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Editorial Board

ASSOCIATION OF KOREAN PHYSICISTS IN AMERICA

Newsletter

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Message from the 32nd President of AKPA

Dr. Young-Kee Kim

University of Chicago

Dear AKPA colleagues,

May 2018 be a healthy, fulfilling and joyful year for you.

The new year starts with great news of cooperation with the physics community in Korea, in particular, the Korean Physical Society (KPS) and Institute for Basic Science (IBS). In December 2017, I had a pleasure to visit three IBS centers: Center for Underground Physics at IBS Headquarter in Daejeon, Center for Soft and Living Matter at UNIST in Ulsan, and Center for Axion and Precision Physics Research at KAIST in Daejeon. Directors of these Centers (Yeongduk Kim, Steve Granick, and Yannis Semertzidis, respectively) are lifetime members of AKPA and they have been introducing research activities at their centers via their Newsletter articles and various workshops held in the U.S. I plan to visit a few other IBS centers Summer 2018 to further strengthen the connection.

On December 15, 2017, I went to the KPS Headquarter in Seoul and had a meeting with Jae Il Lee, President of KPS, and other KPS leaders. At this meeting, we agreed on the program of the 2018 Joint KPS-AKPA Symposium in LA on March 4, 2018, prior to the APS March Meeting. This Symposium is to support young ethnic Korean physicists in Korea and North America. It will provide an opportunity for postdocs and students who attend the APS March Meeting to present their work to the KPS-AKPA community and for the community to understand current concerns and needs of young scientists in this global and rapidly changing society. We will also have an opportunity to congratulate and celebrate the 50th anniversary of Journal of the KPS (JKPS). Detailed information can be found at https://indico.cern.ch/event/690003/ and I hope many of you will be able to participate in this Symposium. The AKPA organizers (the AKPA President-Elect Professor Kyungseon Joo from the University of Connecticut and I) welcome any comments and suggestions from you.

The Award Committee, chaired by Professor Jiwoong Park from the University of Chicago, is in the process of selecting recipients of the 2018 Outstanding Young Research Award (OYRA). These awards will be given at the APS March or April Meeting. Professor Chueng Ji from North Carolina State University once again leads the Program Committee for the National High School Physics Contest (NHSPC). This 6th contest will take place in April.

I would like to take this opportunity to thank you for your strong support in 2017, and I look forward to activities of AKPA in 2018 and your continued support.

Young-Kee Kim

The 32nd President of AKPA

Photo from IBS Center for Axion and Precision Physics Research
(Director, Dr. Yannis K. Semertzidis and AKPA President, Dr. Young-Kee Kim)

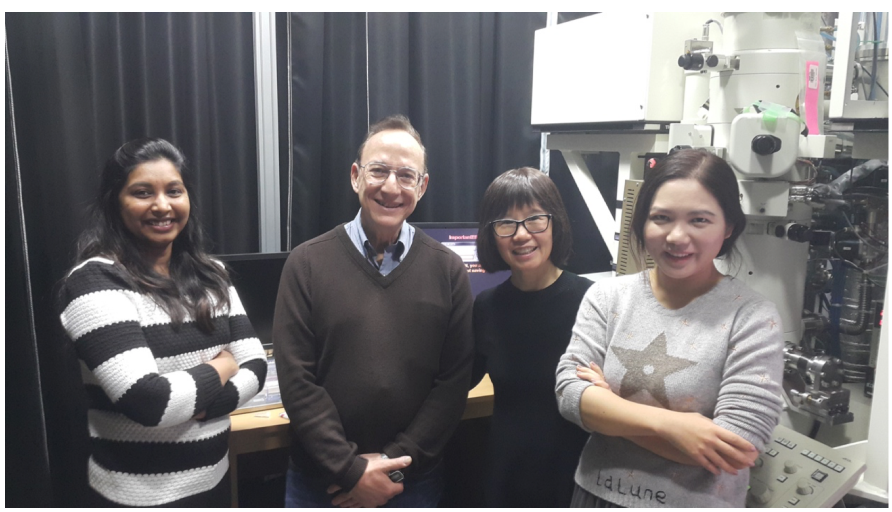

Photo from IBS Center for Soft and Living Matter
(Director, Dr. Steve Granick and AKPA President, Dr. Young-Kee Kim)

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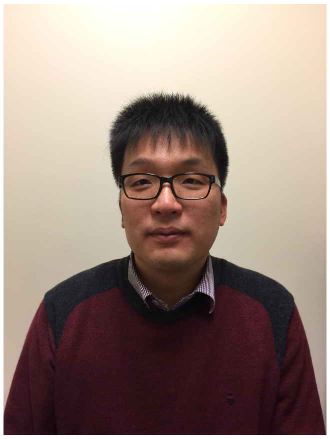
High (z>1) Redshift Galaxy Surveys and Galaxy Bias

by Donghui Jeong, Pennsylvania State University



Dr. Donghui Jeong

Pennsylvania State University

Past two decades have witnessed a rapid progress in observational cosmology led by precise measure- ment of the large-scale structure of the Universe. In particular, the temperature anisotropies and polar- izations of the Cosmic Microwave Background (CMB) radiation mapped by NASA's Wilkinson Microwave Anisotropy Probe (WMAP[1]) and ESA's Planck[2] satellites have revealed most of the cosmological pa- rameters to a percent accuracy. With that, we know that our Universe can be described remarkably well by Friedmann-Robertson-Walker (FRW) world model of the homogeneous and isotropic, expand- ing universe. The concordance cosmological model consistent with essentially all major cosmological observations is the flat ΛCDM world model with 70% of dark energy (if cosmological constant) and 30% of matter (25% of dark matter and 5% of ordinary matter that cosmologists call 'baryons').

