel [1], LEE Jungho [3], JANG Semi [3], KIM Seungchul [*1]
[1]Computational Science Research Center, KIST
[2]Department of Chemistry, Hanyang University
[3]., Virtual Lab. Inc.
sckim@kist.re.kr

Abstract:

DFT(Density Functional Therory)는 inorganic이나 semiconductor의 특징을 연구하는데 사용하는 가장 대중적인 전산모사 이론으로서 물질의 매우 다양한 특징을 잘 예측할 수 있게 한다. 하지만, 이론적 지식이나 프로그램 활용 능력과 같은 연구자 개인에게 필요한 소양과 더불어 고성능 전산장비를 갖추어야 하는 등 폭넓고 쉽게 사용하기에는 여전히 제약이 크다. 이런 제약을 극복하기 위한 방법으로 전산모사 웹플랩폼을 개발했다. 이 플랫폼은 SIESTA 프로그램과 GGA를 활용해 여러 가지 전형적인 DFT 계산과 데이터 분석 기능을 제공한다. 원자구조 모델링과 데이터 가시화 프로그램을 포함해 정형화된 DFT 계산에 필요한 모든 기능을 갖추고 있어, 원자구조 최적화에서 부터 전자구조 분석까지 모든 과정을 웹플랫폼 안에서 실행할 수 있다. 사용자 환경이 단순하고 직관적이어서 사용법을 매우 쉽게 익힐 수 있다. 본 발표에서는 이 Web Platform의 시스템 구조와 활용 방법, 그리고 실제 전자구조 모델링 사례들을 소개하고 앞으로의 발전 방향에 대해 논의하고자 한다.

Keywords:

Web Platform, DFT, SIESTA, Electronic Structure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.501

Correlation between in situ structural and electrical characterization of the Metal-Insulator Transition (MIT) of VO2/C-Al2O3 thin films during thermal cycling

KANG Hyon Chol *[1], OH Ho Jun [2], HA Sung Soo [2], KWON Oh Young [2], CHOI Suk June [2], YUN Young Min [2], KANG Sae Hyun [2], LEE Su Yong [3]
[1]Department of Materials Science and Engineering, Chosun University
[2]1Department of Physics and Photon Science (DPH), GIST
[3]9C beamline, Pohang Accelerator Laboratory
kanghc@chosun.ac.kr

Abstract:

One of the strong correlation materials, VO2, is a material that exhibits MIT at a low temperature (Tc = 68C) near room temperature, and is widely used as a model system for experiments to investigate the mechanism of MIT.

Anderson localization (disorder) or Mott localization (e-e interaction) was proposed as the main mechanism of MIT, and theoretical and experimental discussions related to this have been discussed, but it is still not clear.

To find out the correlation between these two effects, we measured the R-T curve & the diffraction signal using X-rays of several microns of the epitaxial thin film sample grown on the C-plane sapphire, simultaneously.

As a result, when heat is applied, we directly compared the relationship between the electrical properties (resistivity-macroscopic property) and Monoclinic-phase(M1) & Rutile-phase(R) portion (lattice variation-microscopic-property) at same temperature.

Ultimately, what I would like to derive through this research is which parameter contributes more to the 1st-order transition that changes rapidly through the electrical & structural correlation simultaneously measured when two phases (M1&R) coexist.

Keywords:

Vanadium dioxide, 3D-Reciprocal space mapping, In-situ heating combined X-ray diffraction (XRD) & R-T curve

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.502

네마틱 액정을 이용한 Carbon Fiber의 양방향 제어에 관한 연구

이준용[1], 유정선[2], 김종현*[1]
[1]Physics, Chungnam National University
[2]Institute of Quantum Systems, Chungnam National University
jxk97@cnu.ac.kr

Abstract:

네마틱 액정 내에 분산된 콜로이드 입자는 탄성 자유 에너지를 최소화하는 방향으로 정렬한다. 이러한 네마틱 콜로이드계에 전기장을 인가하여 액정 방향자를 재정렬시킬 수 있다. 결과적으로 콜로이드 입자는 전기 자유 에너지와 탄성 자유 에너지의 합을 최소화하는 방향으로 재정렬하게 된다. 이 때, 샘플의 대칭성을 깨뜨려 탄성 자유 에너지와 전기 자유에너지가 입자의 회전에 기여하는 방향이 다른 경우 전기장을 인가하는 방식을 달리하여 입자가 회전하는 방향을 조절할 수 있음을 확인했다. 인가하는 전기장의 세기를 점차적으로 증가시킬 경우 입자는 액정 방향자가 회전하는 방향을 따라서 회전한다. 반면, 처음부터 충분히 강한 전기장을 인가할 경우 입자는 앞의 경우와 반대 방향으로 회전한다. 본 발표에서는 실험에 사용된 샘플의 구조와 이론적 해석에 대해 자세하고 구체적으로 설명한다.

Keywords:

네마틱 액정, 액정 콜로이드, 대칭성 깨짐

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.503

Near-ultraviolet light induced red emission in Sm^{3+}-activated $NaYb(MoO_4)_2$ phosphors for solid-state illumination

ZHANG Anqi [1], CHOI Byung Chun [1], PARK Sung Heum [*1], JEONG Jung Hyun [1]
[1]Department of Physics, Pukyong National University
spark@pknu.ac.kr

Abstract:

Using solid-state reaction technique, the Sm^{3+}-activated $NaYb(MoO_4)_2$ phosphors were developed. Under 409 nm excitation, bright reddish-orange emissions arising from the $^4G_{5/2} \rightarrow (^6H_{5/2}, {}^6H_{7/2}, {}^6H_{9/2}$ and $^6H_{11/2})$ transitions were gained in these resultant compounds. The most intense luminescence intensity was gained at the dopant concentration of 5 mol% and the dipole-dipole interaction mechanism dominated the concentration quenching process in the $NaYb(MoO_4)_2{:}Sm^{3+}$ phosphors. The temperature dependent luminescent results indicated that the prepared phosphors exhibited excellent thermal stability.Moreover, the effect of temperature on the emission intensity ratio of thermally coupled states has also studied. These properties demonstrated that the Sm^{3+}-activated $NaYb(MoO_4)_2$ phosphors were promising red-emitting materials for solid-state illumination and temperature sensors.

Keywords:

Phosphors, Down-conversion, Red emission, Solid-state illumination

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.504

In-situ intramolecular synthesis of tubular carbon nitride S-scheme homojunctions with exceptional in-plane exciton splitting and mechanism insight

LIU Fengwu [1], KIM Junghwan [2], PARK Sung Heum *[1]
[1]Department of Physics, Pukyong National University
[2]Department of materials system engineering, Pukyong National University
spark@pknu.ac.kr

Abstract:

Constructing tubular graphitic carbon nitride homojunctions is an attractive endeavor to accelerate the dissociation of its Frenkel excitons and charge transfer dynamics, but the realization of this strategy remains a major challenge. Herein, carbon nitride homojunction with open tubular interior, porosity and interconnected feature has been developed via one-step pyrolyzing urea and L-cysteine. The experimental results and DFT calculations indicate that such unique tubular S-scheme homojunctions not only apparently boost in-plane exciton dissolution and suppress the inversive charge recombination via built-in electric field, but also decrease Gibbs free energy of intermediate hydrogen absorption. Thus, the tubular carbon nitride homojunctions display an excellent hydrogen production (4548.4 μmol/g/h), which is 35-fold improvement than that of pristine carbon nitride, outperforming the most reported donor-acceptor-based carbon nitride homojunctions and tubular carbon nitride. This work provides useful guidance to rational fabrication of S-scheme carbon nitride homojunction with positive exciton splitting and interfacial charge transfer for energy and environmental applications.

Keywords:

carbon nitride, exciton splitting

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.505

Electrocatalytic properties of polymorphic $BaRuO_3$ epitaxial thin films

LI Ying [1], KIM Ki Seok [1], EOM Tae Hwa [1], LEE Sang A [*1], HWANG Jae-Yeol [*1]
[1]Department of Physics, Pukyong National University
sangalee@gmail.com, jyhwang@pknu.ac.kr

Abstract:

The applications of hydrogen energy are received into spotlight as a global challenge for the development of renewable energy. Hydrogen evolution reaction (HER) by electrocatalysis is an important reaction, but efficient generation of hydrogen is quite problematic. Therefore, HER catalysts with high activity, stability, and low cost are essential for various energy applications.
It has been known that $BaRuO_3$ (BRO) has four different polymorphic crystal phases, including nine-layered rhombohedral (9R), six-layered hexagonal (6H), four-layered hexagonal (4H), and three-layered cubic (3C).   In this study, we prepared epitaxial thin films of 9R-BRO and 3C-BRO by pulsed laser deposition. The structural properties of 9R- and 3C-BRO thin film were characterized by X-ray diffraction. The electrocatalytic properties of epitaxial BRO thin films based on crystal structures were analyzed.

Keywords:

BaRuO3, Hydrogen evolution reaction (HER), electrocatalysis, thin film

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.506

Calculation of the depth information of grains in poly-chromatic X-ray micro-diffraction of poly-crystals using two metal absorption filters

CHUNG Jin Seok *[1], WI Sang Won [1]
[1]Dept. of Physics, Soongsil University
chungj@ssu.ac.kr

Abstract:

In X-ray micro-diffraction measurement, which uses micron-size focused X-ray beam for diffraction, adjusting diffraction angles are not an easy task due to the inaccuracies in the position of the rotation axis. One way of avoiding this problem is using Laue diffraction method, which uses poly-chromatic X-ray beam and do not need to rotate the specimen.

Since the Laue X-ray diffraction method uses poly-chromatic X-rays, there are many peaks with the higher order peaks overlapped in a single peak in Laue images. For example, (111), (222), (333) peaks will overlap in a single peak. The X-rays energies of overlapped peaks are

$$\frac{2d}{n}\sin(\theta_{fixed}) = \frac{\lambda}{n} \ (n = 1, 2, 3 \cdots)$$

In the case of a poly-crystalline specimen, the energy weight of the diffraction peaks varies according to the depth of the grain. In deep grains, low-energy X-rays will be absorbed more than high-energy X-ray while X-ray penetrates to the grain. Therefore, by measuring the weight of the high and the low energy diffraction peaks in Laue peaks, it is possible to estimate the depth of the corresponding grain.

To estimate the energy weights of the diffraction peaks from each grain, two absorption calibrated metal filters were used, one(Al) without an absorption edge and the another(Zr) with a k-edge absorption in the 5~25keV range, which is the energy range of polychromatic X-ray micro-diffraction. The intensity differences with two filters will give the weight of the higher order peaks, from which the depth of the grain can be estimated. The depth resolution and the limitations of this technique will be discussed.

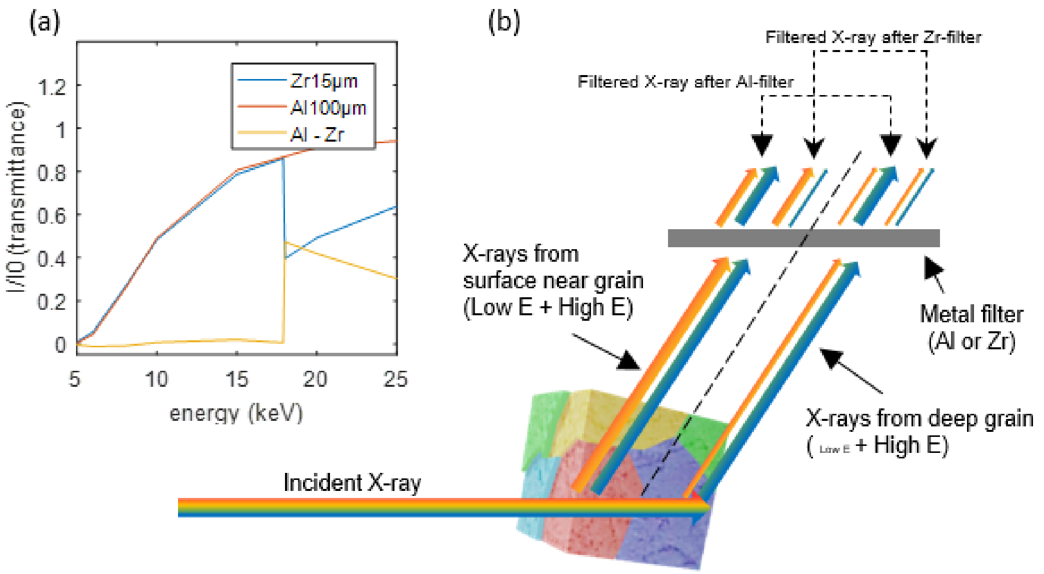

Figure 1 (a) Transmittance of X-ray intensity by Zr 15μm filter (blue), Al 100μm filter (red) and difference between Al and Zr filters (yellow) in range of 5keV~25keV. (b) The schematic of filtering of X-rays which are from surface near grain and deep grain.

Keywords:

X-ray diffraction, X-ray micro diffraction, Laue method, XMD, Poly-crystals

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-co.507

Laser induced ultrafast structural evolution of bismuth selenide

SUNGWON Kim [1], YOUNGSAM Kim [2], KIM Jaeseung [1], CHOI Sungwook [1], YUN Kyuseok [1], KIM Dongjin [1], LIM Soo Yeon [1], KIM Sunan [3], CHUM Sae Hwan [3], PARK Jaeku [3], EOM Intae [3], KIM Kyung Sook [3], KOO Tae-Yeong [3], OU Yunbo [4], KATMIS Ferhat [4], CHEONG Hyonsik [1], SIM Eunji [2], MOODERA Jagadeesh [4], KIM Hyunjung [*1]

[1]Physics, Sogang University
[2]Chemistry, Yonsei University
[3]XSS, Pohang Accelerator Laboratory
[4]Francis Bitter Magnet Laboratory, MIT
hkim@sogang.ac.kr

Abstract:

As a 3D topological insulator and 2D van der Waals material, bismuth selenide has a great potential to be applied to the quantum computing devices and novel electronics due to its peculiar nature of spin-polarized surface states. In addition, the way of controlling this surface unique states and surface photocurrent by inducing polarized photons paving a feasibility to the tunable opto-spintronics has been reported. In that sense, it becomes nessecary to understand light-lattice structural interaction containing the strain evolution in ultrafast time scale, since it generates instant and/or permanent degeneration of the diveices. In order to determining the effect of structural change, time resolved ultrafast x-ray diffraction by using x-ray free electron lasers is a effective measure in terms of direct observation of the lattice dynamics. Here, we report that the ultrafast photon induced lattice dynamics of Bi_2Se_3 thin films involving the mutual interactions of in-plane and out-of-plane strain components in sub picosecond time scale. At the beginning, Bi_2Se_3 shows carricer concentration sensitive conctraction. The dynamics turns into lattice vibrational modes containing breatihing (out-of-plane) and shear (in-plane) modes as time elapsed to hunderds of picoseconds. The lattice contraction is analyzed by using density functional theor and Lifshitz model. Our result further suggests that the study of strain-carrier density interaction and applications for strain band modulations.

This research was supported by the National Research Foundation of Korea (Nos. NRF-2015R1A5A100996 and NRF-2019R1A6B2A02100883).

Keywords:

Topological phase, XFEL, Ultrafast , time-resolved X-ray diffraction, Structural dynamics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.001

Proton decay of ^{23}Mg

KIM Chanhee *[1], CHAE Kyungyuk [1], CHA Soomi [1], KIM Minju [1], KWAG Minsik [1]
[1]Physics Department, Sungkyunkwan University
kch97123@nuclearemail.org

Abstract:

The 31-MeV proton beams have been delivered from the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL). Excited states in 23Mg were populated through the 24Mg(p,d)23Mg nucleon transfer reactions. By analyzing recoiling deuteron spectra, the excited states of 23Mg could be identified. By requiring coincidences between the reaction deuterons and the decay protons, proton decays of the excited 23Mg were studied. This research covers the energy levels of 23Mg ranging from 8.044 to 9.642 MeV decaying to several 22Na levels up to the 7th excited state, which is a wide range compared to the previous research. Branching ratios of all the transitions were obtained. The technique employed in this study is found to be a useful analysis in addition to a transfer reaction study.

Keywords:

proton decay, branching ratio, 23Mg, transfer reaction

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.002

Dependence on annealing temperature of lifetimes in zircon

HONG Duk Geun *[1], LEE Su Hyeong [1], LEE Seung Woo [1]
[1]Department of Physics, Kangwon National University
dghong@kangwon.ac.kr

Abstract:

Time-resolved optically stimulated luminescence (TR-OSL) sensitivity and lifetimes on the various thermal treatment for natural zircon from Brazil were investigated. Analyses of the TR-OSL spectra have showed that the decay is composed of two exponential components with lifetimes depending on the sample treatments. This change of the lifetimes is discussed in terms of a model previously used to explain thermal sensitization. The luminescence lifetime data are best explained by the presence of two luminescence centers, depending on the thermal history.

Keywords:

Zircon, TR-OSL, Lifetime, Annealing temperature

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.003

Design study of quasi-mono energetic neutron source based on ^{9}Be(p,n) reaction using the GEANT4

KIM Gui Nyun *[1], LEE Chang Hui [1]
[1]Department of Physics, Kyungpook National University
gnkim@knu.ac.kr

Abstract:

A quasi-mono energetic neutron source based on the ^{9}Be(p,n) reaction was developed for activation experiment. We present the simulation results of quasi-mono energetic neutron flux of various thickness for Be/C target with 25 ~ 45 MeV proton energies using GEANT4. Neutron target assembly was designed and optimized to produce a quasi-mono energetic neutron field for 25 ~ 45 MeV proton beam. Each result was compared with the results obtained before with MCNP simulation

Keywords:

GEANT4

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.004

Luminescence Study of Eu^{2+} -doped Li_2O-$GdBr_3$-Al_2O_3-$CaCO_3$-P_2O_5 Glasses

SAHA Sudipta [1], KIM Hong Joo *[1], NTARISA Amos [1], QUANG Nguyen Duy[1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

For radiation detection purposes glass samples are becoming very much popular to researchers due to their easy and convenient method of fabrication. Among all rare-earths, Eu_2O_3 has become the most common dopant to study the 4f-4f transition luminescence characteristics for the development of red light-emitting devices. However, Eu^{2+} is also a good candidate for a similar study that exhibits 4f-5d transition emitting broad spectrum with a short lifetime. Due to such emission phenomenon, EuX_2 (X= Cl, Br, I) were doped in the glass network as $30Li_2O$-$7GdBr_3$-$10CaCO_3$-$5Al_2O_3$-$47.5P_2O_5$-$0.5EuX_2$. The glasses were fabricated using the conventional melt quenching technique whereas the melting temperature was 1300 °C and hot melts were quenched using a preheated graphite block. Then the prepared glasses were annealed at 450 °C in an air atmosphere to remove the thermal stress. The prepared glasses were cut and polished optically for luminescence measurements. The luminescence of the sample glasses was tested with X-ray and UV-Vis excitations at room temperature. The lifetimes of emitted photons were also measured with photo excitation sources. The glasses are showing a broad emission from 350 to 550 nm indicating the 5d-4f transitions of Eu^{2+} ions. At the same time, the glasses are showing narrow emission peaks at 591, 612, 652, and 700 nm which indicate 4f-4f transitions of Eu^{3+} ions inside the glass matrix. The energy transfer from Gd^{3+} ions to Eu^{2+} and Eu^{3+} ions are also suspected here which will be verified from the luminescence and decay time measurements under various UV-Vis excitations.

Keywords:

Glass, Luminescence, Eu2+ emission, Decay time, 4f-5d transition

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.005

Internet of things upgrade and characterization of Raspberry Pi pulse counter board

JEONG Dongwoo [1], KIM Hong Joo *[1], PARK Hyeoungwoo [1], KHAN Arshad [1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

The characteristics of the pulse counter board module were investigated by communicating through a Raspberry Pi computer. Using a pulse generator, the dynamic range of frequency, pulse height, pulse width and the voltage value of each threshold were measured. An Internet of Things (IoT) was installed on the Raspberry Pi with a pulse counter board module to make a web counter board controlled based on the web. The web counter board has web and database servers, respectively. Users can communicate with web servers to control the counter board, such as modifying variables and running the counter board. The recorded data is classified and stored for analysis on the database server, along with information like threshold and polarity. The stored data is printed on the web in the graphical form. Due to the advantages of all processes being controllable on the web, easy installation, and small size, the web counter board will be able to replace existing counters for practical applications.

Keywords:

IoT, pulse counter, Raspberry Pi

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.006

Luminescence and scintillation properties on self-reduction of Yb^{3+} to Yb^{2+} in $LaCl_3$ crystal

WANTANA Nuanthip [1,2], VUONG Phan Quoc[3], QUANG Nguyen Duy [3], LUAN Nguyen Thanh[3], KAEWKHAO Jakrapong [1,2], KIM Hong Joo *[3]
[1]Physics Program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand
[2]Center of Excellence in Glass Technology and Materials Science (CEGM, Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand
[3]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

The luminescence and scintillation properties of $LaCl_3$:Yb^{2+} crystal have been investigated. This crystal was grown by the vertical Bridgman method. The self-reduction of Yb^{3+} to Yb^{2+} in the air is the first observed in $LaCl_3$ crystal, which shows broadband luminescence. The strongest emission around 441/446 nm of Yb^{2+} (5d – 4f) in the photoluminescence and X-ray induced luminescence spectrum. The energy resolution of ~7.08% and light output of ~31,000 photons/MeV were obtained for $LaCl_3$:Yb^{2+} crystal under 662 keV γ-rays excitation. The scintillation decay profile was measured under the excitation of α-particles and γ-rays from ^{241}Am and ^{137}Cs sources, respectively. This result indicates that it is useful to Yb^{2+} as a luminescence center in high light yield scintillation.

Keywords:

LaCl3:Yb2+,, Luminescence, Decay time, Light yield, Energy resolution

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.008

Study of nuclear structure lying in the transition path between dynamic symmetries

LEE Su-youn *1, LEE Young-jun 1
1Division of Basic Sciences, Dong-Eui University
syyi@deu.ac.kr

Abstract:

Most nuclei with collective structures have mixed properties instead of only one symmetry among them. The nuclear structure with symmetry breakings have been described using more than one symmetry or explained by phase transitions between the dynamical symmetries. The critical point symmetries, E(5) and X(5), have been recently proposed to describe nuclei at the points of phase transitions between different dynamical symmetries. The critical point symmetries are based on the special solutions of the Bohr Hamiltonian with potentials of the special form instead of the algebraic descriptions of three limits of the IBM. The E(5) critical point symmetry corresponds to the phase transition between U(5) and O(6) while the X(5) critical point symmetry describes the transition between U(5) and SU(3) nuclei. We have studied the collective properties of even-even nuclei based on the U(5) [SU(3)] limit of the IBM and the E(5) [X(5)] critical point symmetry. The present study also described the structure of the nucleus lying between these symmetries.

Keywords:

IBM, dynamical symmetry, critical symmetry

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.009

Measurement of Relative Cross Section of $^{nat}W(p,xn)^{176}Re$ and $^{nat}W(p,xn)^{180}Re$ Reaction by 100-MeV Proton Accelerator

LEE Samyol *[1], YOON Jungran [2]
[1]Department of Radiological Science, Dongseo University
[2]Department of New Material Physics, Dong-A University
samuel@gdsu.dongseo.ac.kr

Abstract:

The Relative Cross Section of of natW(p,xn)176Re and natW(p,xn)180Re Reaction were measured from $^{nat}W(p,xn)$ nuclear reaction with the high-intensity 100-MeV proton linac facility (the Korea Multi-Purpose Accelerator Complex, KOMAC). The gamma-rays from the isotopes of 176Re and 180Re were measured by the gamma-ray spectroscopy system with HPGe detector.
In the present study, we observed that $^{nat}W(p,xn)^{176,\ 180}Re$ nuclear reactions were generated between the tungsten target and the high energy proton beam. The gamma-rays of 240.2 and 902.8 keV from ^{176}Re and the ^{180}Re were measured successfully. The relative cross-section of $^{natW}(p,xn)^{176}Re$ and $^{natW}(p,xn)^{180}Re$ Reaction were measured.
Acknowledgment
This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2020R1F1A1076149).

Keywords:

Proton induced , HPGe detector, natW(p,xn), delayed gamma-ray, 100-MeV proton beam

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.010

Dirac analyses of proton scatterings from Sn isotopes

SHIM Sugie *[1], LIM Hoseong [1]
[1]Kongju National University
shim@kongju.ac.kr

Abstract:

Relativistic Dirac phenomenological analyses are performed using an optical potential model and the first-order collective model for 800-MeV polarized proton inelastic scatterings from Sn isotopes, ^{116}Sn and ^{124}Sn. Lorentz covariant scalar and vector optical potential parameters using the Woods-Saxon geometry and the deformation parameters are determined phenomenologically to reproduce the experimental data by solving the Dirac coupled channel equations using a computer program and the results obtained in the Dirac phenomenological calculations are compared with those obtained in the non-relativistic calculations. The Dirac equation is reduced to a Schroedinger-like second-order differential equation to obtain the effective central and spin-orbit optical potentials and the effective potentials are analyzed considering the mass dependence. The first-oder rotational collective model is used to describe the low-lying excited states that belong to the ground state rotational band at the axially-symmetric nuclei, Sn isotopes, and the optical potential parameters and the deformation parameters obtained by using Dirac phenomenological calculations are analyzed by considering the mass dependence.
Also, 800-MeV unpolarized proton inelastic scatterings from ^{120}Sn are analyzed using an optical potential model and the first-order collective model in relativistic Dirac coupled channel calculations. The channel coupling effects between the excited states that belong to the ground state rotational band are investigated and the deformation parameters for the several lowest-lying excited state obtained using Dirac approaches are analyzed and compared with those calculated by using non-relativistic approaches.

Keywords:

Dirac phenomenology, optical model, collective model, proton scattering

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.011

Calculation using Monte Carlo simulations of the beam quality correction factor k_Q for relative positions of SOBP and ionization chamber

권용철[1,2], JO Hyon-Suk *[1], 이세병*[2], 신욱근[3]
[1]Department of Physics, Kyungpook National University
[2]Proton Therapy Center, National Cancer Center
[3]Radiation Oncology, Seoul National University Hospital
hyonsuk.jo@gmail.com, sebyeong@gmail.com

Abstract:

In proton radiotherapy, the k_Q factor corrects for the difference in physical properties between the reference beam quality, ^{60}Co gamma radiation (used for ionization chamber calibration), and the user beam quality used for patient treatment. The current calculation method of the k_Q factor according to the dosimetry protocol is based on the center of the SOBP (Spread Out Bragg Peak) of the proton beam. The absorbed dose is calculated by applying the k_Q factor calculated at the center of the SOBP equally to all depths of the proton beam. This study aims to check the validity of this calculation method using Monte Carlo simulations by performing TOPAS simulations of the beam nozzle of the National Cancer Center and a proton beam with a 15-cm range and a 15-cm modulation range. The k_Q factor was calculated by simulating the dose absorbed by water and the measured value of the ionization chamber, and compared at the reference depth of 7.5 g/cm^2 proposed by TRS-398 and the depths of 4 g/cm^2 and 13 g/cm^2. The calculated value of the beam quality correction factor at the reference depth is 1.045, which is within the error range of the reference value of TRS-398. Also, the calculated values at 4 g/cm^2 and 13 g/cm^2 are 1.041 and 1.048, respectively. While the calculated values are all within the error range of the reference value suggested by TRS-398, we plan to perform additional calculations for more precise results.

Keywords:

Proton therapy, Monte Carlo simulations, kQ factor

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.012

6인치 웨이퍼 양성자빔 조사를 위한 로드락 챔버시스템 개발

KIM Kye-Ryung *[1], JUNG Won-Hyeok [1], KWON Hyeok-Jung [1], CHO Yong-Sub [1]
[1]Korea Multi-purpose Accelerator Complex, KAERI
kimkr@kaeri.re.kr

Abstract:

고속스위칭 소자로 주로 이용되는 실리콘 전력반도체 제조 공정을 위해 0.5~1 MeV 범위의 에너지를 가지는 양성자빔의 균일조사가 요구되는데 이를 위해 1 MV 정전형 가속기 후단에 6인치 웨이퍼 균일 조사 시스템을 개발하고 설치하였다. 이 때 전력반도체 조사 기술의 산업적 활용을 고려하여 조사 시간을 제외한 웨이퍼의 로딩 시간과 진공 배기에 소요되는 시간을 최소화하여야 하는데 이를 위해 6인치 웨이퍼용 로드락 챔버 시스템을 개발하였다.
로드락 챔버 시스템은 게이트밸브, 진공게이지, 진공펌프, 웨이퍼 홀더, 리크 밸브 등으로 구성되며 웨이퍼를 로딩 후 조사위치로 보낼 수 있는 선형 이송장치를 추가하여 제작하였다. 기존의 조사 챔버 상부에 플랜지 형태로 제작하여 추가함으로써 빔 조사 시 시료 교체에 소요되는 시간을 1/5 이하로 감소시킬 수 있었다. 로드락 챔버 시스템 이외에도 기존의 챔버 내부에 로드락 챔버에서 주어지는 웨이퍼 위치와 간섭이 없이 조사 균일도와 조사량을 측정할 수 있는 빔 전류 측정시스템을 추가함으로써 6인치 실리콘 웨이퍼에 대한 효율적인 양성자빔 조사가 가능해지도록 하였다.
이번 발표에서는 1 MV 정전형가속기 기반의 6인치 웨이퍼 양성자빔 조사 시스템 중 시료 교체 시간을 단축하기 위해 제작된 로드락챔버 시스템을 위주로 소개하고 설치 후 동작과 조사 시험 결과까지 함께 발표하고자 한다.

Keywords:

1 MV 정전형가속기, 전력반도체, 양성자빔 조사, 로드락 챔버, 6인치 웨이퍼

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.013

Development of EPICS-IOC for measuring magnetic field of pre-mass separator

MOON Jun Young *1, LEE SuYeong [1,2], YIM HeeGoong [1], KIM JaeHong [1], SHIN Taeksu [1], LEE JinHo [1], LEE DongHoon [2]
[1]Rare isotope science project, Institute for basic science
[2] Electrical and Electronic Communication Engineering, Tongmyong University
jymoon70@gmail.com

Abstract:

In ISOL system, a variety of RI beams can be produced via the proton-induced fission reactions created by impinging a high-intense 70-MeV proton beam on a thick uranium target. The gaseous fission products are thermally diffused, ionized, and accelerated by the TIS (Target Ion Source) system. The produced RI beams are transported to the accelerator systems through electrostatic beamline components. To select the specific ions of interest among them, on the beamline, two magnetic separators - pre-mass separator and A/Q (mass-to-charge ratio) separator, are installed. By adjusting their magnetic fields and employing a slit system, the specific ions of interest can be selectively transmitted to the experimental devices. The separators are controlled by the EPICS, following the policy on which the RAON control system is based. The IOCs (input-output controllers) allow us to control the current of magnets through power supplies, read magnetic fields measured by the hall probe from the remote place, and simultaneously store the data in an archive server. We have investigated the important features-stability and linearity of B-fields which two separators can produce. The stability has been observed for three hours, while the linearity up to 180 amperes. We found a good "linearity", showing agreement with that in the FAT (Factory Acceptance Test)-In this presentation, the results obtained will be discussed.

Keywords:

ISOL, EPICS, A/Q separator, Pre_mess separetor, RAON

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.014

Encapsulation and Characterization of a 1.5-inch EJ-276 Plastic Scintillator for Neutron Detection

NGUYEN Duy Quang [1], KIM Hong Joo *[1], NTARISA Amos Vincent[1], KIM Jae Hyeok [1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

Plastic scintillators capable of neutron-gamma pulse shape discrimination (PSD) have been increasingly attracted in recent years due to its practical advantages such as robustness, non-toxicity and non-flammability. In this study, we report an excellent PSD performance of a newly produced plastic scintillator EJ-276 at low energy region. A 1.5-inch cylindrical sample have been encapsulated in an aluminum housing and used to measure the PSD characteristics. Monte-Carlo simulation data of different gamma sources was compared to the experimental data to obtain energy calibration parameters. Our measurement shows that the low energy limit is down to 30 KeV for the 1.27 level of PSD figure of merit, corresponding to 3σ neutron-gamma peak separation.

Keywords:

EJ-276 plastic scintillator, pulse shape discrimination, neutron detection, energy calibration

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.015

Fabrication and study of Ce^{3+} doped phosphate glass for alpha and gamma detection

NTARISA Amos Vincent[1], KIM Hong Joo *[1], SAHA Sudipta [1], ARYAL Pabitra [2], KHAN Arshad [1], QUANG Nguyen Duy [1], PANDEY Indra Raj [2], KAEWKHAO Jakrapong [3], KOTHAN Suchart [4]
[1]Department of Physics, Kyungpook National University
[2]Center for Underground Physics, CCES (IBS)
[3]Center of Excellence in Glass Technology and Materials Science, Nakhon Pathom Rajabhat University
[4]Center of Radiation Research and Medical Imaging, Department of Radiologic Technology, Faculty of Associated Medical Sciences, Chiang Mai University
hongjoo@knu.ac.kr

Abstract:

A glass samples were fabricated following the composition of (65-x)P_2O_5:20Li_2CO_3:10$GdBr_3$:5Al_2O_3:x$CeBr_3$ (where, x = 0.5, 1, 2, 3, 4). The amorphous structure of the prepared samples was verified using powder XRD measurements. The emission spectra of these glass samples were obtained from X-ray and UV-Vis excitation sources. Characteristics Ce^{3+} UV-Vis excitation-emission was observed from 300 mm to 450 mm peaking at 350 mm. The peaks position is shifting to the longer wavelength due to the change in O to P ratio. The decay time was measured under UV, ^{241}Am and ^{137}Cs excitation sources. The fastest decay time was found to be 27 μs. The scintillation property was studied with ^{241}Am and clear alpha peak was observed.

