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재미 한인 물리학자 협회

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Contents

Message from the 29th President of AKPA

Dear Colleagues,

I am delighted to report to you that multiple physics sessions were successfully held during the "US-Korea Conference (UKC) on Science, Technology and Entrepreneurship" in Los Angeles, August 8 – 12, 2012. We had six physics sessions (each with 6-7 speakers) as part of the Physics, Astronomy, Chemistry, Math, Stat and other Basic Sciences [BAS] Track, which I chaired. A broad range of topics were covered. I am proud of many young physicists who made quite impressive presentations and who played leading roles in organizing sessions. I would like to thank all the presenters for making the conference so exciting and informative by presenting excellent talks and posters. Special thanks go to the session chairs: Dr. Kyuwan Lee, University of California, Berkeley, for the Plasmonics and Biomolecule Imaging Session; Prof. Kiyong Kim, University of Maryland, for the Plasma: from Lab to Space Session; Prof. Seunghun Lee, University of Virginia, for the Exotic States in Physics Session; Dr. Hyesook Lee, NASA GSFC, for the Physics in Extreme Conditions session; Dr. Cheol-Hwan Park, Robert Bosch Research and Technology Center, for the Novel Physics of Graphene and Related Nanostructures session, and Prof. Chueng-Ryong Ji for the Rare Isotopes and Accelerators session. We also had a Physics Forum (2012 재미과협 석학 초청 물리분야 세미나) sponsored by Korean Federation of Science and Technology Societies (KOFST). I would like to thank Profs. Hojung Paik and Kiyong Kim for presenting Gravitation and Astrophysics, and Terahertz Laser physics, respectively. I would also like to thank panelists, Profs. Chueng-Ryong Ji, Seunghun Lee and Harold Kim, for stimulating discussions on emerging new frontiers in physics with relevant cutting-edge applications, and Dr. Kyuwan Lee, who served as the Secretary to record the discussions. The scientific opportunities for precision experiments with high discovery potential cut across various disciplines of physics. Cooperation and collaborations across traditional boundaries of research areas will play a significant role in basic and applied physics research over the next decade.

Some AKPA members were also invited to the ULTRA (Universal Linkage for Top Research Advisor) Program Round Table discussion, organized by KOFST. Prof. Jungsang Kim, Duke University, presented "Technologies for Engineering Quantum Information Processing Systems: Global Trends and Opportunities." The introduction remark was made by Dr. Sang-Dae Park, President, KOFST, and the discussion was chaired by Ki-Jun Lee, Honorary President, National Academy of Engineering in Korea. The panel included Dr. Na Young Kim, Stanford University; Prof. Ho Jung Paik, University of Maryland; Prof. Eun-Suk Seo, University of Maryland; Prof. Seunghun Lee, University of Virginia; Dr. Kyung-Han Hong, Massachusetts Institute of Technology; Prof. Hanseok Ko, Korea University; Prof. Yoon-Ho Kim, POSTECH; Hak-Min Kim, Director of the Center for Advanced Materials Processing, Korea Institute of Materials Science (KIMS); Ho-Yong Kim, President, Korea Electrotechnology Research Institute (KERI); and Se-Jung Oh, President, Institute of Basic Science (IBS). Dr. Chul-Hwan Park served as the Secretary to record the discussions.

I am proud of the fact that 30% of the invited speakers for the BAS physics sessions were women. As part of the "Korean Women in Physics" initiative after the 6th annual East Coast Conference of Korean-American Women in Science and Engineering (KWiSE), which was held in Vienna, VA, May 14, 2011, our cooperation with KWiSE continues to grow. I presented "Cosmic Journey" at the 7th KWiSE Annual Meeting, which was held in Santa Monica, CA, October 15, 2011. Prof. Youngkee Kim presented "Experimental Particle Physics," at the 2012 Annual Meeting, Vienna, VA, June 16, 2012. At the UKC 2012, I served as a panelist for a KWiSE forum on Global Energy Environment and Nuclear Energy. This forum was chaired by the Honorable Myung-Ja Kim, former Minister of Health & Welfare of Korea, and President, Korea Federation of Women's Science and Technology Associations (KOFWST). Among others, the Honorable In-Sook Park, Member of the National Assembly; the Honorable Hee-Young Paik, former Minister of Gender Equality and Family of Korea; Prof. Do-Sun Na, Vice President, KOFST & President, Korean Biochemical Society; and Prof. Heisook Lee, Director, Korea Advanced Institute of Women in Science, Engineering and Technology (KAI-WIEST) attended this forum.

I heard a lot about how our research and career would benefit from the UKC which provides unique opportunities for information and networking with a rich, diverse mix of sessions, and speakers. Participants commented that they were re-energized and refocused after attending the conference. I would like to invite you all to the next UKC, which will be held in Sheraton Meadowland, NJ, right across the Hudson River from Manhattan in New York City,

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A photo from the 2012 KWiSE Annual Meeting at the KSEA/KUSCO building, Vienna, VA, June 16, 2012: from the left, Prof. Jeahoon Yu, AKPA President Elect; Prof. Eun-Suk Seo, AKPA President; Prof. Youngkee Kim, Deputy Director, Fermilab; Dr. Seongeun Julia Cho, President, KWiSE East Coast Chapter; and Dr. Sanghee Yoo, President, KWiSE.

A photo taken at the UKC 2012, Garden Grove, CA. Note five key delegates from Korea are among the standing: second from left to right, Prof. Hee-Young Paik; third, Prof. Heisook Lee; fourth, Prof. Do-Sun Na; fifth, Prof. Myung-Ja Kim; and sixth, Prof. In-Sook Park.

August 8-10, 2013. The theme of the conference is “Toward Harmonious World with Science and Technology.”

Promoting excellence in research is a key goal of Association of Korean Physicists in America (AKPA). Let me remind you that nominations for the 2013 Outstanding Young Researcher Award (OYRA) are being solicited. AKPA has awarded OYRA annually since 1994 to recognize excellence in research by outstanding young ethnic Korean physicists in North America. Please send your nomination to Prof. Kyungseon Joo, the Award Committee Chair by November 15, 2012.

Another important matter that needs your attention is the upcoming election for the 31st president of AKPA. Join us in our search for pertinent candidates for another order of magnitude growth in our strength. Please send your nomination to Profs. Ki-Hyon Kim and Chueng-Ryong Ji, the Nomination Committee. Please contact Prof. Jaehoon Yu, the Election Committee Chairfor more details.

Best Regards,
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Featured Article 1

Single Cancer mRNA Structure Change Tracking in Living Cells by Plasmonic Coupling

Intracellular molecule detection plays a key role in this biological study, and many methods to detect the molecules inside living cells have been developed to date. For example, nucleic acid sequences have been recognized as practical targets due to its fast, accurate and robust diagnosis. Among many intracellular molecules, mRNA, microRNA (miRNA), and some protein aggregations were especially interesting because they play key roles in cancer development and other major diseases, such as Alzheimer and Parkinson's diseases. Breast Cancer 1 (BRCA1) has also been used as a marker gene because it encodes a nuclear phosphoprotein that plays an important role in maintaining genomic stability and acts as a tumor suppressor. Similarly, it is reported that each cancer cell lines have different level of miRNA expression. Therefore, it is important to develop a powerful probe for the detection and monitoring structural change of the single molecule inside the living single cells.
In recent years, researchers have associated BRCA1 mRNA splicing with malignant transformation in breast and ovarian tissues as the variation in the splicing process plays a major role in tumorigenesis. A reliable technology which can effectively and efficiently differentiate alternative splicing profiles between normal cells and tumor cells in various tissues would help further clarify this issue. Currently, available techniques to detect alternative splice variants include polymerase chain reaction (PCR) based assays, ribonuclease protection assay, bioinformatics approaches, polymerase colony (Polony) technology and microarray-based approaches. Although bioinformatics-based studies have identified a vast number of alternatively spliced transcript variants, these variants can only be taken as a prediction and often require further experimental verification and more importantly, they are all in vitro study. Intracellular exploration has predominantly posed a severe challenge because detection platforms involve the manipulation and interrogation of live cells without changing their physiology. Moreover, it should be highlighted that the detailed information of live cell phenomena can be obtained in real time without destroying the cell membrane or other structures. For example, time- and position-resolved images can provide information on when and how specific biomolecular events occur, which can be identified in various cell lines.

Small gold nanoparticle aggregation is especially useful as a SERS enhancer because their enhancement is very strong despite its small size. It is well-known as a SERS template to enhance the Raman signal dramatically. Recent advances have shown that Raman label-induced nanoparticle aggregates coated with polymers, biomomultilecules, and silica can serve as excellent candidates of signal enhancers. The plasmon resonance of noble metal nanoparticles in visible range has been employed to detect particle aggregation or nanoparticle dimer formation for the single-molecule detection. Multiplexing detection ability of these plasmonic structures is also very useful because disease-state-specific information is indispensable to understanding the role of alternative splicing in tumorigenesis. It does not only increase the detection capability, but also helps with understanding the interaction of multiple variations in alternative gene splicing. Even though it was proven that up to 8 multiplexing events are possible using Raman labels in the former works of our research group, nanoparticles of different shapes, which have different spectral peaks, was also employed to realize multiplex detection. Gold particles were used in this work because they are biocompatible, not toxic and free of safety issues that radioactive labels pose.