Does the flat ΛCDM world model complete the cosmology of our generation? Of course, not! In fact, the name ΛCDM itself poses the puzzle that we do not know 95% of its constituents; thus, we gave them a dark name!

The situation becomes even more absurd with the majority (70%) of the energy budget: dark energy. Dark energy is responsible for the recent accelerated expansion of the Universe, but we have nothing like dark energy in the standard model of particle physics. It is because the accelerated expansion demands a negative equation of state (more specifically, $P < -\varrho/3$). One possible candidate identity of dark energy is energy associated with the vacuum of quantum fields because the vacuum energy satisfies the condition ($P = -\varrho$). For the vacuum energy, however, we don't have a clue of its amplitude from fundamental physics, as vacuum energy imprints almost no observational consequences (except for the Casimir effect, although its relation to the dark energy is still in debate). Also, dimensional argument shows that the amplitude of vacuum energy must be proportional to the quartic power of the UV-cutoff (or symmetry breaking) scale ($\varrho\Lambda \propto \Lambda4$), which is about 10120 (or 1060) times larger than the amount that is required to yield current accelerated expansion if Λ is set at Planck (TeV) scale. Although the vacuum energy contribution from bosonic fields cancels that of fermionic fields (because they have an opposite sign), adding many contributions of order 10120 (1060) to finally result order unity number requires massive fine-tuning.

We also do not know about the beginning of the Universe. The leading theory now is cosmic inflation that the Universe underwent an accelerated

[1] https://map.gsfc.nasa.gov

[2] http://www.esa.int/Our_Activities/Space_Science/Planck

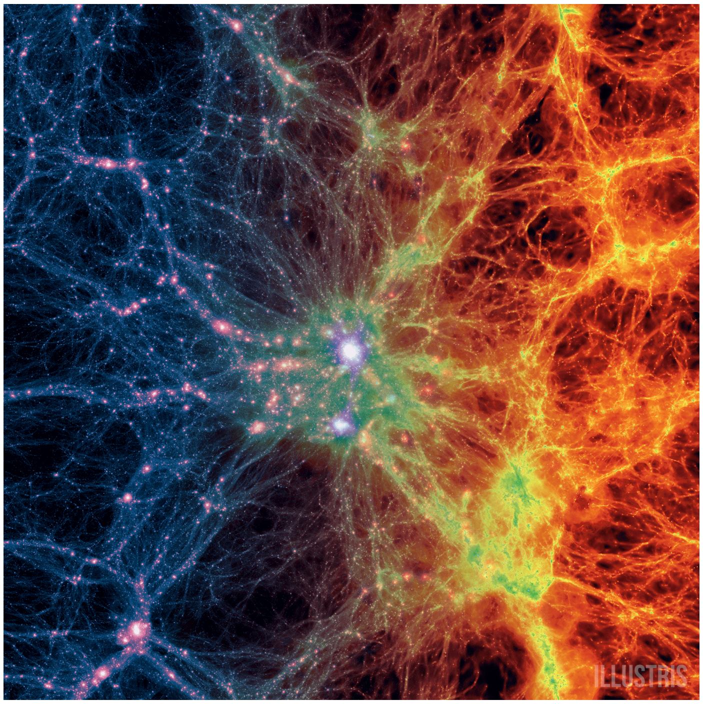


***Figure 1** Illustration of Large-scale structure from Illustris simulation (http://www.illustris-project.org). Large scale projection through the simulation volume at z=0, centered on the most massive cluster, 15 Mpc/h deep. Shows dark matter density (left) transitioning to baryonic gas density (right). Galaxies form where gas density is high.*

expansion phase at least by 60 e-folding at the beginning. Although the idea of inflation is compelling and seems almost inevitable to provide a natural initial condition for the FRW universe, the driving force of the inflation is still unknown. Again, it is because we need some unusual energy component in order to accelerate the expansion of the Universe. This early dark energy is called inflaton, but the fundamental explanation of this scalar field is lacking.

Therefore, to cosmologists, the ΛCDM world model is not the name of the solution, but a name of the problem. In order to address the problems, cosmologists keep increasing the volume and precision of measurement of the large-scale structure of the Universe.

For CMB, Planck satellite has already measured the primary temperature anisotropies and parity-even part (E-mode) polarizations to the cosmic-variance limit, and the next generation experiments are tar- getting to measure the large-scale parity-odd part (B-mode) polarization signatures as well as small-scale polarization signals due to the secondary (all anisotropy signal caused after the CMB photon left their last-scattering surface; due to inverse-Compton scattering of hot gas in cluster or free-electrons after reionization).

The new frontier in large-scale structure observation is high-redshift ($z > 1$) galaxy surveys. While the observations of Baryon Acoustic Oscillations (imprint of primordial coupling between photons and baryons in the galaxy power spectrum with characteristic length scale of 150 Mpc/h that we can use it as a standard ruler) from low-redshift galaxy surveys such as SDSS[3], 2dF[4], WiggleZ[5] greatly aided the geometrical measurement of dark energy, we have not yet exploited the distribution of galaxies as much as we have done for the CMB anisotropies.