Keywords:

Phosphate Glass; CeBr3; Luminescence; Scintillation; Decay time

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-nu.016

Study the gamma and alpha pulse shape discrimination of intrinsic $Cs_3Cu_2I_5$ and $Cs_3Cu_2I_5$:Ag scintillation crystals

NGUYEN Luan Thanh[1], KIM Hong Joo *[1,2]
[1]Department of Physics, Kyungpook National University
[2]The Center for High Energy Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

A $Cs_3Cu_2I_5$ halide scintillation crystal has been attracted attention in the recent years due to its advantages. This crystal shows the air-stability, high light yield, and emitting blue light under X-ray and gamma-ray excitation which well matches with the quantum efficiency of the photomultiplier tube (PMT). The $Cs_3Cu_2I_5$ scintillator also shows a good energy resolution under gamma-ray irradiation. Besides the crystal can be easily grown in large bulk size from the congruent melt of compound CsI-CuI which are not expensive chemicals. Based on these properties, the $Cs_3Cu_2I_5$ scintillation crystal is a promising candidate for the practical applications of radiation detection and measurement. However, so far, the particle discrimination capability of $Cs_3Cu_2I_5$ crystal has not been studied. Therefore, in this work, the gamma and alpha discrimination of the intrinsic $Cs_3Cu_2I_5$ and $Cs_3Cu_2I_5$:Ag crystals are investigated at room temperature. For this purpose, these crystals were synthesized based on a phase diagram and grown by using a Bridgman technique. The pulse shape discrimination was studied using a ^{137}Cs and ^{241}Am sources. The pulse signals were recorded by the Hamamatsu R6233-100 PMT coupled to the 500-MHz NKFADC Notice Korea. In addition, the luminescence and scintillation properties at room temperature have been also measured and the results will be presented.

Keywords:

Cs3Cu2I5 crystal , Cs3Cu2I5:Ag crystal , pulse shape discrimination , Bridgman crystal growth, air-stability

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.001

Large scale simulation of nanophotonics: performance analysis of parallelized Hybrid PSTD-FDTD method

PARK Q-Han *[1], LEE DongGun [1], KIM Taehyung [1]
[1]Korea University
qpark@korea.ac.kr

Abstract:

To reduce the parallelization cost and speed up the computing process in electromagnetic wave simulations, we hybridize the FDTD and PSTD methods. The parallelization strategy and performance analysis of the Hybrid PSTD-FDTD method is presented.

Keywords:

FDTD, PSTD, Hybrid, Parallelization, Roofline Model

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.002

인접 방법 최적화를 활용한 광대역 고효율 TE/TM 광편광 분배기 설계

KIM Doyoung [2], GOUDARZI Kiyanoush [2], HAN Haewook [*1,2]
[1]POSTECH
[2]Electrical and electric engineering, POSTECH
hhan@postech.ac.kr

Abstract:

작은 소자 크기와 실리콘(Si) 포토닉스(photonics) 기술(technology)을 기초로 한 광대역 고효율 광편광(polarization) 분배기(beam splitter)의 개발은 광 집적회로(optical integrated circuit)의 발전에 필수적인 요소다. 우리는 인접(adjoint) 방법을 활용한 inverse design으로 실제 광 집적회로에 적용될 수 있는 Transverse Electric(TE)/Transverse Magnetic(TM) 광편광 분배기를 설계했다. PBS(polarization beam splitter)를 실현하기 위한 전유전(all-dielectric) 메타물질 기반 구조는 경사 하강법(gradient descent) 알고리즘(algorithm) 및 3D FDTD(finite difference time domain) 방법을 활용하여 최적화(optimization) 및 시뮬레이션 되었다. 앞서 언급한 광편광 분배기는 매우 높은 투과 효율(TM_{00} 모드에서 약 96%, TE_{00} 모드에서 약 93%)을 보이고 광대역(200 nm)에서 16 dB 이상의 높은 소광비(extinction ratio)를 보였다. 작은 소자 크기(2.2 x 2.1 μm^2), 광대역(200 nm)에서 높은 투과도 및 소광비 그리고 소자 제작에 있어서 CMOS 공정 기술에 적합하기 때문에 광 집적회로에 효율적으로 응용될 수 있는 가능성을 보여주었다.

Keywords:

Polarization beam splitter, Inverse design, Adjoint method

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.003

Enhanced Raman scattering properties of plasma-synthesized gold nanoparticles loaded on filter paper

NGUYEN Linh Nhat [1], CHOI Eun Ha [1], LEE GeonJoon *[1]
[1]Kwangwoon University
gjlee1978@gmail.com

Abstract:

In this research, we prepared the polyethyleneglycol-coated gold nanoparticles (Au@PEG NPs) via a unique one-step synthesis procedure based on plasma-liquid interactions.[1] The plasma produces a high amount of reactive species, which can induce the reduction of Au^{3+} into zero-valent Au^0 without using any additional reductants.[2] Plasmon resonance effects of Au@PEG NPs were examined for Rhodamine B dye on gold nanoparticles loaded on filter paper. Optical absorption and Raman spectra of Rhodamine B dye were investigated before and after plasma treatment. Optical absorption and Raman spectroscopic measurements indicated that plasma jet can induce destruction and/or structural modification of Rhodamine B dye molecules. This work demonstrates a rapid and cost-effective approach for Raman sensing application of gold nanoparticles.

References:

[1] Richmonds et al. 2008 Applied Physics Letters 93, 131501
[2] Patel et al. 2013 Nanotechnology 24 245604

Keywords:

Plasma-synthesized gold nanoparticles, Filter paper, Rhodamine B

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.004

Reproducing a multimode Fano resonance line shape by imaging mode patterns in an acoustic cavity

AN Kyungwon *[1], KIM Juman [1], FUKUSHIMA Takehiro [2]
[1]Department of Physics and Astronomy, Seoul National University
[2]Faculty Building of Computer Science and System Engineering, Okayama Prefectural Univeresity
kwan@phya.snu.ac.kr

Abstract:

We investigate the spectrum and resonant mode patterns in a water-filled aluminum acoustic cavity with Penrose unilluminable room boundary by applying a frequency tunable ultrasonic field. The line shapes in a spectrum of the acoustic cavities are investigated by measuring the average image intensity in the water region observed with a schlieren imaging setup while tuning the frequency of the ultrasound emitted from an immersion transducer. In a multimode-overlapping resonance regime, Fano resonance line shapes as well as interference mode patterns such as a half-illuminated mode (HIM) are observed. We reproduce the HIM by optimizing the measure of image similarity with the intensity distributions of linear combinations of near resonant 20 quasi-eigenstates computed by using finite element simulation. A variety of simple patterns like alphabets or numbers emerged from interference between eigenstates in different acoustic cavities and their Fano line shapes are also studied.

Keywords:

acoustic cavity, Fano resonance, Schlieren

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.005

Deep-Tissue Super-Resolution Microscopy Using Closed-Loop Accumulation of Single-Scattering Algorithm

PARK Sanghyeon [1,2], CHOI Wonshik *[1,2]
[1]Department of Physics, Korea University
[2]IBS CMSD, Korea University
wonshik@korea.ac.kr

Abstract:

Super-resolution microscopy has enabled sub-diffraction-limit imaging of biomolecules. However, its imaging depth has been too shallow to investigate thick biological tissues or intact animals. A sample-induced aberration is one of the major reasons for this. Also, it blurs and distorts single-molecule emission images. To resolve this issue, we combined the closed-loop accumulation of single scattering (CLASS) microscopy with the single-molecule localization microscopy (SMLM). We calculated sample-induced aberration using CLASS microscopy and corrected it for deep-tissue super-resolution microscopy. We demonstrated super-resolution imaging of cellular microtubules under artificially generated severe aberration and the super-resolution imaging of neurons in an intact zebrafish at the depth of ~55μm.

Keywords:

Super-Resolution, Adaptive Optics, Deep-Tussue

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.006

실리콘 전자렌즈의 라만 산란 특성 연구

KIM Ho-seob *[1,2,3], LEE GeonWoo [1,2], LEE Youngbok [1,2], BAEK Dong-Hyun [2]
[1]Physics and Nanoscience, Sun Moon University
[2]Center for Next-Generation Semiconductor Technology, Sun Moon University
[3]Display and Semiconductor Engineering, Sun Moon University
hskim3@sunmoon.ac.kr

Abstract:

마이크로컬럼은 전자방출원, 소스 렌즈, 디플렉터, 그리고 아인젤 렌즈의 적층으로 구성되어 있으며, 전자방출원은 탄소나노튜브(CNT) 팁을 사용하였다. 전자방출원에서 방출된 전자는 대부분 실리콘 전자렌즈의 어퍼쳐 홀을 통과하지만 일부 전자들은 실리콘 전자렌즈의 어퍼쳐 홀 주변의 표면에 부딪히게 된다. 따라서 마이크로컬럼을 장기간 사용한 경우, 전자렌즈의 어퍼쳐 홀 주변은 전자빔에 의하여 손상되므로 이는 마이크로컬럼의 수명과 연관된다. 본 연구에서는 마이크로컬럼을 약 6개월 동안 작동 후, 전자빔이 조사된 실리콘 전자렌즈의 표면을 분석하기 위하여 비파괴 검사 장비인 라만 분광기를 활용하여 분석하였다. 실리콘 전자렌즈의 어퍼쳐 홀의 주변과 어퍼쳐 홀에서부터 점점 멀어지면서 표면에 나타나는 변화를 라만 산란을 이용하여 측정하였고, 반치폭(FWHM), 실리콘 피크(520 cm-1)의 shift 변화, 피크 강도 등을 라만 스펙트럼을 통해 비교 및 분석하였다.
본 연구는 과학기술정보통신부와 한국연구재단의 지원(No. 2020R1A2C1008944)과 산업통상자원부와 산업기술평가관리원(KEIT)의 지원(K_G012001322301)으로 수행됨.

Keywords:

마이크로컬럼, CNT 전자방출원, 실리콘 전자렌즈, 전자빔, 라만 스펙트럼

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.007

Non-destructive inspection of defects in XLPE insulation material using CW-THz imaging

배민규*[1], 조수빈[1], 이중욱[1]
[1]Physics, Chonnam National University
baemingyu357@naver.com

Abstract:

High voltage transmission lines are mainly used to transmit electricity with minimal power loss. The role of insulators in the cable is so important because the high voltage is very dangerous. During the process of high-voltage transmission, if part of the insulator melts and creates a hole, the insulation breakdown expands due to the imbalance in the insulation level. To prevent such accidents, this study uses a CW-THz system to detect and image defects in XLPE insulators used in high-voltage cables.

Keywords:

Non-destructive Inspection, THz, XLPE, Defects Imaging

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.008

Resonance characteristics of the THz transmission based on the combination effect of two different types of meta-structures

JO Subin *[1], BAE Mingyu [1], LEE Joongwook [1]
[1]physics, Chonnam National University
soobincho95@naver.com

Abstract:

본 연구에서는 서로 다른 두 종류의 meta-atom이 결합하여 이루어진 메타물질에서의 테라헤르츠파 투과 공진 특성 변화를 확인했다. 메타물질은 수직 입사하는 테라헤르츠파의 편광에 대해 symmetric한 투과 특성을 보이는 Y-shape과 asymmetric한 특성을 보이는 C-shape으로 구성되었다. 이와 같은 메타물질에서 나타나는 투과 공진은 두 meta-atom의 결합 구조에 의존하며, 조절가능한 유사 Electromagnetically induced transparency(EIT) 현상을 보여준다. meta-structure의 투과 공진 특성 변화는 comsol multiphysics를 통한 시뮬레이션을 통해 계산되었다. 본 연구는 메타물질 기반의 테라헤르츠파 다기능성 메타물질 합성 소자를 구현하거나 동력학적 특성을 이해하는데 도움이 될 것이다.

Keywords:

metamaterials, THz transmission, THz resonance

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.009

Quantitative Label-free Terahertz Sensing of Transdermal Nicotine Delivered to Human Skin

HAN Haewook *[1], MOON Youngil [1], LEE Gyuseok [1], LEE Haneol [1], KIM Doyoung [1]
[1]Department of Electrical Engineering, POSTECH
[2]POSTECH
hhan@postech.ac.kr

Abstract:

우리는 사람 피부에서 경피 흡수 약물 전달 과정(Transdermal drug delivery)을 테라헤르츠 시영역 분광법(Terahertz time-domain spectroscopy)으로 관측했다. 니코틴 패치 부착 시간에 따른 경피 니코틴 전달의 변화도는 수 피코초 테라헤르츠 펄스의 투과 계수(Transmission coefficient)로 관측하였는데, 이는 단일층 유효 매체 근사법(Single-layer effective medium approximation)으로 분석하였다. 본 연구에서 상용 니코틴 패치(Nicoderm CQ®, 7mg/24h)를 사용했으며, 테라헤르츠 투과 계수를 통해 테라헤르츠 주파수 영역에서 다층 구조 혹은 광학 특성 등 보고된 세부 사양이 없는 니코틴 패치에서 방출되는 니코틴의 누적량을 정량적으로 분석됐다. 분석 결과는 시험관[in vitro : 고성능 액상 색층 분석법(High-performance liquid chromatography)]과 생체[in vivo : 혈액 견본 추축(Blood sampling)]측정 결과와 잘 일치했다. 본 연구로부터 우리는, 테라헤르츠 시영역 분광법이 경피 흡수 약물 전달 과정에 대한 비침습적(Nonunvasive)이고 세포 표기법(Label-free)이 없는 관측을 위한 기존 방법의 효과적인 대안이 될 수 있는 능력을 보여주었고, 생물 의학, 제약 및 화장품 응용에 대한 높은 가능성을 보여주었다.

Keywords:

Terahertz spectroscopy, Nicotine, Transdermal drug delivery

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.010

Photonic structure design with deep neural network

HAN Haewook *1, KIM Sunwook 1, LEE Jonggen 1, KIM Nanhee 1
1Department of Electrical Engineering, POSTECH
2POSTECH
hhan@postech.ac.kr

Abstract:

딥러닝 (Deep Learning) 을 이용하여 테라헤르츠 (THz) 영역에서 동작하는 distributed brag mirror (DBR) 를 설계하고 시뮬레이션을 진행하였다. 설계한 DBR 은 공진 조건을 고려한 이론적인 DBR 과 비슷한 성능을 보이면서도 약 80 um 더 작은 크기에서 동작하였다. 3차원 finite difference time domain (FDTD) 를 이용하여 반사율을 계산하였으며, 1 THz 에서 99% 이상의 반사율을 보여주었다. 본 연구에서 이용된 딥러닝을 통한 역구조 설계 기법은 향후 다양한 광학 소자의 역구조 설계로의 응용에 높은 가능성을 보여주었다.

Keywords:

Terahertz, Deep Learning, Inverse Design, DBR

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.011

Phase retrieval algorithm for the wavefront reconstruction of a high-power laser beam.

KWON Tae Yong [1], KIM Kyung Taec *[1,2]
[1]Department of Physics and Photon Science, GIST
[2] Center for Relativistic Laser Science, IBS
kyungtaec@gist.ac.kr

Abstract:

Ultrahigh intensity can be achieved by tightly focusing a high-power laser beam in a small area. An efficient focusing can be obtained when the laser beam has a reasonably flat wavefront before focusing. However, the wavefront distortion accumulated through a long beam path of a large-scale laser prevents the formation of a Gaussian-like laser beam at the focus. An adaptive optics system can be used for the wavefront correction, which requires an accurate wavefront measurement. Here we discuss a reconstruction algorithm for the wavefront measurement that can be applied for sensorless imaging. Multiple images of the focused laser beam are numerically calculated. The accuracy of the reconstruction algorithm is tested under various conditions. Our reconstruction algorithm will be particularly useful for a high-power laser beam because it supports in situ measurement with a single laser shot at the focus.

Keywords:

wavefront measurement,adaptive optics,Phase retrieval

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.012

광섬유 격자 기반의 깊이 측정 방법

LEE Seung Seok [1], KANG Hwi One [1], CHOI Eun Seo [*1]
[1]Department of Physics, Chosun University
cesman@chosun.ac.kr

Abstract:

본 논문에서는 광섬유 격자가 일정하게 증가하는 형태로 가공된 특수 광섬유 소자(CFBG, Chipred fiber Bragg grating)을 이용하여 직접적으로 가공깊이를 측정할 수 있는 기법을 제시하고자 한다. 가공물의 깊이 정보를 측정하기 위해서는 간섭계 기반의 계측 방법이 가장 널리 이용되었다. 물론 현미경을 이용한 계측 방법도 많이 이용되고 있지만 가공 깊이나 단차가 큰 경우 측정에 한계를 가지고 있는 방법이다. 가공깊이를 간섭신호로부터 추출하기 위해서는 푸리에 변환을 거쳐 윗면과 바닥면에 해당하는 거리차로 환산하는 방법을 이용해야 한다. 이러한 바업은 변환을 통한 간접적으로 정보를 추출하는 방법이다. 하지만 이러한 간섭계 구조를 이용하면서 기준단의 금속 코팅된 거울면 대신에 분산효과가 큰 광섬유 격자를 이용함으로써 간섭신호의 푸리에 변환이 없이도 깊이 정보를 환산할 수 있는 기법을 할 수 있었다. 본 연구에서는 이러한 광섬유 격자를 기준단에 이용하여 간섭계를 구성하고 이 간섭계로부터 가공 단차 및 구멍의 깊이를 계측할 수 있는 방법을 제시하고자 한다. 본 실험에서는 기본적으로 광섬유 기반의 간섭계를 구성하고 기준단에 광섬유 격자를 대치하여 실험 장치를 구성하였다. 샘플단에 단차가 다른 샘플들을 놓아 측정되는 간섭신호의 특성을 파악하고 측정된 간섭신호로부터 단차를 확인할 수 있는 기법을 개발하였다. 제안한 방법은 기존의 푸리에 변환 과정이 없이도 깊이 정보를 확인할 수 있는 장점을 가지고 신호처리가 보다 단순화될 수 있는 장점을 가질 수 있다. 이러한 장점을 이용하여 새로운 광섬유 프로파일러로의 응용이 가능함을 실험결과를 통해 제시하고자 한다.

본 연구는 과학연구재단 사업(NRF-2019R1A6A3A01095557 & NRF-2017R1A2B2009732)과 산학Collabo R&D 사업(S2910948)의 지원에 의해서 수행되었습니다.

Keywords:

OCT, profilometry, Chirped fiber Bragg gratings

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.013

1018 nm 발진 고출력 Yb 광섬유 레이저

PARK Hye Mi [1], OH Ye Jin [1], KIM Jin Pil [1], PARK Eun Ji [1], PARK Jong Seon [1,2], KIM Ji Won *[1], JEONG Hoon [2]
[1]Hanyang University ERICA
[2]Research Institute of Sustainable Manufacturing System, KITECH
jwk7417@hanyang.ac.kr

Abstract:

광섬유 레이저는 회절 한계의 빔질을 유지하면서 >1 kW 급의 고출력을 쉽게 구현할 수 있고, 구조적 특성상 빔 정렬이 필요하지 않아 안정적인 시스템 구조를 만들 수 있다는 장점 때문에 산업 및 군사 분야에서 크게 각광받고 있다. 최근 들어 수 kW 급의 고출력 레이저의 수요가 높아지고 있는데, 기존의 다이오드 펌핑 광섬유 레이저 구조로는 열, 고차 모드 발진, 모드 불안, 펌프출력 한계 등으로 인해 출력을 높이는데 있어 여러 가지 어려움을 겪고 있다. 이러한 어려움을 해결하고 수 kW 이상, 더 나아가 >10 kW의 레이저 출력을 얻기 위한 방법 중 하나로 탠덤 펌핑 레이저 구조가 제안되고 있다. 탠덤 펌핑 레이저 구조는 레이저 방출 파장에 가까운 레이저를 펌핑 광원으로 사용하는 방법으로 양자 결함을 매우 작게 줄이는 것이 가능하기 때문에 발생하는 열 자체를 줄일 수 있어 고출력 레이저 발진에 매우 유리하다. 특히 Yb 광섬유 레이저는 기존 9xx nm 영역대의 다이오드 레이저로 펌핑할 경우 양자 결함이 약 9%인데 반해 탠덤 펌핑 구조에서는 약 5% 이하로 감소하므로 발생하는 열을 대폭 감소시키는 것이 가능하다.
본 연구에서는 고출력 레이저 발진을 위한 탠덤 펌핑 광원용 1018 nm 레이저를 제작하고 고출력 레이저 발진을 구현하였다. Yb 광섬유 레이저를 1018 nm에서 안정적으로 발진시키기 위해서는, 레이저 동작 시 자발형광증폭(ASE)이나 기생발진을 억제할 수 있는 적절한 소자와 구조를 결정하는 것이 중요하다. 본 연구팀은 코어 직경 10 um, 클래딩 직경 130 um의 단일 모드 광섬유와 광섬유 회절 격자를 사용하여 레이저 시스템을 구축, 중심파장 1018.3 nm에서 최고출력 198 W을 얻었다. 이때 발진된 레이저 출력의 기울기 효율은 입사 펌프 출력 대비 66%이고, 1018 nm 레이저 발진 파장과 1030 nm 대역의 ASE 출력이 약 35 dB 이상 차이가 나는 것이 측정되었으므로, 본 연구에서 개발된 레이저가 안정적으로 동작하고 있음을 확인할 수 있었다.

Keywords:

Yb 광섬유 레이저, 탠덤 펌핑, 고출력 레이저

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.014

CW operation of Diode-Pumped Yb:KGW laser

PARK Byeong Jun [1], LEE Seong Yeon [1], SONG Ji Yeon [1], YEE Ki Ju [*1]
[1]Department of Physics, Chungnam National University
kyee@cnu.ac.kr

Abstract:

In this work, we fabricated a CW laser system using Yb:KGW as a gain media. The gain crystal is ytterbium doped potassium gadolinium tungstate(Yb:KGW) at 5% doping rate, and it was cut along Ng axis in 2x2x5 mm cuboid structure. Pumping diode laser made CW light which delivered into the cavity via an optical fiber with output-power up to 27 W and wavelength centered at 976 nm.
We consisted a V-shaped laser cavity with a dichroic mirror, concave mirror, and output coupler. Each components was placed on 'the edges of V.' The concave mirror was in the middle of V. Output-power of the beam passed the output coupler was measured. While changing lengths between the three optics, we measured input-output power curves. Then repeated it on Z-shaped cavity, which is an extended version of V-shape, by placing another concave mirror to find the most input-output efficient condition for Yb:KGW laser cavity.

Keywords:

Yb:KGW, solid state, laser

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.015

Three Dimensional Displacement Sensor using FBGs Embedded in the Two Cross Jointed Metal Ring

JEONG Soong Hyeon *1
1Research Institude, Alfa windows & door Co.,Ltd
lightvalley@daum.net

Abstract:

Fiber Bragg grating have attracted great interest in the sensing of physical, biological, chemical and environmental industries due to capability of remote and distributed sensing, immunity to electromagnetic interference, distributed sensing, wavelength multiplexing and durability to aggressive environments, high sensitivity, fest response, lightweight and small size. The Bragg wavelength of a FBG fixed on the cantilever changes sensitively as the cantilever bends because it induces a variation in the grating period One dimensional motion can be easily detected using a flat cantilever[1-3]. In order to implantation two dimensional tilt sensor using FBGs fixable and thick(~1cm diameter) cylindrical cantilevers have been adopted [4-7]. The insufficient elasticity of those the soft and bulky cantilever may restrict various applications of the two dimensional motion sensing.

We propose three dimensional movement sensor using FBG(Fiber Bragg grating)s embedded in two cross jointed high elastic metal rings. Two sets of FBGs were embedded in a side of metal rings. The bending of thin a metal ring induced a strain into FBG, as result Bragg wavelengths shift along with motion of a supporter attached on the two joined rings. The strain applied to each of the FBGs strongly depends on the direction of movement of the supporter, and therefore, a shift in the Bragg wavelengths of the two orthogonally-positioned FBGs results in a sinusoidal function with respect to the direction of the movement. A 90° in-phase difference exists between the two sinusoidal functions made by the shift in the Bragg wavelengths, and those properties can be used to simultaneously measure the displacement and direction of a movement. Our experimental results showed the sensor indicated amount of displacement as well as direction of movement a supporter. We anticipate that the proposed technique can be applied to develop various fiber optic sensors to measure various phenomena, such as the wind velocity and direction sensor and a tilt gradient and direction sensor

Reference

1. Long Jin, Weigang Zhang, Jing Li, Hao Zhang, Bo Liu, Qinchang Tu, Guiyun Kai and Xiaoyi Dong, **Measurement Science and Technology** , 17,168 (2006).
2. C. Shen, C. Zhong, **Sensors and actuators A: Physical** ,170, 51(2011).
3. M. M. Khan, N. Panwar, R. Dhawah, **Sensors and actuators A: Physical** , 205, 79(2014).
4. X. Dong, L. L. Shao, Y. Wang, Yunpeng, J. Zheng, **Microwave and optical technology letters**, 55, 344(2013).
5. Hualong Bao, Xinyong Dong, Li-Yang Shao, **IEEE** Photonics Global Conference (PGC), pp. 1-4, 2010.
6. K. Ni, X Dong, Y. Jin, and H. Xu, **Microwave and optical technology letter**, 52, 2250(2010).
7. Hualong Bao, Xinyong Dong, Li-Yang Shao, Chun-Liu Zhao, Shangzhong Jin , **Optics Communications**, 283, 5021(2010).

Keywords:

Fiber Bragg Grating, Three Dimensional Displacement Sensor , Two Cross Jointed Metal Ring

P1-op.016

YIG를 이용한 양자 주파수 변환 효율 향상 방안

KIM DongHwan [1], LEE Su-Yong [1], KIM Duk Y. [1], IHN Yong Sup [1], KIM Zaeill [1], JEONG Taek [*1]
[1]Quantum Physics Technology Directorate, Agency for Defense Development
jeongt88@add.re.kr

Abstract:

양자 기술이 발전함에 따라 마이크로파 영역과 적외선 영역의 빛에 담긴 정보를 결맞게 변환하는 것이 중요해지고 있다. 본 연구에서는 강자성체인 구형 YIG 결정에서 마그논을 이용해 두 영역의 빛을 변환하고자 한다. 변환 효율은 YIG 결정의 크기, 외부 자기장, 마이크로파 공진기의 특성 등에 영향을 받으며, 아직 현저히 낮은 수준이다. 우리는 시스템의 협동률(cooperativity)이 매우 클 때 변환 효율이 최대가 되는 외부 자기장의 세기를 이론적으로 구한다. 이러한 결과는 YIG를 이용한 양자 주파수 변환 효율을 높이는 바탕이 될 것이다.

Keywords:

양자 주파수 변환, YIG, 마그논, Walker Mode, 페러데이 회전

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.017

Nd:YAG 레이저 이득 모듈의 성능 평가를 위한 열 효과 및 증폭 효율의 정밀 측정 방법

PARK DaeWoong [1], CHO Seryeyohan [1], HWANG Seungjin [2], JEONG Jihoon [3], YU Tae Jun [*1,2]
[1]Handong Global University
[2]R&D, Hil Lab. Inc.
[3]R&D, SEMES Co. Ltd.
taejunyu@handong.edu

Abstract:

산업 응용 및 차세대 연구 분야의 핵심인 레이저 발생 장비의 시스템 규모를 크게 하고 출력을 제한하는 가장 큰 요인은 레이저 빔 발진 과정에서 발생하는 열 문제이다. 특히, 레이저 이득 모듈(또는 펌프 챔버, 레이저 헤드)은 레이저 발생 장비의 가장 중요한 구성요소로써, 동일한 레이저 매질을 담고 있는 이득 모듈이더라도 여기 방식, 냉각 구조, 여기광 반사체의 재질 및 형태, 제조사 등에 따라 열 효과 및 에너지 효율이 다르다. 따라서, 레이저 발생 장비의 열 문제를 효과적으로 보상하여 시스템 규모를 최소화하면서 동시에 증폭 효율을 높여 고출력 빔을 달성하기 위해서는 사용하고자 하는 이득 모듈 소자에 대한 실험적인 성능평가가 선행되어야 한다. 본 연구에서는 여기 중인 이득 매질의 파면 왜곡 분석을 통해 열 효과 및 수차 영향을 정밀하게 측정하고, 소신호이득 측정을 통해 에너지 저장 효율을 유도함으로써 이득 모듈의 종합적인 성능 평가 방안을 제안한다.

Keywords:

레이저 이득 모듈, 열 효과, 저장 에너지, 성능평가, Nd:YAG

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.018

펄스형 레이저 다이오드를 이용한 노면 위의 얼음과 눈 기상 상태의 판별

KIM Yong Gi *[1], LEE Kiwon [1], HONG SaYong [1]
[1]College of Natural Science, Kongju National University
kimyg@kongju.ac.kr

Abstract:

도로 노면의 기상상태 모니터링은 국민의 생활, 재산 및 안전과 관계되는 중요한 요소이고 국가 사회적 비용을 저감할 수 있는 중요한 기술로 시급히 개발이 필요한 기술이다. 첨단의 엔진 기술 개발에 따른 엔진의 고성능화와 내연기관과 비교하여 상대적으로 큰 토크(Torque)를 발생하는 전기자동차의 등장으로 현대인들은 도로 위를 더 고속으로 달릴 수 있게 되었다. 이러한 상황 속에서 중요한 것은 노면의 기상 상태를 정확하게 파악하여 자동차 사고를 방지하고 탑승자의 생명을 지키기 위해서는 도로 노면의 기상 상태를 정확하고 빠르게 실시간으로 파악하여야 한다. 특히 노면 위의 결빙(얼음)과 눈, 젖음을 구분하는 것은 매우 중요하다. 이 연구에서는 아스팔트 노면 위의 결빙, 눈, 젖음, 건조 등을 비접촉식인 광학적 방법으로 측정하여 노면 기상 상태를 구분 가능함을 확인하였다. 중심 파장이 905 nm와 1550 nm로 서로 다른 두 개의 펄스형 레이저 다이오드 빔을 관측대상 노면으로 쏘아서 후방으로 반사 및 산란되는 빔을 두 개의 디텍터로 수신하고 그 특성을 분석하여 아스팔트 노면의 위의 결빙과 눈, 젖음을 정확히 분석하였다. 수신된 두 개의 파장 신호의 세기 비율인 Color Ratio(CR)"CR = $I_{\lambda1}/I_{\lambda2}$ = I_{905}/I_{1550}"를 측정하면 결빙과 눈, 젖음 등의 노면 기상 상태에 따라 CR 신호의 크기가 서로 달라 정확한 판별이 가능하다. 본 연구에서 발견한 최적의 레이저 다이오드 펄스폭은 약 70 -100 ns 이며 반복율은 100 Hz ~ 200 Hz이었다. 본 연구에서는 매 순간마다 햇빛의 강약과 구름상태에 따라 매 순간마다 달라지는 배경신호의 변화를 디텍터에 수신되는 신호의 베이스라인의 측정과 분석을 통해 실시간으로 배경신호를 처리하여 수신된 신호를 보정하여 실시간으로 도로 노면의 기상상태를 판별하였다.

Keywords:

도로기상, 비접촉식, 배경신호, 레이저 다이오드

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.019

Autocorrelator to Measure Ultrashort Laser Pulse Width

SONG Ji Yeon [1], YEE Ki Ju *[1]
[1]Department of Physics, Chungnam National University
kyee@cnu.ac.kr

Abstract:

Assuming the same pulse energy, the peak intensity of a pulse becomes higher as the pulse width is shortened, which is advantageous in obtaining high peak power even with a low energy pulse. Therefore, it is important to know the pulse width of a laser. In general, the pulse width can be measured using an oscilloscope and photodetector if the width is moderately long, but the measurable pulse width is limited due to the detection limits of the oscilloscope and the detector. To date, this detection limit is approximately 10 ps, that a pulse width of less than 10 ps must be measured by using alternative methods such as interferometric autocorrelator.
In this study, the pulse width of the Ti:sapphire pulse laser was measured using the interferometric autocorrelation method. In addition, the laser pulse width in femtosecond was measured using a GaP detector using two-photon absorption, not using a second harmonic generation crystal. Furthermore, we use low-GDD ultrafast beamsplitter and parabolic mirror to reduce a pulse broadening in optics. We use the pulse laser with a peak at 805 nm and 6.45 nm spectrum width is theoretically has a pulse width of 117 fs. But the pulse width measured by using the autocorrelator was 123 fs.

Keywords:

Autocorrelator, Pulse Width, Ultrashort Laser Pulse

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.020

Neutron detection in security inspection system

PARK Jae Yeon *[1], MUN Jung Ho [1], LEE Jae Hyun [1], YEON Yoeng Heum [1], CHAE Moon Sik [1], LEE Nam Ho [1]
[1]Radiation Research Division, KAERI
jaeyeon@kaeri.re.kr

Abstract:

Korea Atomic Research Institute (KAERI) has been studying the neutron imaging system. This system is developing to localize the security inspection system in the real sized airport container with material discrimination of the 16 materials such as plastics, metals, papers, and bio-materials. The neutron radiation is DT generator with fan beam and its energy is 14.1 MeV. To detect the neutron, we develops the scintillator and photo counter based modules arranged in a line. The scintillator has a property of the green fluorescence regenerating the visible photons by the radiation targeting. This property help the neutron detection but we have to separate the neutron signal with the scattered gamma-ray. The signal processed neutron image is reconstructed with the translation of the airport container including the 16 materials. The imaging results is processed for the material discrimination. In this study, we develops the Neutron imaging system for the security inspector providing the material discrimination.