Conventional sensing mechanism for biomolecule detection depends on the choice of material. Previous studies used different materials such as fluorescent molecules, quantum dots, and gold/silver nanoparticles to measure their unique spectra. However, each method has its drawbacks. Conventional fluorescent tags include photobleaching, narrow excitation with broad emission profiles (usually 50-100 nm full-width at half-maxima (FWHM) Quantum dots (QDs) have a broader excitation and narrower spectral band (~25-40 nm FWHM) than traditional fluorophores; however, the range of choice is limited, and the blinking behavior and cytotoxicity of QD are disadvantageous. Gold nanoparticles are free from these problems and have promising applications in a variety of biological processes. However, its poor multiplexing ability often requires the help of other techniques such as Raman spectroscopy. Moreover, gold nanoparticles have been used for in vitro

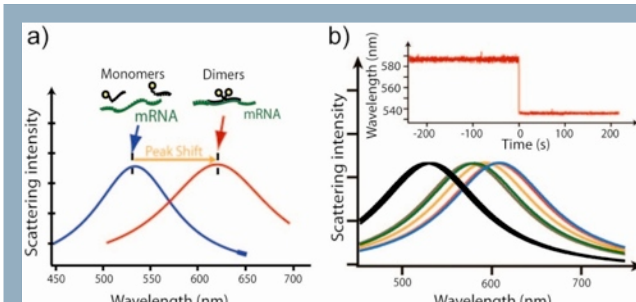

Figure 1. a) mRNA detection design. Gold nanoparticle dimer formed in head-to-head manner produces large peak shift, which can be clearly detectable in the spectra, while the spectral peak of nanoparticle monomers stay on the original position. b) Measured spectra of monomer and dimers. Signals from monomers have a peak at 537±2.7 nm, while dimers have peaks in the range of 583~607 nm. (inset: the spectral peak of dimer fixed on the glass moves to the monomer peak when the temperature reaches the melting point of DNA hybridization, which proves that the signal was from the structure formed by DNA hybridization)

detection due to its lack of differentiation of nonspecific from specific binding without washing.

Recently, the use of gold nanoruler effect as a sensing tool, especially to measure the length of biomolecules became quite popular. This new technique has the potential to replace the conventional distance measurement technique called fluorescent resonance energy transfer (FRET), which has a working distance of less than 10 nm. By using gold nanoparticles, distances as large as 70 nm can be measured at single-molecule sensitivity using tools that are less sophisticated. Achieving high sensitivity will require an elaborate instrumentation such as hyperspectral imaging systems on the dark field spectroscopy. In addition, another hyperspectral imaging system, Raman spectroscopy, was also employed to establish its possible utilization for surface plasmon resonance measurement. Theoretical descriptions about the sensing mechanism of two systems were shown in this work as surface plasmon (SP) on metallic nanostructures and the surface enhanced Raman scattering (SERS) are highly related to each other.

In our research, we also showed that the nanoruler concept based on gold nanoparticles and other nanomaterials are powerful sensing tools for the detection of intracellular biomolecules because it opens various applications in intracellular studies to long distance configuration, multiplexing, and clear evidence of detection without conventional problems described above. Various applications of the two hyperspectral imaging systems were validated. In other words, cell membrane makers profiling, multiplexing single bacteria detection, nanoparticle aggregation quantifying mRNA, multiplexing ion detection, and nanoparticle zeta potential measurement were proven by dark field spectroscopy and Raman spectroscopy. To demonstrate intracellular detection of a single molecule, we applied our concepts to detect splice variants of mRNA of BRCA1, which encode a nuclear protein involved in transcription regulation, DNA damage repair and G2/M checkpoint control. Successful detection of intracellular mRNA can demonstrate that the same mechanism can be applied to many different applications for the detection of a variety of intracellular biomolecules. For example, we presented the preliminary data of multiplexing MicroRNA detection in living single cells as well as early detection, and the continuous measurements of structural information of alpha-synuclein aggregation in vitro.

In conclusion, we have proposed that plasmonic dimers measured by hyperspectral imaging and spectral analysis can quantify and image with single molecule/particle precision single mRNA transcripts at splicing resolution in living single cells, with multiplexing ability. To this end nanoparticle probes were designed to hybridize to target mRNA and generate a characteristic signal including distinct structural information about the molecule. This information is displayed in an image, reconstructed by a hyperspectral imaging system integrated with dark field microscope, to reveal the identity of cell lines and the probability of tumor development. Importantly, our approach

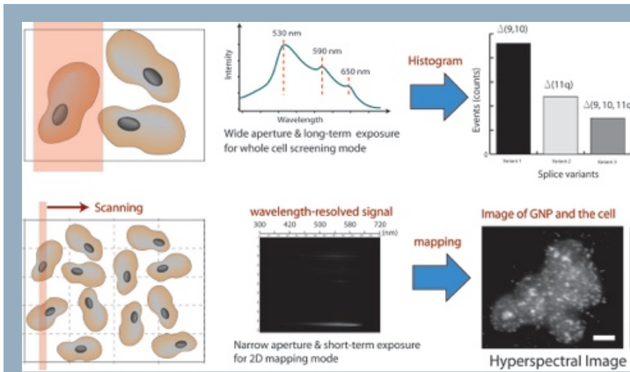

Figure 2. Scanning of the single living cells and dynamical measurements of mRNA detection showing its localization and time-resolved measurements

can differentiate two alternative splicing variants by the strength of particle-particle interaction captured in their scattering spectra as a peak shift and intensity change. Time-resolved imaging shows the localization and targeting dynamics via dimer at single mRNA copy resolution with unprecedented sensitivity in live cells. Our dimer-based approach using facile plasmonic nanoparticles and hyperspectral imaging envisions studies on molecule-molecule interactions and kinetics of interactions in living single cells, providing a quantitative platform for many important biological problems. Future work may encompass the development of a novel probe with multiplexing ability to detect and quantify transcripts and the associated proteins in single cells at single molecule detail for prognosis.

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Featured Article 2

Weighing Dark Matter at the LHC

Astrophysical observations indicate that 80 percent of the mass in the universe is made of a neutral, very weakly interacting type of matter called "dark matter." Dark matter is composed of elementary particles, but these must be of a new type, not found in the Standard Model (SM) of particle physics. Many models of dark matter have been proposed. In most of these, dark matter is composed of a heavy, neutral, stable particle that can be produced at colliders of sufficiently high energy. Now the Large Hadron Collider (LHC) is running at CERN, and this accelerator could well be capable of producing dark matter particles. If researchers can identify the events with dark matter production, we will have a unique opportunity to study the elementary quanta of dark matter in the laboratory.

However, the essential property of dark matter - its weak interaction with ordinary matter - makes it difficult to study. Dark matter particles are expected to leave no signals or energy deposits in the detectors at the LHC. If theory holds true, they will be visible only as a missing element in the aftermath of LHC collisions, for example, as events in which the observed particle tracks have unbalanced momentum. Still, we will want to know what the LHC observations can tell us about the missing particles. Is the invisible particle produced in the laboratory the same as that in the dark matter in space? To answer this question, scientists need to measure the properties of the dark matter particle, such as its mass, spin and interaction strengths.

Recently, there has been a great deal of theoretical effort developing tests to explore the nature of dark matter particles at the LHC and at a future linear collider, such as the proposed International Linear Collider. Most of these studies have been performed in the context of a particular model of dark matter (for example, supersymmetry). The methods and results depend on the parameters of the assumed model and its specific particle content. Rarely is it asked how events from the LHC can be analyzed in a generic and model-independent way to give us information on invisible particles.

At first sight, it looks impossible to make generic statements about events at proton colliders such as the LHC. At these colliders, not only do we not observe dark matter particles in the final state, but also we do not know the total momentum of the initial state. The reason for this is that the proton is a composite state - a bag of quarks and gluons - and new particles are produced in the collision of individual quarks and gluons that carry only a fraction of the momentum of the proton. Even worse, most models predict that dark matter particles are produced in pairs, so that each event has (at least) two invisible final particles. Typically, the original collision of quarks or gluons is predicted to produce two new heavy particles, also of unknown mass, each of which decays to a dark matter particle plus observable quarks, gluons and leptons.

Nevertheless, it is possible to measure the masses of some particles with invisible decay products very accurately at proton colliders. The CDF and D0 experiments at the Fermilab Tevatron measure the mass of the W boson to an accuracy of 0.05 percent, even though the W boson decays to an electron or muon plus an invisible neutrino. The trick used was to construct an estimate of the mass using only the components of momentum perpendicular, or transverse, to the axis of the incoming proton beams. This quantity, called the "transverse mass," must be less than the W mass. The distribution of the transverse mass has a sharp cutoff at the W mass. The precision measurement is made by observing the position of this sharp endpoint of the distribution.

To account for two invisible particles, it is necessary to be even more clever. About twelve years ago, Lester and Summers of Cambridge University suggested a new variable, similar to the transverse mass, called M_{T2} [1, 2] (see Refs. [3, 4] for other related methods discussed in literature). To form this variable, one measures the missing transverse momentum and then considers all possible ways to divide it between the two invisible particles. With the correct definition, one again finds a variable with a sharp endpoint related to the mass of the invisible particle. In the past few years, M_{T2} has been studied extensively by several groups at Cambridge, Sheffield, KAIST and Florida. Many wonderful new properties of this variable have been discovered. We have found methods for mass measurement that are model-independent and can be applied to any new physics model [5, 6, 7, 8].

One of our new ideas is to build two M_{T2} distributions in the same event. In any proton collider event, there are two directions transverse to the beam axis. We found a way to choose, for each event, a reference

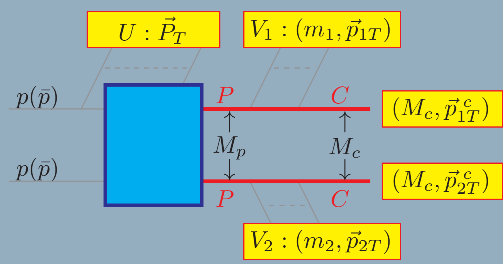

Figure 1. The generic event topology under consideration. All particles visible in the detector are clustered into three groups: upstream objects U with total transverse momentum $\vec{P}_T$, and two composite visible particles V_i, each with invariant mass m_i and total transverse momentum $\vec{p}_{iT}$. The transverse momenta of the two missing particles are labeled by $\vec{p}^{\,c}_{iT}$.

direction in this two-dimensional space. With our choice, the distributions of M_{T2} using momenta parallel and perpendicular to the reference direction have different endpoints. From these two constraints, it is possible to solve for both the mass of the dark matter particle and the mass of the heavier particle of which it is a decay product. This method can always provide an absolute determination of the dark matter particle mass regardless of the complexity of the decay chain that leads to the invisible particle.