The most important difference between the CMB analysis and the galaxy survey analysis is non-linearity. For CMB, the large-scale fluctuation level of the temperature anisotropy is of order $\delta T \sim 100\mu K$, which means that that density contrast is of order $\delta T/T \simeq 10{-}5$ (with mean CMB temperature of $T = 2.726$ K). Fundamentally, it is because the CMB anisotropies are fixed at redshift $z \sim 1100$, about 300,000 years after big bang. Such a small fluctuation can be well modeled by linear perturbation theory, which provides the foundation for the CMB analysis. On the other hand, galaxies are formed and evolved at later times where gravitational instability have amplitude the initially small density perturbation (of the same order of magnitude as the CMB temperature anisotropies) to a considerably large amplitude. For example, the matter density perturbation smoothed over 10 Mpc is already of order unity. As the amplitude of cosmic density field grew over time, the cosmic density field is more non-linear toward the later times. In fact, that is the primary reason why BAO is so popular analysis method for the low redshift galaxy surveys; the BAO scale is relatively immune to the non-linear evolution. Other than BAO, however, the strong nonlinearities prohibits more in-depth study of the large-scale

3 http://www.sdss.org

4 http://www.2dfgrs.net

5 http://wigglez.swin.edu.au/site/

structure from the low-redshift galaxy surveys.

Next generation galaxy surveys such as SDSS-IV[6], HETDEX[7], PFS[8], DESI[9], WFIRST[10], Euclid[11] are targeting galaxies at high ($z > 1$) redshifts. In these high redshift Universe, there are ample amount of quasi-linear regime where the nonlinearities in the matter density and velocity fields are well-modeled by non-linear perturbation theory (PT). For example, Jeong & Komatsu (2006)[12] have shown that at $z = 2$, the analytical calculation of PT can model the non-linearities in density field at Fourier wavenum- ber $k < 0.2$ [h/Mpc] and $k < 0.4$ [h/Mpc] at $z=3$. In addition to that, recent studies[13] provides fast calculation method of calculating the non-linear statistics of galaxy distribution, that will enable data analysis using PT for the high-z surveys.

In order to exploit the high-redshift galaxy surveys, we must also resolve one final issue called galaxy bias. The problem is following. The PT solutions of density and velocity field are for the total matter, not for the galaxies that we are observing in the galaxy survey. Moreover, observations have shown that galaxies are biased tracers of the large-scale distribution of total matter density; that is, the distribution of galaxies is not the same as underlying matter distribution whose statistics can be calculated by using PT. Therefore, in order to use the galaxy survey data as cosmological probe, one must model the distri- bution fo galaxies δg (x) as a function of distribution of matter density $\delta m(x)$: δg (x) = [$\delta m(x')$], this general functional relation is called galaxy bias.

Construct a model for galaxy bias from the first principle requires modeling of entire physical processes involving in the formation and evolution of galaxies. In hierarchical structure formation model, galaxies are formed inside dark matter halos. Therefore, first, we must model the formation and merger history of dark matter halos. Inside of dark matter halos, baryons can radiate photons and (because baryonic gas becomes cooler) sink toward the center of the gravitational potential of hosting halo. The baryons then fragment, generate many local over-density clouds which collapse to form stars and star clusters. Once stars form, old stars end their life quickly (because they are more luminous), then form compact stars such as black hole, neutron stars, and white dwarfs. Supernova explosion involved in the formation process of the compact object, as well as strong jet emitted from black holes and neutron stars, eject energy into the interstellar medium and hinder gravitational collapse and further formation of stars. We call this process ‘feedback’. Although the general procedure that we stated here sounds like a good story, each item in the aforementioned processes is a subject of active research in astronomy and astrophysics. That is, we are far from the complete picture of galaxy formation and evolution, and having the galaxy bias relation from the first principle is even further away.

Instead, cosmologists have been finding a robust perturbative bias expansion that correctly describes the relationship between the galaxy density and matter density on large-scales where analytical PT calculation models density and velocity fields. In such an expansion, complicated astrophysics of galaxy formation and evolution is encoded in the parameters of the expansion, called galaxy bias parameters. This ‘effective theory of galaxy bias’ reaches enough level of maturity so that my collaborators, Vincent Desjacques and Fabian Schmidt, and I have written up an invited review article to Physics Reports that is current in the process of publication. It is impossible to summarize this 258-page long article in a short paragraph, but the bottom line is that the perturbative bias expansion must include all local observables to the comoving observer living in the galaxy.

We have also show that using the Fisher information matrix analysis, even after marginalizing the nuisance bias parameters, we can access a rich set of cosmological information from the high-redshift galaxy surveys. The readers who want to know more about the large-scale galaxy bias expansion can access the final version of the review in arXiv (https://arxiv.org/abs/1611.09787).

6 http://www.sdss.org/surveys/eboss/

7 http://hetdex.org

8 http://pfs.ipmu.jp

9 http://desi.lbl.gov

10 http://wfirst.gsfc.nasa.gov

11 http://sci.esa.int/euclid

12 2006, ApJ 651, 619 [arXiv:astro-ph/0604075]

13 JCAP09(2016)015, PRD, 93, 103528 (2016)

Physics for the 22nd Century

by Steven Granick, IBS Center for Soft and Living Matter, UNIST, South Korea

Dr. Steve Granick

IBS Center for Soft and Living Matter, UNIST
Ulsan, South Korea

Where is it best to do science today? Those who read these words must have deep knowledge of Korea yet almost all of you have chosen to work in the U.S. for now. In spite of the fact that you have families and perhaps parents who live in Korea; in spite of language barriers, the reality being that almost no one who learned English as a second language uses the language with the ease of a native speaker; in spite of cultural differences which imply that one's children born in the U.S. surely adopt the mindset (good and bad) of their adopted land – the U.S. and Europe are the traditional magnets for scientists. It's likely that your parents expected you go study and work abroad. In their generation that was sound advice – but the world turns.