Keywords:

Neutron, Radiation Detection, Security Inspection, Material Discrimination

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-op.021

Lightwave reflected from a plasma mirror

PARK Seong Cheol [1], KIM Yang Hwan [1], CHO Wosik [1], YUN Hyeok [2], KIM Kyung Taec [*1,2]
[1]Department of Physics and Photon Science, GIST
[2] Center for Relativistic Laser Science, IBS
kyungtaec@gist.ac.kr

Abstract:

An electromagnetic wave can be completely reflected from a dense plasma. This property is the basic mechanism of a plasma mirror which can be used for relativistic high harmonic generation and contrast enhancement of a laser beam. In spite of the importance of these applications, the temporal profile of a reflected laser pulse has not been investigated much. Here we discuss a result of numerical calculations made for the temporal profile of the laser pulse reflected from a dense plasma. These studies will provide useful information on the formation of the plasma relativistic high harmonic generation.

Keywords:

Temporal profile, Numerical calculation, Reflected from a dense plasma

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.101

The strategy to study CP violation with the D0 → pi+ pi- and D0 → K+ K- channels using the Belle II experiment

NA Ijeong [1], KIM Doris Yangsoo*[1]
[1]Department of Physics, Soongsil University
dorisykim@ssu.ac.kr

Abstract:

The Belle II experiment started its physics run in 2019 and is continuously accumulating the collision data. The Belle II analysis tools are being refined to exploit this new data set. We will show how to search for time integrated CP violation effect in the D0 → pi+ pi- and D0 → K+ K- channels in this environment. The selection process of the D0 events and the fitting procedures to extract the CP violation effect will be discussed.

Keywords:

Belle II, CPV, D meson, charm quark

Search for B^0 -> l τ decays at Belle experiment

KIM Kyungho [1], KWON Youngjoon *[1]
[1]Physics, Yonsei University
yjkwon63@yonsei.ac.kr

Abstract:

We study the rare leptonic decays $B^0 \rightarrow l\ \tau$ (τ to one lepton and 2 neutrinos), using Monte Carlo based simulation data from Belle detector at KEKB e^+e^- collider. One of the B meson from $\Upsilon(4S) \rightarrow B^0\overline{B^0}$ is fully reconstructed by 4 decay modes of semi-leptonic full event interpretation(FEI), while remaining particles are from signal B decay. The Toolkit for Multivariate Data Analysis with ROOT(TMVA) is used to improve signal purity, with 3 variables.

The momentum of primary lepton on center-of-mass frame(p_l^*) in semileptonic tagged smaple is selected. Expected upper limit is calculated by recursive estimation of signal and backgrounds in signal region with fit result of p_l^* distribution.

Keywords:

Belle, KEKB, B meson

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.103

Search for B0 → $K_SK_S$gamma in the Belle II experiment

LEE Seungcheol [1], KANG Kookhyun [1], KIM Hongjoo [1], LI Jin [1], PARK Hwanbae *[1]
[1]Kyungpook National University
sunshine@knu.ac.kr

Abstract:

The Belle II experiment at Super KEKB asymmetric energy electron-positron collider in Japan began physics data taking in April 2018 and collected 62.8 fb^{-1} data at Y(4S) resonance. B0 → $K_SK_S$gamma is a rare decay mode through b → dgamma quark transition which is forbidden at tree level in the Standard Model. We study this rare decay mode using Monte Carlo simulation for the signal and background in order to estimate signal events with the Belle II data sample and set upper limit of branching fraction. In this poster, we report the result of Monte Carlo simulation.

Keywords:

The Belle II experiment, Rare decay, b → dgamma, Electroweak penguin

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.104

Dark sector searches at Belle experiment

KIM Yongkyu [1], CHO Sungjin [1], KWON Youngjoon *[1]
[1]Physics, Yonsei University
yjkwon63@yonsei.ac.kr

Abstract:

In this presentation, we report recent updated status of two darksector search at Belle Experiment. One is axion like particle search with B to Ka' decay where a' decays into two photons, the other is dark photon search using B to KA'A' decay where A' decays into two leptons.
we are going to present signal extraction procedure.
We used 10 stream of BB, 6 stream of qq 50 stream of rareB and 20 stream of ulna to evaluate this result. Each stream is corresponds to 711fb^-1 full Y(4S) Belle Montecarlo samples that equivalent to 772M BB pairs.

Keywords:

Belle, ALP, Dark photon, B meson

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.105

Archiver System Management for Belle II Detector Operation

KWON Youngjoon *[1], CHO Sungjin [1]
[1]Physics, Yonsei University
yjkwon63@yonsei.ac.kr

Abstract:

In this paper, we present the archiver system used to store the monitoring data of the Belle II detector and discuss in particular how we maintain the system that archives the monitoring process variables of the subdetectors. We currently save about 26 thousands variables including the temperature of components in various subdetectors, water leak sensors status, high voltage power supply status, data acquisition status, and luminosity information of the colliding beams. For stable data taking, it is essential to collect and archive these variables. We ensure the availability and consistency of all the variables from the subdetectors and other systems, as well as the status of the archiver itself are consistent and regularly updated. To cope with a possible hardware failure, we prepared a backup archiver that is synchronized with the main archiver.

Keywords:

Belle II, Archiver

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.106

Quality Control Procedure of New RPCs for Phase-2 upgrade of the CMS Muon System

JO Youngmin *1, KANG Minho 1, LEE Kyong Sei 1
1Department of Physics, Korea University
youngmin.jo@cern.ch

Abstract:

New double-gap phenolic Resistive Plate Chambers are developed for the CMS muon system in future Phase-2 LHC runs. Compared to the existing CMS RPCs, the new RPCs two-dimensionally measure muon tracks with a higher detection rate capability. In order to achieve the desired detector performances, the thickness of the phenolic electrodes and the gap of the RPCs has been reduced from 2 to 1.4 mm. In addition, a higher-level radiation hardness for the RPC electrodes is required when considering the particle rate of a maximum 1 kHz cm^{-2} in the Phase-2 LHC runs. In this presentation, we report details of a new QC procedure for the present functionally 'improved' RPCs (iRPCs). The quality control (QC) procedure for the new RPC electrodes has been fairly reinforced. The most important factor to secure the radiation hardness is firmer polymerization of varnished oil layers formed inside the RPC electrodes. The polymerization of the oil layers is also confirmed by measuring the oxygen concentration and the relevant protocol is established in the QC procedure. Furthermore, the surface resistivity of the conductive part of the RPC electrode has been optimized to suppress increase of strip multiplicities of particle hits with high voltage.

Keywords:

CMS, Resist Plate Chambers, High Luminosity LHC

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.107

New Facilities and Procedures for Construction of Detector Electrodes of Improved RPCs for Phase-2 CMS Muon System

KANG Minho *[1], JO Youngmin [1], LEE Kyong Sei [1]
[1]physics, Korea University
kakakaminho@korea.ac.kr

Abstract:

We report on a development of new double-gap Resistive Plate Chambers for the future Phase-2 CMS muon system. In order to improve the detector sensitivity and to achieve a higher particle rate capability in the Phase-2 LHC runs whose maximum is expected to be 1 kHz cm^{-2} at highest η region of 2.4, the thickness of the phenolic electrodes and the gap of the RPC electrodes has been reduced from 2 to 1.4 mm. For the construction of the new RPC electrodes, we accommodate new facilities in a few private companies in Korea to improve the detector quality. As the result, the accuracy of surface resistivity of the conductive layers of the RPC electrodes where a high voltage and ground potentials are applied has been dramatically improved. Furthermore, the defect in the PET-film insulation has been fairly mitigated when compared to the electrodes for the previous RE4 RPCs. Here, we report the details of the new facilities producing the new RPC electrodes and the modified construction procedures.

Keywords:

CMS, Resist Plate Chambers, Muon, LHC

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.108

On improving Top Quark Tagging using Convolutional Neural Network

OH Young Do *[1], SHIN Jin Yong [1], KIM Dong Hee [1]
[1]Kyungpook National University
ydoh500@gmail.com

Abstract:

The classification of hadronic objects has become the main driving force inside machine learning techniques in LHC physics. The task is to identify the partonic nature of large-area jets or fat jets. Such jets occur for instance in boosted hadronic decays of weak gauge bosons, or top quarks. Top quark is important for new physics and measurements of the standard model properties. As boosted top quark appears as jets in the detector, we present identification hadronically decaying top quarks from QCD jets and improving the sensitivity of classification performance with neural networks.

Keywords:

Top Tagging, Machine Learning, LHC

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.109

Study of WZgamma production in the fully leptonic final state at High-Luminosity LHC environment

YANG Yu Chul *[1], LEE Dong yub [1]
[1]Kyungpook National University
ycyang@knu.ac.kr

Abstract:

The High-Luminosity LHC(HL-LHC) will be operated at the center-of-mass energy of 14 TeV with the largest integrated luminosity ever, 3000 fb^{-1}. It allows a significant improvement in sensitivity to isolate and observe the interesting process that is rarely expected in the Standard Model. We present a detailed Monte-Carlo simulation study of the production of the triple vector boson production, $WZ\gamma$, in the proton-proton collision at the HL-LHC environment. We use the fully leptonic decay channel of the WZ production in the final states containing three leptons, a neutrino, and a gamma. The sample has been generated and simulated using aMC@LO, Pythia, Delphes. We report the potential for the observation of $WZ\gamma$ process at the HL-LHC environments.

Keywords:

HL-LHC, Triple Vector Boson Production

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.110

Measurement of range using electron beams with new liquid scintillator based on alcohol

KIM Byoung Chan *[1,2], KIM Do Yeon [2], SONG Ye Sung [2], CHOI Ji Young [2], KIM Ye Ji [2], WOO Hee Jin [2], BAK Seon Young [2], CHOI Ji Won [2], JOO Kyoung Kwang [2]
[1]Department of Oncology, Chonnam National University Hwasun Hospital
[2]Department of Physics, Chonnam National University
y2kchan@nate.com

Abstract:

액체섬광검출용액 (Liquid Scintillator)은 높은 빛 방출량을 주기 때문에 물리학뿐만 아니라 다른 분야에서 많이 사용되고 있다. 또한 고에너지 입자 검출기 혹은 의학물리에서 활용하기 위해서는 안정된 액체섬광검출용액의 개발은 매우 중요하다. 본 포스터는 알코올을 기반한 새로운 액체섬광검출용액의 제조와 여러 특성을 살펴보았고 하나의 활용으로 의학물리에서 전자선을 이용한 비정 측정의 가능성에 대해 살펴보았다. 또한 실제 암치료에 사용하는 의료용 가속기 (LINAC)를 이용한 여러 어플리케이터 결과와 Geant4 결과를 비교 분석을 하였다.

Keywords:

AbLS, Medical Physics, Geant4, Range, LINAC

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.111

A study on color image analysis with liquid scintillators

JOO Kyung Kwang *1, CHOI Ji Won 1, 우희진1, 김병찬1, 김예지1, 김도연1, 송예성1, 박선영1, 최지영1
1Department of Physics, Chonnam National University
kkjoo@chonnam.ac.kr

Abstract:

액체섬광검출용액 (liquid scintillator)은 입사한 입자의 에너지를 받아 빛을 방출한다. 본 포스터는
액체섬광검출용액의 형광체에서 방출하는 주요 파장대인 370~420nm의 푸른 계열의 빛을 이용하였다. 또한 해상도 높은
CMOS 반도체 소자를 이용해 color image processing 분석 가능성을 살펴보았다.

Keywords:

liquid scintillator, color image

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.112

A simulation study of the Antiproton Trap for the GBAR experiment

LEE Byungchan *[1], YOO K. H. [2], KIM S. K. [1], KIM B. H. [3], PARK K. H. [1], WON D. H. [1], KIM E. S. [4], CHUNG M. [2], LIM E. H. [4]

[1]Dept. of Physics and Astronomy, Seoul National University
[2]Dept. of Physics, UNIST
[3]Center for Underground Physics, IBS
[4]Department of Accelerator Science, Korea University
chin900@naver.com

Abstract:

The GBAR experiment is to measure the gravitational acceleration of antihydrogen atoms in a terrestrial gravitational field. The antiproton trap is developed to trap and accumulate antiprotons. The antiproton beam extracted from the antiproton trap is transported to the reaction chamber, in which the antihydrogen is produced. In developing the antiproton trap, a simulation study is needed for predicting the behaviour of antiprotons while trapping or extracting antiprotons. A simulation model of the antiproton trap is developed with the PIC(Particle-In-Cell) code WARP. The trapping efficiency and the beam parameters of the extracted antiproton beam are obtained by the simulation.

Keywords:

Antiproton, Penning Trap, Particle-In-Cell code, GBAR

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.114

Updated measurement of the cosmic ray induced background at the JSNS2 experiment.

JEON Hyoungku *[1], ROTT Carstem [1], KIM S.B [1], YU I.T [1], JEON S.H [1], JUNG D.E [1], ROELLINGHOFF Gerrit [1], KIM J.Y [2], JOO K.K [2], MOON D.H [2], SHIN C.D [2], LIM I.T [2], PARK R.G [2], PAC M.Y [3], CHOI J.H [3], YEO I.S [3], JANG J.S [4], KIM E.J [5], GOH J.H [6], KIM W.Y [7], JANG H.I [8], KANG S.K [9], CHEON M.K [7]

[1]department of physics, Sungkyunkwan University
[2]Department of Physics, Chonnam National University
[3]Laboratory for High Energy Physics, Dongshin University
[4]Department of Physics, GIST
[5]Division of Science Education, Jeonbuk National University
[6]Department of Physics, Kyung Hee University
[7]Department of Physics, Kyungpook National University
[8]Department of Fire Safety, Seoyeong Univsersity
[9]School of Liberal Arts, Seoul National University of Science and Technology
[10]Department of Physics, Soongsil University
zayunsna@gmail.com

Abstract:

The J-PARC Sterile Neutrino Search at the J-PARC Spallation Neutron Source (JSNS^2) experiment has started a search for sterile neutrinos apparent through neutrino oscillations with $\Delta m^2 \sim 1$ eV^2 from anti-muon neutrinos to anti-electron neutrinos detected via inverse beta decays(IBD) which are tagged via gammas from neutron captures on Gadolinium. JSNS^2 is the only experiment that can directly test such a scenario favored by the LSND anomaly without having to rely on theoretical scaling assumptions. The JSNS^2 experiment successfully started its second physics data run from Jan 2021, which follows the first run with 10 days of data in June 2020. Based on the enlarged data set we can now improve upon background predictions presented at the last KPS meeting. Results will be shown in comparison to the previous background predictions in this poster. The focus of this presentation will be on the cosmic ray-induced background rate and detector stability for JSNS2.

Keywords:

JSNS2, background, J-PARC, Sterile neutrino, neutrino

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.115

Beam induced gamma background at the JSNS2

JUNG Da Eun *[1], YU I. [1], ROTT C. [1], JEON S. [1], JEON H. [1], ROELLINGHOFF G. [1], CHOI J.W. [2], JANG M.C. [2], JOO K.K. [2], KIM J.Y. [2], LIM I.T. [2], MOON D.H. [2], PARK R.G. [2], SHIN C.D. [2], ZOHAIB A. [2], CHOI J.H. [3], PAC M.Y. [3], YEO I.S. [3], JANG J.S. [4], KIM E.J. [5], LEE D.H. [6], GOH J. [7], LEE S. [7], YOO C. [7], KIM W. [8], JANG H.I. [9], KANG S.K. [10], CHEOUN M.K. [11]

[1]physics, Sungkyunkwan University
[2]Department of Physics, Chonnam National University
[3]Department of Radiology, Dongshin University
[4]Department of Physics, GIST
[5]Division of Science Education, Jeonbuk National University
[6]., High Energy Accelerator Research Organization, KEK
[7]Department of Physics, Kyung Hee University
[8]Department of Physics, Kyungpook National University
[9]Department of Physics, Seoyeong Univsersity
[10]School of Liberal Arts, Seoul National University of Science and Technology
[11]Department of Physics, Soongsil University
cowalker12@gmail.com

Abstract:

The purpose of the JSNS2 experiment is to search for sterile neutrinos with Δm2 near 1eV2. A 3 GeV J-PARC proton beam incident on a mercury target produces an intense neutrino beam from muon decay at rest which oscillates to anti-electron neutrinos. The JSNS2 detector is located at 24 m baseline from the target. The detector has a fiducial volume of 17 tons filled with GdLS, that efficiently can detect electron antineutrinos via the inverse beta decay reaction followed by a gamma signal from the captured neutron on Gd. The external gamma events induced by proton beam is one of the main backgrounds in sterile neutrino search. In this talk, we study beam related gamma background data taken in June 2020 and January 2021.

Keywords:

Beam background, JSNS2

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.116

e+e-→μ+μ-A' with A'→μ+μ-

PARK Kihong [1], CHO Kihyeon *[1]
[1]UST, KISTI
cho@kisti.re.kr

Abstract:

According to the theory[1], dark photon(A') can be coupled with any heavy charged leptons. Based on this theory, we studied dark photon with signal channel: e+e-→μ+μ-A' with the dark photon A'→μ+μ-. In this work, we studied various center of mass energies at the electron-positron colliders such as Belle II, FCC-ee, CEPC, and ILC. In a background study, we used the standard model decay. The final state is e+e-→μ+μ-μ+μ-. In the signal mode, we used simplified model[2] which includes dark matter particles and dark photon particles as well as the standard model particles. For this analysis, we used a stand-alone code with KISTI-5 supercomputer. At the generation level, we studied the cross-section depending on center of mass energy, dark photon mass, and coupling constant using MadGraph5. At the reconstruction level, we studied detector acceptance, invariant mass, and transverse momentum using MadAnalysis5.

REFERENCES

[1] B. Shuve, L. Yavin, Phys. Rev. D, 89, 113004 (2014). https://doi.org/10.1103/PhysRevD.89.113004
[2] D. Alves, N. Arkani-Hamed, S. Arora, Y. Bai, M. Baumgart, et al., J. Phys. G: Nucl. Part. Phys., 39, 105005 (2012). http://dx.doi.org/10.1088/0954-3899/39/10/105005

Keywords:

Dark matter, Dark photon, Electron-positron collider, MadGraph5, MadAnalysis5

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.117

Fast simulation for Dual-Readout calorimeter using GAN

PARK Inkyu *[1], LEE Sehwook [2], KIM Bobae [2], LEE Junghyun [2], KO Sanghyun [4], LEE Jason Sang Hun[1], RYU Minsang [1], WATSON Ian James[1], LEE Yunjae [1], KIM Doyeong [1], YOO Hwidong [3], HA Seungkyu [3], KIM Minsoo [3], HWANG Kyuyeong [3], EO Yun [3], KIM Sungwon [3]
[1]University of Seoul
[2]Department of Physics, Kyungpook National University
[3]Department of Physics, Yonsei University
[4]Department of Physics, Seoul National University
icpark@uos.ac.kr

Abstract:

The dual-readout calorimeter is designed with scintillating and Cerenkov fibers to measure electromagnetic and hadronic showers with high resolution. The dual-readout calorimeter simulation performed with GEANT4 requires a huge amount of computing time, leading to limited statistics for physics studies. The machine learning technique, Generative Adversarial Network (GAN) can provide a replaceable functionality and performance of the GEANT4 simulation, while reducing processing time significantly. We present the dual-readout calorimeter responses generated by GAN with the initial particle type and energy, and they are compared to GEANT4 simulation results.

Keywords:

Dual-readout calorimeter, KFC, GAN, Fast simulation, deep learning

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.201

Pulse shape discrimination analysis with COSINE-100

JU Han wool *1, LEE Hyunsu 2, KIM Kyungwon 2
1Physics & astronomy, Seoul National University
2Center for Underground Physics, IBS
hwjoo1240@gmail.com

Abstract:

In direct detection of WIMP dark matter particles, scintillation crystals such as NaI(Tl) are commonly used as targets/detectors. In these crystals, nuclear recoil events and beta/gamma-induced events can be discriminated based on their differences in scintillation characteristics. By using a so-called pulse shape discrimination (PSD) analysis, discrimination between WIMP-induced recoils and the background beta-gamma events can be possible.
To perform the PSD analysis, the responses of a NaI(Tl) crystal to nuclear recoils by neutron beam and electron recoils by 137Cs source were measured. A small NaI(Tl) crystal (2cm x 2 cm x 1.5 cm) from the same Alpha Spectra-grown ingot as one of a large crystal used for COSINE-100 experiment was chosen to suppress multiple scattering events in the crystal. The PSD analysis for the COSINE-100 WIMP search data was performed with the result of the small crystal.

Keywords:

Dark matter, NaI(Tl), PSD, COSINE

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.202

Background modeling for 4-years COSINE-100 data

YU Gyunho *1
1Physics, Sungkyunkwan University
tksxk752@naver.com

Abstract:

COSINE-100 is a direct dark matter search experiment that uses an array of scintillating NaI(Tl) crystals as a target/detector. The experiment started taking data in September 2016, and has been running stably ever since. We have fitted the NaI(Tl) crystals' measured energy spectra for about 4 years of data with a Monte Carlo simulation model that contains a variety of background components. Here, the modeling of background sources for the COSINE-100 WIMP search data will be presented.

Keywords:

dark matter , MC simulation, COSINE-100

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.203

Further lowering the COSINE-100 energy threshold to 0.5 keV using ^{22}Na calibration data

NEAL Robert John*[1]
[1]Centre for Underground Physics, IBS
rjneal@sheffield.ac.uk

Abstract:

COSINE-100 is a direct dark matter detection experiment that uses NaI(Tl) crystals to search for an annually modulating WIMP dark matter signal and test the positive dark matter signal reported by the DAMA/LIBRA experiment. In order to raise the detector sensitivity at COSINE-100 sufficiently to conclusively test the DAMA/LIBRA signal, the energy threshold must be lowered below the 1 keV threshold used by DAMA/LIBRA and currently used by COSINE-100. The goal for this is 0.5 keV. This will be achieved using data from a ^{22}Na calibration run in an updated boosted decision tree for event selection that has been trained to accept signal and reject noise below 1 keV. This poster will describe the ongoing efforts to achieve the 0.5 keV energy threshold, as well as associated studies using the ^{22}Na data, such as a measurement of the detector trigger efficiency at low energies.

Keywords:

Dark matter, WIMPs, COSINE-100, machine learning

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.204

Th-232 components alpha measurement of COSINE-100

LEE Hyunseok *1
1Basic Science, UST
gksmrf222333@naver.com

Abstract:

COSINE is a dark matter search experiment, aimed at the confirmation or refutation of DAMA/LIBRA's claim of an annual modulation signal. COSINE-100, which consists of eight NaI(Tl) crystals, has been taking data since September, 2016. Prior to the startup of data-taking, purification aimed at removing high mass radioactive contaminents was done, however an increase in some contaminent signals has been detected. We measure the time evolution of the quantity of Th-232 components over the past 3.5 years by counting the time-correlated events due to α-decays of Rn-220, with half-life 0.144 seconds, and its daughter Po-216. As a result, we have determined that Th-232 chain radioactive components have been increasing and seem to have been approaching an equilibrium level.

Keywords:

Th-232 chain, COSINE-100, Quenching factor, Alpha decay

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.205

Low temperature scintillation measurement of Czochrlaski grown pure NaI crystal

PARK Sedong [1], KHAN Arshad [1], KIM Hong Joo *[1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

For searching dark matter (weakly interacting massive particles), crystal scintillators are widely used as detectors. NaI(Tl) crystal is one of crystal scintillator used for dark matter search by DAMA, COSINE and ANAIS experiments. To improve the sensitivity limit, crystal scintillators with lower background and higher light yield are required. Since pure NaI crystal have a two times higher light yield than NaI(Tl) crystal at low temperature, therefore it can be a good candidate for low temperature dark matter search experiments. We studied the characteristics of pure NaI scintillator at low temperature to check its feasibility for dark matter search. The NaI single crystal was grown from high purity astro grade (99.999%, ultra low potassium) NaI powders by Czochrlaski technique in Pt Crucible at Ar atmosphere. Under X-ray excitation at room temperature the intrinsic luminescence peaking at 310 nm was observed. The light yield, alpha/gamma ratio, decay time and pulse shape discrimination in the temperature range of 10 K to 300 K was measured under γ-rays and α-particles excitations. In this talk, I will present the temperature dependent scintillation characteristic of pure NaI crystal.

Keywords:

scintillator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.206

Weighted K-mean clustering for localization of positronium annihilation

KIM Hong Joo *[1], JEGAL Jin [1], PARK Hyeoung Woo [1], JEONG Dong Woo [1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

A hermetic novel detector consisting of bismuth germanate crystal scintillators coupled with 400 channels silicon photomultiplier pixels has developed for positronium annihilation physics such as visible and invisible decay studies in rare decay, and C, CP, and CPT violation studies in discrete symmetries. The detector is a compact 4π detector capable of detecting gamma-ray decay in all directions at one go, enabling the study of visible and invisible exotic decay process by distinguishing the back-to-back 2-gamma ray of the singlet state with the triplet state. In this study, we investigate the use of a weighted k-mean clustering algorithm for predicting the initial positronium annihilation position. The 2-gamma system of the positronium annihilation caused by the radioactive source ^{22}Na and ^{18}F is simulated by GEANT4 and used for the dataset after preprocessing to energy cut. We discuss the applicability of the weighted k-mean clustering-based positronium annihilation reconstruction with an improvement of the spatial resolution by comparing conventional methods.

Keywords:

Positronium annihilation, Weighted k-mean clustering

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.207

Glass-Metal sealing for the development of SiPMT

KIM Hong Joo *[1], LEE Jik [1], NASIR Hamza [1], ANJUM Faizan [1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

We have been developing a new type of photodetector called Silicon photomultiplier tube (SiPMT) with a large area of photocathode that could be utilized in the photodetector array of the neutrino detector at the Korean Neutrino Observatory (KNO). For these vacuum-tube types of photodetectors, the vacuum-tight sealing of glass and metal is essential for vacuum and electrical connections. The glass and metal can be purely bound through chemical interaction. The presence of an oxide layer on the metal surface, during the interaction, results in strong sealing because a glass-oxide bond is stronger than a glass-metal bond. We present the method to produce a vacuum-tight sealing of glass and Kovar alloy as well as the characteristics of the oxide layer formed by the method. This method can apply to the fabrication of vacuum-tube-type photodetectors with photocathode.

Keywords:

SiPMT, Photocathode, Glass-Metal sealing, Oxidation of Kovar

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.208

Metal Photocathode fabrication and photocurrent measurement of SiPMT demonstrator

ANJUM Faizan [1], NASIR Hamza [1], LEE Jik [1], KIM Hong Joo [*1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

We are developing a new kind of photodetector called SiPMT, which could be used for neutrino detection in water-Cerenkov experiments. SiPMT is composed of a vacuum tube, photocathode, SiPM, and scintillator. Conventional photodetector like PMT has a series of dynodes that do the electron amplification while the SiPMT uses SiPM as the electron amplifier. The working principle of SiPMT is such that the incident photons hit the photocathode to generate photoelectrons, which are then accelerated due to potential differences between the photocathode and anode. The accelerated photoelectrons hit the scintillator and emit the light that the SiPM will detect. We have made a demonstrator to prove the principle of the SiPMT. We have chosen the silver metal as a photocathode for the demonstrator because silver is the most stable metal after gold and has a work function value of 4.28-4.74eV. Metal photocathodes are very robust and have fast response time and can be exposed to air for a short period. The problem with these photocathode types is that they have very low quantum efficiency, typically around 10^{-6} to 10^{-7}. Annealing can increase quantum efficiency up to 10^{-4} or 10^{-5}. This presentation reports the silver metal photocathode fabrication process, an alternative method to measure the photocurrent by using a pre-amp and shaping amp with an oscilloscope, and the calculation of quantum efficiency using the charge injection method.

Keywords:

Scintillator, photocathode, photodetectors, quantum efficiency, shaping amp.

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.209

Monte Carlo simulations of scintillation photons for a SiPMT detector prototype for KNO

정제경[1], JO Hyon-Suk *[1], KIM Hong Joo [1], LEE Jik [1]
[1]Department of Physics, Kyungpook National University
hyonsuk.jo@gmail.com

Abstract:

Monte Carlo simulations have been performed for a Silicon Photomultiplier Tube (SiPMT) prototype which is being developed as a detector candidate for KNO (Korean Neutrino Observatory), a project proposing a next-generation neutrino detector in Korea. This SiPMT prototype consists of a photocathode, a scintillator crystal, and a silicon photomultiplier (SiPM) in a vacuum tube. Incident light on the photocathode generates photoelectrons which induce scintillation light when reaching the scintillator crystal, and the scintillation photons are then detected by the SiPM. We performed Geant4 simulations of scintillation photons induced by electrons in a scintillation crystal, for different values of electron energy and scintillator thickness, aiming to optimize the detector design.

Keywords:

Monte Carlo simulations, Geant4, Scintillation photons, Neutrino, KNO

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.210

Characterization of bi-alkali and MCP Photomultiplier Tube

KIM Geon Woo [1], KIM Hong Joo *[1], LEE Jik [1]
[1]Department of Physics, Kyungpook National University
hongjoo@knu.ac.kr

Abstract:

The photomultiplier tubes(PMT) receives light from the glass surface and generates photoelectrons inside, and the photoelectrons are accelerated and amplified by the internal voltage. As a result, it is an optical sensor capable of sensitively measuring the number of photoelectrons. I measured the single photo-electron distribution of noise according to the voltage using a 2-inch PMT called H7195 of hamamatsu to parameterize the dependence of the gain on the voltage. And it was confirmed that the same gain parameter was stably displayed using the LED light source and the gamma ray source. Through the 20-inch large-area MCP-PMT, we will present the gain parameters in the same way and dark rate, peak to valley ratio, and other quantities measured with the MCP-PMT.

Keywords:

Bi-alkali PMT, MCP-PMT, PMT characterizaion

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.211

Neutrino Event Reconstruction in the KNO Detector

YU Seonghyeon *[1], YU Intae [1], KWON Eunhyang [1], SEO Jiwoong [1], HONG Jaejin [1], KIM Hyunsoo [2], JANG Jeeseung [3], LEE Youngmin [4], SHIN Bokkyun [5]
[1]Department of Physics, Sungkyunkwan University
[2]Department of Physics and Astronomy, Sejong University
[3]Department of Physics and Photon Science, GIST
[4]Department of Physics, KAIST
[5]Department of Physics, UNIST
savior63@naver.com

Abstract:

The KNO (Korean Neutrino Observatory) project has been discussed as a next-generation water Cherenkov neutrino detector because of its potential of making important discoveries such as CP violation, proton decays, and supernova neutrinos for the next several decades. To understand the detector performance, we have made an effort to make a neutrino event reconstruction tool. In this presentation, we introduce a step-by-step event reconstruction tool with MC data in the KNO detector.

Keywords:

KNO, neutrino, reconstruction

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.212

Reconstruction of low energy electron in the KNO detector

HONG JaeJin *[1], SEO JiWoong [1], YU SeongHyeon [1], KWON EunHyang [1], YU InTae [1], KIM HyunSoo [2], JANG JeeSeung [3], LEE YoungMin [4], SHIN BokKyun [5]
[1]Department of Physics, Sungkyunkwan University
[2]Department of Physics and Astronomy, Sejong University
[3]Department of Physics and Photon Science, GIST
[4]Department of Physics, KAIST
[5]Department of Physics, UNIST
jjhong96@gmail.com

Abstract:

The Korean Neutrino Observatory(KNO) has been proposed as a multi-purpose water Cherenkov detector and it is expected to observe secondary leptons from various astronomical neutrino sources. Due to its sensitivity at low-energy regions, the reconstruction method differs from the higher energy range. Electron energy can be reconstructed using the estimated number of photons from the PMT hit pattern. We present preliminary results of the low energy electron reconstruction over various water Cherenkov detector configurations.

Keywords:

KNO, Water Cherenkov Detector, Low energy electron, PMT hit distribution

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.213

Image processing analysis for machine learning applications in particle experiments

CHOI Ji Young [1], 김도연[1], 김병찬[1], 김예지[1], 송예성[1], 우희진[1], 최지원[1], JOO Kyung Kwang *[1]
[1]Department of Physics, Chonnam National University
kkjoo@chonnam.ac.kr

Abstract:

이미지 분석에서 특징 추출은 정해진 형상 혹은 가장자리 수치값을 통해 얻을 수 있다. 패턴 인식 단계에서는 수학적 모델에 정해진 판별 혹은 데이터 주도형 학습에 의한 판별에 따라, 통계적 학습 측면 혹은 기계 학습 측면이 좀 더 부각될 수 있다. 본 포스터에서는 차세대 중성미자 검출기 후보 물질과 중성미자 검출기 물질의 형광 사진에 대한 특징 추출과 이미지 분석을 검증된 컨볼루션 신경망을 이용해 알아보고 한다.