The first order of business after the discovery of a missing energy signal at the LHC will be to measure the mass of the missing particle and prove that it is not simply a SM neutrino. This deceptively simple task turned out to be a notoriously difficult challenge. The generic topology of a prototypical "SUSY-like" missing energy event is schematically depicted in Fig. 1. Consider inclusive production of an identical pair of new particles P (from now on referred to as "parents"). Each parent decays semi-invisibly to a set of SM particles V_i, $(i = 1, 2)$, which are visible in the detector, and a dark matter particle C (from now on referred to as the "child") which escapes detection. In general, the parent pair may be accompanied by a number of additional "upstream" objects U (typically jets) with total transverse momentum $\vec{P}_T$. They may originate from various sources such as initial state radiation or decays of even heavier particles up the decay chain. We shall not be interested in the exact details of the physics responsible for U, adopting a fully inclusive approach to the production of the parents P. Given this general setup, the goal is to determine *independently* the mass M_p of the parent and the mass M_c of the child.

In the past, several approaches to this problem have been proposed, e.g. invariant mass endpoint measurements or exact reconstruction of the missing particle momenta $\vec{p}^{\,c}_{iT}$. Unfortunately, they only apply to sufficiently long decay chains, where the visible particles in V_i arise from a sequence of at least three 2-body decays [5]. In the simplest example of a short, single-step decay chain, each V_i consists of a single SM particle of fixed mass m_i, and neither of these two approaches will work. One must then resort to methods based on the Cambridge M_{T2} variable or the related Sheffield M_{CT} variable. Unfortunately, in order to apply those techniques, one must work with a subset of events within a relatively narrow fixed P_T range, incurring some loss in statistics.

We have proposed a new method which uses the full data set, with no such loss in statistics [7]. Our method is based on the "subsystem" variant [5] of the original M_{T2} variable [1]. The key idea is to introduce one-dimensional (1D) decompositions of M_{T2} onto the two special directions defined by the upstream momentum vector $\vec{P}_T$. Following Ref. [5], first project the visible transverse momenta $\vec{p}_{iT}$ of Fig. 1 onto the $\vec{P}_T$ direction ($T_\parallel$) and its orthogonal direction ($T_\perp$):

$$\vec{p}_{iT_\parallel} \equiv \frac{1}{P_T^2}\left(\vec{p}_{iT}\cdot\vec{P}_T\right)\vec{P}_T, \tag{1}$$

$$\vec{p}_{iT_\perp} \equiv \vec{p}_{iT} - \vec{p}_{iT_\parallel} = \frac{1}{P_T^2}\vec{P}_T \times \left(\vec{p}_{iT}\times\vec{P}_T\right), \tag{2}$$

and similarly for the two transverse momenta $\vec{p}^{\,c}_{iT}$ of the children and for $\not{\vec{P}}_T$. Considering the corresponding 1D decompositions of the transverse parent masses, we define 1D M_{T2} decompositions ($M_{T2_\perp}$ and $M_{T2_\parallel}$) in complete analogy with the standard M_{T2} definition.

These decompositions are extremely useful. For once, the 1D variables can be calculated via simple analytic expressions. In contrast, a general formula for the original M_{T2} variable in the presence of arbitrary P_T is unknown and one still has to compute M_{T2} numerically. More importantly, $M_{T2_\perp}$ allows us to measure the reference quantity from the full data set, using events with *any* value of P_T. Finally we can quantify the effect of this new variable via the following function,

$$N(\tilde{M}_c) \equiv \sum_{\text{all events}} H\left(M_{T2} - M^{max}_{T2_\perp}(\tilde{M}_c)\right), \tag{3}$$

where the H is the Heaviside step function. From the definition of $N(\tilde{M}_c)$ it is clear that it is minimized at $\tilde{M}_c = M_c$, where in theory we would expect

$$N_{min} \equiv \min\{N(\tilde{M}_c)\} = N(M_c) = 0\,. \tag{4}$$

In reality, the value of N_{min} will be lifted from 0, due to finite particle width effects, detector resolution, etc. Nevertheless we expect that the *location* of the $N(\tilde{M}_c)$ minimum will still be at $\tilde{M}_c = M_c$, allowing a direct measurement of the child mass M_c:

$$M_c = \left\{\tilde{M}_c \,|\, N(\tilde{M}_c) = N_{min}\right\}. \tag{5}$$

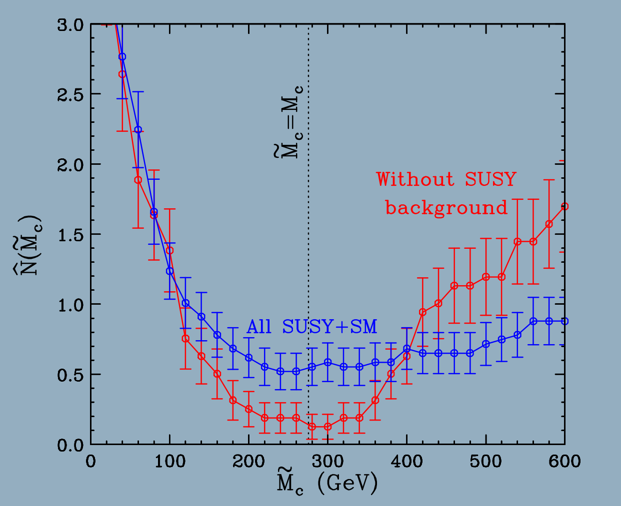

Figure 2. The function $\hat{N}(\tilde{M}_c)$ defined in (6). The blue (red) set of measurements are with (without) SUSY combinatorial background. The error bars shown are purely statistical.

The $M_{T2_\perp}$ analysis just described allows a very precise measurement of the benchmark quantity $M_{T2_\perp}^{max}(\tilde{M}_c)$ appearing in (3), so that the function $N(\tilde{M}_c)$ itself can be reliably reconstructed, using *the whole* event sample all the way throughout the analysis, without any loss in statistics. As an illustration of the idea, we use a SUSY spectrum given by the LM6 CMS study point, where the chargino (sneutrino) mass is $M_p = 305.3$ GeV ($M_c = 275.7$ GeV). In our simulations we use the PYTHIA event generator and the PGS detector simulation program at the 14 TeV LHC assuming 100 fb^{-1}. Result is shown in Fig. 2, where for convenience we unit-normalize the function $N(\tilde{M}_c)$ as

$$\hat{N}(\tilde{M}_c) = N(\tilde{M}_c)/\langle N(\tilde{M}_c)\rangle \,, \tag{6}$$

where the averaging is performed over the plotted range of $\tilde{M}_c$.

As expected, the function $\hat{N}(\tilde{M}_c)$ exhibits a minimum in the vicinity of the true sneutrino mass $\tilde{M}_c = M_c = 275.7$ GeV. Ignoring the SUSY combinatorial background, this measurement (red data points) is quite precise, at the level of a few percent. In order to reduce the combinatorial background, we select events with $\tilde{M}_c < M_{T2_\perp} < M_{T2_\perp}^{max}$ and veto very hard leptons with $p_T > 60$ GeV. The resulting M_c measurement (blue data points) is at the level of 10%. This precision is clearly sufficient to exclude SM neutrinos as the source of the missing energy, hinting at a potential dark matter discovery at the LHC.

Further exploration with M_{T2} provides a way to measure whether or not the two missing particles in an event are identical. All previous studies have assumed that there is only one dark matter particle, or a particle and antiparticle with identical masses. However, we found that this assumption is unnecessary. By suitable modifications of the existing analysis techniques with M_{T2} one can test both the number and the type of the missing particles in the observed events [6].

We have also demonstrated that many of the existing mass-measurement variables proposed for hadron colliders (m_T, $M_{\rm eff}$, M_{T2}, missing $\vec{p}_T$, h_T, $\sqrt{\hat{s}}_{\rm min}$, etc.) are far more closely related to each other than is widely appreciated, and indeed can all be viewed as a common mass bound specialized for a variety of purposes [4]. A consequence of this is that one may understand better the strengths and weaknesses of each variable, and the

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Featured Article 3

Photodisintegration for the Fundamental Test of GDH Sum Rule on Deuteron

In this letter, I describe work which has been planned for the studies of a fundamental sum rule in photonuclear physics known as the Gerasimov-Dell-Hearn (GDH) sum rule. The GDH sum rule is a measure of the spin response of any composite system. The sum rule relates the helicity dependent photoabosorption cross section difference to the anomalous magnetic moment, κ, of the target. For a nuclear target with a ground state mass M, an anomalous magnetic moment κ, and a spin S, the GDH sum rule states

$$I^{GDH} = \int_{\omega_{th}}^{\infty} \left(\sigma_p(\omega) - \sigma_A(\omega)\right) \frac{d\omega}{\omega} = 4\pi^2 e^2 \frac{\kappa^2}{M^2} S,$$

where $\sigma_{P/A}$ is the photoabsorption cross section with photon and target spins parallel/anti-parallel, ω is the incident photon energy, and ω_{th} is the threshold energy for the inelastic process. The GDH sum rule is interesting since it relates a static ground state property, the anomalous magnetic moment, to the excitation spectrum of the target. A finite anomalous magnetic moment restricts the energy-weighted integrated photoabsorption cross section asymmetry to be positive, in other words, the energy-weighted cross section with photon and target spins parallel must be greater the antiparallel cross section over the full integral.

The deuteron has a small anomalous magnetic moment (κ_d= -0.143) [1]. The measured value of κ_d predicts a GDH value of I_d^{GDH}=0.652 μb. This value is significantly less than the predicted GDH values for proton (I_d^{GDH}=240 μb) and the neutron (I_d^{GDH}=232 μb). Measurements of the GDH integral on the proton and the neutron to test GDH sum rule have been and are being performed at MAMI, LEGS, ELSA, and JLAB. A theoretical calculation of the GDH integral for the deuteron has been performed by Arenhövel et al. [2] up to an energy of 2.2 GeV as shown in Fig. 1. This calculation includes the contribution from the photo-disintegration channel along with the contribution from the coherent and incoherent single-pion production channels. A very interesting and important result of this theory is the large negative contribution from the photodisintegration channel near the breakup threshold along with a large relativistic contribution below 100 MeV. This large relativistic effect is not surprising since the correct form of the term linear in photon momentum in the low-energy expansion of the Compton amplitude is only obtained if leading order relativistic contributions are included. The present work is the first attempt to test the prediction of the value of the GDH integral between photodisintegration threshold and 10 MeV.