In fact, fundamental science is in a state of rapid advance in many Asian countries. In Korea I find one of the most dynamic and successful scientific environments there is. Peering ahead to the early 22nd century, it is interesting to speculate how much of what we do today will still be at the forefront of physics. The problems that thrill us today, they will mostly have been solved, if they were important, or dismissed as ephemeral, if they were not. It's the unknown problems, the problems we cannot even formulate yet, that will matter at that time. What is in our power to do as physicists today, that might help to influence physics of the 22nd century?

Wisely, the Korean government has decided to invest in its people. It created the impressively ambitious network of research institutes known as the Institute for Basic Science (IBS). Established to form hubs of international-level research working on forefront scientific problems, it interprets this mission not just to produce scientific papers but also young scientists. Those who are good enough to join an IBS Center are given scientific resources second to none at any other research institutes anywhere. By hard work and good luck, the most successful will later form independent labs of their own; they will foster, train, and nurture their own students; those students will have their students; and the IBS system will propagate. The academic genealogy of some of the best 22nd century physicists will be rooted in this visionary, long-term project.

Opportunities for young scientists: With a military service waiver to do research in this IBS Center, one postdoc working with me is Dr. Kisung Lee. Collaborating with Dr. Hyun-Sook Jang, who returned to Korea as a postdoc after receiving her Ph.D. in the U.S., he seeks to understand the statistical fluctuations of shape and contour of vesicles and other soft membranes. This old problem (regarding equilibrium) is new and exciting because in their hands it challenges basic questions of non-equilibrium physics. He speaks English throughout the day because the lab feels like a U.S. lab: two-thirds of this IBS Center is international, a mix of experimentalists and theorists.

My postdoc Ah-Young Jee also returned from the U.S. and this year discovered powerful new ideas that unite enzyme action with the field of "active matter." The conventional view is that enzyme kinetics is only a matter of catalyzing chemical reactions, yet there is mounting evidence that the enzyme catalysis enhances enzyme mobility. With simple and clever experiments, capitalizing on instrumentation freely available to her within the IBS network, Dr. Jee showed that enhanced diffusivity of enzymes is a "run-and-tumble" process analogous to that performed by swimming microorganisms, executed in this situation by molecules that lack the decision-making machinery of microorganisms. She is showing how physics can change accepted ideas in biology.

Intellectual challenges of "soft and living matter." The intellectual challenge is to understand honestly, from the standpoint of rigorous physics, everyday things, and to improve them. Soft matter is about the physics of daily life, about discovering the underlying simplicities in daily life, complex though it is. Not surprisingly, many similar questions arise from the standpoint of technology. The science-technology link often gives rise to new fundamental research questions and allows the field to provide service to society. To the extent that this field meets its goals, we will better understand how we are born, how we die, and how to improve our lives in between.

We believe it's false dichotomy to splinter condensed matter into islands, "hard" and "soft." As

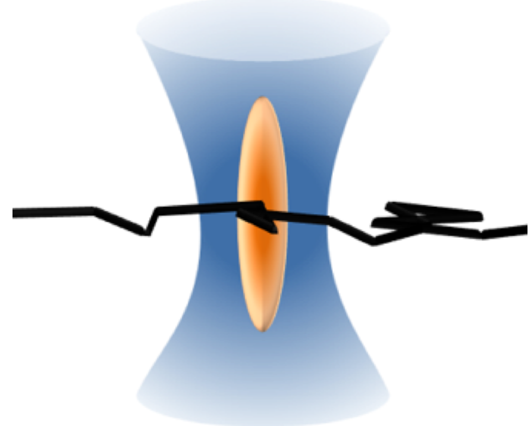


Figure 1. *Overcoming the diffraction-limited resolution of normal confocal microscopy using stimulated emission-depletion (STED), and combining this with fluorescence correlation spectroscopy (FCS), Dr. Ah-Young Jee evaluates enzyme mobility critically by varying the "beam waist", the diameter of the needle-shaped optical structure perpendicular to the focal plane sketched here schematically. This is the length scale of the problem as fluorescence fluctuations are dominated by passage through the beam waist, the shortest path through the optical structure. In her experiments it is as small as 50 nm.*

physicists, we share the goal of discovering the quantitative rules of scientific law and order; and we face common overarching challenges. For example, the problem of emergence and collective behavior – when many atoms/molecules come together, what fundamentally new properties emerge? For example, the problem of nonequilibrium – when matter is driven out of equilibrium, when energy is pumped into systems, how can we understand the emergent properties of systems whose mode of excitation is not thermal? What are the resulting global dynamics, in these systems that so commonly are crowded and collective in response? Regarding biomolecular science – when does quantum mechanics matter (or not), and how to generalize the answers beyond a zoological inventory of myriads of individual systems? How, recognizing that profound answers would have ramifications from technology to biology, does nature make such materials? These and related problems embrace some of the greatest scientific challenges of physics today. I do not believe the skeptics who might argue these problems are too difficult for physics. The riskiest path of all, would be to avoid risks.