Keywords:

convolutional neural network, water-based liquid scintillators, alcohol-based liquid scintillators

P1-pa.214

Development of water-based liquid scintillators based on hydrophile-lipophile balance index

JOO Kyung Kwang *[1], WOO Heejin [1], 최지영[1], 김병찬[1], 최지원[1], 김예지[1], 김도연[1], 송예성[1], 박선영[1]
[1]Department of Physics, Chonnam National University
kkjoo@chonnam.ac.kr

Abstract:

액체섬광검출용액(liquid scintillator)은 입사 입자의 에너지를 받아 빛을 방출하는 물질로, 고에너지 물리학이나 의학물리 등 다양한 분야에 활용되고 있다. 액체섬광검출용액을 구성하고 있는 물질들의 비율을 조절함으로써, 여러 가지 물리 광학적 특성을 비교적 쉽게 변형시킬 수 있는 장점을 가지고 있다. 본 포스터는 친수성-친유성 밸런스에 기반한 물-기반 액체섬광검출용액을 소개하고, 최적화하는 과정을 살펴보았다.

Keywords:

liquid scintillator, 액체섬광검출용액, HLB

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.215

A Camera System for the calibration of the IceCube Upgrade.

CHRISTOPH Toennis *[1], CARSTEN Rott [1], KANG Woosik [1], ROELLINGHOFF Gerrit [1], LEE Jiwoong [1]
[1]Physics, Sungkyunkwan University
christoph.toennis@gmx.de

Abstract:

The IceCube neutrino observatory, located at the geographic south pole, has the currently largest volume amongst all underground neutrino detectors. IceCube observes neutrinos using Cherenkov light emissions from charged particles produced in neutrino interactions. The optical properties of Antarctic ice, a major uncertainty for event reconstruction in IceCube, has to be studied well to guarantee the good performance of IceCube and its planned extensions. A novel camera system will be integrated with the optical sensor modules of the IceCube upgrade to measure the properties of the local Antarctic ice. The Neutrino Astro Particle Physics Laboratory(NAPPL), located in Sungkyunkwan University(SKKU), is currently mass producing these camera systems. A total of 1051 cameras have been characterised and prepared for integration. We will present the final design of the camera system and a summary of characterisation of the cameras and improvements to the testing procedure.

Keywords:

IceCube, IceCube Upgrade

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.216

Understanding of Gaussian Shape Noise for the NEON experiment

CHOI Jaejin *1
1Department of Physics and Astronomy, Seoul National University
jjchoi1375@gmail.com

Abstract:

NEON (Neutrino Elastic-scattering Observation with NaI) aims at observing coherent elastic neutrino-nucleus scattering (CEvNS) using reactor anti-electron neutrinos impinging on NaI(Tl) crystal detectors at Hanbit nuclear power plant in Yeounggwang. Last year, we installed the detectors next to reactor 6 and have been taking data since last December. However, a new source of noise has been observed that worsens the data quality even the application of event selection requirements. We reproduced a new type of noise using the other detector in IBS HQ. The most probable origin of the noise is an electrostatic discharge that occurs when the PMT's metal casing accumulates an electrostatic charge. In the case of the NEON experiment, the Liquid scintillator contributes to the production of this noise. The poster elucidates where noise in the NEON experiment originates and strategies to eliminate it are discussed.

Keywords:

NEON, neutrino, CEvNS, reactor

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.217

Update of photon simulation for AMoRE-Pilot experiment

MAILYAN Bagrat *[1], JEON Eunju [1]
[1]Center for Ungerground Physics, IBS
bagrat@ibs.re.kr

Abstract:

Geant4 simulation toolkit has been extensively used for the AMoRE-Pilot experiment consisting of six $^{48dep}Ca^{100}MoO_4$ crystals located at the Yangyang underground laboratory. 2.6 MeV gamma-ray simulations are done including the generation of optical photons. In this work, we give an update on the photon simulations for AMoRE-Pilot and $^{48dep}Ca^{100}MoO_4$ -based scintillation detectors in general. By tuning the simulation parameters related to optical properties of the detector materials, using values from the literature survey and available measured data, we try to make comparisons with the light yield experimental data. From the experiment, we obtained that 0.6-1% of the energy from 2.6 MeV gamma-rays is observed by the light detector in the form of optical photons. However, the result of our simulations is 2-4 times less. This can be attributed to many not well-known properties of the $^{48dep}Ca^{100}MoO_4$ at mK temperatures. However, by varying the detector design, we show that the light collection efficiency can be improved by ~20% after decreasing the distance between the crystal and the light detector in comparison to the current design.

Keywords:

AMoRE, Underground experiment, Monte Carlo simulations, Light detector

^{210}Pb background simulation from lead shield for AMoRE-II

SEO Jeewon [1], JEON Eun Ju *[2], LEE Moo Hyun [2,1]
[1]IBS school, University of Science and Technology
[2]Center for Underground Physics, Institute for Basic Science
ejjeon@ibs.re.kr

Abstract:

AMoRE-II (AMoRE phase-II) is next phase of the AMoRE searching for neutrinoless double-beta decay of ^{100}Mo isotopes using ~100 kg of ^{100}Mo enriched (~96.5%) molybdenum contained in cryogenic detectors. In order to reach the goal of 10^{-5} background events/keV/kg/year, various shield materials will be installed. The lead blocks for the neutron shield will be placed at the inner and outer areas of the cryostat. Inside of the lead shield, ^{210}Pb isotopes will decay and make the background signals. This study aims to find the event rates from different types of lead blocks. We performed a Geant4 simulation to estimate the event rates and obtain event rates from the random coincidence between ^{210}Pb background and two-neutrinos double beta decays. Details of the study will be presented.

Keywords:

Underground experiment, Geant4 simulation, 210Pb background, AMoRE experiment

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.219

Low-energy background study for AMoRE-Pilot

JEON Eun Ju *[1], SARI Mona Berlian[1,2], KIM HongJoo [3], DJAMAL Mitra [2]
[1]Center for Underground Physics, Institute for Basic Science
[2]Department of Physics, Bandung Institute of Technology
[3]Department of Physics, Kyungpook National University
ejjeon@ibs.re.kr

Abstract:

The Advanced Mo-based Rare process Experiment (AMoRE) is an experiment for neutrinoless double-beta decay search of ^{100}Mo using molybdate crystals. The AMoRE experiment requires extremely low radioactive background contributions from crystals and detector materials. Therefore, to increase the half-life sensitivity of neutrinoless double beta decay, understanding the background contributions and their effects is mandatory. This study describes the background contribution in low-energy. A prominent peak around 46.5 keV from the decay of ^{210}Pb to ^{210}Bi is studied. In addition to that, the lead characteristic X-ray peaks around 75 keV and 85 keV from the interaction of gammas with lead material by photoelectric effect are also studied. We conducted the Monte Carlo simulation by GEANT4 Toolkit and compared it to the low energy data to have a better understanding of the backgrounds in the low energy region. Details of these studies are presented in this poster.

Keywords:

AMoRE, background modeling, GEANT4, Low energy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.220

PSD study using rise times of the heat signals

WOO Kyungrae *[1,2], LIM HoSeong [2,3]
[1]Institute for Basic Science, UST
[2]Center for Underground Physics, Institute for Basic Science
[3]Department of Physics, Kongju National University
krwoo@ust.ac.kr

Abstract:

AMoRE (Advanced Mo-based Rare process experiment) is an international project to search for neutrinoless double beta decay (0νββ) of 100Mo in Mo-based enriched scintillating crystals with the use of metallic magnetic calorimeters (MMCs) in a mK-scale cryogenic system. Probing neutrinoless double beta decay signals requires clear particle identification capability to discriminate alpha-induced events from beta-induced ones. We studied the pulse shape differences between alpha and beta signals measured in the AMoRE-I composed of CaMoO4 and Li2MoO4 crystals with MMC readouts. The values of discrimination power (DP) were investigated using various definition of signal rise-time as a PSD parameter. We present the optimal PSD parameters with their corresponding DP values for the CaMoO4 and Li2MoO4 crystals.

Keywords:

AMoRE, neutrinoless double beta decay, Discrimination Power (DP), rise-time, PSD

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pa.221

Scintillation decay time study from AMoRE-I signals of CMOs and LMOs

WOO Kyungrae *[1,2]
[1]Institute for Basic Science, UST
[2]Center for Underground Physics, IBS
krwoo@ust.ac.kr

Abstract:

The advanced Mo-based rare-process experiment (AMoRE) is an underground cryogenic particle detection experiment searching for neutrinoless double beta($0\nu\beta\beta$) decay of ^{100}Mo. The experiment uses scintillating crystals composed of enriched ^{100}Mo isotopes as the target material for simultaneous detection of phonon and scintillation signals with MMC readouts at mK temperatures. AMoRE-I has been carrying out with thirteen $^{40}Ca^{100}MoO_4$ and five $Li_2{}^{100}MoO_4$ crystals at Yangyang underground laboratory. This study compares and analyzes the scintillation characteristics of two types of crystals through light signals and discusses how these properties relate to Pulse Shape Discrimination(PSD).

Keywords:

Scintillation decay time, AMoRE, double beta decay, neutrino, majorana

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.101

Modeling a numerical dispersion free in the longitudinal direction for PIC

CHO Myung Hoon *[1], KIM Minseok [1], NAM Inhyuk [1]
[1]Pohang Accelerator Laboratory
mh0309@postech.ac.kr

Abstract:

We present a field solver for the numerical dispersion free in the longitudinal axis which is realized in a particle-in-cell code called 'JOPIC'. The field solver introduces P-polarized and S-polarized variable by re-organizing Maxwell equation. Mathematical anlysis of the new field solver addresses PIC simulations show exact calculations in the wave axis. The field solver is applied both of Cartesian and Fourier-expanded Cylindrical geometry. Validity of the new scheme has two major advantages of simulating the exact laser group velocity and electron beam propagation. Even in considering numerical errors in minor scale, applications of the laser wake-field acceleration and the electron beam generation are quite sensitive depending on low plasma density and low beam emittance. Some examples of laser-plasma interaction and electron beam propagations are presented to show the importance of exact calculations.

Keywords:

PIC, numerical dispersion, LWFA

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.102

Non-equilibrium clustering and droplet formation in supercritical fluids and their effects on the laser-produced plasmas

LEE Juho [1], LEE Seungtaek [1], KIM Dong Eon [1,3], YUN GUNSU *[1,2]
[1]Department of Physics, POSTECH
[2]Division of Advanced Nuclear Engineering, POSTECH
[3]Max Planck POSTECH/KOREA research Initiative, Max Planck Center for Attosecond Science
gunsu@postech.ac.kr

Abstract:

For the first time, a transient coexistence of liquid-like (LL) and gas-like (GL) phases in supercritical fluid (SCF) is experimentally demonstrated. A dense population of submicron size LL droplets and smaller size clusters is created through a compression-expansion process and persists over an hour while floating in a GL SCF. The existence of the LL package in the GL background reveals a non-equilibrium phase separation of SCFs. Such a prolonged survival of LL droplets in GL fluid is explained by a mass transport mediated by the clusters. Our observation is an intriguing non-equilibrium phase separation phenomenon in SCFs, distinct from the recent understanding of the phase transitions across the Widom line and the Frenkel line.

Furthermore, we found that the long-lived LL droplets affect the energy transport process within the plasma generated by a high-power Nd:YAG laser (1064 nm, 6 ns, 900 mJ, peak intensity ~ 1 TW/cm^2). The laser-produced jet-like plasma is a blackbody with a high enough electron density to absorb the plasma radiations. The blackbody radiation intensity increases with higher density of clusters (and droplets), suggesting that the clusters slow down the energy transport in the plasma. Meanwhile, an intense emission is observed from the surface of the droplets. The surface charging is expected to play an essential role in energy storage and release (via recombination with the ions) similar to the dust particles in a dusty plasma.

*Work supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (No. 2019R1A2C3011474 and 2016K1A4A4A01922028) and Ministry of Education (No. 2019R1A6A3A13091407).

Keywords:

Supercritical fluid, Non-equilibrium phase separation, laser plasma, dusty plasma

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.103

Development and characterization of 1 TW Ti:sapphire laser amplifier for THz-wave generation.

PHUNG Vanessa Ling Jen [1], JEON Seongjin [1], KANG Keekon [1], ROH Kyungmin [1], KIM Jinju [1], SUK Hyyong [*1]
[1]Dept. of Physics and Photon Science, GIST
hysuk@gist.ac.kr

Abstract:

Since the invention of the chirped-pulse amplification (CPA) technique in 1985, the development of high power laser systems has been extensive. In this work, we will present the development of a compact Ti:sapphire laser amplifier system in Laser Plasma Acceleration Laboratory (LPAL) at GIST, generating intense laser pulses with a peak power of > 1 TW, a pulse duration of 34 fs, a central wavelength of 800 nm, and a repetition rate of 10 Hz. The laser amplifier system consists of a mode-locked Ti:sapphire oscillator, a regenerative amplifier, and a single-side-pumped 4-pass amplifier. The CPA-based laser amplifier provides an energy of 49 mJ after compression by gratings in air, where the pumping fluence of 1.88 J/cm^2 was used. The ASE (amplified spontaneous emission) level was measured to be lower than 10^{-7} and ps-prepulses were in 10^{-4} or lower level. The developed laser amplifier system will be used for laser-plasma-based THz source generation research.

Keywords:

laser amplifier, Ti:sapphire laser, THz radiation, CPA laser

P1-pl.104

K-shell emission spectroscopy of Si nanowire array plasmas

CHO Byoung Ick *[1,2], SOHN Janghyeob [1], KANG Gyeongbo [1,2], LEE Gyusang [1,2], LEE Chang Hoo [1], CHO Min Sang [1]
[1]GIST
[2]Center for Relativistic Laser Science, IBS
bicho@gist.ac.kr

Abstract:

Nanowire arrays are known as efficient light absorbers which can create very hot near-solid-density plasma in the interaction with a high-power laser. The K-shell spectra of silicon nanowires heated by high-contrast(~10^{11}) femtosecond laser pulses of ~2 J energy and ~10^{20} W/cm^2 intensity have been investigated in the 1.70 – 2.08 keV energy range. The spectra of Si nanowire plasma are successfully reproduced using the simulation code FLYCHK with a bulk electron temperature of 500 eV and electron density of 4x10^{23} cm^{-3}. The nanowire targets promise to create high-energy-density plasma with only a few J of laser energy and may also generate KK hollow atoms, which require a strong x-ray radiation field.

Keywords:

nanowire, K-shell spectra, hollow atom, radiation field, high-energy-density

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.105

Laser induced plasma in a helium gas flow at atmospheric pressure

TRAN Tuyen Ngoc[1], LEE Wonwook [1,2], OH Cha-Hwan [*1]
[1]Hanyang University
[2]Research Institute of Natural Sciences, Hanyang University
choh@hanyang.ac.kr

Abstract:

Laser-induced plasma (LIP) is a phenomenon in which substances are ionized by a focused high energy laser beam as the vaporization and excitation source. LIP configuration was developed to produce plasma in helium gas flow. Nanosecond Nd:YAG pulse laser at 532 nm and 1064 nm was adapted as the excitation source. The laser beam was delivered and focused in the helium gas flow which was controlled by a gas mass flow controller. A lens system and an optical fiber were used to collect the emission light from the plasma. A portable spectrometer was selected to measure the plasma spectra. LIP was produced in He gas flow at atmospheric pressure. The emission spectra were measured and analyzed with the gas flow rate adjusted from 0.5 – 10 LPM. Characteristics of plasma were discussed when two different laser lights with wavelengths of 532 nm and 1064 nm were used.

Keywords:

Laser-induced plasma, helium plasma, atmospheric pressure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.107

Electromagnetic-Mechanical Coupled Analysis of Half-Wave Resonator for KOMAC Proton Linac

DANG Jeongjeung *[1], KWON Hyeok-Jung [1], KIM Han-Sung [1], LEE Seung-hyun [1], CHO Yong-Sub [1]
[1]KAERI
jjdang@kaeri.re.kr

Abstract:

A superconducting RF cavity has been studied at KOrea Multi-purpose Accelerator Complex (KOMAC). This SRF cavity is developed for increasing the proton beam energy from 100 MeV to 200 MeV. The type of cavity is a half-wave resonator (HWR) and its diving frequency is 350 MHz. The HWR is designed to provide a 3.6 MV accelerating voltage for the proton beam energy upgrade. In this study, an electromagnetic and mechanical coupled analysis was conducted. Effects of mechanical deformations of the cavity by a helium pressure or a Lorentz force on the resonance frequency of the HWR were estimated. Also, design improvements to reduce these frequency detuning effects are introduced.

Acknowledgments
This work has been supported through KOMAC operation fund of KAERI by the Korea government (MSIT).

Keywords:

Proton accelerator, Superconducting accelerator, Superconducting Radio Frequency (SRF), Half Wave Resonator (HWR)

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.108

Preliminary optimization study of superconducting linac for KOMAC proton linac energy upgrade to 1 GeV

LEE Seunghyun *[1], KWON Hyeok-Jung [1], DANG Jeong-Jeung [1], KIM Han-Sung [1], CHO Yong-Sub [1]
[1]KOMAC, KAERI
shl@kaeri.re.kr

Abstract:

Korea Multipurpose Accelerator Complex has a goal to build a 1 GeV, 20 mA proton linac for a neutron spallation source in future. Superconducting resonating cavities such as a half wave resonator, medium and high beta elliptical cavities are opted for the 100 MeV ~ 1 GeV proton acceleration. With the given accelerating gradients and realistic component dimensions and spacings, an optimization is performed to achieve the shortest linac. The geometrical beta, number of cells and transition energies were compared among the family of cavities, and we selected the optimal combination of parameters which gives the shortest linac length.

Keywords:

proton linac

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

1 MeV/n 고주파 사중극의 저출력 고주파 특성 시험

KIM Han Sung *[1], KWON Hyeok-Jung [1], DANG Jeong-Jeung [1], KIM Kyung-Hyun [1], JUNG Won-Hyeok [1], KIM Dong-Hwan [1], CHO Yong-Sub [1]
[1]KOMAC, KAERI
kimhs@kaeri.re.kr

Abstract:

한국원자력연구원 양성자과학연구단에서는 가속기 기반 중성자원 및 고속 중이온 응용을 위해 핵자당 1 MeV까지 가속이 가능한 고주파 사중극(Radio-Frequency Quadrupole, RFQ)을 개발 중이다. 개발 중인 RFQ는 4 vane-type이며 운전주파수는 200 MHz이다. 진공 브레이징을 통해 조립된 RFQ에 대해 저출력 고주파 특성 시험을 수행하였다. 주파수 스펙트럼 및 무부하 Q값을 측정하였으며 장분포 측정 및 튜닝을 위해 bead-pull 측정을 수행하였다. 본 연구에서는 1 MeV/n RFQ의 저출력 고주파 특성 시험 결과에 대해 발표한다.

본 연구는 과학기술정보통신부 연구비 지원을 받았음.

Keywords:

RFQ, KOMAC, RF tuning, RF property

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.110

KOMAC 양성자가속기의 200 MeV 에너지 업그레이드를 위한 고주파 증폭기 운전값 분석

KWON Hyeok-Jung *[1], KIM Han-Sung [1], JEONG Hae-Sung [1], DANG Jeong-Jeung [1], LEE Seunghyun [1], CHO Yong-Sub [1]
[1]KOMAC, KAERI
hjkwon@kaeri.re.kr

Abstract:

한국원자력연구원 양성자과학연구단에서는 200 MeV 에너지 업그레이드를 위하여 초전도 기반 Half-wave resonator (HWR)을 설계중에 있다. 이의 고주파 시스템으로는 350 MHz Solid state amplifier (SSA) 기반의 고주파 증폭기를 선택하였으며, HWR 1기당 1기의 SSA 시스템을 고려하고 있다. 초전도 가속기의 경우 여러 가지 섭동에 대한 제어 마진을 고려하여 고주파 증폭기의 운전값을 설정해야 한다. 본 연구에서는 HWR cavity 섭동에 의한 효과와 고주파 증폭기 운전값 그리고 이에 따른 고주파 제어 한계에 대해서 논한다.

본 연구는 과학기술정보통신부 연구비 지원을 받았음.

Keywords:

양성자가속기

핵융합 재료 표면 분석을 위한 KAHIF 기반 이온빔 분석의 타당성 기초 연구

CHO Yong-Sub *[1], HUH SungRyul [1], CHANG Dae-Sik [1], KIM Kye-Ryung [2], LEE Dong Won [1]
[1]Nuclear Physics Application Research Division, KAERI
[2] KOMAC, KAERI
choys@kaeri.re.kr

Abstract:

한국원자력연구원은 다양한 중이온을 핵자당 1 MeV까지 가속할 수 있는 선형 가속기를 기반으로 한 KAERI 중이온 시설 (KAHIF)를 운영하고 있다. 선형 가속기의 장점인 대전류 특성을 활용하여 주로 핵융합 재료의 방사선 조사 손상 연구에 사용되고 있다. 수십 ~ 이백 MeV의 중이온을 얻을 수 있는 장점을 활용하여 핵융합 재료에 대한 이온빔 분석의 타당성에 대해 검토하였다. ERDA (Elastic Recoil Detection Analysis)는 시료 표면의 원소 조성 및 깊이 분포를 얻기 위한 이온빔 분석의 일종으로, 가속된 이온에 의해 튕겨 나오는 시료의 표면 원자를 측정한다. 특히 중이온을 사용하는 경우 a) 가벼운 원소에서 무거운 원소까지 동시에 측정 할 수 있고, b) 모든 원소에 대해 높은 감도로 측정 할 수 있고, c) 낮은 이온 빔 강도로 측정 할 수 있다는 장점이 있다. 일반적으로 아이오딘과 같은 무거운 원소를 음이온으로 만들어 탄뎀 가속기로 가속하여 분석에 사용하는데, 수십 MeV의 이온빔을 얻기 위해 수 MV 탄뎀 가속기가 사용된다. KAHIF의 경우 제논을 가속하면 130 MeV의 빔을 얻을 수 있으며, 이 빔으로 ERDA를 수행하면 다양한 분야의 박막에 대해 깊이 방향의 원소 조성 분석이 가능하다. 특히 핵융합 분야에서는 플라즈마 대향 재료에 포함된 수소, 중수소, 붕소, 탄소, 질소, 몰리브데넘, 텅스텐 등 다양한 원소를 동시에 분석 할 수 있어 핵융합 연구에 많은 기여를 할 것으로 기대된다. 기존 시료 조사 챔버에 ERDA용 입자 검출기를 추가하고 분석 성능 향상을 위해 ToF (Time-of-Flight) 장치를 추가하는 타당성 결과를 제시한다.

Keywords:

KAHIF, 이온빔 분석, ERDA

beta = 0.3 부근에서 HWR과 SSR의 공학적 관점에서의 비교

CHO Yong-Sub *1
1Nuclear Physics Application Research Division, KAERI
choys@kaeri.re.kr

Abstract:

beta = 0.3 부근의 양성자 또는 중이온을 가속하기 위한 초전도 가속관으로 HWR (Half Wave Resonator) 와 SSR (Single Spoke Resonator)를 들 수 있다. 두 종류의 가속관은 빔동력학 측면에서는 두개의 가속 갭을 갖는 반파장의 TEM 모드 공동으로 별다른 차이가 없다. 하지만 실제 가속기의 제작을 위해서는 공학적 관첨에서의 검토가 필요하므로, 단순화된 모델을 이용하여 두 가속관을 비교하였다. 두 가속관의 부피를 비교한 결과 SSR이 HWR에 비해 70% 크며, 이로 인해 저온모듈 내의 더 많은 공간을 차지하여, 결과적으로 더 큰 저온모듈을 필요로 하게 된다. 또한 더 많은 질량이 냉각되어야 하므로, 극저온냉각시스템에도 더 많은 부하를 가하게 된다. 표면적을 비교하면 SSR이 HWR에 비해 40% 커서 니오븀 판재가 더 소요되므로, 재료비 상승으로 이어지게 된다. 구조적으로 HWR은 자연스러운 동축 구조로 외부 압력에 대해 매우 안정된 형태이나, SSR은 빔축 방향의 구조적 취약성을 보강하기 위한 보강재가 많이 요구되어 제작에 어려움이 따르게 된다. 초전도 가속관의 경우 내부 표면 처리가 매우 중요하나, 제한된 관통부로 인해 쉽지 않다. HWR의 경우 동축 구조로 비교적 처리가 용이한 반면, SSR의 경우 처리가 어려워 실패의 확률이 높아지게 된다. 제작이 완료된 이후 마지막 주파수 튜닝 공정에서 HWR은 가상 용접 등의 방법으로 용접 부위의 손상을 방지할 수 있으나, SSR의 경우 소성 변형에 의존하게 되어 용접 부위 손상의 확률이 높은 단점이 있다. 이러한 공학적 관점에서의 비교 결과 beta = 0.3 부근에서는 SSR보다 HWR 초전도 가속관을 사용하는 것이 유리함을 알 수 있다.

Keywords:

초전도 가속기, HWR, SSR

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.113

SASE FEL intensity enhancement by considering impact of self-seeding section on the micro-bunching in the electron beam

SHIM Chi Hyun *[1]
[1]Accelerator Control Team, Pohang Accelerator Laboratory
sch0914@postech.ac.kr

Abstract:

Most of XFEL facilities have utilized the self-seeding section, which is generally installed in the middle of undulator line,to increase the spectral intensity and the longitudinal coherence. When the SASE FEL is on operation, however, the self-seeding section can disrupt the lasing process of the SASE FEL. Micro-bunching structure in the electron beam, which has been developed along the unudlator line before the section, can be collapsed by the linear longitudinal dispersion of the drift space. In this presentation, we discuss about the impact of self-seeding section on the SASE FEL intensity with GENESIS simulation results. Also, the experimental results will be showed.

Keywords:

SASE FEL, PAL-XFEL

Design study for the re-buncher system of KoBRA experimental facility

LEE Yumi [1], KIM Eun San *[1], JANG Siwon [1], BAHNG Jungbae [1], JIN Hyunchang [2], JANG Ji-Ho [2], SHIN Taeksu [2]
[1]Department of Accelerator Science, Korea University
[2]Rare Isotope Science Project, Institute for Basic Science
eskim1@korea.ac.kr

Abstract:

KOrea Broad acceptance Recoil spectrometer & Apparatus (KoBRA) is the low energy experimental facility at the end of the SCL3 in the heavy ion accelerator complex RAON. Two re-buncher structures with interdigital H-mode are selected for beam longitudinal focusing at transfer beam line between SCL3 and KoBRA. A main design requirement of the re-buncher cavity is to reduce the total power consumption because the re-buncher will be operated in continuous wave (CW) mode. The parameters of geometry and figure of merit for the re-buncher cavity are determined from the EM and thermal simulation results. The detailed design of 162.5MHz re-buncher results and main parameters will be presented.

Keywords:

Re-buncher, IH-DTL, KOBRA, RAON, heavy ion accelerator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.115

Optical emission spectroscopic analysis of plasma properties in the 2.45 GHz microwave ion source for the KOMAC

KIM Dong-Hwan [1,2], DANG Jeong-Jeung [1], KWON Hyeok-Jung *[1], KIM Han-Sung [1], CHOE Kyu-Min [1], KIM Dae-Il [1], JUNG Won-Hyeok [1], CHUNG Kyuong-Jae [2], HWANG Yong-Seok [2]
[1]KOMAC, KAERI
[2]Department of Nuclear Engineering, Seoul National University
hjkwon@kaeri.re.kr

Abstract:

Microwave ion source has been adopted to produce high-current proton beams in the Korea Multi-Purpose Accelerator Complex (KOMAC). The extractable ion current is generally proportional to the product of electron density and the square root of electron temperature. These plasma properties also affect the beam formation along with the extraction electric field strengths and shapes. Therefore, the characterization of plasma properties is essential for obtaining high-current and low-emittance beam with a matched beam optics. Optical emission spectroscopy (OES) is performed as a non-invasive hydrogen plasma diagnostics. The OES analysis is carried out to estimate electron density and electron temperature by comparing the measured line ratios to the theoretically derived ones from a collisional radiative (CR) model. This study presents experimental setups and estimated plasma properties at various plasma operating conditions.

Keywords:

Microwave ion source, Plasma properties, Optical emission spectroscopy, Line ratio

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.116

A brief overview of accelerator-driven neutron sources, and the applications of neutron instruments

LEE Pilsoo *1
1Korea Multi-purpose Accelerator Complex, KAERI
pilsoolee@kaeri.re.kr

Abstract:

Neutron source is a keystone in neutron science, the capabilities of neutron instruments largely depend on the performance of the neutron source in a neutron-science facility. Therefore, accelerator-driven neutron-science facilities in the world have dedicated neutron-target systems, which are optimized for their own driving accelerators and science goals. In this presentation, the characterizations of the neutron sources and corresponding neutron-target systems in SINQ, ESS, ISIS, LANSCE, SNS, J-SNS, RCNP, and C-SNS are summarized and reviewed. Besides the performance of the hardware, in the case of SNS at ORNL (Oak Ridge National Laboratory) and ISIS at RAL (Rutherford Appleton Laboratory), recent scientific publications are reviewed in the aspect of neutron instrument suite for understanding the matter of interest and concern in neutron-science society.

Keywords:

neutron source, neutron instrument, neutron target system

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.201

Shearing rate of ExB vortex flow in a magnetic island

HAHM Taik Soo *1, KIM Yong Jik 1, DIAMOND Patrick 2, CHOI Gyung Jin 3
1Seoul National University
2Center for Astrophysics and Space Sciences, UCSD
3Department of Physics and Astronomy, UC Irvine
tshahm@snu.ac.kr

Abstract:

We have derived the ExB shearing rate associated with vortex flow inside a macroscopic magnetic island (MI) in toroidal geometry. Due to the elongation of the MI and incompressibility of the ExB flow, the shearing rate near X-points is much lower than that near the mid-plane (x-axis of the local Cartesian coordinate) of the MI on the same flux surface. Furthermore, the rate formally vanishes at the X-points where the local poloidal magnetic field associated with the MI vanishes. This calculation of ExB shearing profile [T.S. Hahm et al., Phys. Plasmas 28, 022302 (2021)] and, in particular, minimal ExB shear near the X-points is consistent with the recent experimental finding that turbulence tends to spread into an MI through regions around the X-points [K. Ida et al., Phys. Rev. Lett. 120, 245001 (2018)].

Keywords:

Turbulent flows, Plasma confinement, Tokamaks, Magnetic islands, E × B flow shear

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.202

Analysis of divertor heat load in large-scale Tokamaks

RA Ookjoo [1], KWON Kyu Been [1], HUR Min Sup *[1]
[1]Physics, UNIST
minshur@daum.net

Abstract:

Over the decades, there have been remarkable achievements in fusion research. For the demonstration of high-power, ITER- or K-DEMO-class fusion reactors as practical power generators, the issues of removing heat flux and impurities loaded on the divertor target should be resolved. K-DEMO (initiated in 2012) is characterized by the major and minor radii of 6.8 and 2.1 m. This size is significantly different from the currently operating KSTAR with major and minor radii of 1.8 and 0.5m. Such differences will affect the heat flux and particle flux imposed on the divertor target. There have been studies using two-points-analysis of upstream and downstream in edge plasmas in several different Tokamaks. However, research on the effects of different Tokamak scales on the divertor heat load have not been conducted in detail. In this study, we compare and analyze various divertor target designs in large-scale and high-power tokamaks. These studies were conducted using the SOLPS-ITER package.

Keywords:

Tokamak, SOLPS-ITER, Divertor

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.203

Automated postprocessing and distribution of big image data on the KSTAR tokamak

KIM Dong Kwon [1], LEE Jieun [1], CHOI Minjun Jung[2], LEE Jaehyun [3], YUN Sangwon [4], YUN GUNSU *[1]
[1]Department of Physics, POSTECH
[2]MHD Stability Research Team, KFE
[3]Pedestal Stability Research Team, KFE
[4]KSTAR Control Team, KFE
gunsu@postech.ac.kr

Abstract:

The electron cyclotron emission imaging (ECEI) system installed on the KSTAR tokamak is capable of resolving MHD-scale instabilities and turbulence. Although the ECEI data contain rich physics information, the data utilization has been hampered by the time-consuming manual processing of the raw data that contain unwanted background signals and system noises. An automated postprocessing code has been developed to cope with the increasing demand for 2D ECEI images. The code performs the following duties in sequence for each plasma discahrge: (1) Download the large-size raw ECEI data stored in a remote server, (2) Postprocess the raw data and generate 2D images with a virtual frame rate of 100 Hz, (3) Compress and upload the images to the remote server. The 10 Gbps KERONET network enables the whole process to be completed in 5 minutes, facilitating fast dissemination of the postprocessed images. Step (2) is based on the threshold filtering method, capable of removing low-intensity frequency components without manual filtering. By parallelization and optimization of the code, the postprocessed ECEI images can be looked up at the KSTAR data integration system within the inter-shot period. This work is supported by NRF of Korea under grant no. NRF-2019M1A7A1A03088456.