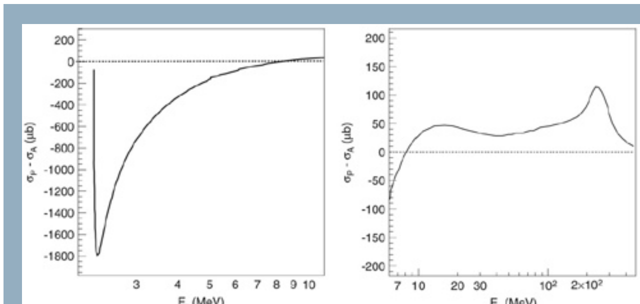

Figure 1. The GDH sum rule integrand (σ_p-σ_A) for the deuteron as calculated in Ref 2. The figure in left shows the large, negative near-threshold prediction, and in right shows the positive contributions which appear at higher energies.

A direct determination of the GDH sum rule integrand requires three components to perform an experiment; circularly polarized γ-ray beams, neutron detector system, and polarized target system. The experiment uses a high-intensive circularly polarized gamma beamat HIγS [3] from breakup threshold up to 20 MeV as the first phase. High Intensive gamma-ray Source (HIγS) is uniquely suited to studies of the GDH sum rule for deuteron below pion threshold. HIγS at Duke Free-electron Laser Laboratory (DFELL) in Fig.2 is a new generation Compton gamma-ray source covering a wide range of beam energy with high flux and high linear and circular polarization (>98.5%).

This measurement uses the large solid-angle coverage (25% of 4π) of a segmented neutron detector array (Blowfish) to make precision measurements of the d(γ,n)p reaction from 4 MeV to 20 MeV. The Blowfish detector array [4] shown in Fig.3, consists of 88 liquid scintillator (BC-505) neutron detectors positioned spherically around the target location at radial distance of 16" from the target

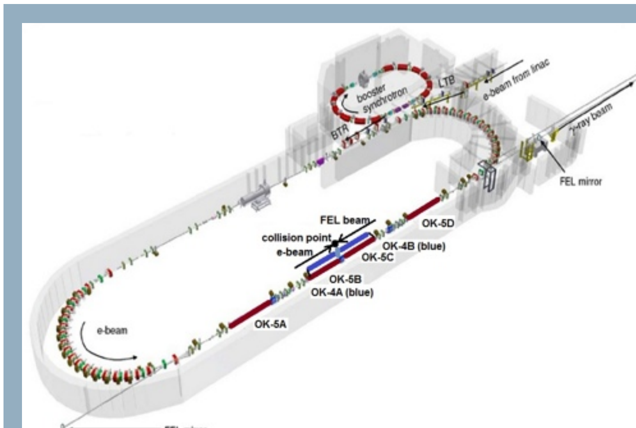

Figure 2. The fully operational photon-collider HIγS facility in 2012. In summer 2012, the upgrade project, Switch-yard for OK-4 (for linear polarization) and OK-5 (for circular polarization) wiggler magnets, has been completed.

center. The large angular coverage allows the detailed shape of the angular distribution of the polarized cross section to be measured. The detectors allow pulse-shape discrimination for distinguishing neutrons from gammas which enter the detectors. A gain monitoring system is used to carefully monitor the gains of each detector by means of a light pulse from a LED which is periodically sent to each detector in the array. In addition, the entire array can be rotated as a rigid body around the beam axis, allowing systematic effects to be canceled by performing periodic rotations of the array by 45° in φ.

The University of Virginia (UVa) group has been developing frozen spin target system for the GDH experiment at HIγS. The HIγS Frozen-Spin-Target (HIFROST) system consists of several major sub-systems: the target refrigerator injunction with ^{3}He/^{4}He pumping system, NMR, microwave, superconducting magnets, and polarized material. The dilution refrigerator as shown in Fig. 4 is the heart of HIFROST. It is used in conjunction with a 2.5-T superconducting magnet and 70-GHz microwave to polarize the target material using dynamical nuclear polarization technique (DNP). The value of the polarization will be measured with an NMR system whose components are Liverpool Q-meter, associated electronics, and a Labview DAQ system. Microwaves at frequencies of around 70 GHz are generated through an extended-interaction-oscillator(EIO) tube (or a Carcinotron as backup), each powered by an appropriate supply. After target polarization with the 2.5-T superconducting magnet, the dilution refrigerator temperature is lowered to below 50 mK to operate in frozen-spin mode, and the magnet is turned off. Holding magnet (longitudinal or transversal coils) of about 0.5-T maintains the polarization at a high level over many hours. In order to keep the dilution refrigerator cold, liquid helium (LHe) is continuously fed, ^{3}He is continuously circulated, and vapor ^{4}He is vented out. Various polarized materials (e.g. butanol) and their deuterated versions are available to use.

Currently UVa group in the collaboration with TUNL is making steady progress of constructing the HIFROST system which proceeded in parallel at UVa and DFELL/TUNL. An extensive cryo-cooling test has been performing at UVa while a lot of progress at DFELL/TUNL has been made on microwave and NMR systems, ^{3}He and

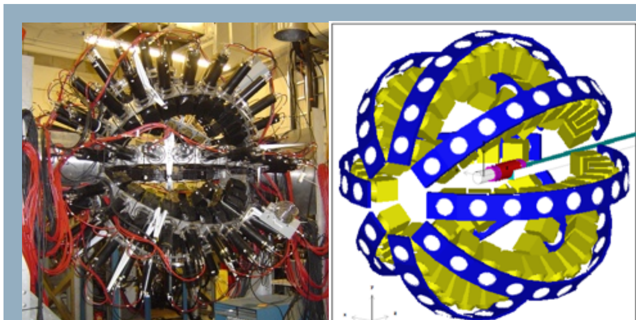

Figure 3. The Blowfish detector array which consists of 88-liquid scintillation detectors (left) and the detector array with an active target for GEANT simulation (right) [4].

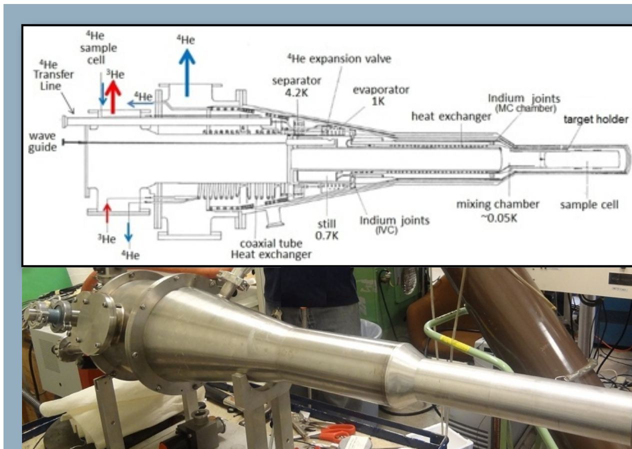

Figure 4. Details of assembled dilution refrigerator for HIFROST (top) and the dilution refrigerator under test (bottom).

^{4}He gas handling system as well as on the design of several critical components. Our efforts for HIFROST aim for commissioning the system in next 6 months and testing the system as a whole in February of 2013. This leads us to perform the GDH experiment for the first time to test fundamental GDH sum rule on deuteron.

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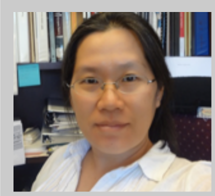

Featured Report 1

UKC 2012: Physics, Astronomy, Chemistry, Math, Stat. and other Basic Sciences

The BAS track was organized to bring together world leading scientists and young researchers in various fields of basic science from across the U.S. and Korea. This meeting served as a timely event for establishment of the Institute for Basic Science (IBS) and construction of the Korea Rare Isotope Accelerator (KoRIA) as part of the International Science & Business Belt (ISBB). There were 7 oral sessions and a poster session, for 70 papers total. Participants commented highly on the quality and quantity of the presentations. Details of each session are summarized below.

Track Chair: Prof. Eun-Suk Seo
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BAS Session1. Plasmonics and Biomolecule Imaging

In the session of "Plasmonics and Biomolecule Imaging", six outstanding speakers talked about interesting issues in surface plasmonics for bio-imaging as well as other basic physics topics. Dr. Leiming Wang from University of Pittsburgh presented their unique technique about direct visualization of surface plasmon propagation. He and his colleague combined femto-second laser pump-probe interferometry with photoemission electron microscopy (PEEM) to image ultrafast SPP phenomena in nanostructured metal films. The interferometric time-resolved PEEM technique enables us to record movies of ultrafast electric polarization field and electron dynamics with <100 nm spatial resolution and ~330 atto-second pump-probe time interval. In this presentation, he discussed his PEEM study of two simple SPP structures, a nano slit and a plasmonic lens, lithographically fabricated in an 80 nm thick Ag film deposited on a Si substrate.

Dr. Myung-Ki Kim from Caltech introduced his advanced simulation results about surface plasmon propagation and its enhancement in various nanostructures. He and his colleagues demonstrate the surface-plasmon-polariton based photonic crystal defect nanolasers, the so called plasmonic crystal defect nanolasers. Using conventional III-V semiconductors, they achieved lasing in a

Group photo of UKC 2012 BAS Participants mode volumes as small as $V_{eff}=0.3(\lambda_0/n)^3$ at $\lambda_0=1342$ nm, which is 10 times smaller than similar modes in photonic crystals of the same size. This demonstration is expected to pave the way for achieving engineered nanolasers with deep-subwavelength mode volumes.

Dr. Ji-Young Kim from Intel Corporation showed how they tune natural physical constants using advanced metamaterial structure. She and her colleagues at Purdue University demonstrated the higher quantum yield of Rh800 with the HMM (hyperbolic meta material) layer comparing to the measurement with other control layers by changing layer materials, thickness, and the distance from the structures. Finally, she validated the effective control HMM by showing that multilayer hyperbolic metamaterials provide an extraordinary high radiative decay rate relative to those from monolayer thin or thick gold films. Her study provides the quantitative platform for the studying about tuning of the optical property of the molecules both experimentally and theoretically.

Dr. Kyuwan Lee from University of California Berkeley introduced a versatile method to detect single molecules in living cells using nanoparticle plasmonic dimers. He and his colleagues at Berkeley and Purdue University proposed a new approach of a single molecule imaging method by a multispectral measurement technique, accompanied with the designed plasmonic nanoparticle probe. Among many different techniques, the hyperspectral imaging system (HSI) stands out as a method that can measure the full spectrum of each point in the sample image with the high sensitivity of single gold nanoparticle detection. They utilized HSI as a single molecule imaging tool by employing engineered gold nanoparticle probes targeting specific single molecules inside the living single cells or on the cell membrane.