A paradox is that progress in other countries is held back by various economic difficulties, yet scientific promise has never been more exciting. It is relevant that numerous industries revolve around applying these principles: among them, food and drugs, pollution control, synthetic polymers, membrane systems, protein assays, and bioengineering. Inadequate understanding of soft matter holds back progress in vital societal needs: health issues with ramifications from genetic development to nanomedicine, and environmental issues from climate change and water purity, to affordable energy. Long-term investment can have major impact whereas the secular trend elsewhere in the world is to focus on the short-term. Great intellectual problems require sustained funding for their solution, but research

Figure 2. *There is mounting interest in the emergence of collective mobility in systems of self-propelled objects that transduce energy into mechanical work to drive their motion, most commonly through fluids. Examples include motor proteins in biology, whose motion is driven by the consumption of ATP; synthetic particles including nanoparticles and colloids, whose motion is driven by chemical reactions at their interface; synthetic micro-robots whose rules of interaction with their neighbors are programmed; and collective structures in the living world of organisms, from the microscopic and macroscopic living world with examples from bacteria colonies to bird flocks and schools of fish, respectively.*

projects in the U.S. and Europe are tied to the 3-year lifecycle of grants, which confines them to being relatively uncreative and incapable of taking risks. Institutions elsewhere in the world are under economic stress, and increasingly under pressure to pursue short-term engineering of an applied nature. This is the Korean competitive advantage.

Machine Learning Quantum Emergence

by Eun-Ah Kim, Cornell University

Dr. Eun-Ah Kim

Cornell University

Across many disciplines, researchers are trying to revolutionize data-intensive scientific research by employing artificial intelligence, i.e., ANN[1]. A key motivation is that modern science has developed a vastly improved ability to collect data, but this torrent of data overwhelms human insight and analysis. In a very promising new approach to this challenge, a combination of human intelligence and ANN is steadily surpassing previous algorithms and manual approaches[2]. The field of quantum matter is no exception when it comes to appearance of vast data sets, for example in visualization of quantum electronic matter using spectroscopic imaging STM and in high data volume studies using modern X-ray and neutron-scattering facilities. These data are riddled with noise from heterogeneity of intrinsic and extrinsic origin as well as quantum fluctuations. There is a unique challenge in that quantum mechanical imaging of electronic behavior is probabilistic, and existing ANN-based-approaches developed for classical images cannot be simply adapted to extract organizing principles behind the emergence of collective behaviors.

The application of machine learning[3] to central questions in the theory of quantum matter is a rapidly developing field[4]. To harness the power of ANNs [5], efforts focus on representing many-body states compactly through ANN [6] and on identifying and classifying different phases of matter[7]. The driving insight here is that the problems of theoretical interests are essentially those of regression in which an exponentially large amount of data must be condensed into a more accessible or meaningful form, e.g. labeled with phases. ANNs are universal function approximators that facilitate nonlinear regression. Hence, ANN-based machine learning effectively distills relevant information from complex data taken as a whole, which is appealing for phases outside the traditional regression scheme where a local order parameter may not be readily available. Such phases include topological phases and out-of-equilibrium eigenstate phases.

My group entered the field from a unique perspective emphasizing human-ANN synergy, which was highlighted in a physics view point article featuring our paper. This perspective arose from our experience in examining large sets of numerical and experimental data, particularly those from scanning tunneling microscopy. Our experience empowered us to see how human-ANN synergy can yield new insights that are critically needed in the field. Building on this insight, Dr. Yi Zhang and I proposed a new strategy for such synergy, dubbed quantum loop topography. The effectiveness and the advantages of this strategy were demonstrated on models with known properties in the context of topological phases in our works[8,9].

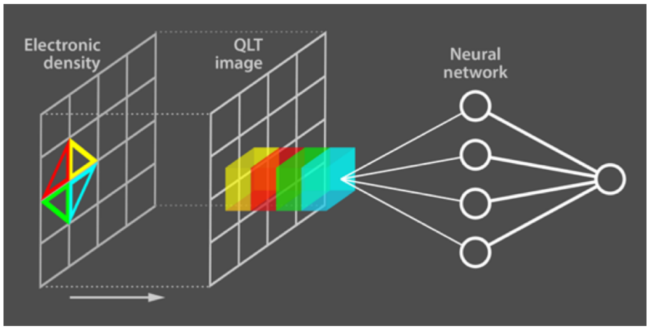


***Figure 1** Adapted from [8] by APS/Alan Stonebraker. Quantum loop topography (QLT) is a preprocessing layer that selects and organizes input guided by physical properties of the target phase, such as characteristic response.*

We have introduced the process that interfaces traditional theoretical understanding with a neural network, dubbed quantum loop topography[8,9], to the field of machine learning. Quantum loop topography is a procedure of constructing a multidimensional image from the quantum state of the system by evaluating two-point operators that form loops at independent Monte Carlo steps (see Fig. 1). The use of the quantum loop topography is critical for detecting phases without order parameters. When available, order parameters allow for classical descriptions of phases; order parameter configurations can be readily fed into ANNs with the usual image recognition abilities[7]. However, when the order parameter is absent or numerically inaccessible, detecting the relevant quantum phase had been challenging, even with state-of-the-art networks using TensorFlow[10]. With quantum loop topography, we were able to obtain quantum phase diagrams with a fractional Chern insulator[8] and Z2 quantum spin liquid using a simple, locally built ANN with a single hidden layer. We obtained quantum phase diagrams at orders of magnitude faster pace, benefitting from the ANNs recognition abilities and by-passing Monte Carlo updates, once quantum loop topography was fed into our ANNs. Quantum loop topography is a versatile strategy for designing and selecting input data guided by the key physical property of the target phase.