Keywords:

KSTAR, ECEI, Data postprocessing, Threshold filtering, KSTAR data integration system

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.204

Impact of Nitrogen seeding location in KSTAR PFC upgrade

KWON KyuBeen [1], LEE Hyung Ho [2], RA Ookjoo [1], HUR Min Sup *[1]
[1]Physics, UNIST
[2]Pedestal Stability Research Team, KFE
minshur@daum.net

Abstract:

Abstract:
Enhanced volumetric power loss by impurity radiation is required in KSTAR as the gradual upgrade of the heating system is being planned [1]. The power losses for two different locations of impurity seeding were compared for the KSTAR PFC upgrade geometry: one is at the inner target on the high field side (HFS) and the other is at the outer target on the low field side (LFS). Each seeding location at the vicinity of the strike point is modeled using the SOLPS-ITER code. Nitrogen is considered as the low Z radiator and hence is useful to avoid excessive core radiation loss preserving power loss near the target. Note that the fractional impurity level is characterized by the separatrix-averaged relative ion impurity concentration [2]. For both seeding locations, the radiation loss by Nitrogen contributed to the volumetric power loss leading to the detachment. Nevertheless, we found that the impact of Nitrogen seeding location is low for the KSTAR PFC upgrade geometry. This weak impact of seeding location is in agreement with the results of SOLPS 5.0 simulations for ASDEX Upgrade [3]. Little differences in the heat flux loads and in the electron temperatures at the target were observed. Only the distance of the seeding location from the strike point was moderately effective in the electron temperature profile at the outer target. We also found that the fueling efficiency of the Nitrogen puff on the HFS is higher than that on the LFS with a gap of less than 10% for the fixed seeding rate.

Reference:

[1] H.K. Park et al 2019 Nucl. Fusion **59** 112020
[2] R.A. Pitts et al 2020 Nucl. Mater. Energy **20** 10069
[3] F. Hitzler et al 2020 Plasma Phys. Control. Fusion **62** 085013

Keywords:

SOLPS, Divertor, Detachment, Nitrogen, Seeding location

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.205

Implementation and Simulation of NTM Stabilizing EC mirror Controller Via Minimum Seeking Method for Island Width Growth Rate

CHA MinSoo [1], WOO Minho [2], HAHN Sanghee [2], NA Yong Su *[1]
[1]Nuclear Engineering, Seoul National University
[2]KSTAR research center, Korea Institute of Fusion Energy
ysna@snu.ac.kr

Abstract:

We report the ongoing development of neoclassical tearing mode(NTM) stabilization scheme in the Korea Superconducting Tokamak(KSTAR) by utilizing the minimum seeking control for 'the island width growth rate', which is defined as dW/dt. A concept of the minimum island width growth rate seeking method was proposed for the real-time feedback control of the NTM by using electron cyclotron heating device (ECH)[1]. In this work, the ECH mirror controller[2] based on the minimum island width growth rate seeking method is implemented in the Plasma Control System(PCS) for the KSTAR. To verify the performance of this algorithm, several modules are implemented in the KSTAR simulation sever (Toksys simulator)[3]. They include 1) ECH mirror simulator to get mirror response, 2) Modified Rutherford Equation (MRE) solver to get island evolution response, and 3) resulting mirnov diagnostics data for the current perturbation causing the magnetic island. The response of the ECH mirror to the PCS command is measured in a real mirror control experiment in vacuum, and it is reproduced by a simulator with a PID controller. With the response from the mirror, the MRE solver calculates an evolution of the magnetic island including the effect of local current drive by ECH. The updated island width is converted to the mode amplitude in terms of the helical current perturbation and again converted to magnetic field measured by the mirnov coil diagnostics. For the robustness, about 10% of noise is added to the mode amplitude signal. The result shows full suppression of neoclassical tearing mode, verifying an effectiveness of the minimum island width growth rate seeking controller.

References:
[1] M. Kim et. al, Nuclear Fusion, Volume 55, January 2015, 023006
[2] M. Jung et. al, Fusion Engineering and Design, Volume 151, February 2020, 111395
[3] Sang-hee Hahn et. al, Fusion Engineering and Design, Volume 89, Issue 5, May 2014

Keywords:

minimum seeking controller, neoclassical tearing mode, KSTAR PCS, island width growth rate, Toksys simulator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.206

Inference of spatially continuous kinetic profiles with Gaussian processes and neural networks in KSTAR

KIM Minseok [1], JOUNG Semin [1], KO W.H. [2], LEE J.H. [2], GHIM Young Chul *[1]
[1]KAIST
[2]Korea Institute of Fusion Energy, KFE
ycghim@kaist.ac.kr

Abstract:

As a pressure profile in a tokamak is an important parameter for solving the Grad-Shafranov equation [1], having the profile in a continuous spatial domain can increase the validity of the solution. Thus, we infer the continuous profiles by applying Gaussian process on spatially discrete profiles of KSTAR discharges obtained by the charge exchange system (CES) and the Thomson scattering (TS) together with their uncertainties. Results of Gaussian process depend on the types of kernel functions [2], and we use Gibbs kernel to embrace typically observed gradient scale lengths of the pedestal [3] in KSTAR H-mode discharges. With an aim of real-time availability, the inferred continuous profiles are used to train a neural network with magnetic infromation as an input to the network [4]. In this work, we present our preliminary results on profile inference using Gaussian process and the neural network.

[1] L.L.Lao et al., MHD equilibrium reconstruction in the DIII-D tokamak, Fusion Sci. Technol. 48:2, 968-977 (2005)
[2] A.Ho et al., Application of Gaussian process regression to plasma turbulent transport model validation via integrated modelling, Nucl. Fusion **59** 056007, (2019)
[3] M.A. Chilenski et al., Improved profile fitting and quantification of uncertainty in experimental measurements of impurity transport coefficients using Gaussian process regression, Nucl. Fusion **55,** 023012 (2015)
[4] A Pavone et al., Neural network approximated Bayesian inference of edge electron density profiles at JET, Plasma Phys. Control. Fusion **62,** 045019 (2020)

Keywords:

KSTAR, Gaussian Process, Neural Network, Kinetic Profile

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.207

Plasma wave diagnostic system based on the modulation of electron cyclotron emission in KSTAR plasma

KIM Minho [2], KIM Jayhyun [3], LEE Jaehyun [4], THATIPAMULA Shekar Goud[2], YUN GUNSU *[1,2]
[1]Department of Physics, POSTECH
[2]Division of Advanced Nuclear Engineering, POSTECH
[3]MHD Stability Research Team, KFE
[4]Pedestal Stability Research Team, KFE
gunsu@postech.ac.kr

Abstract:

Strong plasma waves can modulate the electron cyclotron emission (ECE) in the mm-wave range in magnetically confined plasmas. We have developed an RF diagnostic system utilizing the superheterodyne mm-wave mixers in the ECE imaging system on the KSTAR tokamak and a high-speed (20 GSa/s max.) digitizer that can capture the intermediate frequency (IF) signals of the mixers [1]. Using the RF diagnostic system, we have found various types of modulations in tokamak plasmas. As an example, we have confirmed that the amplitude-modulated ECE signals at the plasma boundary collapse in high-confinement mode plasmas, which the generation of the whistler-frequency waves can drive. For another example, we have observed a regularly-spaced harmonic structure in the spectrum over a wide frequency range (4–5 GHz) resulting from the frequency-modulated ECEs in low-density ohmic plasmas called quiescent runaway electron regime [2–3]. This example shows the strong kinetic instability from the runaway electrons and can be applied to estimate the energetic electron energy.
This work is supported by the National Research Foundation of Korea under contract No. NRF-2019M1A7A1A03088456 and 2019R1F1A1057545.

References:

1. M.H. Kim et al, Nucl. Fusion 60, 126021 (2020)
2. D.A. Spong et al, Phys. Rev. Lett. 120, 155002 (2018)
3. W.W. Heidbrink et al, Plasma Phys. Control. Fusion 61, 014007 (2019)

Keywords:

Plasma diagnostic, Tokamak, Plasma wave, Radio frequency (RF) diagnostic

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.208

Measurement of Deuterium Transport Parameters in Hastelloy and SS316LN

NOH Seung Jeong *[1,2], SEO H. J. [1,2], KIM H. S. [2], BYEON W. J. [3], CHUNG Bo-Hyun [4]
[1]Department of Physics, Dankook University
[2]Applied Physics, Dankook University
[3]Center for Scientific Instrumentation, Korea Basic Science Institute
[4]Physico-Technology Laboratory, Korea Accelerator and Plasma Research Association
sjnoh@dankook.ac.kr

Abstract:

For a safe nuclear fusion operation, nuclear fusion devices require materials that resist severe environments such as high temperature, high energy neutron irradiation, and corrosion. In this study, we have measured deuterium permeation in Hastelloy and SS316LN, which have excellent corrosion resistance and mechanical features in the temperature ranges of 400–800 °C and 350–850 °C, respectively. The samples were fabricated into disk-shaped coins [diameter: 20 mm, thickness: 0.2 mm (Hastelloy), 0.5 mm (SS316LN)]. The deuterium transport parameters (permeability, diffusivity, and solubility) were determined using the custom-built hydrogen-isotope permeation measurement system located at Dankook University. The results are presented and compared with previously reported ones by other authors.

Keywords:

Hastelloy, SS316LN, Deuterium, Transport

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.209

Visualization of Core Magnetohydrodynamic-Instability Structures in Versatile Experiment Spherical Tokamak

HWANG Yong Seok *[1], JUNG Eui Chan [1], KIM Seongcheol [1], JEONG Won Ik [1]
[1]Seoul National University
yhwang@snu.ac.kr

Abstract:

Visualization of core magnetohydrodynamic (MHD) instability structures in a spherical tokamak has been conducted using the MHD-instability coherent frequency filtering of visible fast camera images in versatile experiment spherical tokamak (VEST). Employing a visible charge coupled device camera with a sampling rate of 50 kHz, the coherent MHD perturbation frequency (5 to 10 kHz) that are measured in Mirnov coils are found in the camera images. These coherent signals in the images are extracted via fast Fourier transform method [1] and the obtained images are compared with other 48 differently located Mirnov coils around the vessel. The images represent a rotating perturbation that lies near the rational surface (q = 2 or 3) and have the relevant poloidal mode number (m = 2 or 3) estimated from the magnetic diagnostics. Different from conventional tokamak, a significant difference in the perturbation sizes between the high field side and the low field side in spherical tokamaks is experimentally observed as expected in the theory [2]. Although the visualization of core MHD activities from visible lights is possible in the small-size device like VEST due to its moderate core temperature (~100 eV), this technique can still be used to investigate some MHD instabilities such as tearing modes or magnetic reconnection that can also occur in the moderate-temperature fusion plasma.

[1] Yu, J. and M. Van Zeeland (2008). "Spectrally filtered fast imaging of internal magnetohydrodynamic activity in the DIII-D tokamak." Review of Scientific Instruments **79**(10): 10F516.
[2] Kruger, S. E., et al. (1998). "Geometrical influences on neoclassical magnetohydrodynamic tearing modes." Physics of Plasmas **5**(2): 455-460.

Keywords:

plasma instability, spherical tokamak, fast camera, magnetohydrodynamics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.211

Nonlinear dynamics of charged particles in a uniform magnetic field

KANG Teyoun [1], HUR Min Sup *[1]
[1]Physics, UNIST
minshur@daum.net

Abstract:

일정한 자기장 내부의 하전입자는 등속원운동을 한다고 잘 알려져 있지만, 플라즈마 내부에서는 조금 상황이 달라진다. 자유전자들은 자기장에 의해 등속원운동을 하려고 하지만, 양이온들의 쿨롱힘이 그것을 방해하기 때문이다. 더욱이 전자들 사이에 발생하는 척력 역시 방해요소가 될 수 있다. 이런 복합적인 요소들을 모두 고려하면, 일정한 자기장 내부의 플라즈마는 등속원운동과는 전혀 다른 비선형적인 운동을 하게 된다. 또한, 자기력이 매우 강력한 상황에서는 라디에이션에 의한 전자의 에너지 감소가 발생하게 된다. 이는 위에서 언급했던 요소와 다른 새로운 형태의 비선형성이다. 이 발표에서는 일정한 자기장 내부의 플라즈마 유체가 어떤 운동을 하게 되는지 수학적으로 계산해본다. 이렇게 얻어진 해를 푸리에 급수로 표현해볼 것이다; 플라즈마의 운동에는 ω_R, $2\omega_R$, ω_L, $2\omega_L$, $\omega_R+\omega_L$, $\omega_R-\omega_L$, ...의 하모닉들이 나타난다. 마지막으로 등속원운동하는 전하가 느끼는 라디에이션 리액션을 계산하고, 그 의미를 논의해본다.

Keywords:

plasma oscillation, harmonic, radiation reaction, magnetized plasma

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.212

New concept of MHD accelerator by using a microwave source

LEE Kiyong [*1], JANG Soo-ouk [1]
[1]Fundamental Technology Research Division, KFE
kylee@kfe.re.kr

Abstract:

MHD (magnetohydrodynamic) sources are known to produce high velocity output of the plasma jet. With the hall term E×B, charged particles are accelerated in the same direction by Lorentz force. This concept is advantageous, since the electrons and ions move equally so that no space charge effects could degrade acceleration. However, to produce an electric field (E) requires having electrodes, which eventually causes erosion when directly exposed to the plasma. To initiate plasma separately, a 2.45 GHz microwave source is attached at the front side. In combination, a set of permanent neodymium magnets are placed to produce the magnetic field (B). Up-down are electrode plates that gives the E-field. The microwave propagates through the E×B channel while simultaneously the Lorentz force provides acceleration. With a simple formula, it is shown that a 30 cm channel could reach about 200 km/s. This turns out to be five times more efficient than having only the E-field applied that is equal in value.

Keywords:

MHD, plasma, mircowave, accelerator

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.213

Observation and characteristics of kink instability of flux ropes in Versatile Experiment Spherical Torus (VEST)

HWANG Yong Seok *1, PARK Jong Yoon 1, JUNG EC 1
1Seoul National University
yhwang@snu.ac.kr

Abstract:

VEST[1], the first Spherical Torus in south Korea and operating at SNU, have two miniaturized electron gun[2] that successfully discharge two flux rope (a magnetized plasma column) following its vacuum magnetic field by toroidal field, poloidal field coils of VEST. The kink instabilities of these flux rope are observed and show three distinctive states (internal kink, external kink and chaotic), which are driven gradually according to its kink conditions such as plasma current, vacuum magnetic field strength and column length. Also, this kink instabilities are confirmed coherent behavior and analyzed its state by Magnetic Diagnostics (Magnetic pickup coils, Rogowski coil). Using both theoretical works done by Ryutov[3] and electromagnetics, simple rotating model that simulating external kink behavior (frequency and kink radius) are developed and calculated. The model calculation results show good agreement with experiments, which result in high value of cross-correlation.

[1] Chung, K. J., et al. "Design Features and commissioning of the versatile experiment spherical torus (VEST) at Seoul National University." Plasma Science and Technology 15.3 (2013): 244.
[2] Park, JongYoon, et al. "Design and development of the helicity injection system in Versatile Experiment Spherical Torus." Fusion Engineering and Design 96 (2015): 269-273.
[3] Ryutov, D. D., et al. "Phenomenological theory of the kink instability in a slender plasma column." Physics of plasmas 13.3 (2006): 032105.

Keywords:

flux rope, kink instability, VEST, electron gun

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.214

저온 플라즈마 광진단을 위한 알곤, 헬륨 충돌복사 모델 개발

CHAI Kil-Byoung *[1], KWON Duck-Hee [1], LEE Minkyu [1]
[1]Nuclear Physic Engineering Research Division, KAERI
kbchai@kaeri.re.kr

Abstract:

광진단(OES) 기술은 저온 플라즈마의 온도나 밀도 등 플라즈마 변수의 측정을 위해 널리 사용되고 있다. 그런데 플라즈마 방출광 스펙트럼으로부터 플라즈마 변수를 얻기 위해서는 플라즈마에 존재하는 중성종 및 이온종 여기상태의 population density를 알아야 한다. 즉, 플라즈마 온도 및 밀도에 따라 국소열평형(local thermodynamic equilibrium) 모델, 충돌복사(collisional-radiative) 모델, 코로나(corona) 모델 등으로부터 population density를 구해야 한다. 핵융합 경계 플라즈마나 반도체 공정플라즈마와 같은 저온 플라즈마는 플라즈마에서 일어나는 충돌 및 복사 반응을 모두 고려한 충돌복사 모델을 사용하여야 한다.
우리는 저온 플라즈마 광진단을 위해 알곤과 헬륨 중성종의 충돌복사 모델을 개발하였다 [1,2]. Ar 모델에는 ground state와 14개의 excited state를 고려하였고 He 모델은 ground state와 66개의 excited state를 고려하였다. 두 모델 모두 전자충돌에 의한 여기화와 이온화, radiation decay와 radiation trapping 효과, heavy particle간의 충돌에 의한 이온화, metastable state의 diffusion, non-Maxwellian electron energy distribution을 고려하였다. 또한 방출광 스펙트럼 측정의 불확실도가 충돌복사 모델에 전파되어 광진단 결과에 어떤 영향을 미치는지 분석하여 랑뮤어 탐침의 측정결과와 비교하였다. 그 결과 불확실도 범위 내에서 랑뮤어 탐침 측정결과와 경향성 및 측정값이 일치하는 것을 확인하였다[1, 2]. 그리고 스펙트럼과 광진단 결과의 불확실도를 줄일 수 있는 방법에 대해 고찰하였다.

[1] K.-B. Chai and D.-H. Kwon, J. Quant. Spectrsc. Radiat. Transf. **227**, 136 (2019).
[2] K.-B. Chai and D.-H. Kwon, will be submitted (2021).

Keywords:

Optical Emission Spectroscopy (OES), CR model, plasma diagnostics, Langmuir probe

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.215

Zernike polynomial을 이용한 스펙트럼 보정법

LEE Minkyu *[1], CHAI Kil-Byoung [1], KWON Duck-Hee [1]
[1]Nuclear Physics Application Research Division, KAERI
leeminkyu@kaeri.re.kr

Abstract:

실험실 및 우주 플라즈마에서 분광학을 이용해 여러 가지 유용한 정보를 얻을 수 있다. 예를 들어, 은하의 적색편이로부터 허블 상수를 얻어 우주의 팽창률을 계산하고, 태양의 흡수선으로부터 태양 표면의 구성 성분을 확인할 수 있다. 또한 광방출분광학(OES, Optical Emission Spectroscopy)을 통해 얻어진 스펙트럼을 분석하여 플라즈마의 전자온도나 전자밀도를 계산한다. 하지만, 스펙트럼 측정 시 사용되는 광학 기기(렌즈, 거울)는 그 기하학적인 형태 등에 의해, 구면 수차, 코마 수차 등의 수차가 발생하게 되며, 관측 값 평가에 오류를 야기한다.
이러한 수차를 보정하고자 linear CCD를 사용하는 단색기(Monochromator)로부터 얻어진 스펙트럼의 데이터를 Zernike polynomial을 모델 함수로 하여, Zernike 계수를 찾아 보정하는 프로그램을 개발하고 있다. 현재 Noll’s index 5까지의 Zernike 계수를 찾을 수 있으며, 코마 수차와 연관이 있는 값인 Noll’s index 7, 8 이상의 계수까지 찾을 수 있는 프로그램을 제작하고자 한다. 또한, 추후 프로그램으로부터 얻어진 관측 기기의 수차 값으로부터 측정된 플라즈마 방출광 스펙트럼을 보정하여, 알곤 충돌 복사(collisional-radiative) 모델 및 랑뮤어 탐침 측정 값과의 비교를 통하여 보다 불확실도를 줄여볼 계획이다.

Keywords:

OES, Aberration , Zernike

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.216

전극 구조 변화에 따른 용량성 결합 플라즈마 특성의 유체 시뮬레이션과 Particle-in-Cell 시뮬레이션 비교

KIM Hwan Ho [1], KIM Chang Ho [1], SHIN Ji Hyun [1], LEE Hae June [*1]
[1]Pusan National University
haejune@pusan.ac.kr

Abstract:

용량성 결합 플라즈마 장치는 전자 가열의 효율성 및 방전 균일성에 장점이 있어서 반도체 공정의 식각, 박막 증착 공정에 널리 이용되고 있다. 하지만 상하부 전극과 side wall로 이루어진 전극 구조의 특성 상 공간의 전위 분포가 전극 중심부와 edge에서 비대칭성을 갖게 되므로 플라즈마의 균일성을 유지하는 데 한계가 있게 된다. 특히 wafer 가장자리와 side wall 사이의 전기장 강화 효과는 시간 평균된 플라즈마 sheath 형상 분포의 기울어짐을 발생시키므로 wafer에 입사된 이온의 에너지 및 각도 분포의 불균일성을 야기하고 이로부터 공정의 수율이 저하된다. 작은 불균일성도 공정의 수율에 큰 영향을 주기 때문에 이에 대한 엄밀한 해석이 필요하다. 이러한 불균일성을 해결하기 위해 인가 전력, 유량, 혼합가스 비율 제어 등 입력 변수 조절과 전극 간 간격, sidewall 구조 변화 등의 장치 구조를 변화시키는 방법이 다양한 관점에서 제안되고 있다. 본 논문에서는 side wall의 효과에 따른 플라즈마 특성을 파악하기 위해 유체 기반 Hybrid Plasma Equipment Model (HPEM) 시뮬레이션과 병렬화된 Graphics Processing Unit (GPU) 기반의 2차원 Particle-In-Cell (PIC) 시뮬레이션을 이용하여 세 가지 서로 다른 구조의 장치에 대한 시뮬레이션을 수행하였다. 두 개의 전극과 side wall로 이루어진 용량성 결합 플라즈마 장치, 기본 전극 외측에 유전체와 접지된 도체를 추가한 장치 그리고 접지된 side wall 대신 두꺼운 dielectric 층을 추가한 장치로 연구하였다. 특정 장치 구조에서만 발생한 non-local 전자 가열 현상을 100 mTorr, 500 mTorr 에서 압력의 변화에 따라 관찰하였으며, 전위 및 전자 유량을 위상 별로 비교하여 전자 역학을 설명하였다. 그리고 용량성 결합 플라즈마 장치의 특성 해석 및 개선에 시뮬레이션 방법이 미치는 영향을 함께 살펴보았다.

Keywords:

2D Graphics processing unit Particle-in-cell simulation, Hybrid Plasma Equipment Model, sidewall effect

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.217

Effect of a target on helium atmospheric pressure plasma jet

TRAN Tuyen Ngoc[1], KIM Bumsoo [1], LEE Wonwook [1,2], OH Cha-Hwan [*1]
[1]Hanyang University
[2]Research Institute of Natural Sciences, Hanyang University
choh@hanyang.ac.kr

Abstract:

Atmospheric pressure plasma jet (APPJ), generates plasma at low gas temperature, is suitable for a plenty of applications such as surface modification, biological decontamination and environmental protection. For the configuration of the APPJ, a target plays an indispensable role and have many important influences on the operation of APPJ. Helium APPJ was configured using a quartz tube and two metal electrodes. The first electrode made of a tip-shape copper rod was placed inside the quartz tube. The second electrode made of a copper plate was wrapped outside the quartz tube a distance 10 mm. A target was placed outside the quartz tube. An AC voltage at the frequency of 5kHz and the amplitude of 10kVp.p was supplied to the first electrode to generated plasma. The second electrode and the target were connected to ground. Plasma spectra were measured along the APPJ by using a spectrometer with the resolution up to 0.01 nm. Plasma spectra of the APPJ were changed when the target was installed. The plasma spectra were examined when conducting and dielectric target were used. Characteristics of plasma properties were discussed when the distance between the quartz tube and the target was changed.

Keywords:

Atmospheric pressure plasma jet, helium plasma, dielectric barrier discharge

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.218

Measurement of the chromium ion beam current and charge distribution with the MEVVA ion source

LEE Seung Ho [1,3], CHO Yong-Sub [2,3], KIM Han Sung [1,3], KWON Hyeok-Jung [*1,3]
[1]Accelerator Development and Operation Division, KOMAC, KAERI
[2]Nuclear Physics Application Research Division , KAERI
[3]Department of Accelerator and Nuclear Fusion physics engineering, UST
hjkwon@kaeri.re.kr

Abstract:

양성자과학연구단은 금속 증기 진공 아크 (Metal Vapor Vacuum Arc, MEVVA) 기반 수직이온빔 장치를 구축하였다. MEVVA 이온원은 진공 아크 방전을 이용하여 금속 이온빔을 인출하는 장치이다. MEVVA 이온원의 가장 큰 특징으로는 진공 아크 방전을 이용하여 금속 플라즈마를 생성하기 때문에, 대부분의 금속 이온빔 인출이 가능 할 뿐만 아니라, 실리콘, 게르마늄과 같은 반도체 금속 역시 플라즈마 생성 및 빔인출이 가능하다. 또한 수직이온빔을 인출함으로 고전류, 대면적 빔전류 인출이 가능하다는 특징 또한 가지고 있다. 본 연구에서는 MEVVA 이온원을 이용하여 크롬 이온빔을 인출하였으며, 크롬 이온빔의 빔전류 측정 및 전하 분포 측정에 대한 결과를 발표하고자 한다.

Keywords:

Metal vapor vacuum arc ion source , Vacuum arc discharge , Chromium ion beam , beam current , charge distribution

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-pl.219

디버터 모사장치에 대한 PIC code와 ERO code를 사용한 표면 반응 예측

PARK Heesung [2], CHAI Kil-Byoung [3], KWON Duck-Hee [3], LEE Hae June [*2], HUR Min Sup [*4]
[1]Pusan National University
[2]Department of Electrical Engineering, Pusan National University
[3]Nuclear Data Center, KAERI
[4]Department of Physics, UNIST
haejune@pusan.ac.kr, minshur@daum.net

Abstract:

Applied-Field Magnetoplasmadynamic(AF-MPD) 추력기는 고밀도 플라즈마를 만들어 고온의 높은 입자속을 타겟에 조사할 수 있어 디버터 모사장치로 활용될 수 있다. 디버터 모사장치에 대한 실험 및 시뮬레이션 결과는 디버터 데이터베이스에 대한 참고 자료로 활용될 수 있으며, 디버터에 직접 실험을 하는 것과 비교했을 때 상대적으로 이용이 용이하다. 이 연구에서는 디버터 모사장치의 표면 반응을 예측하기 위한 방법으로 AF-MPD 추력기 기반의 이온빔 발생장치를 수소, 아르곤, 제논 가스로 각각 구동한 경우에 대하여 Particle-in-cell Monte Carlo collision (PIC-MCC) 시뮬레이션을 실시였다. AF-MPD 추력기에 대한 PIC-MCC 시뮬레이션으로 얻은 플라즈마 분포는 ERO(Erosion and RedepOsition) code에 입력값으로 사용되었다. ERO 시뮬레이션으로 구리, 베릴륨 타겟에 각각 PIC-MCC 시뮬레이션에서 계산된 이온빔이 조사되었을 때 표면 손상에 대한 결과를 얻었다. AF-MPD 추력기 시뮬레이션을 통해 얻은 결과와 다른 linear plasma device 실험 및 시뮬레이션 결과와 비교하였다.

Keywords:

Particle-in-Cell simulation, Plasma Surface Interaction, AF-MPD thruster

육방정 $Cd_{0.98}Mn_{0.02}S$ 단결정 박막의 결정구조와 광학적 특성

LEE Jongwon *[2], KIM Daejung [1]
[1]School of Basic Sciences, Hanbat National University
[2]Department of New Materials Engineering, Hanbat National University
jwlee@hanbat.ac.kr

Abstract:

CdMnS는 II-Mn-VI족 화합물 반도체로서 에너지밴드갭은 약 2.50 eV 정도를 가지며, 낮은 Mn 조성(<1 %)을 갖는 경우에도 밝은 오렌지색 발광을 하는 것으로 잘 알려져 있고, Mn 조성 증가에 따라 휨효과(bowing effect)가 나타난다. 박막들은 열벽적층성장법 (Hot-Wall Epitaxy;HWE)으로 GaAs(111) 기판위에 두께에 변화를 주어 성장시켰다. 성장된 박막들의 결정구조와 결정성을 알아보기 위하여 XRD 패턴을 이용하였고, 표면상태와 조성비율을 확인하기 위하여 Nomarski 간섭현미경과 SEM-EDS을 사용하였다. 또한 광학적 특성을 알아보기 위하여 분광학적 엘립소미트리을 이용하여 측정하였고 측정된 박막의 데이터들은 복소유사유전함수인 $<\varepsilon>=<\varepsilon_1>+i<\varepsilon_2>$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 이들 데이터의 이계도함수를 이용하여 임계점 피크를 구하였다.

Keywords:

CdMnS, 타원편광분석법, 열벽적층성장법, 유사유전함수, 이계도함수

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.102

육각형 마이크로 바늘 모양 Si의 성장과 특성

PARK Jung Hyun [1], AHN Hyung Soo *[1], LEE Gang Seok [1,2], KIM Kyung Hwa [1,2], LEE Jae Hak [1], CHUN Young Tea [1], YANG Min [1], YI Sam Nyung [1], KIM Suck-Whan [3], LEE Won-Jae [4]
[1]Electronic Materials Engineering, Korea Maritime and Ocean University
[2]Compound Semiconductor Education Center, Korea Maritime and Ocean University
[3]Department of Physics, Andong National University
[4]Division of Advanced Materials Engineering, Dong-Eui University
hsahnpusan@daum.net

Abstract:

Si은 지구 지각에서 풍부한 원소 중 하나로서 반도체의 주재료로 사용된다. Si은 표준 조건에서 일반적으로 다이아몬드 입방구조를 가지며 강한 공유결합을 이룬다. 본 연구에서는 직경 50um, 최대 3000um의 길이를 가지는 육각형 마이크로 바늘 모양의 Si을 혼합 소스 수소화물 기상 성장법 (mixed-source HVPE)에 의해 성장하였다. 우물형 그라파이트 보트에 Al, Ga, Si 소스를 HCl gas와 반응시켜 질화처리된 Si 기판 위에 육각형 마이크로 바늘 모양의 Si을 성장시켰다. 실험 조건은 1250℃의 온도에서 다량의 HCl을 흘려 약 1시간 동안 성장시켰다. 성장 전 기판의 질화처리를 위해 약 1시간 동안 NH3를 흘려주었다. 종횡비 1:200 이상을 가지는 육각형 마이크로 바늘 모양 Si이 성장되었다. 성장된 육각형 마이크로 바늘 모양 Si은 전계방사형 주사전자현미경(FE-SEM), 에너지 분산 X-선 분광법(EDS), 고분해능 X-선 회절분석기(XRD), X-선 광전자 분광법(XPS)을 통해 그 특성을 분석하였다. 혼합소스 HVPE 방법으로 성장된 육각형 마이크로 바늘 모양의 Si은 발광소자, 전력반도체 소자, 리튬 이차전지의 음극 활물질 등에 응용이 가능할 것으로 판단된다.

Keywords:

Si, HVPE, Crystal Growth

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.103

HVPE Al(N) 나노구조 Seed에 의한 Si micro 결정의 성장 및 특성

LEE Gang Seok [1,2], KIM Kyung Hwa [1,2], PARK Jung Hyun [1], AHN Hyung Soo *[1], LEE Jae Hak [1], CHUN Young Tea [1], YANG Min [1], YI Sam Nyung [1], KIM Suck-Whan [3], LEE Won-Jae [4]
[1]Electronic Materials Engineering, Korea Maritime and Ocean University
[2]Compound Semiconductor Education Center, Korea Maritime and Ocean University
[3]Department of Physics, Andong National University
[4]Division of Advanced Materials Engineering, Dong-Eui University
hsahnpusan@daum.net

Abstract:

AlN은 높은 열전도성과 전기저항을 가지는 wurtzite 구조의 반도체 물질로서, 물리적 안정성을 기반으로 핵심 산업인 전력반도체 연구에 중요한 위치에 있는 물질이다. 본 연구에서는 혼합소스 수소화물 기상 증착법 (mixed-source HVPE)에 의해 Al(N) 나노구조 Seed를 형성하고, 그 형태에 따라 성장된 Si 결정의 특성을 분석하였다. HVPE로 성장한 Al(N) 나노 구조에 따라 성장된 Si 결정의 micro복합구조는 전계방사형 주사전자현미경(FE-SEM), 에너지 분산 X-선 분광법(EDS), X-선 광전자 분광법(XPS)을 통해 그 특성을 분석하였다. 분석결과 Al(N) 나노구조가 성장된 부분으로부터 시작하여 Si 결정이 성장된 것을 확인 할 수 있었다. Raman 분광법을 이용하여 복합구조의 위치에 따른 Raman shift의 극적인 변화를 관측하였다. 혼합소스 HVPE 방법에 의해 성장한 Al(N) 나노구조 seed를 바탕으로 성장된 Si 결정의 새로운 성장 메커니즘을 제시한다.

Keywords:

Al nano structure, Si Crystal Growth, HVPE

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.104

Atomic and electronic structure of acetonitrile molecules on Si(111)-(7x7)

HONG SukLyun *[1], PARK Jinwoo [1]
[1]Sejong University
hong@sejong.ac.kr

Abstract:

We have investigated the adsorption of acetonitrile molecules on Si(111)-(7x7) using density functional theory calculations. In order to understand the multimolecular adsorption, we consider possible site-by-site and step-by-step adsorption mechanisms. From theoretical simulations, we find energetically most stable structures, which are compared with experimental observations obtained by the scanning tunneling microscopy (STM) measurement. For most stable structures, we determine chemical or physical bonding structures between acetonitrile molecules and topmost Si atoms of the substrate. Then, multimolecular adsorption configurations are investigated. Details are analyzed in terms of partial density of states and charge density difference.