Professor Harold Kim presented a framework to study sequence-dependent bending of short DNA duplexes through looping dynamics, which combines single-molecule FRET (Förster resonance energy transfer), gel electrophoresis, a semi-analytical model, and coarse-grained simulations. We find that the looping kinetics of DNA correlates more with curvature (the static persistence length) than flexibility (the dynamic persistence length) at ~180 base pair length scale. He argued that his measured looping kinetics can be directly related to the end-to-end distance probability distribution and show that our experimental data are in excellent agreement with Monte Carlo simulations.

Professor Kinney Kim did a great introduction about that experimental gamma-ray spectroscopy measurements have revealed the presence of an isomeric excited state in Th-229 slightly above the ground state. Strizhov and Tkalya suggested that the isomeric level would decay by exciting a 6d to 7p transition in the Th atom, with an energy change of 1.28 eV. Therefore red shifted photons of energy 2.22 eV should be observable. Professor Kim and his group searched for optical photons in this energy range emitted from sources of U-233, which populates the isomeric level in Th-229 approximately 2% of the time. In two samples studied optical photons in this range were indeed observed around 2.3 eV, along with emission in the ultraviolet.

All the speakers above together suggested a big possibility of many applications, for example, bioimaging and single molecule study, of our basic physics phenomena in surface plasmon on the nanostructure, isomer, and rare isotope. This session brought great interests to interdisciplinary research, combining high energy physics, nanotechnology and biological application.

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BAS Session 2. Plasma: from Lab to Space

In the Thursday morning session, four invited and two contributed talks were presented and summarized below.

(BAS-7) Hard X-ray from betatron oscillations of a wakefield-accelerated electron beam by asymmetric laser pulses, Inhyuk Nam (GIST): Mr. Nam presented hard X-ray generation from betatron oscillations of electron beams in laser wakefield acceleration (LFWA). In particular, he investigated enhanced x-ray generation by using temporally asymmetric laser pulses.

(BAS-8) Matter in Extreme Condition and Experimental Capabilities at LCLS, Hae Ja Lee (SLAC): With the recent advent of a high peak brightness x-ray free electron laser source, the Linac Coherent Light Source (LCLS), Dr. Lee's team is constructing the Matter in Extreme conditions (MEC) instrument that will cover a wide range of the extreme conditions in phase space. Dr. Lee presented the overview of the LCLS, MEC instrument, and related experiments.

(BAS-9) High-harmonic generation for attosecond science in the soft X-ray range, Kyung-Han Hong (MIT): Dr. Hong presented the recent progress on the soft X-ray attosecond light sources based on long wavelength-driven

BAS Session 2. Plasma: from Lab to Space
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high-harmonic generation at MIT. He also talked about underlying physics and enabling technologies, such as optical parametric amplifiers and picosecond pump laser technology.

(BAS-10) STEREO observations of fast magnetosonic waves in the extended corona, Ryun Young Kwon (NASA GSFC): Dr. Kwon presented fast magnetosonic waves propagating across solar radial magnetic fields. His results suggest that the coronal disturbances associated with flares/CMEs are fast magnetosonic waves propagating with local fast magnetosonic speeds and passing through magnetic separatrices. He concluded that EIT waves are 'real' fast magnetosonic waves.

(BAS-11) Integrated Space Weather Analysis System Application to Space weather operation and model validation, Hyesook Lee (NASA GSFC): NASA/GSFC-CCMC developed the iNTEGRATED Space Weather Analysis (hereinafter iSWA) system on 2009. The iSWA is the web-based dissemination system for NASA-relevant space weather information. In her talk, Dr. Lee introduced iSWA as a tool for space weather analysis and present Fok's RBE model evaluation results using iSWA.

(BAS-12) Investigating Warm and Dense States of Matter with an X-ray Free Electron Laser, Byoung-ick Cho (Lawrence Berkeley Nat`l Lab): Dr. Cho presented the first experimental study of warm and dense plasmas created by X-ray free electron laser (FEL). Solid density matter at temperature over a million degree is created, and X-ray matter interactions channels with multiphoton and resonant processes are unveiled that are inaccessible with conventional X-ray sources.

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BAS Session 3. Exotic States in Physics

One of the main basic science [BAS] topics at UKC2012 was about exotic states that exist in nature. The exotic states can be produced in extreme conditions or by intrinsic properties of the topology of the systems under consideration. In the session, 'Exotic States in Physics', held on August 9, Thursday, some of the examples were discussed, that ranged from single impurity bound state by Dr. Kun Woo Min (Caltech), dynamical nuclear polarization states of diamond by Dr. Seungjoo Nah (Ames Lab), to the nonconventional superconducting state of Fe-pnictides by Dr. Kyuil Cho (Ames Lab), and to the exciton-polaronic condensates in two-dimensionally fabricated nano-scale semiconductors by Dr. Nayoung Kim (Stanford Univ.). One of the theoretical methods that can be utilized to understand the collective exotic states, called a density functional theory, was also discussed by Dr. Cheol-Hwan Park (Bosch Center). Two invited talks in the session were delivered by Drs. Cheol-Hwan Park and Nayoung Kim who were previous recipients of the AKPA's Outstanding Young Researcher Award (OYRA). A chemist, Prof. Young-Seok Shon (California State Univ., Long Beach) was courageous enough to give a talk to the physics audience on a chemical aspect of palladium nanoparticles, which was very much appreciated by the audience.

BAS Session 3. Exotic States in Physics

This session clearly showed that exciting problems are abound in condensed matter science. Dr. Nayoung Kim demonstrated in her excellent talk that GaAs-based semiconductors can be manipulated in a nano-scale to form arbitrary lattices such as two-dimensional square-, triangular-, honeycomb-, and kagome lattices. This is an emerging field aiming at providing an excellent platform to explore exotic quantum states in two-dimension. Dr. Kyuil Cho showed by his London penetration depth studies using tunnel diode resonator technique that the superconducting mechanism of the new Fe-based superconductors must involve a competition of the inter- and intra-band Coulomb interactions. Dr. Seungjoo Nah explained that nitrogen-vacancy centers in diamond can be a unit for quantum memory if their nuclear spins are polarized via an optical pumping under an external magnetic field. Dr. Cheol-Hwan Park explained how to tackle the electron self-interaction problem in the density functional theory for the many body systems. He showed that the self-interaction contribution can be taken out by dividing the energy minimization process into two steps, first to identify the occupied orbitals and second to find an optimal linear transformation among the orbitals, which makes the whole minimization process much faster. Prof. Shon showed that controlling the particle size and the surface ligand density of alkanethiolate-capped palladium nanoparticles leads to the optimization of catalytic activity and selectivity for various organic transformations (i.e. isomerization of allyl alcohols, tandem semi-hydrogenation and isomerization of propargyl alcohols, and isomerization of terminal alkenes).

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BAS Session 4. Physics in Extreme Conditions

Spin liquid and spin glass states in frustrated magnets, Seunghun Lee (Univ. of Virginia): The categorization of magnetic materials was presented by considering a few model materials for those states. It was presented that a spin liquid state becomes the ground state for a system where the relevant spin degrees of freedom are disordered. On the other hand, a spin glass can be the ground state for a quasi-two-dimensional frustrated magnet where ordered and disordered degrees of freedom coexist.

Quantum superresolution with entangled photons, Heedeuk Shin (Sandia National Lab.): It is introduced that optical centroid method enhances the spatial resolution with entangled photons and its associated experimental results are presented. It shows that its detection efficiency is higher than that of well-known quantum lithography.

In-situ impedance measurement of Gold Nano-Island Assembly and Polymer Thermolysis in Self-Assembled Multilayer Flim, Chuhee Kwon (California State Univ., Long Beach): The formation of nano-islands from a self-assembled Au-314 multilayer film was monitored by performing in-situ impedance measurements. And it is presented that these measurement provide an insight to the thermolysis process of the polymers and the formation of nano-islands.

Calibration of instrumental polarization crosstalk for the New Solar Telescope at Big Bear Solar Observatory, Kwangsu Ahn (Big Bear Solar Observatory): The random error can be corrected by multiplying correction matrix and applying weight factors. This method is applied to IRIM (InfraRed Imaging Magnetograph) installed at the New Solar Telescope.

Novel Force Spectroscopy and its application to Nano-Liquid Physics, Corey Stambaugh (National Institute of Standards and Technology): It is presented that a novel technique for dynamic/static force spectroscopy by combining a quartz tuning-fork based NC-AFM with a micromechanical force sensor (MEMS) is applied to measure the visco-elastic properties of nanoscale water.

Antiferromagnetic exchange coupling between GaMnAs layers separated by a nonmagnetic GaAs:Be spacer, Jonathan Leiner (Univ. of Notre Dame): As per the recent work found the existence of antiferromagnetic coupling between GaMnAs layers in a superlattice comprised of GaMnAs layers separated by non-magnetic GaAs:Be spacers, a systematic experimental study of the carrier-mediated inter-layer exchange coupling in trilayer (GaMnAs/GaAs:Be/GaMnAs) is presented.

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BAS Session 5. Novel Physics of Graphene and Related Nanostructures

In the session 'Novel physics of graphene and related nanostructures', recent progresses in the electronic, optical, and structural properties of graphene nanostructures have been presented and actively discussed.

BAS Session 4. Physics in Extreme Conditions

In graphene monolayer or multilayer, there are more than one carbon atoms in a unit cell. Pseudospin state indicates the index of a carbon atom in a unit cell. For example, pseudospin-up state in monolayer graphene is the Bloch sum of the p_z electronic states in one of the two sublattice carbon atoms. Two predicted interaction-driven ordered states in graphene double layer have been discussed by Prof. Hongki Min (Seoul National Univ.): pseudospin magnets, i.e., spontaneous polarization of charge carriers in one of the two layers, and excitonic superfluids. It was then suggested by Dr. Eun Gook Moon (UC Santa Barbara) that, because the density of states in bilayer graphene is almost constant near the Fermi level, electron-electron interactions could induce Skyrmion excitations with charge 4e.