Moving forward, we will extend human-ANN synergy to unsolved problems, targeting new discoveries not only from computational but also experimental data.

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[10] M. Abadi et al., "TensorFlow: Large-Scale Machine Learning on Heterogeneous Systems", http://temsorflow.org/

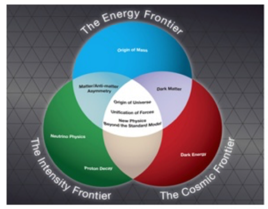
Is Orange County of California becoming the AKPA ex-Presidents' HQ?

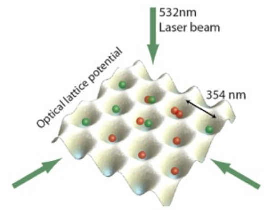
by William Chu, Lawrence Berkeley National Laboratory

When "used-to-be physicists" gather to socialize in Orange County, California, so many of the ex-Presidents of AKPA are present, they chuckle that they have a quorum to conduct an AKPA business meeting there. The photo shows one of the recent meetings, where seven ex-Presidents were present.

Standing, right to left: Tong-Nyong Lee [1st President, AKPA] directed construction of the Korea's first large scale accelerator, 2-GeV Synchrotron Radiation facility, and served Director of Pohang Light Source (1990–1996); Sungkwun Lyo [23rd] of Sandia National Labs (1977-2011), and Invited Foreign Professor at KAIST (2002-2005), developed quantum transport theories for quantum nano structures; Hyo-Gun Kim [14th], as President (1998-2002) of Gwangju Institute of Science and Technology, developed the newly founded institute into one of the premier research-oriented universities in Korea; and William Tongil Chu [8th] directed the multi-disciplinary research on use of accelerated heavy ion to treat human cancer (1979-2004) at EO Lawrence Berkeley National Laboratory (LBNL). Sitting r to l: Kongki Min [9th], Prof. Physics, Rensselaer Polytechnic Institute (1976-2000) carried out a research on electromagnetic interaction in nuclei; Yoon Soo Park [4th] served Program Director at the Office of Naval Research until his retirement after 40 years of service to the U.S Government; and sitting at the left end is Kwang-Je Kim [24th], of LBNL (1978-1998) and currently Professor of Physics, The University of Chicago and Enrico Fermi Institute, and Associate Director for Research, Advanced Photon Source at Argonne National Laboratory. This gathering was to welcome the recent visit by Prof. K-J Kim to California. Not shown is Nowhan Kwak [15th] of University of Kansas, who has moved to Orange County after this photo was taken. List of the former AKPA president can be found at http://akpa.org/2014-01-31-05-24-56/former-presidents

UKC 2017 Physics Symposium





About the SYMPOSIUM:

The Physics Symposium brought together world leading scientists and young researchers in various fields of Physics from across the U.S. and Korea. Fundamental, applied and emergent physics were organized and the link among these three paradigms was discussed. The progress of the Institute for Basic Science (IBS) and the associated Rare Isotope Science Project (RISP) in Korea is in close connection with Facilities in US. This meeting served as a timely event for the enrichment of research collaboration and networking between US and Korea. The Physics Symposium consisted of 3 invited sessions with 16 oral presentations. In the Poster Session, 10 physics posters were presented.

Chair	Co-Chair	Co-Chair
		
Chueng-Ryong Ji North Carolina State University ji@ncsu.edu	Bum-Hoon Lee Sogang University bhl@sogang@ac.kr	Kyungseon Joo University of Connecticut kjoo@phys.uconn.edu

KEY MESSAGES:

The Physics Symposium brought together world leading scientists and young researchers in various fields of Physics from across the U.S. and Korea. Fundamental physics, applied physics and emergent physics were presented and the link among the three paradigms was discussed. Topics included High-Energy Physics, Nuclear Physics, Cosmology, Astrophysics, Biophysics, Optics, Plasma Physics and Condensed Matter Physics. In particular, the technology development in the measurement of physical phenomena was remarkable. The fundamental understanding of the basic principles in physics has also progressed significantly on a par with the technology development. This meeting served as a timely networking event for the basic science topics centered by fundamental, applied and emergent physics.

CRITICAL CHALLENGES:

While the technical progress of instrumentation is critical in many branches of physics, focusing too much just on instrumentation could be double edged. One may easily forget the physics that was originally aimed at, when the researchers are indulged in the instrumentation itself too much. It is also necessary to understand clearly the similarity and the difference between the fundamental physics and the emergent physics

FUTURE DIRECTIONS:

More networking opportunities among the experts in the fundamental physics, the applied physics and the emergent physics will be desirable to enhance the more active discussion on solving the challenging questions addressed at the turn of the century. Interface between the theory and the experiment is particularly crucial for the physical understanding to answer the challenging science questions.