Keywords:

Si, STM

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.105

Temperature gradient modulation of $MoTe_2$ for Phase and composition engineering via van der Waals encapsulation

RYU Huije [1], LEE Yunah [1], JUNG Jae Hwan [2], LEE Yangjin [3], CHEON Yeryun [4], WATANABE Kenji [5], TANIGUCHI Takashi [6], KIM Kwanpyo [3], CHEONG Hyeonsik [4], LEE Gwan-Hyoung *[1]
[1]Department of Materials Science and Engineering, Seoul National University
[2]Department of Materials Science and Engineering, Yonsei University
[3]Department of Physics, Yonsei University
[4]Department of Physics, Sogang University
[5]Research Center for Functional Materials, National Institute for Materials Science
[6]International Center for Materials Nanoarchitectonics, National Institute for Materials Science
gwanlee@snu.ac.kr

Abstract:

To engineer physical properties of transition metal dichalcogenides (TMDs), one of two-dimensional (2D) materials, phase transition has attracted widespread attention due to its different electronic properties depending on the phase. Even though laser-induced phase patterning, a fast, clean and accurate patterning technique, has been extensively studied, it is difficult to control the instantaneous heat of laser that causes the crystal structure to be deformed. Here we control the phase of transition of molybdenum ditelluride ($MoTe_2$) under laser irradiation by fabricating hexagonal boron nitride (hBN)-$MoTe_2$ van der Waals heterostructures. After laser irradiation, single crystal 2H-$MoTe_2$ transformed into polycrystalline 1T'/T_d-$MoTe_2$ in hBN/$MoTe_2$/hBN structures, which is differ from previous studies that showed surface-evaporated laser-induced metallic (LIM) phase. Using hBN as an efficient heat modulator and evaporation barrier, we transit the phase of $MoTe_2$ cleary by laser without unwanted defects. Interestingly, we got the Mo/Te-based nanomaterials with varying stoichiometric ratio from 2H-$MoTe_2$ including crystalline Te and Mo_3Te_4 in stacking-sequence-modulated hBN-$MoTe_2$ heterostructures. Our work provides insight into the phase transition of 2D materials in van der Waals heterostructures, and shows an efficient way for the fabrication of monolithic 2D electronic devices consisting of different phases of the same 2D materials.

Keywords:

2D materials, MoTe2, Phase transition, Laser, van der Waals heterostructure

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.106

디지털 합금 InGaAlAs 다중 양자 우물의 열처리 온도에 따른 광학적 특성 연구

KIM Jong Su *[1], PARK Gyoung Du [1], JO Hyun Jun [1], RYU Mee Yi [2], SONG Jin Dong [3]
[1]Yeungnam University
[2]department of physics, Kangwon National University
[3]Center for Opto-Electronic Materials and Devices, KIST
jongsukim@ynu.ac.kr

Abstract:

본 연구에서는 디지털 합금 (digital alloy) InGaAlAs 다중 양자 우물 (multiple quantum wells : MQWs) 구조의 열처리 (rapid thermal annealing : RTA)온도에 따른 광학 적 특성을 광발광 분광법 (photoluminescence : PL)과 광반사 분광법 (photoreflectance : PR)을 통해 분석하였다. PL 실험을 통하여 20 K에서 InGaAlAs MQW 신호 (0.97 eV) 와 InP 기판 신호 (1 eV)를 관측하였다. 열처리 온도가 높아짐에 따라 MQW의 Ga과 Al 혼합 (intermixing)으로 인하여 850°C 열처리 시료가 700°C 열처리 시료보다 MQW 신호가 0.03 eV 적색 편이를 하였다. 또한, 850°C 열처리 시료의 InP의 균일도가 낮아졌음을 확인하였다. PR 신호에서는 PL 결과에서 관측되지 않은 비발광성 준위가 관측되었으며 PR 실험을 통해 20 K에서 850°C InAlAs 클래딩 층의 신호 (1.51 eV)가 다른 시료들의 InAlAs 클래딩층의 신호 (1.57 eV)에 비해 0.06 eV 적색 편이 하였으며 이는 InP 기판과 InAlAs 클래딩 층 계면에서의 interdiffusion이 일어나며 Al 함량이 감소하였기 때문으로 사료된다.

Keywords:

photoluminescence, photoreflectance, DA, MQW

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.107

Characterization of GaN epilayers grown by MOCVD for vertical power device application

AHN Chang Wan [1], BONG Chung-Jong [1], BAE Sung-Bum [2], KIM Eun Kyu [*1]
[1]Department of Physics, Hanyang University
[2]RF/전력부품연구실, ETRI
ek-kim@hanyang.ac.kr

Abstract:

We have grown the vertical GaN power device structures on GaN and sapphire substrates by MOCVD. Their structural properties by XRD, Raman, and PL measurements clearly show that the structural quality of the undoped GaN epilayer grown on the GaN is improved over the epilayer grown on the sapphire substrate. Through optical conductance DLTS, four traps were observed in all the GaN layers. The activation energies of these traps were 0.93 eV (H1), 0.61 eV (H2), 0.50 eV (H3), and 0.2 eV (H4) above the balance band edge, and their capture cross-sections were 3.41×10^{-14} cm^2 (H1), 3.04×10^{-14} cm^2 (H2), 1.35×10^{-12} cm^2 (H3) and 2.90×10^{-16} cm^2 (H4), respectively. The origins of the H4 and H1 traps may be related to gallium vacancy (V_{Ga}) and V_{Ga}-related defects, and the H2 and H3 traps were from nitrogen-vacancy (V_N). The total trap concentration of the GaN-on-GaN obtained using via the space-charge-limited-current method was 1.18×10^{15} cm^{-3}, while the GaN-on-sapphire was 1.52×10^{17} cm^{-3}, respectively. The GaN substrate exhibited a low defect density of about two orders of magnitude less than the sapphire substrate.

Keywords:

GaN, Shottky diode, Defecet state, MOCVD, Conductance DLTS

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.108

장벽형 InGaAsSb/GaSb 이중대역 적외선 검출기의 시분해 광전류 특성 평가

KIM Jong Su *1, KWAK Minsoo 1, JO Hyun-Jun 1, LEE SANG JUN 2, KIM Yeungho 2
1Yeungnam University
2smart device team, KRISS
jongsukim@ynu.ac.kr

Abstract:

본 연구에서는 InGaAsSb/GaSb nBn 이중대역 적외선 검출 소자의 운반자 수명에 대한 장벽층의 효과를 시분해 광전류 (Time resolved photocurrent; TRPC) 특성평가 방법을 이용하여 분석 하였다. 소자의 구동 Bias 및 여기광의 세기 의존성 실험을 통해 장벽층이 운반자 수명에 미치는 영향에 대해 알아보았다. 일반적인 p-n 접합 구조를 가지는 시료의 TRPC를 측정할 경우 광발생 운반자의 소멸 현상이 여기광의 세기와 무관하게 하나의 지수 함수형으로 감소하지만 본 연구에 사용된 nBn 구조에서는 높은 여기광의 세기에서는 운반자의 소멸 현상이 다중의 지수 함수형으로 나타났다. 그러나 nBn 구조에서도 낮은 여기광 세기에서는 이보다 적은 수의 다중의 지수 함수형으로 관측되었다. 이는 장벽층에 의해 blocking된 운반자의 수송 지연에 의한 결과로 판단하였다. 지연되는 운반자 수명과 지연되지 않는 운반자 수명을 인가된 bias voltage에 따라 비교해 보았을 때 지연 되지 않는 운반자의 수명은 인가 전압이 증가할 수록 증가하는 반면 지연된 운반자 수명은 0.4 V 이상에서 감소하였다.

Keywords:

nBn, Time resolved photocurrent, TRPC, carrier lifetime

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.109

MOCVD를 이용한 금속 기판 위의 Ga_2O_3 박막 성장 및 수직형 다이오드 특성

YANG MIN *1, AHN NamJun 1, LEE JUNG BOK 1, KIM SO YOON 1, AHN Hyung Soo 1, KIM Kyoung Hwa 1, BANG Hyo Jin 1
1Korea Maritime and Ocean University
myang@kmou.ac.kr

Abstract:

β-Ga_2O_3는 단사정계(monoclinic) 구조로 약 4.9 eV의 넓은 에너지 밴드갭을 지닌 화합물 반도체이다. 높은 열적, 화학적 안정성과 더불어서 8.0 MV/cm의 큰 항복전압, 높은 유전상수, GaN(667), SiC (134)에 비해 훨씬 큰 값(3571)의 Baliga 성능 지수를 가지고 있어서 차세대 전력 반도체 소자로 활용하기 위하여 많은 연구가 진행되고 있다. 현재 기판 제조기술의 발달로 인하여 β-Ga_2O_3 결정의 homoepitaxy에 의한 소자 제작이 가능하지만, 기판 내에 존재하는 높은 결함 밀도와 낮은 열전도율로 인한 소자 성능 향상에 제약이 따르고 있다. 이에 따라서, 여러 가지 종류의 기판들을 이용한 이종접합(heterojunction) 박막을 이용하여 앞에서 언급한 단점들을 극복하고, 고성능의 소자 제작을 위하여 많은 연구들이 진행되고 있다. 그러나 다양한 기판 중에서도 금속 기판은 아직까지 연구가 거의 진행되지 않고 있는 분야이다. 금속기판을 활용하면 열전도율 문제를 해결할 뿐만 아니라 다양한 형태의 소자 응용이 가능하기 때문에 금속기판을 이용한 이종접합 박막 성장에 대한 연구는 매우 중요하다. 본 연구에서는 Ti 기판을 이용하여 MOCVD 방법으로 Ga_2O_3 이종접합 박막 성장을 수행하였다. 2장의 Ti 기판 위에 650도에서 H_2O flow를 400cc, TMG를 1.71×10^{-5} mol/min으로 ε-phase 박막들을 각각 성장하였고, 그 후에 1 개의 박막은 고온에서 열처리를 진행하여 β–phase로 변환시켰다. ε-Ga_2O_3, β-Ga_2O_3 박막들 위에 Schottky (Ni/Au) 전극을 각각 형성하여 수직형 다이오드 특성을 확인하였다. ε-Ga_2O_3 박막 다이오드는 β-Ga_2O_3 박막 다이오드에 비하여 낮은 직렬저항과 높은 built-in 전압을 가짐을 확인할 수 있었다. ε-Ga_2O_3 박막 다이오드에서 높은 built-in 전압을 보이는 이유는 기판 온도 상승 과정에서 Ti 기판의 표면 산화에 원인이 있는 것으로 여겨지며, 열처리에 의해 형성된 β-Ga_2O_3 박막 다이오드에서 다시 built-in 전압이 낮아진 것은 고온 열처리 과정에서의 Ga_2O_3과 Ti의 계면의 상태 변화에 의한 것으로 판단된다. ε-Ga_2O_3, β-Ga_2O_3 박막 성장 과정, 구조적 특성 및 다이오드의 전류-전압 특성에 대한 보다 자세한 내용들은 추후 언급할 예정이다.

이 연구는 2021년도 정부(산업통상자원부)의 재원으로 한국산업기술진흥원의 지원을 받아 수행된 연구임 (P0012451, 2021년 산업전문인력역량강화사업)

Keywords:

산화물 반도체, Ga2O3, 파워반도체, 전력소자, 이종접합

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.110

Sensing mechanical responses of the tens of water molecules

KIM Hyensu [1], AN Sangmin *[1]
[1]Department of Physics, Institute of Photonics and Information Technology, Jeonbuk National University
san@jbnu.ac.kr

Abstract:

Nanoscale water plays an important role in nature, and it is a still on-going research item to fully understand its characteristics, although many studies have been conducted to study the physical (mechanical, electrical, optical, chemical) properties. We expect that characteristics of extremely small volume of the nanoscale water would be quite interesting behavior, which consisted with tens of water molecules. Here, we introduce an active-Q controller (increasing quality factor of the sensor) to obtain experimental sensing capability of small interaction of extremely small volume of the nanoscale with a high Q-factor(~20,000) in ambient condition, which is performed with a quartz tuning fork-based atomic force microscopy (QTF-AFM) [1,2]. We expect this technique would be solution for observing extremely small amount of low-dimensional materials for studying their physical properties that are not revealed in ambient condition.

[2] S. Kim, D. Kim, J. Kim, S. An, and W. Jhe, Phys. Rev. X 8, 041046 (2018).
[1] M. Lee, B. Sung, N. Hashemi and W. Jhe, Faraday Discuss. 141, 415–421. (2009)

Keywords:

nanosclae water, QTF-AFM, Active Q controller

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.111

Exciton-polariton trapping in a locally strained transition metal dichalcogenides layer

UHEON Choi [1], SU-HYUN Gong *[1], JUNG-HYUN Sung [1]
[1]Department of physics, Korea University
shgong@korea.ac.kr

Abstract:

After the discovery of graphene, two-dimensional (2D) transition metal dichalcogenides(TMDCs) have attracted a great attention due to their unique physical properties. When thinned down to an atomic scale, 2D TMDCs have a direct band gap and thereduced dimension make their excitons are strongly bounded. They also haves no inversion center which allow to access an additiona lvalley degree of freedom, called valley pseudospin. Exciton polaritons (EPs) in 2D TMDCs also have been of great interest. Most of the studies on EPs in TMDCs are have been mostly focused on excitons coupled with cavity photons. But recently, without a cavity structure, formation of EPs in a bare TMDCs as a form of non-radiative guided mode has been reported both theoretically and experimentally. Existence of EPs in multilayered TMDCs layers has been confirmed via near-field scanning microscope. Here, we present the control of local distribution of EPs using strained TMDCs layers. In order to produce strain in TMDC layers, we intentionally made wrinkles in TMDC layers on a glass substrate by a scotch tape peeling method. To investigate the strain-induced trapping of EPs, we measured spatial-resolved photoluminescence near a wrinkle structure using a micro-photoluminescence spectroscopy set-up. Continuous-wave laser with a wavelength of 594 nm was utilized to excite excitons in few-layers TMDCs and modified spatial distribution of EPs was found near the wrinkle. We also investigated Fourier space images at the wavelength of EPs modes to check momentum distribution of trapped EPs. We observed modified momentum pattern of EPs that correspond to the orientation of the wrinkle axis due to a broken translational symmetry. We anticipate that our demonstration paves a way to achieve the condensation of EPs in a bare TMDCs layer.

Keywords:

Exciton, Exciton-Polariton, Strain engineering

cubic ZnP_2 나노선의 성장

OH Suenghwan [1], KIM Yong *[1]
[1]Dong-A University
yongkim@dau.ac.kr

Abstract:

풍부한 Zn로 이루어진 Zn_3P_2, Zn_3As_2, ZnP_2과 같은 5족 나노선들은 광학적 소자 혹은 배터리 양극 물질들로 촉망받고 있다.
본 실험에서는 Bi 촉매를 사용하여 Zn_3P_2와 ZnP_2 나노선을 물리기상전달(physical vapor transport)법으로 성장하였다. Zn_3P_2 나노선은 Zn_3P_2 원료를 사용하였고 ZnP_2 나노선은 Zn_3P_2 원료와 P 원료를 통해 추가적인 P 증기를 공급하여 성장했다. 성장된 Zn3P2 나노선은 일반적인 α-Zn_3P_2 tetragonal 결정 구조를 가지고 있었다. 하지만 ZnP_2 나노선은 기존에 1.5 GPa보다 더 높은 기압에서 안정적이라고 알려진 cubic γ-ZnP_2 구조가 관측되었다. ZnP_2 나노선의 격자 상수(a = 0.53578 nm)는 나노선의 d-spacing에 의해서 결정되었다. α-Zn_3P_2 나노선과 달리, γ-ZnP_2 나노선에서는 무한한 P 사슬구조(chains)의 내부 진동에 의한 Raman 밴드(430 ~ 470 cm^{-1})가 관측되었다. 접촉각 분석을 통해 α-Zn_3P_2와 γ-ZnP_2 나노선들의 성장은 삼상계면 핵생성보다 중심 핵생성에 의해 결정된다는 것을 확인했다. 크기가 작은 핵에서는 중심 핵생성이 삼상계면 핵생성보다 에너지적으로 선호된다. 따라서 초기 단계에서 형성된 γ-ZnP_2 핵은 cubic γ-ZnP_2 나노선의 형성을 유도한다.
이 성과는 2018년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임 (No. NRF-2018R1A2B6001011).

Keywords:

ZnP2, XRD, FESEM, FETEM, nanowire

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.114

Population dynamics of excitons and biexcitons in a 2D halide perovskite single crystal

NAM Seohyun [1], YANG Jae hyun [2], YI Yeon jin [2], JANG Joon Ik *[1]
[1]Physics, Sogang University
[2]Department of physics, Yonsei University
jjcoupling@sogang.ac.kr

Abstract:

Halide perovskites have attracted significant attention owing to their excellent optical properties. In the case of 2D Ruddlesden-Popper series, $A'_mA_{n-1}Pb_nX_{3n-1}$ (A', A = organic cations and X = halogen anion with n = 1 ~ ∞), the A' cations acts as an insulating barrier that strongly confines charge carriers in the 2D perovskite layer. This specific arrangement of alternating organic-inorganic layers generates a 2D quantum-well structure, under the quantum and dielectric confinement effects. These properties give rise to large Coulomb interaction, leading to the formation of excitons and biexcitons with large binding energies. In this work, we prepared a single crystal of PEA_2PbI_4 ($PEA=C_6H_5(CH_2)_2NH_3$) and investigated characteristics of the biexciton based on the time-integrated photoluminescence spectroscopy. First, we experimentally determined the exciton-exciton capture coefficient C≅5.20×10-14 $ns^{-1}cm^2$ to form a biexciton at 10 K under one-photon absorption (1PA) by analyzing the simultaneous rate equations for the exciton-biexciton dynamics in the steady-state regime. Second, we created biexcitons directly without going through the exciton state under resonance two-photon absorption (2PA). And we identified two biexciton levels generated by longitudinal excitons and transverse excitons. Additionally, the lasing characteristics were found in our data, and we will study their origin in the future.

Keywords:

exciton, biexciton, 2D, perovskite, photoluminescence

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.115

Gate-Tunable Different Types of Diodes and Current Fluctuation in BP/ReS_2 Broken-Gap Heterojunction

JOO Min-Kyu *[1], SEO Youkyung [1], LEE Byung Chul [2]
[1]Department of Applied Physics, Sookmyung Women's University
[2]School of Electrical Engineering, Korea University
mkjoo@sookmyung.ac.kr

Abstract:

Different types of diodes such as Zener diode, backward/forward rectifying diode, and band-to-band tunneling diodes are essential circuit components to precisely control charge flow direction and to boost frequency of amplifier. Most recently, because of the thickness-dependent band gap energy and atomically thin tunneling thickness, two-dimensional (2D) semiconducting materials become promising candidates for quantum mechanical tunneling devices and their numerous applications in neuromorphic computing and multi-valued logic system. Nevertheless, the important role of interfacial trap for quantum tunneling current as a function of electrostatic gate and drain bias condition is little known. Here, we demonstrate a high feasibility of gate-tunable different types of diodes in ambipolar black phosphorus (BP) and n-type rhenium disulfides (ReS_2) broken-gap heterojunction. The wide Fermi level tunablity and small band gap of BP multilayers allow us to realize forward-/backward-rectifying diode and band-to-band tunneling diode. The observed dramatic charge fluctuation mechanism transition from random telegraph to log-normal distribution at BP/ReS_2 interface was mainly attributed to the matched quasi-Fermi level, induced by drain voltage, to intrinsic trap energy state of BP. Besides, clear Gaussian distribution features of BP and ReS_2 multilayer device regardless of gate and drain bias further support this interlayer tunneling current fluctuation.

Keywords:

2D materials, black phosphorus (BP), rhenium disulfide (ReS2), heterojunction, diode

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.116

$MAPbCl_{3-x}$ Br_x 결정에서 할로겐 원소 비에 따른 Rashba-Polaron 효과

KIM Yongmin *1, JEONG Moon Seok 2, PARK Daeyoung 2, SHIN Yong Ho 1
1Physics, Dankook University
2Physics, Hanyang University
yongmin@dankook.ac.kr

Abstract:

유무기 페로프스카이트 $MAPbCl_{3-x}$ Br_x (x =0, 0.5, 1, 1.5, 2, 2.5.) 단결정을 고자기장하에서 측정하였다. 모든 시료들은 극저온 (4.2 K)에서 free exciton (FX) 전이를 보였는데, 고자기장하에서 할로겐 원소 조합 비율에 따라 FX 전이는 극명하게 서로 다른 변화를 나타낸다. $MAPbCl_3$ 결정의 경우 두 개의 FX 전이는 모두 red-shift 하는 경향을 보였으며, 20 T를 넘어서며 새로운 전이가 나타나며, 이 새로운 전이는 blue-shift 경향을 보였다. 고자기장하에서 이들 FX 전이는 Rashba 효과와 polaron 효과가 결합하여 나타나는 것으로 이해된다. $MAPbBr_3$ 결정의 경우 일반적인 diamagnetic shift를 보이나 기존 알려진 parameter들과는 상당한 차이를 보이고 있다. 두 할로겐 원소를 조합하여 제작한 결정에서는 x>=1.5 인 경우 MAPbBr3의 경향을 나타내며, x<=1 인 경우 MAPbCl3 결정과 유사한 경향을 보인다. 이는 할로겐 원소 배합 비율에 따른 격자상수 크기의 변화가 polaron 형성에 큰 영향을 주어 광전이 특성의 변화를 유도하는 것으로 해석할 수 있다.

Keywords:

유무기하이브리드 페로프스카이트, Rashba 효과, polaron, 고자기장

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.117

MOCVD 방법에 의해 형성된 Ga_2O_3/SiC 박막의 결정성 및 다이오드 특성

YANG MIN *[1], KIM SO YOON [1], LEE JUNG BOK [1], AN NAM JUN [1], AHN Hyung Soo [1], KIM Kyoung Hwa [1]
[1]Korea Maritime and Ocean University
myang@kmou.ac.kr

Abstract:

Ga_2O_3는 ~4.9eV의 넓은 밴드갭, 8.0 MV/cm의 높은 항복 전압과 GaN(667), SiC (134)에 비해 훨씬 큰 값 (3571)의 Baliga 성능 지수를 가지고 있어서 차세대 전력 반도체 소자 응용을 위하여 많은 연구가 진행되고 있다. Ga_2O_3의 결정 상에는 α, β, γ, δ, 그리고 ε의 다섯 가지 다형체가 있다. 이러한 다형체 중에서 β-Ga_2O_3는 가장 열적으로 안정한 상이며 전력 소자 제조에 적용하기 위해 적극적으로 연구되어왔다. 현재 기판 제조기술의 발달로 인하여 β-Ga_2O_3 결정의 homoepitaxy에 의한 소자 제작이 가능하지만, 기판 내에 존재하는 높은 결함 밀도와 낮은 열전도율로 인한 소자 성능 향상에 제약이 따르고 있는 상황이다. 보다 다양하고 높은 성능의 소자를 제작하기 위해서는 기존에 잘 발달된 기술 체계를 가지고 있는 Si, GaN, SiC 등의 전력 반도체 재료를 기판으로 이용한 Ga_2O_3의 heteroepitaxy 기술의 개발과 응용이 적극적으로 필요하다.
본 연구에서는 육각형 결정 구조의 4H-SiC를 기판으로 이용하여 MOCVD 방법으로 Ga_2O_3 heteroepitaxy를 수행하였다. 우선적으로 기판의 결정 구조와 동일한 육각형 결정 구조로 박막 성장이 이루어지는 ε-Ga_2O_3 박막 결정을 성장하여 평탄성이 양호한 박막을 성장하였으며, 그 후에 고온에서 열처리를 진행하여 박막의 평탄성은 양호한 상태로 유지하면서 결정성과 전기적 전도성이 우수한 β-Ga_2O_3 박막으로 결정상을 변화시켰다.
결정 성장 조건과 열처리 조건 변화에 따른 ε-Ga_2O_3 과 β-Ga_2O_3 박막의 구조적 특성을 XRD 및 SEM을 이용하여 분석을 하였다. ε-Ga_2O_3 박막의 경우에는 온도 650C, H2O flow 350cc 조건에서 비교적 양호한 특성을 보였으며, 열처리 방법에 의하여 형성된 β-Ga_2O_3 박막에 대해서는 열처리 온도 650C, H2O flow 400cc 분위기 조건에서 양호한 결정상태를 확보할 수 있었다. 열처리에 의해 형성된 β-Ga_2O_3 박막 표면에 Ohmic (Ti/Au) 전극과 Schottky (Ni/Au) 전극을 형성하고, SiC 기판 표면에 Ohmic (Ti) 전극을 형성하여 β-Ga_2O_3 박막 자체 및 수직형 β-Ga_2O_3/SiC 구조의 Diode 특성을 확인하였다.
Acknowledgments: 이 연구는 2021년도 정부(산업통상자원부)의 재원으로 한국산업기술진흥원의 지원을 받아 수행된 연구임(P0012451, 2021년 산업전문인력역량강화사업)

Keywords:

semiconductor, Ga2O3, oxide semiconductor, power device, wide-bandgap

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.118

Raman study of two-dimensional MoS_2 under uniaxial tensile stress

KIM Young Chan [1], LEE Taegeon [1], RHO Heesuk *[1]
[1]Department of Physics, Jeonbuk National University
rho@jbnu.ac.kr

Abstract:

MoS_2 층상 물질에 변형력을 가하는 실험 방법을 고안하고 이를 이용한 라만 산란 실험 결과를 보고한다. 폴리카보네이트와 PDMS로 구성된 유연한 기판 위에 기계적으로 박리된 MoS_2를 전사한 뒤에 유연한 기판을 구부림으로써 MoS_2에 한 방향으로 인장 변형력을 가했다. 그 결과, MoS_2 층 내부의 포논인 E_{2g}^1 포논과 A_{1g} 포논 에너지뿐만 아니라 층과 층 사이의 층밀림(shear) 포논과 층 숨쉬기(breathing) 포논 에너지 또한 단축 인장 변형력이 증가함에 따라서 에너지가 점차 감소하였다. 특히, MoS_2의 결정축 방향과 단축 변형력이 가해지는 방향 사이의 각도를 달리하여 실험한 결과 변형력이 가해짐에 따른 포논 에너지의 감소율이 변화함을 알 수 있었다. [이 성과는 2019년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구임 (No. 2019R1A2C1003366)]

Keywords:

Raman spectroscopy, Strain, Stress, MoS2

MOCVD를 이용한 Si 기판 위의 β-Ga2O3 나노 와이어 성장과 다이오드 특성

YANG MIN *1, LEE JUNGBOK 1, KIM SOYOON 1, AHN NAMJUN 1, AHN HYUNGSOO 1, KIM KYUNGHWA 1
1Korea Maritime and Ocean University
myang@kmou.ac.kr

Abstract:

산화물 반도체 중에서도 β-Ga2O3는 단사정계(monoclinic) 구조로 약 4.9 eV의 가장 넓은 에너지 밴드갭을 가진다. 이로 인해 UV 영역에서의 발광 특성과 산소 공공에 의한 본질적인 전도성으로 인해 광전자 소자와 투명 전극, 고온 동작 가스 센서 등을 위한 물질로써 주목을 받고 있다. 앞서 언급한 소자에 응용하기 위해서는 물질을 다양한 형태로 제작할 수 있어야 한다. 그중에서 나노 벨트와 나노 로드, 나노 와이어와 같은 1차원 구조는 작은 크기와 높은 체적 대 면적 비율 등에 기인하는 새로운 물리, 화학적 현상을 이해하고 응용하기 위해 많은 연구가 이루어지고 있다. 나노 와이어의 길이와 지름, 조성, 불순물, 결정구조, 성장 방향 등은 나노 와이어의 광학적 특성과 밀접한 연관이 있으며, 이는 성장 과정에서의 물리적, 화학적 상태가 나노 와이어 특성에 영향을 준다는 것을 보여준다. 나노 와이어의 성장 방법으로는 다양한 방법이 보고되고 있지만 대표적으로 금속 촉매를 이용한 성장 방법이 있다. β-Ga2O3 나노 와이어 형성에 있어서 성장 메커니즘은 형태와 특성 등에 영향을 미치기 때문에 물리적, 화학적 특성이 다른 다양한 금속 촉매에 대한 연구는 필수적이다. 본 연구에서는 metal organic chemical vapor deposition (MOCVD)를 이용하여 Si 기판 위에서의 β-Ga2O3 나노 와이어 성장의 최적 성장 조건을 비교하였다. 금속 촉매로는 Au, Cu, Ni 등을 이용하였으며, 각각의 금속 촉매가 β-Ga2O3 나노 와이어의 형태 및 특성에 미치는 영향에 대해 조사하였다. β-Ga2O3 나노 와이어 형성을 위해서 온도는 800, 900, 950, 1000℃의 범위에서 변화를 주었고, 산소 공급을 위한 H2O 유량은 150cc 그리고 성장 시간은 30분으로 하였다. Ni과 Cu 촉매의 경우는 성장 온도 950℃에서 그리고 Au의 경우에는 800℃에서 나노와이어의 밀도가 가장 높은 것을 확인할 수 있었다. 또한, 2차원 Si 기판과 1차원 β-Ga2O3 나노 와이어로 구성되는 전자 소자로의 응용 가능성을 확인하기 위하여 Si 기판과 β-Ga2O3 나노 와이어 종단 부분에 금속 전극을 형성하여 다이오드 특성을 확인하였다. β-Ga2O3 나노 와이어 영역은 폴리머를 이용하여 나노 와이어들의 형상을 유지함과 동시에 나노 와이어 표면에서의 재결합 전류를 줄일 수 있도록 하였다. β-Ga2O3 나노와이어와 금속 전극, 그리고 β-Ga2O3 나노와이어와 Si 기판 사이의 계면 특성 및 누설 전류에 대한 평가를 진행하였다.
ACKNOWLEDGMENT: 이 연구는 2021년도 정부(산업통상자원부)의 재원으로 한국산업기술진흥원의 지원을 받아 수행된 연구임(P0012451, 2021년 산업전문인력역량강화사업)

Keywords:

nanowire, MOCVD, semiconductor, Ga2O3, β-Ga2O3

Facile synthesis of white light emission Cu, Mn co-doped ZnSe/ZnS core-shell quantum dots

KIM Ju Seok [1], KIM Sung Hun [1], LEE Hong Seok *[1]
[1]Department of Physics, Jeonbuk National University
hslee1@jbnu.ac.kr

Abstract:

Recently, colloidal quantum dots (QDs) have been highly attractive materials in the fields of light emitting diodes (LEDs), photovoltaics, and biolabeling. In particular, bright white light emission from single-emitting QDs in LED platform has drawn much attention in recent years for its many advantages such as lower energy cost, environmental friendliness, and a simpler fabrication processes. In addition, the long-term practical applications of Cd-based QDs have thrown a doubtful future owing to the intrinsic toxicity of Cd. Specifically, Mn-doped zinc chalcogenide QDs have also been developed to combine transition emission of Mn^{2+} and defect state emission for white light emitting material. However defect state would be highly sensitive to the environment (such as temperature, oxygen, and moisture, etc.) and it is difficult to control and produce desired optical properties of zinc white. In this work, we synthesized Cu, Mn co-doped ZnSe QDs using versatile hot injection method and appropriate doping strategy. These results provide an efficient strategy to achieve stable white light emission from co-doped ZnSe QDs coated with different shell materials. Absorption and fluorescence measurements were carried out for the optical properties of the Cu, Mn co-doped ZnSe QDs.

Keywords:

ZnSe quantum dots, Co-doped, Transition metal, Core-shell, White light emission

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.121

Selective area wavelength tuning of CdSe nanocrystals via laser irradiation

KIM Yong Bin [1,2], KIM Sung Hun [1], YIM Sang-Youp [2], LEE Hong Seok [*1]
[1]Department of Physics, Jeonbuk National University
[2]Advanced Photonics Research Institute, GIST
hslee1@jbnu.ac.kr

Abstract:

CdSe nanocrystals (NCs) synthesized under high temperature have received considerable attention because of the band gap tunability by varying the NCs size and various investigations in the field of nano-patterning have been reported. However assembling and locating NCs with desirable optical properties on the same solid surfaces and interfaces remains a significant challenge. Therefore postsynthetic and selective control of optical properties of NCs have been realized by surface modification techniques and this techniques can improve the spectral properties of NCs. Recently, it has been shown that changes in both emission wavelength and intensity can be controlled with laser power, wavelength and irradiation time. The changes in emission wavelength and intensity is attributed to the size reduction caused by photo-oxidation process and several factors such as decrease of surface trap and accumulation of electrons in the organic surroundings, respectively. In this work, we illuminated 405 nm CW laser on CdSe NCs to investigate laser irradiation effect on optical properties and carrier dynamics of CdSe NCs using hyperspectral imaging system. Upon laser irradiation, it is found that the changes in relative photoluminescence intensity of the CdSe NCs, along with blue shift in emission wavelength with increasing laser irradiation power and time.

Keywords:

CdSe nanocrystals, Laser irradiation, Photo-oxidation, Optical properties, Carrier dynamics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.122

Effect of reaction parameters on optical properties of $CsPbBr_3$ Nanocrystals

KIM Sung Hun [1], LEE Hong Seok [*1]
[1]Department of Physics, Jeonbuk National University
hslee1@jbnu.ac.kr

Abstract:

All inorganic cesium lead-halide perovskite nanocrystals (NCs) have attracted significant interest owing to unique optoelectronic properties including high absorption capacity, easily tunable photoluminescence (PL) over the entire visible window, high PL quantum yield, and long carrier diffusion length. Despite considerable progress and achievements made in the field, the optimal growth conditions of perovskite nanocrystals remain unclear and further development and improvement of their controllable synthesis is challenging. The case for the $CsPbBr_3$ NCs with various crystal phases can be strongly dependent on preparation conditions and reaction parameters. Specifically, the precursor molar ratio in the synthetic procedure can lead to variations in kinetics because fully converted solutions yield identical results to provide uniform conditions for a homogeneous reaction and uniform growth. The other cesium lead bromide perovskite derivatives with the diversity of structure and morphology such as $CsPb_2Br_5$ NCs would possess particular structure-dependent physicochemical properties. In this work, we investigate optical properties of $CsPbBr_3$ NCs with different phase composition tuning the reaction parameters. In particular, we reveal the influence of varying reaction parameters on optical properties of $CsPbBr_3$ NCs and the phase transformation was systematically tested for different phase transition by changing reaction temperature, time, and precursor molar ratio.