On the experimental side, it was reported, based on the results of angle-resolved photoemission experiments on graphene, by Dr. Choongyu Hwang (UC Berkeley) that change in the substrate can induce a change in the magnitude of the Fermi velocity by three times. Dr. Duhee Yoon (Sogang Univ.) reported Raman measurements on graphene on silicon dioxide substrate at various temperatures, from which the thermal expansion coefficient of graphene was deduced by considering the thermal expansion of silicon dioxide. Finally, a very recent aberration-corrected transmission electron microscopy study on the edges of graphene nanostructures have been presented by Kwanpyo Kim (UC Berkeley).

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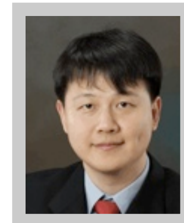

BAS Session 6. Rare Isotopes and Accelerators

I. Presentation Titles and Speakers

- Overview of the Rare Isotope Science Project, Prof. Yong-Kyun Kim (substituting Prof. Sun Kee Kim; President of IBS), IBS and Hanyang Univ.
- Experimental Facility Design of Rare Isotope Science Project in Korea, Prof. Yong-Kyun Kim, IBS and Hanyang Univ.
- Activities of the Korea CMS Collaboration at CERN, Prof. Inkyu Park, Univ. of Seoul

BAS Session 5. Novel Physics of Graphene and Related Nanostructures

- Combination Nano-Photodynamic Therapy and Radiation Therapy for Cancer Treatment, Prof. Wei Chen, UTA
- Nuclear Science with Rare Isotope Beams - the neutron dripline, Dr. Alexandra Gade, NSCL and MSU
- Frontier Nuclear Physics with Rare Isotope Accelerators, Prof. Chueng-Ryong Ji, NCSU

II. Key Messages

The Rare Isotope Science Project (RISP) stems from the international science business belt (ISBB) plan established in Korea around January 2009 and very recently, in July 2012, completed its baseline design summary. RISP is organized under the umbrella of the Institute for Basic Science (IBS) and provides an excellent opportunity to investigate the forefront research topics in nuclear physics, nuclear astrophysics and atomic/particle physics as well as to acquire the nuclear data with fast neutrons for future nuclear energy and apply the rare isotopes to material science for production and characterization of new materials and to medical and bio sciences for advanced therapy technology and medical imaging.

Prof. Yong-Kyun Kim presented the experimental facility design of RISP in Korea discussing the high intensity rare isotope beams by isotope separator on-line (ISOL) and in-flight fragmentation (IF) and providing the development plan as well as the current status. As an another ongoing example of international collaboration initiated from Korea, Prof. Inkyu Park presented the activities of the Korea CMS collaboration at CERN and reviewed the recent Higgs particle search conclusion announced in the press conference on July 14, 2012.

In conjunction with the medical application aspect in RISP, Prof. Wei Chen presented combination nano-photodynamic therapy and radiation therapy for cancer treatment and discussed the utility of afterglow nanoparticles for photodynamic activation and cancer treatment. As the RISP makes a significant progress in Korea, the facility for rare-isotope beams (FRIB) is planned in Michigan State as the US national user facility for rare isotope research and education in nuclear science, astro-nuclear physics, accelerator physics, and societal applications. Representing FRIB, Prof. Alexandra Gade presented the nuclear science with rare-isotope beams, in particular the neutron dripline, discussing what combination of protons and neutrons can be made into a bound system and the limit of nuclear existence characterized by the nucleon driplines. She reviewed the recent experimental evidence showing that ^{26}O and ^{28}O don't exist while ^{31}F, ^{34}Na and ^{34}Ne exist and discussed how hard experimentally to reach the neutron dripline as she made an analogy to find a needle in a haystack. Despite the difficulty in finding the correct neutron dripline, the impact from the dripline search is enormous in understanding the fundamental nuclear structures from the forefront nuclear physics. As an example, the non-existence of ^{26}O and ^{28}O may already indicate that 3N forces are essential for medium mass nuclei.

This session was summarized by the session chair, Prof. Chueng Ji, presenting the frontier nuclear physics issues with rare isotope accelerators and discussing the road map of theory support for the ongoing projects of FRIB and RISP.

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BAS Session 6. Rare Isotopes and Accelerators

BAS Session 7. Basic Energy Sciences in Chemistry

This session consisted of seven invited speakers in the field of solar energy conversion. Synthesis of novel materials, spectroscopic characterization, device physics and chemistry, and theoretical modeling were discussed for systems such as nanoporous materials, quantum dots, dye sensitized solar cells, plastic solar cells, silicon solar cells, and natural light harvesting complexes. The session gave unique opportunity for the attendees to appreciate the broad issues and to put challenges into perspective in this field of interdisciplinary and multifaceted research. More detailed description of each talk is provided below.

1. Highly Transparent Mesoporous Metal Oxide Films for Energy Applications, Prof. Dong-Kyun Seo (Arizona State University)
Highly transparent mesoporous metal oxide films with electrically conducting properties are highly desiredcomponents in fabrication of organic- or bio-based solar fuel production devices. The speaker presented a new scalable synthetic methodology that provides such materials at low cost. The final products showed good crystallinity and had high surface areas up to 100 m^2/g and high porosities up to 69 %. The average pore sizes range from 7 to 33 nm. The materials exhibit remarkably low resistivity (> 0.14 Ω-cm) for a mesoporous ATO material and a fast electron transfer rate, which is comparable to that of glassy carbon electrodes. It has been demonstrated that the material can function as a high surface area transparent electrode with impregnated DNA superstructures and proteins.

2. Energy and Charge Transfer Dynamics in Doped Semiconductor Nanocrystals, Prof. Dong Hee Son (Texas A&M University)
Doped semiconductor quantum dots show new optical and electronic properties distinct from their undoped counterparts, arising from the energy and charge transfer between exciton and dopant state. The presentation discussed the dynamics of the energy transfer and charge transfer processes in doped semiconductor nanocrystals correlated with the structurally tuned donor-acceptor wavefunction overlap.

3. Functional Nanostructured Materials for Enhancing Charge Collecting and Light Harvesting Properties in Dye-sensitized Solar Cells, Prof. Hyun Suk Jung (Sungkyunkwan University)

BAS Session 7. Basic Energy Sciences in Chemistry

This talk presented new advances in the design of photoelectrode materials which light harvesting and charge collection in dye sensitized solar cell (DSSC). It was shown that inverse opal structured TiO2 layers show good light scattering property as well as charge generating property. It was shown that TiO2 nanutube arrays oriented in preferred direction exhibit excellent charge transport property and can be used as promising photo-electrode materials. This material exhibits a nice charge transport property.

4. Nanocone-based three dimensional thin film silicon solar cells, Dr. Jeehwan Kim (IBM)
The speaker presented new experimental efforts to create three dimensional heteo-junction solar cells based on amorphous silicon materials. Three different structures were considered, among which cone shaped morphology was promising. The speaker succeeded in creating such morphology and stabilizing with lithographic technique. Initial tests showed promise in this approach.

5. Recent Progress in Organic Bulk Heterojunction Solar Cells, Dr. Chang-Yong Nam (Brookhaven National Laboratory)
The speaker gave general overview of organic solar cell (OSC) and addressed promises and major challenges that lie ahead. While OSCs are potentially cost effective and have gone through dramatic improvement in the efficiency during the past decade, future success requires significant enhancement of charge transport capability, module efficiency, and stability. Despite these pending issues, the speaker noted that the progress so far meets the expectation of the long term goal of the Department of Energy and projected that achieving an efficiency over 12% by 2020 is feasible.

6. High-Performance Inverted Polymer Solar Cells Introducing Novel Functional Interlayers, Dr. Kwanghee Lee (GIST)
The speaker presented recent breakthrough in polymer tandem solar cell, which broke the record in 2007 and was published in Science. As the leading practitioner in this field, he gave insights into major challenges to be overcome and fierce competition for achieving higher efficiency. Two pending issues are developing new efficient dye molecules and test for large enough solar cell. The speaker is leading new synthetic efforts and slot-dye coating method for large scale creation of solar cells.

7. Quantum Effects in the Solar Energy Conversion Dynamics of Soft Molecules, Prof. Seogjoo Jang (CUNY)
This talk gave overview of main theoretical issues in understanding and modeling exciton energy flow dynamics in soft and complex environments, and demonstrated how quantum coherence plays a significant role efficient exciton flow photosynthetic light harvesting complexes of purple bacteria. The speaker also demonstrated the capability of new coherent resonance energy transfer theory in understanding the energy transfer dynamics in pi-conjugated organic molecules.

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BAS Poster Presentations

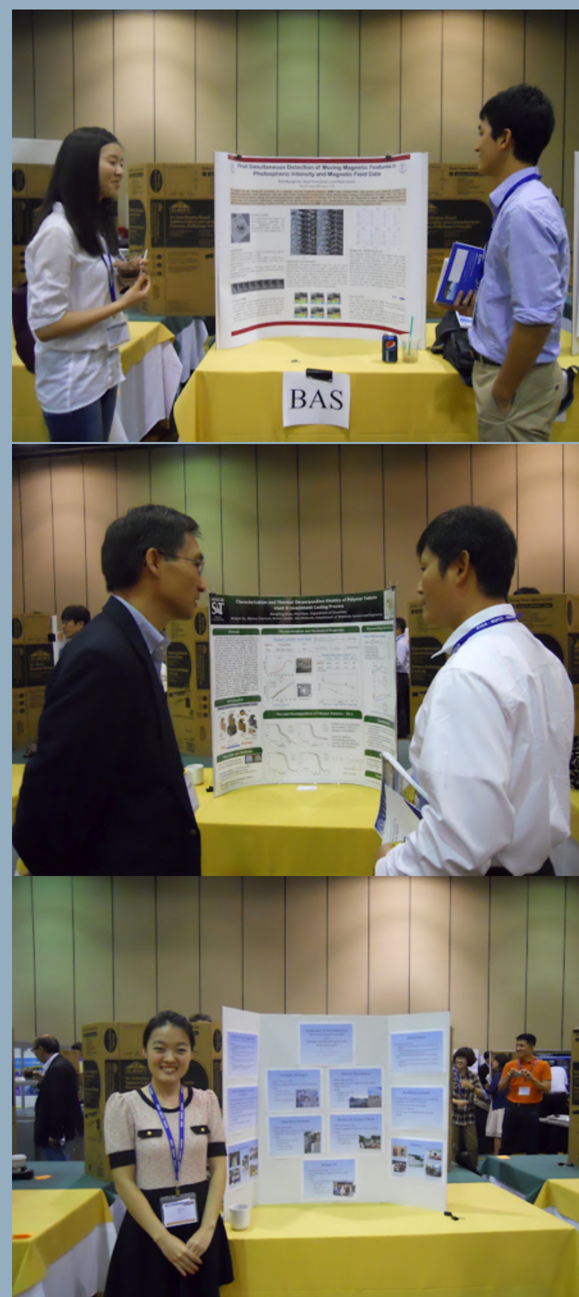
The total number of abstracts for the BAS poster session was 14. Six posters were presented during the poster session:

- First Simultaneous Detection of Moving Magnetic Features in Photospheric Intensity and Magnetic Field Data, Eun-Kyung Lim (Big Bear Solar Observatory)
- Multiplexity-facilitated cascades in networks, Charles Brummitt (UC Davis)
- The h-p Version of Stochastic Galerkin FEM for Stochastic Optimal Control Problems, Jangwoon Lee (University of Mary Washington)
- Giving back to the community, Eun Jin Joo (Brown Public Health)
- Characterization of Polymer Patterns Used in the Metal Casting Process, Paul K. Nam (Missouri University of Science and Technology)
- Random Walks in a sparse random environment, Youngsoo Seol (Iowa State U.)