PROGRAM:

Fundamental Physics chaired by Sung-Won Lee, Texas Tech University
Thursday, August 10 at Potomac I

Time	Title and Speaker
08:00 – 08:30	Recent Results from CMS Experiment at LHC, Sung-Won Lee (Texas Tech University)
08:30 – 09:00	Exclusive Meson Photoproduction off Bound Nucleons, William J. Briscoe (The George Washington University)
09:00 – 09:30	Proton Puzzle, Chueng-Ryong Ji (North Carolina State University)
09:30 – 09:40	2 mins Speed Talks by Poster Presenters: Investigating anomalous ultrafast energy transfer between fluorescent proteins, Youngchan Kim (National Institutes of Health) Secondary Interstellar Helium and Oxygen Distribution at Earth's Orbit, Jeewoo Park (NASA Goddard Space Flight Center)

Applied Physics chaired by Ki-Yong Kim, University of Maryland
Friday, August 11 at Potomac I

Time	Title and Speaker
08:00 – 08:20	On the Collapse and Magnetization of Primordial Gas Clouds, Daegene Koh (Georgia Institute of Technology)
08:20 – 08:40	Photonic downconversion based on antenna-integrated phase modulator, Donghoon Park (Laboratory for Physical Sciences)
08:40 – 09:00	Enhanced third harmonic generation via a combination of plasma defocusing and fifth-order nonlinearity, Bonggu Shim (Binghamton University)
09:00 – 09:20	Micro/Nano-Structured On-Chip Photonics: All-Dielectric Metamaterials and Frequency Comb Generation, Sangsik Kim (National Institute of Standards and Technology)
09:20 – 09:40	In-Situ Coherent Raman Imaging of Polymers and Complex Materials, Young Jong Lee (National Institute of Standards and Technology)

Emergent Physics chaired by Harold Kim, Georgia Institute of Technology
Saturday, August 12 at Potomac I

Time	Title and Speaker
08:00 – 08:15	The physics of DNA strand displacement, Harold Kim (Georgia Institute of Technology)
08:15 – 08:30	Single molecule biophysical investigations on non-canonical DNA structures, Seok-Cheol Hong (Korea University)
08:30 – 08:45	Visualizing DNA compaction by SMC using single-molecule tools, Hyeongjun Kim (Harvard Medical School)
08:45 – 09:00	Coffee Stains: Physics and Beyond, Byung Mook Weon (Sungkyunkwan University)
09:00 – 09:15	2016 Physics Nobel Prize and Topological Insulator: Route toward resistance-free conductors, Seongshik Oh (Rutgers University)
09:15 – 09:30	Effect of sequence imperfection on base-triplet stepping in strand exchange by the Rad51/RecA family of recombinase, Ja Yil Lee (Ulsan National Institute of Science and Technology)

Poster Session chaired by Ki-Yong Kim and Sung-Won Lee
Friday, August 11, 15:40 – 17:40 at Independence

Poster ID	Title and Presenter
PHY-P01	The High-Energy Llano Estacado Detector (HELADO), Jay Park (Texas Tech University)
PHY-P02	Investigating anomalous ultrafast energy transfer between fluorescent proteins, Youngchan Kim (National Institutes of Health)
PHY-P03	Using GALPROP to Study H and He Flux Anomaly in Cosmic-Ray Data , Lucy Lu (University of Maryland)
PHY-P04	The BACCUS Instrument, R.P. Weinmann (University of Maryland)
PHY-P05	ISS-CREAM Housekeeping Data, A.M. Moiseeva (University of Maryland)
PHY-P06	Decoherence dynamics of divacancy quantum bits in SiC, H. Seo (University of Chicago)
PHY-P07	Secondary Interstellar Helium and Oxygen Distribution at Earth's Orbit, Jeewoo Park (NASA Goddard Space Flight Center)
PHY-P08	Automated Instrument Network for Coordinated Geospace Observations at Remote Antarctic Locations, Hyomin Kim (New Jersey Institute of Technology)
PHY-P09	Full-Wave Modeling of Ultra-low Frequency Magnetospheric Waves, Eun-Hwa Kim (Princeton University)
PHY-P10	Single-shot Capture of Ultrafast Laser-induced Plasma through Spatial Division, Sarang Yeola (University of Maryland)

Report on UKC 2017 Fundamental Physics Session

by Sung-won Lee, Texas Tech University

The Fundamental Physics session was held on August 10, Thursday, as part of the Physics Symposium during the UKC 2018. This session, chaired by Prof. Sung-Won Lee from Texas Tech University, covered broad areas in Physics including High Energy Physics, Nuclear Physics, and Astrophysics and there were four invited talks given as follows.

Prof. Sung-Won Lee from Texas Tech University discussed the recent experimental results from LHC (Large Hadron Collider) at CERN (European Organization for Nuclear Research, Switzerland) with emphasis on the updated measurements on the Higgs boson. He also presented the most recent CMS (Compact Muon Solenoid experiment and one of two large general-purpose particle physics detectors at LHC) results in the search for new particles that have surpassed previous energy frontier experiments, in breaking new ground looking for unseen particle phenomena.

Prof. William J Briscoe from the George Washington (GW) University gave an overview of the GW-based SAID group effort to analyze pion photoproduction on the neutron-target data. The disentangling of the isoscalar and isovector EM couplings of N* and Δ* resonances does require compatible data on both proton and neutron targets. The final-state interactions play a critical role in the state-of-the-art analysis in extraction of the n data from the deuteron target experiments. In this presentation, the resonance couplings determined by the SAID PWA technique are also