Keywords:

CsPbBr3, Nanocrystals, Reaction parameters, Phase transformation, Optical properties

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.201

Ag가 증착된 crater 구조 내에서의 증가된 표면 플라즈몬 분석

RYU Jae-Hoon [1], KIM Sung-Hyun [1], KIM Han-Sol [1], BYEON Jae Yeop [1], LEE Ha Young [1], CHUN Young Tea [1], AHN Hyung Soo [1], HA Dong Han [2], YI Sam Nyung [*1]
[1]Korea Maritime and Ocean University
[2]Materials and Convergence Measurement Institute, KRISS
snyi@kmou.ac.kr

Abstract:

표면 플라즈몬(surface plasmon) 현상은 금속이 유전체와 계면을 형성할 때 외부의 전자기파에 의해 금속 표면의 전자가 집단적으로 진동하는 현상이다. 표면 플라즈몬 현상은 국부 표면 플라즈몬과 전파형 표면 플라즈몬 현상으로 나뉘는데 특히, 국부 표면 플라즈몬은 금속 나노입자 (10 ~ 200 nm)에서 관찰된다. 이와 같은 표면 플라즈몬 공명 현상은 다양한 소자의 효율성을 높이기 위해 많이 사용된다. 하지만 표면 플라즈몬을 형성하는 방법은 다양하나 본 논문에서는 GaAs (100) 기판에 습식 화학적 식각 방법을 이용하여 crater 구조를 제작하고 그 위에 Ag 박막을 증착하고 Ag nanowire를 스프레이 코팅법을 추가로 도포하여 표면 플라즈몬의 세기를 향상 시키는 방법을 연구하였다.
다양한 양의 Ag nanowire를 도포하여 최적의 용량을 선택하고 crater 구조의 내부와 외부의 라만 신호를 분석하여 crater 내부에서 더 높은 신호를 얻을 수 있었다. 이는 crater 구조와 내부에 증착된 Ag nanowire에 의한 hot spot 효과에 의해 전기장이 증가된 것으로 확인 할 수 있다.
전계 방출 전자 현미경 (FE-SEM)과 광학 현미경을 사용하여 형상을 측정하였고 Raman spectrometer 장비를 사용하여 표면 플라즈몬 공명의 정도를 분석하였다. 최적의 조건을 구한 구조에 적합한 물질을 증착한다면 다양한 용도에 적용할 수 있을 것이다.

Keywords:

표면 플라즈몬, Ag nanowire, GaAs crater, Raman

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.202

PbS 양자점을 이용한 다중색상 근적외선 photodiode

장세환[1,3], 김지훈[2], 박홍규[3], 송진동*[1]
[1]Center for Opto-Electronic Convergence Systems, Korea Institute of Science and Technology
[2]Quantum-Functional Semiconductor Research Center, Donguk University
[3]Department of Physics, Korea University
jdsong@kist.re.kr

Abstract:

PbS 양자점은 근적외선 영역에 속하는 밴드갭을 가지고 있으며, 수광 효율이 우수하여 태양전지 및 근적외선 광센서 소재로 크게 주목받고 있다. 또한, 양자점은 크기 조절을 통해 밴드갭을 조절하기 쉽다는 이점이 있기 때문에 다중파장 광센서를 만들기에 적합한 소재이다. 본 연구에서는 PbS 양자점을 patterning 하여 pixel화 하는 방법과 이를 이용하여 다중색상 근적외선 photodiode를 제작하는 방법에 대해 논의하고자 하며, 이를 통해 저비용 다중색상 근적외선 이미지 센서의 개발에 기여할 수 있을 것으로 기대한다.

Keywords:

Quantum dots (QDs), PbS, photodiode, NIR, 근적외선

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.203

Molecular-Dipole-assisted Fermi-level Engineering of vdW Schottky Junctions for 2D Semiconductor Photovoltaics

YANG Seunghoon [1], SHIN Jaeho [1], LEE Jaeho [1], EO Jung Sun [1], WANG Gunuk [1,2], LEE Chul-Ho *[1,2]
[1]KU-KIST Graduate School of Converging Science and Technology, Korea University
[2]Department of Integrative Energy Engineering, Korea University
chlee80@korea.ac.kr

Abstract:

Two-dimensional (2D) semiconductors have attracted much attention for ultrathin optoelectronics due to their exceptional optical properties and the ability to build artificial heterostructures. Nevertheless, the Fermi-level (E_F) pinning at the metal-semiconductor interface still impedes the realization of high-performance optoelectronic devices. In this regard, it is highly demanding to develop the appropriate strategies to control the Schottky barrier in a predicted manner according to the ideal Schottky-Mott rule. However, in the case of van der Waals (vdW) transfer methods previously reported, the use of different metals is necessary to control the work function and corresponding energy barrier. Here, we report a facile approach to modify the work function of metals and the associated built-in potential in vdW Schottky junctions utilizing interface molecular dipoles. The dipole field induced by self-assembled monolayers (SAMs) on the metal surface leads to the work function difference and the built-in potential across the vdW metal-semiconductor junction. As a result, when the SAMs interlayer was introduced at the interface, the photovoltaic characteristics such as the short-circuit current and open-circuit voltage were tuned depending on differently polarized molecules. Furthermore, the photoresponsivity can be substantially enhanced by creating a strong built-in field via interface dipole control. Our work suggests a new route to achieve molecular band engineering in vdW heterostructures toward realizing high-performance 2D optoelectronics.

Keywords:

2D materials, Photovoltaics, Interface Engineering

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.204

물과 열에 안정성을 가지는 친환경 할라이드 페로브스카이트 신틸레이터

IM Hyun Sik *[1], KIM Hyunsang [1], NOH Samkyu [1], JO Yongcheol [1], CHO Sangeun [1], HAN Jonghoon [1], PARK Sunjung [1], SHIN Giho [1], YEON Seungun [1]
[1]Dongguk University
hyunsik7@dongguk.edu

Abstract:

기존의 고체 신틸레이터에 비해 액체 신틸레이터는 낮은 밀도와 방사선 발광 양자 수율로 인해 X-ray 이미징에 거의 사용되지 않았다. 하지만 금속 할라이드 페로브스카이트 물질이 액체 신틸레이터에 응용되며 기존의 액체 신틸레이터와 비교하여 훨씬 우수한 특성을 보였고 이에 따라 페로브스카이트 기반 액체 신틸레이터를 이용한 X-ray 이미징 구현이 가능하게 되었다. 하지만 많은 장점들에도 불구하고 페로브스카이트는 친환경적이지 않으며 무극성 용매가 아닌 극성 용매에 대한 안정성과 열에 대한 안정성이 현저히 떨어진다는 단점을 갖고 있다. 따라서 페로브스카이트를 이용한 액체 신틸레이터의 상용화를 위해서는 물과 열에 대한 안정성이 뛰어나며 친환경적인 페로브스카이트를 제작하는 것이 필수적이다. 본 연구에서는 β-Cyclodextrin과 Tetramethyl orthosilicate를 이용해 두 차례 인캡슐레이션을 하였고 그 결과 물과 열에 안정성이 뛰어난 페로브스카이트 나노크리스탈을 제작하였고 높은 발광특성을 확인하였다.

Keywords:

신틸레이터, 페로브스카이트 나노크리스탈, 인캡슐레이션, 안정성

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.205

하이브리드 슈퍼커패시터용 증기성장 탄소섬유와 통합된 망간 코발트 산화물 나노입자의 합성

MANCHI Nagaraju [2], S. Chandra Sekhar [1], BHIMANABOINA Ramulu [2], S. Junied Arbaz [2], YU Jae Su [*1,2]
[1]Department of Electronic Engineering, Kyung Hee University
[2]Department of Electronics and Information Convergence Engineering, Kyung Hee University
jsyu@khu.ac.kr

Abstract:

오늘날 화석 연료의 점진적인 고갈과 환경 오염 문제의 증가와 관련하여 재생 에너지 저장 시스템 개발에 많은 연구가 집중되고 있다. 일반적으로 슈퍼커패시터는 높은 전력 밀도, 빠른 충전-방전, 우수한 사이클링 안정성 및 안전한 작동 특성을 가지고, 전하 저장 메커니즘에 따라 전기 이중층 커패시터와 의사커패시터로 분류된다. 전기 이중층 커패시터 유형 재료에 비해 의사커패시터 유형 재료는 높은 산화 환원 특성과 전기화학적 활성으로 인해 우수한 정전 용량/용량 성능을 나타낸다. 또한 두 개의 전이 금속 산화물을 하나의 구성으로 결합하는 것은 정전 용량과 에너지 밀도 성능을 향상시키는 효율적인 전략 중 하나이다. 본 발표에서는 수열합성법에 의해 Mn_2CoO_4 나노입자를 합성했다. 그런 다음 이러한 Mn_2CoO_4 나노입자를 전도성 증기성장 탄소섬유와 결합하여 전체 전도도와 전기 역학을 더욱 향상시켰다. 또한, 우리는 알칼리 전해질에서 각각 양극 및 음극으로 준비된 증기성장 탄소섬유@Mn_2CoO_4 복합재와 활성탄을 사용하여 하이브리드 슈퍼커패시터를 제작하고 전기화학적 특성을 측정하였고, 탁월한 사이클링 안정성과 함께 우수한 에너지 저장 특성을 보여주었다.

Keywords:

망간 코발트 산화물, 슈퍼커패시터, 전기화학적 특성

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.206

MoS_2 Quantum Dots based Colorimetric Biosensor for Detection of Lactobacillus Bacteria

BYEON Clare Chisu*[1], ALI Luqman [2], BOBY Naila [3], PARK Seung Chun[3], LEE Yong Joong[1]
[1]School of Mechanical Engineering, Kyungpook National University
[2]Department of Mechanical Engineering, Kyungpook National University
[3]Department of Veterinary Medicine, Kyungpook National University
byeon@knu.ac.kr

Abstract:

Precise quantification and detection of H_2O_2 plays a vital role in the diagnosis of several diseases such as diabetes, Alzheimer, Parkinson's disease and vaginosis. Therefore, fabrication of a sensitive and accurate sensing device for its detection is very crucial. We employed, MoS_2 quantum dots (QDs) exfoliated by a sonication-assisted ion-intercalation exfoliation method (will be reported elsewhere), for the colorimetric detection of H_2O_2 releasing Lactobacillus Plantrum (L. Plantrum) and Lactobacillus Acidophilus (L. Acidophilus) bacteria. These bacteria are very important for the production of H_2O_2 to maintain healthy vaginal flora and prevent against vaginosis. The MoS_2 QDs based colorimetric biosensor showed a better peroxidase-like catalytic activity and had a limit of detection (LOD) of □ 0.31 μM with H_2O_2 corresponding to □3 CFU/mL for the bacteria.

Keywords:

MoS2 quantum dots, H2O2 colorimetric detection, Lactobascilli biosensing

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.207

$MAPbI_3$ solar cell fabrication using anti-solvent dropping time depending on ambient temperature

YANG JungYup *[1], SIN Jaegwan [1], KIM Gisung [1], KIM MoonHoe [1], KIM Mijoung [1], PARK Geon [1], JANG Hyoseong [1], KIM Jaeho [1], KIM Mina [1], OH Juyoung [1]
[1]Department of Physics, Kunsan National University
jungyup.yang@kunsan.ac.kr

Abstract:

Perovskite solar cells are attracting a lot of attention due to the manufacturing process of simple and inexpensive solutions with high power conversion efficiency. However, since organometallic halide perovskites are easily soluble in water, the manufacturing process is usually done inside a glove box to avoid moisture. In this study, we use chlorobenzene as an anti-solvent and present the anti-solvent dripping time related to the ambient temperature. The spin coating process is divided into fluid and evaporation dilution. In the first fluid dilution process, it is strongly related to the RPM of the spin coating. Subsequent evaporation dilution is related to RPM and ambient temperature and atmosphere. In spin coating of perovskite precursor solution, the precise dropping time of anti-solvent is the point between fluid dilution and evaporation dilution. This means that optimum anti-solvent dripping time changes according to the ambient temperature and atmosphere. We have achieved a maximum photoconversion efficiency of 18.2% for $MAPbI_3$ solar cells through analysis of accurate relationship between the ambient temperature and anti-solvent dripping time.

Keywords:

MAPbI3, anti-solvent, temperature, evaporation dilution, fluid dilution

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.208

할라이드 페로브스카이트 기반 폴리머 신틸레이터 필름 제작

IM Hyun Sik *[1], PARK Sun jung [1], KIM Hyung sang [1], NO Sam kyu [1], CHO Sang eun [1], HAN Jong hoon [1], HONG Seong su [1], YEON Seung un [1], JO Yong cheol [1]
[1]Dongguk University
hyunsik7@dongguk.edu

Abstract:

최근 의료, 보안 등 많은 분야에 걸쳐 고해상도 X-ray sensing 기술에 대한 관심이 늘어나면서 신틸레이터 물질에 대한 연구가 증가하고 있다. 하지만 기존의 상용화 된 신틸레이터 물질은 고체 형태가 일반적으로, 플랙시블 및 대면적 형태의 필름 제작에 한계가 있다. 본 연구에선 고체 신틸레이터의 한계를 극복하기 위해 CsPbBr3 페로브스카이트 나노크리스탈(PNCs)의 표면을 polymer가 감싼 액체 상태의 Hybrid 신틸레이터를 합성하였다. 이렇게 제작된 Hybrid 신틸레이터 물질은 강한 X-ray 흡수율을 보이며, 흡수된 고에너지 photon을 가시광선 파장의 photon으로 효율적으로 변환하며 높은 신틸레이터 특성을 보였다. 이어 합성된 hybrid 신틸레이터 물질을 응용하기 위해 Electro-deposition 방법으로 필름을 증착 하였고, 나아가 더 나은 신틸레이터 특성을 위해 multi-layer 필름 증착을 시도해 두꺼운 필름을 증착하는 것에 성공하였다. 동일한 방식을 통해 필름을 증착한 결과 기존 고체 신틸레이터 물질에서는 한계가 있었던 플랙시블 및 대면적 형태의 신틸레이터 필름을 증착하는 것에 성공하였다.

Keywords:

신틸레이터, 페로브스카이트, 페로브스카이트필름, electrodeposition

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.209

할라이드 페로브스카이트 기반의 고성능 플렉시블 신틸레이터 제작

IM Hyun Sik *[1], SHIN Giho [1], HAN Jonghoon [1], JO Yongcheol [1], CHO Sangeun [1], HONG Seongsoo [1], PARK Sunjung [1], YEON Seungun [1], NOH Samkyu [1], KIM Hyungsang [1]
[1]Dongguk University
hyunsik7@dongguk.edu

Abstract:

최근 엑스레이 센서 기술이 발달함으로써 다양한 분야에서 엑스레이 센서에 대한 수요가 급증하고 있다. 그 중 엑스레이 이미지 검출에 관한 연구로서 디지털 엑스레이 이미지 측정뿐만 아니라 곡면 측정을 위한 플렉시블한 신틸레이터에 관한 연구가 활발하게 진행되고 있다. 현재 상용화되어 있는 엑스레이 신틸레이터는 고체형 물질로서 엑스레이 검출을 통해, 대상에 대한 2차원적인 정보를 제공한다. 즉, 고체형 신틸레이터는 2차원적 정보만을 제공하기 때문에 대상의 굴곡이나 내부의 세부적인 명확한 이미지를 제공하는데 어려움을 가지고 있다. 따라서 본 연구에서는 대상의 3차원적 정보를 세부적으로 명확하게 제공하기 위한 방법을 고안하였다.

뛰어난 광특성을 지니고 있을뿐만 아니라 잠재성이 우수한 페로브스카이트(ABX3)가 신틸레이터 대체 물질로써 연구중에 있다. 그 중 할라이드 페로브스카이트 (CsPbX3, X = Cl, Br, I)는 높은 발광 효율과 우수한 안정성을 가진다. 따라서 이러한 장점을 가진 할라이드 페로브스카이트를 PDMS 와 섞어 플렉시블한 신틸레이터를 제작하였고, 이는 기존의 3차원적 형상을 제공하지 못하는 신틸레이터의 단점을 보완할 수 있다. 또한 필요한 용도에 따라 다양한 신틸레이터 구조와 대면적 필름 제작이 가능하다. 뿐만 아니라, 유기분자인 PPO를 혼합하여, 발광특성을 증폭하는 Light transfer (LT) 메커니즘을 증명하였다.

λ_{UV} = 365 nm 와 254 nm를 조사하여 비교하였을 때, 더 짧은 파장 대역(고에너지영역)에서 발광 특성이 보다 증폭하는 현상을 확인할 수 있었으며, 이에 따라 보다 더 짧은 파장대역, 엑스선에서 보다 향상된 신틸레이터의 성능을 보일 것으로 기대한다.

Keywords:

할라이드 페로브스카이트, Flexible, 신틸레이터, 2,5-diphenyloxazole

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.210

Solar blind UV detector with Lead free $Cs_3Cu_2I_5$ nanocrystal as a wavelength converter

IM Hyun Sik *[1], HAN Jonghoon [1], JO Yongcheol [1], CHO Sangeun [1], HONG Seongsoo [1], PARK Sunjung [1], YEON Seungun [1], SHIN Giho [1], NOH Samkyu [1], KIM Hyunsang [1]
[1]Dongguk University
hyunsik7@dongguk.edu

Abstract:

할라이드 페로브스카이트는 그 물질의 우수한 광학적 특성으로 인하여 자외선 검출기에 적합한 물질로 주목 받고 있다. 그러나 할라이드 페로브스카이트에 포함된 납 성분의 독성으로 인한 환경적인 문제점을 가지고 있다. 대부분의 자외선 검출기는 유리 기판 위에 Indium Tin Oxide(ITO) 투명 전도성 산화물 위에 제작된다. 하지만 UV-C (200-280 nm) 파장은 유리/TIO 기판을 투과하지 못한다. 그 때문에 그 위에 제작되는 자외선 검출기의 흡수층이 효과적으로 UV-C 파장을 흡수하지 못하게 되어 검출 효율이 떨어지는 문제점이 있다. UV-C 파장을 검출하기 위해서는 UV-C 파장을 유리/ITO 기판을 투과할 수 있는 파장으로 변환해주는 파장 컨버터가 필요하다.

본 연구에서는 UV-C 파장을 효과적으로 검출하기 위하여 유리/TIO 기판 뒷면에 450 nm 발광 파장을 내며 납 성분이 포함 되지 않은 $Cs_3Cu_2I_5$ 나노크리스탈을 코팅하여 UV-C 파장을 유리/ITO 기판을 투과할 수 있는 450 nm 파장으로 변환시켰다. 그 후에 유리/ITO 기판 위에 흡수 피크 파장이 440 nm인 $Cs_2AgBiBr_6$ 더블 페로브스카이트를 흡수층으로 사용하는 광 검출기를 제작하여 효과적으로 UV-C 파장을 검출할 수 있는 광 검출기를 제작하였다. $Cs_3Cu_2I_5$ 나노크리스탈을 코팅한 광검출기는 $Cs_3Cu_2I_5$ 나노크리스탈을 코팅하지 않은 광 검출기에 비하여 10배 향상된 효율을 보여주었다.

Keywords:

Lead free perovksite, UV-C detection

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.211

Interlayer interaction in MoO_3/graphene heterostructure grown by van der Waals epitaxy

KIM Hangyel [1], KIM Jong Hun [5], KIM Jungcheol [6], PARK Kwanghee [7], BAEK Ji-Hwan [1], SHIN June-Chul [1], RYU Sunmin [7], CHEONG Hyeonsik [6], LEE Gwan-Hyoung [*1,2,3,4]
[1]Department of Materials Science and Engineering, Seoul National University
[2]Research Institute of Advanced Materials, Seoul National University
[3]Institute of Engineering Research, Seoul National University
[4]Institute of Applied Physics, Seoul National University
[5]Department of Materials Science and Engineering, Yonsei University
[6]Department of Phyiscs, Sogang University
[7]Department of Chemistry, POSTECH
gwanlee@snu.ac.kr

Abstract:

Since successful isolation of graphene, it has attracted enormous attention because of its unique electric, mechanical, and optical properties, which make graphene a promising candidate for next-generation electronic devices. Various methods have been proposed to modify or enhance properties of graphene. However, most of them change graphene temporarily or leave a permanent damage. Therefore, a non-destructive method has been required for engineering graphene. In this regard, coating of graphene with highly stable layers is an effective method to provide strain or dope the graphene under the coated layers. Crystalline molybdenum trioxide (α-MoO_3) is a layered oxide material, where octahedral layers are stacked along b-axis direction with weak van der Waals force. Bulk state of MoO_3 has been utilized as hole transport layer of solar cell and light emitting diode due to its high work function. Therefore, it would be possible that coating of MoO_3 modify the properties of graphene.
Here we demonstrated a novel method to engineer graphene by epitaxial growth of MoO_3. When thin MoO_3 layers are synthesized on the graphene by proximity evaporation of Mo thin film in ambient condition, strong interaction between graphene and the grown MoO_3 is observed due to ultraclean hetero-interface with a crystalline correlation. The MoO_3-coated graphene is compressed by ~ 0.2 % due to large lattice mismatch of graphene and MoO_3. In addition, graphene is p-doped up to 2.0 $\times 10^{13}$ cm^{-2} due to extraction of electrons from graphene to MoO_3 which is originated from high work function of MoO_3. More interestingly, we observed asymmetric doping level between top graphene layer and bottom layers in MoO_3-deposited multilayer graphene, which is probably due to screening effect of graphene. Our work shows a possibility of engineering graphene by using epitaxial growth of 2D oxides, including strain modulation and permanent and non-destructive doping control.

Keywords:

van der Waals epitaxy, interlayer interaction, in-plane anisotropy, graphene, MoO3

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.212

The electronic properties of the magnetic quantum ring in bilayer graphene

DAEHAN Park [1], HSKIM Kim [1], NAMMEE Kim *[1]
[1]department of physics, Soongsil University
nammee@ssu.ac.kr

Abstract:

The electronic structure of a magnetic quantum ring in bilayer graphene is investigated analytically. The magnetic quantum ring (MQR) has an isotropic inhomogeneous magnetic field, which is zero inside the ring and constant elsewhere. Here, we investigate the properties of MQR based on bilayer graphene; energy state, wavefunction, and Abranobov-Bohm effect. In addition by comparison with monolayer graphene, we discuss the difference between the two systems.

Keywords:

Bilayer graphene, Magnetic quantum ring

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.213

N- to p-type conversion of the MoS_2 surface using He ion sputtering

HAN Sang Wook *[1], YUN Won Seok [2], KIM D.-H. [3], KIM Hyesun [4], RYU S. [4]
[1]Basic science research institute, University of Ulsan
[2]Convergence Research Institute, DGIST
[3]Beamline Research Division, Pohang Accelerator Laboratory
[4]Department of Chemistry, POSTECH
swhan72@ulsan.ac.kr

Abstract:

After discovering graphene, an atomically thin monolayer MoS_2 has attracted intensive attention due to its noble features, such as the thickness-dependent indirect-to-direct bandgap transition and lattice vibration. In particular, the successful realization of field-effect transistors composed of monolayer MoS_2 has boosted the development of high-performance flexible electronic and optoelectronic devices. However, strong Fermi level pinning and high contact resistance between the metal electrode and underlying few- and monolayer MoS_2 predominantly induce n-type unipolar conductivity. A few p-type MoS_2 semiconductors limit practical application in constructing functional 2D devices.
Doping technology is essential in the semiconductor electronics industry. Various approaches to converting n-type to p-type TMDs have been proposed and employed, such as substitution, intercalation, charge transfer, and electrostatic doping methods. Among varous approaches, the use of noble gas ions can tailor various defect types on the basal plane of MoS_2 depending on the incidence angle, ion mass, and ion energy. For example, the selective generation of mono-sulfur vacancy defects on the basal plane of MoS_2 monolayer using Ar ion sputtering has enabled activation of the inert MoS_2 surface to be catalytic, resulting in taking significant interest for the hydrogen evolution reaction. Moreover, the focused He ion microscope or He plasma can precisely etch and pattern 2D materials, introduce n-type doping in a highly controlled fashion, and tune the insulator-to-metal transition.
By contrast, we report that the He ion sputtering can act as a highly tunable capture of the excess electrons accumulated at the n-type MoS_2 surface under the controlled ion energy and irradiation time, converting to a p-type MoS_2 surface without producing sulfur vacancies. Our finding provides a stable and universal method to convert n-type to p-type 2D TMDs.

Keywords:

2D material, Doping methodology, noble gas ion sputtering

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.214

Effects of Oxygen plasma treatments on the MoS_2-based device

LEE Jeongwoo [1], YANG Woochul *[1]
[1]Department of physics, Dongguk University
wyang@dongguk.edu

Abstract:

O2 plasma treatment is a well-known process to remove photoresistor (PR) residues under a low temperature in fabricating semiconductor devices. However, for metal contact of two-dimensional(2D) semiconductor, it is necessary to investigate the effects of the structural and electronic modification at the interfaces because the metal contact significantly affects the charge transport in 2D materials-based FET. In this study, we report that the effects of O2 plasma on the surface cleaning of MoS2 and charge transport through contact interface between Cr and MoS2 in MoS2-based FET. Few layer MoS2 exfoliated mechanically and Cr/Au as a contact metal were used for FET fabrication. Particularly, we employed a mild low frequency (LF) plasma for O2 plasma treatment. The PR removal and modification of MoS2 surface were characterized using atomic force microscopy (AFM), Scanning electron microscopy (SEM), Raman spectroscopy, Kelvin probe microscopy (KPM), and X-ray photoelectron spectroscopy (XPS). I-V characteristics were also performed to examine charge carrier transport behavior of the FET. After O2 plasma exposure with LF plasma of developed MoS2 layer, AFM, SEM, and Raman results showed PR residues were completely removed without oxidation of MoS2 surface. Also, XSP and KPM measurements of the Cr-contacted MoS2 exhibited the formation of CrS at the interface, which resulted in the enhancement of electrical characteristics of FET devices. The improved charge transport behaviors will be discussed in terms of O2 plasma reaction with MoS2 surface and tunneling barrier formation at the interface.

Keywords:

Molybdenum disulfide(MoS2), O2 plasma, Ohmic contact, Photoresist residue

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.215

Efficient Photo Electrochemical Water Splitting using Dibenzo[b,f][1,5]diazocines/ZnO Organic/inorganic hybrid Photoelectrodes

SISSEMBAYEVA Yana [1], CHO Soo Kyung [1], HWANG Yoon Hwae [*1]
[1]Department of Nanoenergy Engineering, Pusan National University
yhwang@pusan.ac.kr

Abstract:

A solar water splitting is one of the promising technologies towards clean energy generation through direct conversion from water and sunlight to electrical current and hydrogen gas. Much research was conducted on the inorganic semiconducting materials with high efficiency despite several disadvantages such as a difficulty in tuning the innate properties such as bandgaps, relatively higher cost due to limited availability and low structural tenability. These limitations can be resolved by applying the organic semiconducting materials with tunable bandgap, energy levels and charge transport mobility. Therefore, the development of a new class hybrid organic-inorganic semiconducting materials for solar water splitting is in high demand.

In this study, we synthesized various dibenzo[b,f][1,5]diazocine derivatives from substituted 2-aminobenzophenones which were applied as an organic film on the top of the inorganic hydrothermally grown for 3 hours ZnO nanorods to produce a hybrid photoanode for oxygen evolution reaction. The self-assembly behavior of organic film to successfully make interfaces was characterized as well as chemical and physical properties of a hybrid semiconducting photoanode. Moreover, dibenzo[b,f][1,5]diazocine derivatives stability at aqueous electrolytes which is a critical concern for organic semiconductors used in water splitting, showed promising results in various test conditions. We propose hybrid dibenzo[b,f][1,5]diazocine derivatives organic - ZnO nanorods inorganic photoelectrode as a new class of semiconducting material with low cost, easy processing, optoelectronic tenability and good stability for solar driven water splitting.

Keywords:

solar water splitting, organic-inorganic hybrid photoanode, ZnO nanorods

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.216

Role of Interface Reaction on Resistive-Switching of Al_2O_3/AZO Bi-layer.

SEO Sunae *[1], SONG Hyeon-kyo [1], LEE Myoung-Jae [2], KIM Taekwang [1], DU Hyewon [1], KIM Seonyeong [1]
[1]Department of Physics, Sejong University
[2]Division of Nanotechnology, DGIST
sunaeseo@sejong.ac.kr

Abstract:

In this study, we fabricated Al_2O_3/AZO Bi-layers Reram and analyzed interface reactions through electrical measurement.
Recently, with the progress of Neuromorphic computing technology, there is a need to develop a suitable device. ReRAM is showing potential as a neuromorphic computing device due to its non-volatile property and low driving power. Especially, Metal oxides which are typical materials on ReRAM can practice various resistance states by adjusting the amount of oxygen vacancy.
We fabricated a Metal/Oxide/Metal Reram device with ALD and E-beam evaporator. The oxide film is composed Al_2O_3/AZO Bi-layer. AZO takes the role of oxygen vacancy reservoir, which can create a proper amount of oxygen vacancy with Al2O3 and ZnO by the nanolaminate method. Also, the top Al_2O_3 layer was deposited 0~15cycle for the role of tunneling barrier. This device showed Bipolar resistive switching. The resistive switching occurs as the thickness of the tunneling barrier changes with the movement of oxygen ions in the top Al_2O_3 interface layer. Also, this device does not have a forming process contrary to the previously reported oxygen migration model and has secured a self-rectifying property that can act as a selector in one device. These characteristics confirmed the conduction model analysis through electrical measurements.

Keywords:

ReRAM, Neuromorphic, Memory, Self-rectifying, forming-free

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.217

Si 마이크로 바늘의 가시광 발광 특성

LEE Gang Seok [1,2], PARK Jung Hyun [1], KIM Kyung Hwa [1,2], AHN Hyung Soo [*1], LEE Jae Hak [1], CHUN Young Tea [1], YANG Min [1], YI Sam Nyung [1], KIM Suck-Whan [3], LEE Won-Jae [4]
[1]Electronic Materials Engineering, Korea Maritime and Ocean University
[2]Compound Semiconductor Education Center, Korea Maritime and Ocean University
[3]Department of Physics, Andong National University
[4]Division of Advanced Materials Engineering, Dong-Eui University
hsahnpusan@daum.net

Abstract:

Si은 일반적으로 다이아몬드 입방 구조를 가질 때 1.1eV의 밴드갭을 가지는 간접천이형 반도체 물질이며 광통신 소자 등의 적외선 발광소자에 응용하기 위해 많은 연구가 진행되고 있다. 기존 연구에서 벌크 Si의 발광은 간첩 천이에 의한 비효율적인 광원으로서, 다ㅅ른 물질의 도핑 방법이나 나노 구조를 통한 가시광 발광영역의 확장 등의 다양한 시도가 있어 왔다. 본 연구에서는 혼합소스 수소화물 기상 증착법 (mixed-source HVPE)에 의해 성장시킨 마이크로 바늘 모양의 순수한 Si의 광특성을 분석했다. 50um의 직경과 약 5mm 길이를 가지는 Si 마이크로 바늘 양끝에 Silver paste를 도포하여 Shottky 전극을 형성한 후 상온에서 프로브 스테이션 장비를 이용하여 전류를 인가했다. AvaSpec-2048 분광기를 통해 Si 마이크로 바늘로부터 방출된 빛의 main 파장이 740nm인 가시광 발광을 육안으로 확인하였다. 따라서 이 결과로부터 혼합소스 HVPE 방법에 의해 성장한 Si 마이크로 바늘은 Photovoltaic(PV)소자 등에 응용이 가능할 것으로 판단된다.

Keywords:

Si, HVPE, Visible, Optical

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.218

올-이차원 그래핀/MoS_2/그래핀의 수직 이종접합 반투명 유연 광검출 소자

이원준[1], 고정선[1], 장찬욱[1], 김성[2], 신동희[3], CHOI Suk-Ho *[1]
[1]Department of Applied Physics, Kyung Hee University
[2]Humanitas College, Kyung Hee University
[3]Department of Physics, Andong National University
sukho@khu.ac.kr

Abstract:

최근 이차원 물질은 우수한 전기적 및 광학적 특성으로 광전자 소자로 활용하기 위한 다양한 연구가 진행되고 있다. [1] 그러나 이차원 단일층 물질의 한계로 인하여 효율 향상에 어려움이 있어서 여러가지 종류의 다른 차원 또는 물질과의 이종접합을 형성하여 소자의 특성을 향상시키고자 하는 시도가 많이 보고되고 있다. [2] 본 연구에서는 도핑물질인 Trifluoromethanesulfonyl-amide (TFSA)을 이용하여 그래핀(GR)을 p형으로 변형하여 (TFSA-GR) 이차원 물질로만 구성된 TFSA-GR/MoS_2/TETA-GR 수직 이종접합을 처음으로 제작하여 반투명 유연 광검출소자에 적용하였다. 그 결과, 0.128 A/W의 반응도, 1.69 x 10^9 cm $Hz^{1/2}$/W의 검출능 등의 비교적 우수한 광검출소자 특성과 더불어 가시광선 영역에서 평균 58%의 투과도를 보였다. 또한 같은 구조에 기반하여 플라스틱 기판 위에서 유연 소자로 제작한 결과, 2000번 구부렸다 피는 작업을 반복해도 기존 반응도의 32%를 유지할 정도로 우수한 유연특성을 보임으로써, TFSA-GR/MoS_2/TETA-GR 수직 이종접합 구조가 유연하고 접을 수 있을 뿐만 아니라 반투명한 광전자 소자로 응용이 가능함을 보였다. 본 발표에서는 이러한 실험적인 결과를 바탕으로 물리적인 메커니즘에 대해서 논의하고자 한다.