Eun-Kyung Lim (BAS-PP-1) presented observational results of moving magnetic features in the solar photosphere using the New Solar Telescope at Big Bear Solar Observatory and the space telescope on board Hinode. The observations provide a clear intensity counterpart of the observed MMF in the photosphere, and strong evidence of the connection between the MMF and the penumbral filament as a serpentine field. Eun Jin Joo (BAS-PP-9) shared her experiences in several mission trips and argued how many needy people are there in the world and our educations and works should not solely go to accumulate our wealth or reputations. Paul K. Nam (BAS-PP-10) presented characterization of polymer patterns used in the metal casting process which is a widely employed for manufacturing of precision metal components used in the automobile, aerospace and biomedical industries. He provided a way to produce accurate and complicated shape castings. A proof of random walks in a sparse random environment was given by Youngsoo Seol (BAS-PP-14). The mathematical results may be applied to the particle physics.

The UKC 2012 Poster Award was given to Eun-Kyung Lim (Big Bear Solar Observatory) for her poster entitled “First Simultaneous Detection of Moving Magnetic Features in Photospheric Intensity and Magnetic Field Data”.

Session Chair
Dr. Ryun Young Kwon
NASA GSFC
ryunyoung.kwon@nasa.gov



BAS Poster Presentations

Featured Report 2

The 2012 UKC Physics Forum

In UKC2012, the seminar sponsored by The Korean Federation of Science and Technology Society (KOFST) was held to discuss future-leading basic science and high technology to build close network between Korean and American science communities for the co-advancement of both societies. Professor Eun-Suk Seo of University of Maryland, as a chair of the meeting, opened the discussion and presented her recent progresses in the high energy cosmic ray detection based on a series of her balloon-borne detector projects. Her past works include discovery of the mysterious electron anomaly, which may have a connection with darkmatter. Recently, she and her group initiated the cosmic ray projects using the international space station (ISS) approved by NASA to extend the cosmic ray measurements to higher energies. She illustrated experiments with high discovery potential cut across various disciplines of physics, and emphasized the importance of collaborations across traditional boundaries of research areas.

Two panel scientists, Professor Ho Jung Paik and Ki-Yong Kim from University of Maryland also discussed their proceeding researches. First, Professor Paik discussed his innovative study about “Determination of Gravitational Constant G Using a Superconducting Differential Accelerometer”. He introduced their creative planetary system design of “the source and levitated test masses”, in which the gravitational force on the test masses is balanced by centrifugal acceleration and the superconducting differential accelerometer formed by the two test masses is used a null detector. He and his group already initiated a joint cryogenic experiment with the Korea Research Institute of Standards and Science (KRISS) to determine the gravitational constant G to one part in 10^6, as well as several projects approved by NASA.

As a second panel speaker, Professor Ki-Yong Kim presented his remarkable progress on “Generation of Broadband Coherent Light in Laser-Produced Plasmas” to address the rising terahertz technology and the important role of his research. He and his group introduced a novel mechanism of strong terahertz generation in plasma, using ultra-short intense laser pulses. This plasma current model, first proposed by his group, is now widely adopted in the community.

The Discussion board of the meeting, Professor Cheong-Ryong. Ji (North Carolina State University), Seunghun Lee (University of Virginia), and Harold Kim (Georgia Institute of Technology), agreed that the efficient collaborations between Korean and American science societies are required on the platform of the KOFST foundation. Professor Eun-Suk Seo and all the meeting attendees acknowledged the support of the meeting by KOFST.

Reported by Dr. Kyuwan Lee
University of California, Berkeley

(From left) Kyuwan Lee, Kiyong kim, Cheong-Ryong Ji, Eun-Suk Seo, Hojung Paik, Harold Kim, and Seunghun Lee

Featured Report 3

The 2012 US-Korea Ultra Program Round Table

At 2012 Korea-US ULTRA program round table session held on the 9th of August in Garden Grove, Orange County, California, the discussion was initiated by a presentation by Dr. Jungsang Kim who is an associate professor in the department of electrical and computer engineering at Duke University. The presentation title was "Technologies for Engineering Quantum Information Processing Systems: Global Trends and Opportunities." The panel consisted of Sang-Dae Park, President, Korea Federation of Science and Technology (KOFST); Ki-Jun Lee, Honorary President, National Academy of Engineering of Korea, Jung Sang Kim, Associate Professor, Duke University; Na Young Kim, Physical Science Research Associate, Stanford University; Ho Jung Paik, Research Professor and Professor Emeritus, University of Maryland; Eun-Suk Seo, Professor, University of Maryland; Seunghun Lee, Professor, University of Virginia; Kyung-Han Hong, Principal Research Scientist, Massachusetts Institute of Technology (MIT); Hanseok Ko, Professor, Korea University; Yoon-Ho Kim, Associate Professor, POSTECH; Hak-Min Kim, Director of the Center for Advanced Materials Processing, Korea Institute of Materials Science (KIMS); Ho-Yong Kim, President, Korea Electrotechnology Research Institute (KERI); and Se-Jung Oh, President, Institute of Basic Science (IBS).

When quantum effects are used in information processing, unprecedented breakthroughs can be made such as fundamentally secure communication and quantum computers which are much more effective than classical computers. Research activities in quantum information processing (QIP) have gradually increased over the past 18 years. It is an extremely exciting field for both fundamental scientific interest and potential applications. Dr. Kim's team explores QIP using Yb^{+} ion traps (which play the role of qubits) fabricated on substrate surfaces; communication between those ion traps is done by optical methods. Because the field requires specialties in quantum physics, computer science, atomic physics, surface science, and optics, multi-disciplinary collaborations are necessary.

The presentation was followed by a series of serious questions and answers. Especially, the importance of QIP researches in Korea and the ways to initiate such research activities were the main focus. It has been agreed among the panel that the science and engineering community in Korea has a very good potential for QIP researches. The differences in the research funding system in the US and that in Korea were discussed.

Reported by Dr. Cheol-Hwan Park
Robert Bosch Research
and Technology Center

Around AKPA

Prof. Eun-Suk Seo receives the 2012 KWiSE Woman Scientist Award.

The KWiSE Woman Scientist Award has been established in 2007 to recognize:

1. member(s) who have made outstanding contributions to advances in science and engineering or applications of technology for the general welfare of society,
2. member(s) who have made outstanding contributions in fostering international cooperation especially between the US and Korea, and
3. person(s) who have made outstanding services to the betterment of the KWiSE.

http://www.akpa.org/membership/member-news

Featured Report 4

After Attending UKC 2012

It has been a few years since I attended the UKC last. Wow, what a difference! This year there were five different sessions in physics, from plasma, to nuclear, to nanophysics. In addition, there were a KOFST-sponsored ULTRA (Universal Linkage for Top Research Advisor) Program round table discussion on quantum computing and an ULTRA forum with invited speakers discussing astroparticle physics, gravitation and astrophysics, and femtosecond laser physics. Over 30 different speakers from US and Korea gave presentations! Just six years ago, when I had served as president of AKPA, it was difficult to organize even a single physics session at UKC. This year I saw an order of magnitude increased activity at the UKC.

Among other things, what impressed me most is the participation of so many young physicists, some of whom are clearly rising stars in their own fields. Although they come from different fields, their mingling together like this at a conference and listening to one another's talks gives them an opportunity to learn from one another and to possibly collaborate in the future. This is exactly what AKPA was set out to do. However, many old timers remember how difficult it has been to help AKPA fulfill such a task. I now see a bright future for AKPA. I do not know how Professor Seo and her administration were able to pull such success. They certainly have worked very hard with enthusiasm and energy. They deserve our heartfelt applause and support. We all hope that future presidents of AKPA will be able to take over the baton and continue to run like Professor Seo.

Prof. Ho Jung Paik
Department of Physics
University of Maryland

Korea-U.S. Collaboration Center for Accelerator Science Opens at Fermilab

The Ministry of Education, Science and Technology and the Rare Isotope Science Project (RISP) of Institute for Basic Science (IBS) have opened the Korea-U.S. Collaboration Center for Accelerator Science (KUCC) at the Fermi National Accelerator Laboratory in Batavia, Illinois, on Aug. 7, 2012. The KUCC's opening has provided crucial momentum for IBS/RISP to carry out one of its biggest projects in earnest: building a rare isotope accelerator in Korea by 2017. The Fermi National Accelerator Laboratory, known as Fermilab, is one of the world's major accelerator research centers. It has built and operated "TEVATRON" which was known to be the world's largest particle accelerator until few years ago.

Fermilab is currently working on Project X to develop a high-intensity superconducting proton accelerator that would support experiments in neutrino and rare processes physics. Fermilab is one of the best partners for collaboration in developing a superconducting radio frequency cavity which is the most critical components of the accelerator. The newly opened KUCC will serve as a base for IBS/RISP to collaborate with the world's leading accelerator laboratories in North America in building a heavy ion accelerator, as well as promoting technology/ personnel exchanges.