[1] S. Das et al., Adv. Mater. **31**, 1802722 (2018).
[2] W. J. Yu et al., Nat. Nanotechnol. **8**, 952–958 (2013).

Keywords:

이차원 물질, 그래핀, MoS2, 광검출소자, 반투명 유연

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.219

2D/3D 페로브스카이트 이종접합 구조의 압전 및 광압전 효과(piezo-electric and -phototronic effects) 특성 연구

장찬욱[1], 이원준[1], 김재국[1], 김성[2], 신동희[3], CHOI Suk-Ho *[1]
[1]Department of Applied Physics, Kyung Hee University
[2]Humanitas College, Kyung Hee University
[3]Department of Physics, Andong National University
sukho@khu.ac.kr

Abstract:

2D/3D 페로브스카이트 이종접합 구조는 높은 광전효율과 안정성을 바탕으로 최근에 광전자 소자로 활용하고자 하는 연구가 각광을 받고 있으며, 특히 다기능 전자/광 소자의 응용의 가능성이 높아서 많은 관심을 받고 있다. 본 연구에서는 계면제어를 통해 제작한 2D/3D 페로브스카이트 이종접합 소자 구조에서 압전 및 광압전 (**piezo-electric and -phototronic effects)** 특성을 처음으로 관찰하였다. 압전 특성을 분석하기 위하여 0, 10, 20, 30, 40, 및 50 kPa의 압력을 소자에 인가하여 압력에 따른 암전류 변화를 측정하였다. 2D/3D 페로브스카이트 소자는 기존의 2D와 3D 단층 소자보다 더 큰 암전류 변화를 나타내었으며, 압전 현미경을 통해서 측정된 압전상수도 4.33 pm/V로 가장 높았다. 그리고 광압전 특성을 분석하기 위하여 532 nm 파장의 레이저를 조사하여 다양한 압력에 따른 광전류 변화를 측정하였다. 2D/3D 소자의 압력에 따른 광반응도의 변화는 다른 소자들보다 더 높게 나타났으며 30 kPa이하의 압력에서는 광반응도가 압력에 따라 증가하고 30 kPa 이상의 압력에서는 감소함을 보였다. 이는 계면에서의 밴드정렬이 인가된 압력에 따라 변화하여 30 kPa 이하일때에는 전하의 수집이 용이하나 더 높은 압력이 인가될 때에는 밴드정렬이 어긋나 전하의 이동을 방해하기 때문이다. 온도와 습도가 각각20℃와 30~35%일 때 소자의 안정성을 30일간 측정한 결과, 소자의 특성이 70% 이상 유지됨으로써 소자의 안정성이 매우 우수함을 확인하였다. 본 발표에서는 위의 실험 결과들을 토대로 2D/3D 페로브스카이트 이종접합 구조의 계면 특성에 기반하여 소자의 메커니즘에 대하여 논의하고자 한다.

Keywords:

페로브스카이트 , 2D/3D 이종접합, 압전, 광압전

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-se.220

Fabrication and Characterizations of PTB7-Th/MoS_2 Hybrid Heterostructures

SONG Jungeun [1], NGUYEN Anh Thi[1], CHOI Hyeji [1], BYEON Heekyung [2], JANG Yujin [1], BAEK Suyeun [1], LEE Byoung Hoon [2], YOON Seokhyun [1], KIM Dong-Wook [*1]
[1]Department of Physics, Ewha Womans University
[2]Division of Chemical Engineering and Materials Science, Ewha Womans University
dwkim@ewha.ac.kr

Abstract:

Transition metal dichalcogenides (TMDs) have been investigated for ultrathin integrated circuits for electronic and photonic applications due to their interesting physical characteristics. Organic semiconductors also have received great attention, since they have unique properties, including large light absorption at broad wavelength range, adjustable energy band alignment, and competitive fabrication cost. Despite of such merits, extremely short exciton diffusion lengths in organic materials limit efficient exciton dissociation and collection of carriers. Therefore, organic/TMD hybrid structures are expected to overcome such limitation, since the TMDs can provide pathways for efficient carrier transport. In this work, we fabricated PTB7-Th/MoS_2 heterostructures and investigated their physical characteristics. In particular, we paid attention to understanding the energy and charge transfer at the organic/TMD heterointerface based on current-voltage and Kelvin probe force microscopy measurement as well as conventional optical spectroscopy studies. These research activities can suggest the benefits of organic/TMD hybrid structures for optoelectronic devices.

Keywords:

MoS2, organic, hybrid heterostructure

Ag crater 구조에서의 서로 다른 유전체 효과에 대한 표면 플라즈몬 세기의 FDTD simulation 분석

KIM Han-Sol [1], RYU Jae-Hoon [1], KIM Sung-Hyun [1], BYEON Jae Yeop [1], LEE Ha Young [1], CHUN Young Tea [1], AHN Hyung Soo [1], HA Dong Han [2], YI Sam Nyung *[1]
[1]Korea Maritime and Ocean University
[2]Materials and Convergence Measurement Institute, KRISS
snyi@kmou.ac.kr

Abstract:

표면 플라즈몬(surface plasmon) 현상은 금속이 유전체와 계면을 형성할 때 표면에서 발생하는 자유전자의 집단적인 진동을 의미한다. 특히, 표면 플라즈몬은 입사하는 빛에 의해서 여기될 수 있는데 이를 플라즈몬 공명 (surface plasmon resonance) 이라고 하며 표면 플라즈몬 공명 발생 시 빛의 전기장은 나노 구조체 표면에서 강하게 증폭되고 빛의 흡수와 산란이 매우 증대 된다. 이와 같은 표면 플라즈몬 공명 현상은 LED, OLED, 태양전지 및 센서와 같은 장치의 효율성을 높이기 위해 많이 사용된다. 우수한 표면 플라즈몬 특성을 나타내는 대표적 물질로 은 (Ag)이 있는데 은 (Ag)은 공기 중에서 시간이 지날수록 산화되는 단점이 있다. 본 논문에서는 은 (Ag) 박막이 증착된 crater 구조를 이용해 각각 다른 유전율을 가진 유전체들을 채워 은 (Ag) 이 산화하는 것을 방지하는 동시에 입사하는 빛의 흡수도를 측정하여 표면 플라즈몬의 세기를 높이는 방법을 연구하였다.
습식 화학 식각 방식으로 GaAs(100) 기판에 마이크로 단위의 crater 구조를 만들고 e-beam evaporator를 이용해 두께가 다른 Ag 박막을 증착시켰다. 그리고 crater 구조에 유전율이 다른 물질을 채우고 엘립소미터 장비를 이용하여 각 유전체의 굴절률을 측정하였다. 형상은 광학 현미경을 이용하여 측정하였다. 이어서 흡수도는 UV-visible spectrophotometer와 photoluminescence에 의해 측정하였고 굴절률을 이용하여 FDTD simulation을 통해 흡수도를 분석 및 비교하였다. 최적의 굴절률을 찾게 된다면 crater 구조에 적합한 물질을 증착하여 표면 플라즈몬의 세기를 더욱 증가시킬 수 있을 것이다.

Keywords:

표면 플라즈몬, Ag, 유전체, crater, 엘립소미터, FDTD simulation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.001

Quantifying Stock Price using Social Media

YOON JINJOO [1], PARK DANBI [1], OH GABJIN [*1]
[1]Division of Business Administration, Chosun University
phecogjoh@gmail.com

Abstract:

In this paper, we analyse whether investor sentiment measured, bullishness and disagreement, from text data on social media has information power and predictive power on stock returns, and examine how the impact of sentiment differs according to the trading volume of individual investors. Through empirical studies, we realized that the statistically significant positive relationship between the stock return and bullishness, and volatility and disagreement. In addition, as a result of portfolio analysis constructed by according to bullishness score, all of portfolio have higher sharpe ratio than the market portfolio. These results have been more influential on companies with high trading volumes of individual investors. Our findings suggest that individual investors, who are under information asymmetry, use social media to obtain information, and the individual investors, known as irrational investors, will have information by sharing their opinion, which is influential as a market participant.

Keywords:

netwok, social media

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.003

Divergence of the Density of the Yang-Lee Zeros for the Honeycomb-Lattice Ising Model

KIM Seung-Yeon *1
[1]School of Liberal Arts and Sciences, Korea National University of Transportation
sykimm@ut.ac.kr

Abstract:

The zeros of the grand partition function in the complex magnetic-field plane for the Ising model in an external magnetic field, the so-called Yang-Lee zeros, have played an important role in understanding its thermodynamic functions, phase transition, and critical phenomena. In particular, the density of the Yang-Lee zeros determines the free energy, the equation of state, and all other thermodynamic functions. However, the density of the Yang-Lee zeros for the Ising model has not been known except for the one-dimensional Ising model in an external magnetic field. Kortman and Griffiths found the divergence of the density of the Yang-Lee zeros, the so-called the Yang-Lee edge singularity, for the Ising model on the square lattice and the diamond lattice. The unknown properties of the divergence of the density of the Yang-Lee zeros for the Ising model on the honeycomb lattice in an external magnetic field are investigated.

Keywords:

Divergence of the density of the Yang-Lee zeros

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.004

Specific Heat of the One-Dimensional Ising Antiferromagnet in an External Magnetic Field

KIM Seung-Yeon *1
1School of Liberal Arts and Sciences, Korea National University of Transportation
sykimm@ut.ac.kr

Abstract:

The behavior of the specific heat of the one-dimensional Ising ferromagnet in an external magnetic field is well known. Schottky anomaly is an abnormal peak in the specific heat of matter at a low temperature. It is one of the most universal phenomena, and it is important in understanding experimentally the low-energy structure of matter. However, the behavior of the specific heat of the one-dimensional Ising antiferromagnet in an external magnetic field is not known. The unknown properties of the specific heat and the Schottky anomaly for the one-dimensional Ising antiferromagnet in an external magnetic field are investigated.

Keywords:

External magnetic field, Ising antiferromagnet

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.005

Toward Multiscale Shear Rheology

SHIM Jaewon [1], KIM Choongman [1], AN Sangmin [2], LEE Manhee [3], JHE Won Ho [*1]
[1]Seoul National University
[2]Department of Physics, Jeonbuk National University
[3]Department of Physics, Chungbuk National University
whjhe@snu.ac.kr

Abstract:

The quartz tuning fork (QTF)-based Atomic Force Microscopy can be used as Rheometer. It offers quantitative understanding of fluid beneath tip surface such with help of high sensitivity. Also, the QTF-based AFM is able to manipulate the tip-sample distance sub-nanometer resolution(~0.05nm) with long-range(~150μm) and avoid instable 'jump to contact' phenomenon due to its high stiffness unlike other commercial cantilever-based sensors. Therefore, it provides high stability to study on nanofluidics. There are many attempts researching the nanoscale dynamic properties of confined liquid such as viscoelasticity and Shear Complex modulus. The conventional approaches of shear rheology, however, the inherent scale limits which prohibit the nano-, micro-scale of fluidics. Henceforth, applying QTF-based sensor, we examine the properties of nano-, micro- and bulk scale, which overcomes scale limits, so called multiscale fluid properties. In addition, in order to improve the precision of measurement, we used Maxwell fluid model to analyze the viscoelastic data and obtained the only confined liquid data.

Keywords:

nanofluidics, microfluidics, soft matter, rheology, Atomic Force Microscopy

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.006

Birth and Death of Domains in One-dimensional Model System Using Cylindrically Confined Liquid Crystals

ALMUKAMBETOVA Madina [1], EUN Jonghee [1], JEONG Joonwoo [*1]
[1]Department of Physics, UNIST
jjeong@unist.ac.kr

Abstract:

Nematic liquid crystal is a partially ordered matter that has been a popular model system to study a variety of topological defects. In this work utilizing spontaneously twisting achiral liquid crystals, we introduce a one-dimensional (1D) model system to investigate how domains and topological defects come and go, reminiscing Kibble-Zurek mechanism. Because of the unusual elastic properties, lyotropic chromonic LCs form a double-twist (DT) structure in a cylindrical capillary with degenerate planar anchoring. Consequently, the domains of different handedness coexist with equal probabilities, forming the domain-wall-like defects between them. We experimentally measure the length-distribution of the domains and the time evolution of the distribution, which seem to follow a three-parameter Lognormal distribution. Inspired by the domain formation from droplet coalescence during isotropic-nematic phase transition, we propose that the random coalescence within a chain of normally distributed domains may lead to the log-normally distributed domains. The elastic energy of LC drives the time evolution of the domain-size distribution, which requires further investigation. This simple 1D system would help us better understand the domain and defect formation in higher dimensions and more complicated systems.
The authors acknowledge the support from the Korean National Research Foundation through NRF-2020R1A4A1019140.

Keywords:

Lyotropic chromonic liquid crystals, Topological defects, Domain formation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.007

Statistical Physics of Star-shaped Block Copolymers Forming Tube-like Nanostructure in Thin Film

JEONG Hyeon U [1], KIM Jaeup [*1]
[1]Physics, UNIST
jukim@unist.ac.kr

Abstract:

The formation of block copolymer (BCP) nanostructures in a thin film system has many features different from that in a bulk system because of its interaction with interfaces. The surface preference of BCPs can affect the orientation of nanostructure in their microphase separation. Recently, an experiment using star-shaped BCPs found tube-like microstructure combined with lamellar phase which was not reported in experiments using only linear BCPs. By using self-consistent field theory calculation on six-arm star-shaped BCPs, we investigated this interesting structure and found out that the preference differences between the two surfaces and the two BCP domains are important for the formation of the tube-like structure. This conclusion is supported by several theoretical methods: 1) effective interfacial tension calculated from the interfacial free energy between two nanostructures, 2) direct free energy comparison between competing phases, and 3) analysis of polar order parameter of polymer chains.

Keywords:

Self-constent field theory, Polymer, Thin film

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.008

Magnetic Field Effects on Spontaneously Twisted Liquid Crystal in a Cylindrical Confinement

LEE Junghoon [1], JEONG Joonwoo *[1]
[1]Physics, UNIST
jjeong@unist.ac.kr

Abstract:

Confined lyotropic chromonic liquid crystals exhibit chiral symmetry breaking despite the absence of intrinsic chirality, because of their unusual elastic properties such as large saddle-splay and small twist elastic moduli. When the LCLC is cylindrically confined with a degenerate planar boundary condition, the directors representing the local averaged direction of LC's building block, twist along the radial direction, i.e., from the direction parallel to the capillary axis toward the circumferential direction. In this study utilizing polarized optical microscopy, we investigate how a magnetic field affects this chiral director configuration of DSCG, a representative LCLC with negative magnetic anisotropy. When the magnetic field is applied along the capillary axis, the director configuration is still chiral but with a different twist profile. The delicate interplay among LCLC's elastic moduli, curved confinement, and external field deepen our understanding of the unusual energetics of LCLCs.

The authors acknowledge the support from the Korean National Research Foundation through NRF-2020R1A4A1019140.

Keywords:

Lyotropic chromonic liquid crystal, Cylindrical confinement, Magnetic field effect

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.009

Anomalous diffusion of active Brownian particles attached to a wormlike chain

HAN HyeongTark [1], JOO Sungmin [1], JEON Jae-Hyung [*1]
[1]Department of Physics, POSTECH
jeonjh@gmail.com

Abstract:

Based on Langevin dynamics simulations and a scaling theory, we study the active viscoelastic system with an active Brownian particle (ABP) attached to a wormlike chain (WLC). This work is an extension to our previous study using flexible chain polymers [1]. We observe that the center ABP has a sub-diffusive motion with the scaling $\langle \Delta R^2(t) \rangle \approx t^\alpha$ with $1/2 \le \alpha \le 3/4$ through the viscoelastic feedback from the semi-flexible polymer, while the WLC shows sub-diffusive monomer dynamics with $\alpha = 3/4$. For the stiff chain limit $(l_p \gg b)$, the apparent anomaly exponent α approaches towards $1/2$ as the ABP moves with a larger propulsion velocity v_0. The ABP exhibits subdiffusive but active motion throughout from the stiff chain limit to a flexible chain limit, which seemingly follows a Gaussian non-Markovian process. Using a scaling theory, we explain the active collective dynamics $[\sim t^{1/2}]$. Our results suggest a novel interpretation for the active anomalous dynamics with $\alpha \approx 1/2$ observed in the endoplasmic reticulum network [2].

References

[1] S. Joo, et al., Soft Matter **16**, 9188-9201 (2020).
[2] K. Speckner, L. Stadler, M. Weiss, Phys. Rev. E **98**, 012406 (2018).

Keywords:

Active Brownian particle, Wormlike chain, Viscoelastic feedback, Anomalous dynamics

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.010

Quantifying entropy production and dissipation map of Brownian movies via neural networks

BAE Youngkyoung [1], KIM Dong-Kyum [1], JEONG Hawoong *[1,2]
[1]Physics Department, KAIST
[2]Center for Complex Systems, KAIST
hjeong@kaist.ac.kr

Abstract:

Entropy production (EP) is an essential energetic quantity to make sense of nonequilibrium systems characterized by time irreversibility and dissipation into a surrounding environment. As growing interests in EP, many studies have been carried out to infer it from system's trajectories, but they have a limit that requires tracking the system's relevant variables, and it is difficult to figure out where and how much the dissipation occurs on an image. Therefore, to address this issue, we propose a new method not only for estimating stochastic EP but also for quantifying the dissipation map from time-series image data, called the Brownian movies, without detailed information about the system such as drift force or diffusion fields. This approach, named the convolutional neural estimator for entropy production (CNEEP), has the same objective function as our previous work, NEEP, but comprises different architecture to apply image data and see the dissipation map. We demonstrate our method in two stochastic systems, the bead-spring model and the network of elastic filament, and examine the validity on noisy or partially informative situations caused by the measurement noise, the existence of inaccessible relevant variables, or the low spatiotemporal resolution of a microscope.

Keywords:

Entropy production, Artificial neural networks, Nonequilibrium statistical mechanics, Brownian motion

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.011

Struggle between aggressive and coexistent inhabitants

CHAE Sunhee [1], LEE Nahyeon [1], BAEK Seung Ki [2], JEONG Hyeong-Chai *[1]
[1]Department of Physics and Astronomy, Sejong University
[2] Department of Physics, Pukyong National University
hcj@sejong.ac.kr

Abstract:

In a low-dimensional system, assortative clustering plays an important role in evolutionary dynamics by modifying local environments. Let us consider a one-dimensional grid of cells, where each cell is either empty or occupied by an inhabitant with a genetically inheritable replication strategy. Neighboring inhabitants interact indirectly through competition of their offspring: If more than one offspring compete for a cell, they can be all exterminated because of the cost of conflict, or one of them is randomly chosen as a survivor. For the sake of simplicity, this work focuses on two representative strategies: One is aggressive reproduction (AR) and the other is coexistent reproduction (CR). Both the strategies produce offspring in their own cells, but the difference is that AR attempts to produce offspring in all the neighboring cells whether they are empty or not, whereas CR does only in empty neighboring cells. We investigate population dynamics through a series of Monte Carlo simulations and find a non-equilibrium phase transition between AR and CR as the cost of conflict varies. Interestingly, the population density tends to be higher when conflict incurs such a high cost that it easily leads to extermination of competitors. This observation agrees reasonably well with a mean-field analysis which takes assortative clustering into consideration. To capture the transition nature precisely, we measure the number of CR inhabitants as a function of time, as well as their survival probability and root-mean-square distance. At the critical point, the power-law exponents of these quantities show that the phase transition belongs to the universality class of the annihilating random walks in one dimension.

Keywords:

population growth, evolutionary game, absorbing transition

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.012

Predator-prey model from the perspective of cooperation and evolution

LEE Nahyeon [1], CHAE Sunhee [1], JEONG Hyeong-Chai *[1]
[1]Department of Physics and Astronomy, Sejong University
hcj@sejong.ac.kr

Abstract:

We study an agent-based predator-prey model on a two-dimensional continuum space and analyze efficiencies of chasing strategies against two escaping strategies of prey. We consider three chasing strategies for predators: direct chasing strategy (DCS), prior chasing strategy (PCS), and group chasing strategy (GCS). DCS is a strategy to move directly to the observed position of the target, while PCS is a strategy to move to the predicted position of the target. A predator with GCS calculates an optimal position to catch the target for a group of predators near the target. The GCS predator moves to the optimal position for the group although it may not coincide with the individual's own interest. For preys, we first use the simple escaping strategy (SES), which has been used widely to represent the motion of prays for decades. A prey with SES simply runs away from its nearest chaser. We then employ a novel strategy named advanced escaping strategy (AES), in which a prey considers all chasers in a certain range. A prey with AES moves to the position to maximize the minimum distance from the chasers. Through an extensive series of simulations, we first evaluate the performance of escaping and hunting abilities by measuring the number of survived preys for each pair of chasing and escaping strategies. The best chasing strategy is GCS for both cases, while the worst ones depend on escaping strategies: DCS for SES and PCS for AES. For preys, AES always outperforms SES regardless of predators' strategies. We then study the evolution of strategies by introducing the learning process of successful strategies. Surprisingly, GCS is still the winner despite its cooperative nature under the social dilemma. Predators in ``selfish'' groups may learn the successful strategies of nearby ``cooperative'' groups initiated by simple fluctuations of strategies.

Keywords:

predator prey, evolution, cooperation

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-st.013

Nonequilibrium kinetics of excess defect generation and dynamic scaling in the Ising spin chain under slow cooling

JEONG Kangeun *[1], KIM Bongsoo [2], LEE Sung Jong [3]
[1]Departmentof Physics, Changwon National University
[2]Department of Physics and Institute for Soft and Bio Matter Science, Changwon National University
[3]Institute for Basic Sciences, Changwon National University
j92724@gmail.com

Abstract:

We investigate the relaxation dynamics of a one-dimensional Ising chain via Glauber kinetic Monte Carlo simulations when the system is cooled slowly from infinite temperature to zero temperature with different cooling protocols. The main quantity of interest is the excess defect density that represents the total defect density minus the equilibrium defect density at varying temperatures. We find that, for three classes of cooling protocols, the time dependence of the excess defect density for various cooling speeds shows a dynamic scaling
behavior that largely encompasses the Kibble-Zurek mechanism as well as Krapivsky's calculation of the final defect density at zero temperature. We also find distinct features in the behavior of the dynamic scaling when the temperature approaches in a power-law fashion to zero temperature and the excess defect density reaches a peak at finite temperature, where the scaling of the excess defect density at its peak and that at zero temperature exhibits different asymptotic behavior due to different logarithmic corrections. This characteristic behavior can be attributed to the exponential divergence of the relaxation time near-zero temperature. While the qualitative theoretical predictions by Krapivsky on the asymptotic exponents are confirmed, the asymptotic predictions for amplitudes overestimate by up to 40% of the simulation results.

Keywords:

Kibble-Zurek mechanism, non-equilibrium physics, ising spin chain

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.001

공과대학 신입생들의 물리교육에 관한 인식 조사
- 충청지역 국립대학교 신입생을 중심으로 -

A Study on the Perception of Physical Education in Freshman students of Engineering College

PARK Seonhwa *[1], KIM Yubae [2], AHN Eunjun [3], KIM Youngyou [3]
[1]Department of physics, Chungbuk National University
[2]Innovation Center for Engineering Education, Chungnam National University
[3]Department of Data Information & Physics, Kongju National University
shpark9001@gmail.com

Abstract:

충청지역에 소재한 3개 국립대학교 공과대학 신입생들의 물리교육에 대한 인식을 조사하였다. 연구내용은 고등학교 과정에서의 물리교육에 대한 인식 및 대학에서의 물리실험에 대한 인식 등이다. 연구방법은 설문지 투여 후 분석하였다.

분석결과 고등학교에서 자연계열 선택 현황은 94%로 나타났으며, 특히 C대학에서는 10년 동안 약 20% 증가하였다. 자연계열 선택자 중에서 물리Ⅰ과 물리Ⅱ 모두를 공부한 학생은 33%로 나타났다. 고등학교에서 물리실험은 거의 이루어지지 않은 것으로 조사되었다. 응답자의 93%가 대학에서 물리학이 전공이수에 중요한 기초 교과로 여기고 있었다. 2020학년도 대면실험 과정에서 실험기구의 준비상황은 70%가 비교적 잘 되었다고 답한 반면, 실험내용에 대한 긍정적 이해도는 43%로 높지 않았다.

연구 결과 공과대학 신입생들이 가지고 있는 물리교육에 대한 인식의 단면을 파악할 수 있었으며, 본 자료가 공과대학 <일반물리학> 지도에 유용하게 활용되길 기대한다.

Keywords:

물리교육, 물리Ⅰ, 물리Ⅱ, 물리실험, 공학교육인증

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.002

물리학 I 교과서의 양자물리 단원평가 문항의 분석

KIM Jinha [1], YOO June Hee *[1]
[1]Physics Education, Seoul National University
yoo@snu.ac.kr

Abstract:

2015개정 교과서의 양자물리 관련 단원평가 문항을 네델란드에서 개발한 내용영역 분석틀과 TIMSS 인지적 영역의 분석틀로 분석하여 고등학생을 위한 양자물리의 평가목표 및 평가내용 개선에 필요한 시사점을 도출하고자 하였다. 교과서 8종의 양자물리학 단원에 해당하는 단원평가 문항 94문항을 분석한 결과, 빛의 이중성에 대한 평가 문항은 개념을 용어나 관련 변인으로 기술하는 문항이, 물질파에 대한 평가 문항은 관계식을 적용하여 물리량의 크기를 비교하는 문항이 대부분인 것으로 나타나, 기억/암기 또는 문제풀이 이상의 고차원적 사고력과 인지적 영역에 대한 문항이 부족한 것으로 판단된다. 또한 CCD와 전자현미경 관련 문항은 자세한 작동원리를 알아야 하거나 분해능이나 광학카메라와 같이 다른 내용요소를 알고 이를 적용해서 풀 수 있는 내용을 포함하여 평가내용이 평가목표의 범위를 벗어난다고 판단되었다. 고등학생 대상의 양자물리에 대한 평가 목표와 평가 문항에 대한 연구가 요구된다.

Keywords:

양자물리학 교육, 입자파동 이중성, 교과서 평가문항, 인지적 영역, 내용적 영역

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.003

지구온난화에 의한 영구동토층 융해의 대체실험 설계

CHO JoogHyun *1, PARK JungKi 1, LEE KiWon 1, HONG SaYong 1, KIM YongGi 1
1department of physics, Kongju National University
acminong06@smail.kongju.ac.kr

Abstract:

최근 지구 온난화로 영구동토층 융해에 의해 매장되어있던 온실기체가 대기로 급격히 방출되고 있다. 본 연구에서는 대기 온도 상승으로 인한 영구동토층 융해현상을 보여주는 모델을 구현하고 대체 실험하였다. 이를 위해 영구동토층과 비슷한 환경조성을 위하여, 드라이아이스를 4°C 전 후의 물속에 넣어 드라이아이스 주변에 얼음층이 만들어 지도록 하였다. 이렇게 함으로서 물은 지구대기, 영구동토층은 드라이아이스 주변의 얼음층, 영구동토층 내 온실기체는 드라이아이스 융해로 발생하는 이산화탄소 기체로 개념을 대치하였다. 드라이아이스 주변의 얼음층 형성을 확인하기 위하여 물의 온도가 드라이아이스 투입 후 계속 측정되었다. 물의 온도는 드라이아이스 투입 후 급속히 감소되었고 일정시간이 지난 후 열평형 온도로 유지됨을 관찰하였다. 이 열평형 현상은 드라이아이스 주변에 얼음층이 형성됨으로서 드라이아이스가 흡수하는 열량과 물로 유입되는 외부 열량이 균형을 이루고 있음을 뜻한다. 이 현상을 관찰하여 지구온난화에 의한 영구동토층 융해 현상과의 관련성을 해석하였다. 본연구가 더욱 심화적으로 이루어진다면 영구동토층 융해 현상을 보다 상세히 이해 할 수 있게 될 것이다.

Keywords:

지구온난화 , 영구동토층 , 온실기체 , 드라이아이스 , 대체실험

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.004

학업성취도 기반 물리학습비교과프로그램의 학습성과 분석

PARK Seonhwa [1], KIM Dae Jung [1], KIM Bong Jin [1], LEE Chang-Won [1], PARK Jiyong [1], KANG DongYel [*1]
[1]School of Basic Sciences, Hanbat National University
dykang@hanbat.ac.kr

Abstract:

4년제 대학 공학 전공의 물리학 교과목 수강자들에게 한 학기 동안 학업성취도를 고려한 세 종류의 물리학습비교과프로그램을 운영하였다. 첫 번째 프로그램은 질의응답 방식의 물리클리닉이고, 두 번째 프로그램은 10주 동안 진행된 문제풀이 특강이다. 마지막 프로그램은 학업 저 성취자를 위한 학습상담이다. 운영결과 프로그램에 참여한 학생들은 평균 학업성취도가 B+등급으로 나와 교과목 전체 수강자 평균 B0보다 높았다. 이는 세 종류의 학업성취도를 고려한 물리학습비교과프로그램이 물리학 학습성과 증진에 긍정적 효과를 준 것으로 볼 수 있다. 그러므로 본 연구를 통해 질의응답, 문제풀이특강, 학습상담으로 구성된 비교과프로그램이 공학 전공의 교수학습모델로서 화학, 생물학 등 기초 교과목의 학습성과 효율성 증진을 위해 적용될 수 있을 것으로 판단된다.

Keywords:

물리교육, 학업성취도, 비교과프로그램, 학습성과

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.005

A 3D-printable worm-synchronization apparatus

LWIN Eaindra Moh Moh[1], PARK Sang Tae [1], JUNG Keeju [1], LEE Kyung Suk [*1]
[1]Department of Physics Education, Kongju National University
leeks@kongju.ac.kr

Abstract:

A 3D printer provides a unique opportunity for students to make useful, and even practical DIY devices without too much education. Students get to see how the devices that they made for themselves are working in place, which strengthens their motives for understanding and exercising scientific principles. Here, we made a simple worm-synchronization apparatus using a 3D-printer. Even with its simple design and affordable components, this apparatus replaces rather expensive nutators used in laboratories perfectly, creating well-synchronized worms, This device is also as an interdisciplinary education tool: as its design is based on a simple seesaw mechanism that maximizes the tilting angle, while its application is for growing many worms with the same size.

Keywords:

3D printer, DIY

2021 KPS Spring Meeting
2021-04-21 - 2021-04-23

P1-te.006

Simulation을 활용한 작용과 반작용 개념의 이해

LEE Insook *[1]
[1]Dept. of Physics and Earth Science, Korea Science Academy
ilee@kaist.ac.kr

Abstract:

뉴턴의 운동 제3법칙인 작용과 반작용 법칙은 힘이 일방적인 것이 아니라 본질적으로 상호작용이며, 물체의 힘과 운동을 기술하는데 가장 기본적인 중요한 법칙 중 하나이다. 그럼에도 불구하고 여러 연구결과에 의하면, 학생뿐 아니라 예비교사 조차도 이에 대한 이해가 충분하지 않고 상당한 오개념을 가지고 있음을 지속적으로 보여주고 있다. 한편, 컴퓨터의 발달과 보급이 가속화되면서 복잡하고 비가시적인 물리적 상황에 대한 학습자의 이해에 도움을 줄 수 있는 Computer Simulation이 유용한 학습 도구로써 주목받고 있다. 이에 본 연구에서는 작용과 반작용 개념의 바른 이해를 돕기 위한 교수-학습의 한 방법으로 Simulation을 활용하는 방법을 제시하고자 한다. 물리 교수-학습 활동에서 Simulation이 효과적으로 활용되기 위해서는 Simulation tool 자체도 중요하지만 Simulation tool의 사용설명서나, 물리 개념을 올바로 이해하는데 결정적 도움이 되거나 개념을 바르게 이해하고 있는지 확인할 수 있는 적절한 질문지를 Simulation tool과 병행하여 활용하는 것이 매우 중요할 것이다. 본 연구에서 사용한 Simulation tool은 설명 동영상과 Worksheet도 함께 웹 사이트에 공개되어 있다. 사용설명은 물론 Simulation을 통하여 무엇을 학습해야 하는지 명확하여 스스로 학습할 수 있다는 장점이 있어 수업시간이나 과제로 사용하기에 매우 유용할 것으로 판단된다. Worksheet에 주어진 7개의 질문(Challenging and Interesting Questions) 외에 Simulation을 수행하면서 개념을 정확하게 이해하는데 도움이 될 만한 새로운 질문 8개를 개발하여 추가함으로써, Simulation 수행과 함께 질문에 답을 하면서 자연스럽게 개념을 바르게 이해할 수 있는 효과적인 학습방법이 될 것으로 기대한다.

Keywords:

작용과 반작용, 힘, Simulation, 오개념