To this end, IBS plans to dispatch roughly 10 master's or doctoral-level researchers every year to the US accelerator laboratories in an effort to secure specialized manpower necessary for the development of the heavy ion accelerator in International Science & Business Belt (ISBB).

Meanwhile, the KUCC's opening is a follow-up of the memorandum of understanding (MOU) concluded between IBS and Fermilab last June. The opening is significant in that it represents the first major fruit reaped in bilateral cooperation in the accelerator area between Korea and the U.S. since the Department of Energy of the United States and the Ministry of Education, Science and Technology of Korea signed arrangement for collaboration in the area of high energy and nuclear physics research.

The inauguration ceremony of the KUCC was attended by Yul-rae Cho, second Vice Minister of the Ministry of Education, Science and Technology; Dr. Sun-kee Kim, Director of Rare Isotope Science Project; Dr. Pier Oddone, Director of Fermilab; and Dr. Young-kee Kim, Deputy Director of Fermilab.

RISP Information & Collaboration team

Inauguration ceremony of the Korea-U.S. Collaboration Center for Accelerator Science (KUCC)

Participants of the inauguration ceremony of the Korea-U.S. Collaboration Center for Accelerator Science (KUCC) discuss ways to promote bilateral collaboration.

Audit Report

Association of Korean Physicists in America (AKPA)
Review Analyst: In-Saeng Suh, Auditor
Review Date: May 1, 2011 – April 30, 2012

Objective and Scope:

- This audit was conducted to examine and evaluate whether the organization exercised its financial and organizational processes adequately and effectively as required by the by-laws of the organization.
- Reviewed the financial activity from 5/1/2011 to 4/30/2012 for the 29th AKPA administration. All financial materials were provided by Dr. Taeksu Shin, Treasurer of the 29th administration.

Audit Findings:

- All the records of transactions (incomes and expenses) for May 2011 through April 2012 were well organized and kept and the accounting was accurate.
- The organization maintains a health balance $13,272.25 as of April 30, 2010.

Balance transferred from the 28th AKPA administration: $5,567.07
Total Income: $17,770.00
Total expenditure: $10,064.82

Income sources during this period are

- Membership fee: $3,950.00
- Donation: $610.00
- Support from ORG: $12,880.00
- Misc. $330.00

In the period of May 2011 to April 2012, the significant and active fund drive was achieved, which is essential to maintain the organization very healthy. Considering current incomes and expenditures, the organization keeps the balance well.

Dr. In-Saeng Suh
The 29th AKPA Auditor
University of Notre Dame
July 15, 2012

Nomination for the 31st President and Auditor Being Accepted

Nominations for the AKPA 31st president and auditor are currently accepted by the nomination committee. Any current AKPA member who is interested in either positions or any member who would like to recommend another member(s) should contact the nomination committee chair, professor K.H.Kim (khk@nccu.edu). The candidate must be a regular AKPA member. The nomination needs to include the following information:

- Name of the Nominee
- Affiliation
- Position/rank
- Short description of qualification
- Consent from the nominee

The deadline for nomination is Oct. 15, 2012.

2013 AKPA Outstanding Young Research Award Solicitation for Nominees

PURPOSE:

In order to recognize and promote excellence in research by outstanding young ethnic Korean physicists in North America, the Outstanding Young Researcher Award (OYRA) has been awarded annually since 1994 by the Association of Korean Physicists in America (AKPA). The list of previous recipients is available on the AKPA webpage.

QUALIFICATION:

Candidates are limited to ethnic Korean physicists who are working at research universities/ institutions or industrial/government laboratories in North America. At the time of nomination, each candidate should be within five years from completion of his/her Ph.D. dissertation. For 2013 nomination, each candidate should have his/her Ph.D. awarded on or after January 1, 2007. Exceptions to this eligibility can be allowed for extenuating circumstances, such as military service or extended medical leave. The award committee will review such cases to determine their eligibility.

NOMINATION:

Each candidate must be nominated by the Chair or Head of the department where they are employed or by the candidate's doctoral or postdoctoral advisor in a letter detailing the importance and impact of the candidate's work. Supporting documents should include the candidate's curriculum vitae with representative publications and three letters of recommendation. Nominations and supporting letters are to be sent electronically, preferably in PDF format, to the AKPA OYRA Committee at OYRA@akpa.org with the subject line "OYRA2013 for <candidate name>" by the dates given below.

Nomination Deadline: November 15, 2012
Supporting Documents Deadline: December 15, 2012

AWARD COMMITTEE:

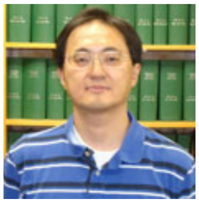
Prof. Kyungseon Joo (U. Conn.), Chair
Prof. Kyungwha Park (Virginia Tech.)
Dr. Inseob Hahn (NASA JPL)
Dr. Kyoungchul Kong (University of Kansas)

PRESENTATION:

One or two award winners will be selected by the Award Committee. The winners will be announced early in 2013. The award of $1,500 with a plaque will be presented at the AKPA annual meeting, which will be held in conjunction with an American Physical Society Meeting in the Spring. The exact location of the annual meeting and time will be announced later.

New Life Time Members and Donators

New Lifetime Member



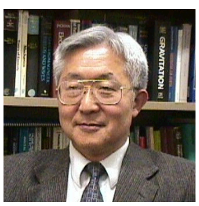
Prof. Sangwook Park
Assistant Professor, Department of Physics, University of Texas at Arlington

email: s.park@uta.edu
Research area: X-ray Astronomy

Donators

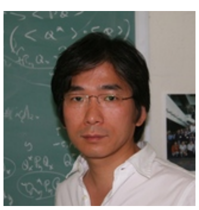
Prof. Kinney H. Kim
Professor, Department of Physics, North Carolina Central University

e-mail: khk@nccu.edu
Former President: AKPA (1985), KSEA (1986), AKUPA(1995)
Medal of Honor "Mokryun Jang" (Science & Technology) (1988)
KSEA Distinguished Service Medal (1987, 1991)



Prof. Hojung Paik
Research Professor and Professor Emeritus, Department of Physics, University of Maryland

email: hpaik@umd.edu
Research area: General Relativity
Former President: AKPA (2005)



Prof. Seunghun Lee
Professor, Department of Physics, University of Virginia

email: sl5eb@virginia.edu
Research Area: Experimental Condensed Matter Physics
The 29th AKPA Web Management Committee

Prof. Yongkyun Kim
Professor, Department of Nuclear Engineering, Hanyang University/IBS, Korea

email: ykkim4@hanyang.ac.kr
Research Area: Radiation Instruments & Accelerator Physics

Prof. Inkyu Park
Professor, Department of Physics, University of Seoul, Korea

e-mail: icpark@uos.ac.kr
Research Area: Experimental High Energy Physics
National PI of the Korea CMS Collaboration

I. AKPA values your contributed articles!!

AKPA solicits your articles in the area of your research for the publication as a featured article or your thoughts and opinions in upcoming Newsletters. If you want your article to be considered for publication in upcoming AKPA Newsletters, please send your title and abstract to pec@akpa.org anytime of the year. The next AKPA Newsletter is scheduled to be issued in December 2012

II. Submit news, events or information!

Submit news, events, or information to pec@akpa.org to be considered in the next AKPA. Newsletter. Email to akpa@akpa.org to subscribe AKPA Newsletters.

III. Submit your information on AKPA web!!

AKPA welcomes any information including conference, meeting, and job announcement to be posted on AKPA web site. Please send your information to akpa@akpa.org.
Visit http://www.akpa.org/ to see more about the AKPA including the archive of Newsletters.

IV. AKPA Membership registration and payment information!!

AKPA membership registration, update, and due payment have been made easy.
Please, visit https://akpa.org/membership/membership-registration.html for your membership!!
Your memberships are greatly appreciated.

V. Specify AKPA as your APS on the KSEA web site!

1. Go to the KSEA member site https://hq.ksea.org/login.aspx, and log-in.
2. Go to My profile (from the top menu bars).
3. Go to the bottom of "Personal information" (Most left table).
4. Click on "edit personal information".
5. At the bottom of the table, select "AKPA" from the "APS" drop down menu.

When you make a payment for the KSEA membership fee, choose “pay to my APS”.
Your first year membership fee will be refunded.

Postdoctoral Research Positions in the Astrophysics group of Sungkyunkwan University

The Astrophysics group of Sungkyunkwan University (SKKU), Seoul, Korea has three immediate openings for postdoctoral research associates in the following research areas: (1) Gamma Ray Burst experiment, (2) High Energy Cosmic Ray experiment, and (3) Semiconductor devices and its applications to various fields.

The postdoctoral position in the Gamma Ray Burst experiment involves the experimental study of Gamma Ray Bursts. This work includes the completion and data analysis of the Ultra Fast Flash Observatory (UFFO) Pathfinder which is being installed on the Russian satellite Lomonosov and will be launched in 2013. The first and foremost goal of the upcoming UFFO Pathfinder is to observe the early UV/optical photons from Gamma Ray Bursts first ever. This work also includes the development of the larger and heavier next generation UFFO series.

The post-doctoral position in the High Energy Cosmic experiment involves the construction of the silicon charge detector for the ISS-CREAM experiment which will be launched to the International Space Station in 2014. It also involves the experimental study of energetic cosmic rays using the existing Antarctica balloon-flight data of the CREAM experiment.

The last postdoctoral position involves the development of next generation silicon sensors for photon counting and particle detection in space applications as well as various interdisciplinary applications.

The successful candidate must have a Ph.D. degree or an equivalent degree in physics, astronomy, optical engineering, materials science, chemical engineering, electrical engineering, or a closely related field. Prior experience in the particular research areas is not required. However, we are looking for creative, self-motivated individuals who have the ability and the drive to pursue challenging, interdisciplinary projects in a fast-paced research environment.

The initial appointment is for 2 years, and can be extended to an additional years depending on mutual satisfaction. The starting date is flexible, but should not be later than December 2012. The salary will be commensurate with experience.

Any interested candidate should send the resume, a statement of research interest, and 2 letters of recommendation to Prof. Il Hung Park at ilpark@skku.edu and Prof. Jik Lee at jiklee999@gmail.com. Any inquires are welcome and should be addressed to the same email address.