Group Photo from UKC 2017 Fundamental Physics Session

reported and compared to previous findings. The neutron program is an important component of the current Jefferson Lab, MAMI-C, SPring-8, ELSA, and ELPH studies.
Prof. Chueng-Ryong Ji from North Carolina State University gave an overview talk on the proton puzzle. The proton is a fundamental constituent of the atomic nucleus. However, many features of the proton, even its fundamental entities such as its mass, charge radius and spin are not yet well understood. In this presentation, Prof. Ji discussed another piece of the proton puzzle, "isospin asymmetry of the proton sea", that may offer some insights to unravel the proton mysteries. The isospin asymmetry, or more broadly known as the flavor asymmetry, of the proton sea has been observed in worldwide experimental facilities, typically at CERN, Fermilab, and DESY. He briefly reviewed why it is puzzling, how it may offer more in-depth theoretical understanding and what experiment is forthcoming at Jefferson Lab to reveal the internal structure of the proton.
Dr. Daegene Koh from Georgia Institute of Technology (now at Stanford University) gave a presentation on "On the Collapse and Magnetization of Primordial Gas Clouds". Magnetic fields are speculated to influence the IMF, which may be imprinted in the local metal-poor population. Dr. Koh presented his recent study on the amplification of magnetic fields using MHD simulations with a uniform seed field from cosmological initial conditions to the formation and supernova of a Pop III star. He found that a weak seed field can be amplified to μG at the density peak and by a factor of 100 around the shell of the supernova. He also explored the dynamics of metal-poor mini-halos in varying metallicities and Lyman-Werner flux to measure the minimum collapse mass. These results are essential to building a full MHD simulation of the first galaxies.
At the end of the session, 2-min speed talks were given by two poster presenters:

- Investigating anomalous ultrafast energy transfer between fluorescent proteins, Dr. Youngchan Kim (National Institutes of Health)
- Secondary interstellar Helium and Oxygen distribution at Earth's orbit, Dr. Jeewoo Park (NASA Goddard Space Flight Center)

Report on UKC 2017 Applied Physics Session

by Ki-Yong Kim, University of Maryland, College Park

The Applied Physics session was held on August 11, Friday, at 8-9:40 am. The session mainly focuses on nonlinear/ ultrafast optics, Raman spectroscopy, RF photonics, and on-chip photonics. This session was chaired by Ki-Yong from University of Maryland, College Park, and there were four invited talks given as follows.
Donghoon Park from Laboratory for Physical Sciences gave a talk entitled "RF photonic downconversion of a QPSK signal with a millimeter-wave coupled polymer phase modulator." Dr. Park gave an overview of radio frequency (RF) photonic technologies with unique applications in wide bandwidth microwave and millimeter-wave (mmWave) distribution, frequency conversion, detection, and more. He also reported his recent work on RF photonic downconversion of a quadrature phase-shift keyed (QPSK) signal using a mmWave coupled phase modulator based on SEO125 nonlinear polymer. He emphasized that nonlinear polymers can provide high modulation bandwidth at RF carrier frequencies higher than 100 GHz without significant performance degradation, which is critical in telecommunications.
Bonggu Shim from Binghamton University presented "Time-resolved third harmonic enhancement via plasma defocusing and fifth-order nonlinearity." Harmonic

Group Photo from UKC 2017 Applied Physics Session

generation (HG) is an intriguing phenomenon involving nonlinear wave-mixing and phase matching between fundamental and harmonic beams. A great effort has been made to enhance HG, particularly third-harmonic generation (THG). In his talk, Dr. Shim introduced a novel method of enhancing THG in air by up to two orders of magnitude. This involves two-color, time-resolved methods utilizing both plasma-defocusing and fifth-order nonlinearity. He discussed his experimental results along with numerical calculations using the sophisticated carrier-resolved unidirectional pulse propagation equations (UPPE). Sangsik Kim from Texas Tech Univerisity gave a presentation on "Micro/nano-structured on-chip photonics: all-dielectric metamaterials and frequency comb generation." Dr. Kim presented his two recent research projects: 1) frequency comb generation with dispersion-engineered concentric resonators and 2) photonic skin-depth engineering with all-dielectric metamaterials. First, he presented a concentric resonator that can engineer and significantly modify the dispersion so that it can generate coherent frequency combs and soliton pulses. Then he presented a method to engineer the skin-depth of photonic waveguides using all-dielectric metamaterials. He introduced a new class of waveguide scheme, i.e., extreme skin-depth (e-skid) waveguide. He also talked about his experimental demonstration of e-skid waveguides that reduce the waveguide cross-talks and bending losses significantly, thus enabling dense integration of optical waveguides on a chip.

Young Jong Lee from National Institute of Standards and Technology (NIST) presented a talk on "Hyper-structural imaging: 3D molecular orientation on a hyper-spectral Raman image." Dr. Lee presented a new optical imaging method as a measurement tool which can determine 3D molecular orientation at each image pixel in a 3D hyperspectral Raman image. He explained that conventional approaches based on single Raman mode analysis can determine only the projected angle of the single mode. He emphasized that his new method can analyze multiple Raman modes to determine all three Euler angles of molecular orientation. He also presented a theoretical description and data analysis results of polarization-controlled broadband CARS image from semicrystalline polyethylene.

Report on UKC 2017 Emergent Physics Session

by Harold Kim, Georgia Institute of Technology

At UKC 2018, Prof. Harold Kim from Georgia Tech organized a new session entitled Emergent Physics session as part of the physics symposium. This session consolidated condensed matter physics and biological physics sessions which had been organized separately until last year. As the title of the session indicates, the session was intended to place a special focus on emergent phenomena where collective properties emerge at the system level from microscopic interactions. Despite being scheduled in the early morning on the last day of the conference, the session was well attended and fostered lively discussion between talks among the attendees.

Prof. Harold Kim kicked off the session with a talk on DNA strand displacement. In this thermally driven reaction, a single stranded DNA invades a double-stranded DNA and can eventually replace one of the strands. In simplest terms, this process can be modeled as a one dimensional random walk. Prof. Kim described an experimental scheme to measure the first passage times of this process and showed that strand displacement time depends on DNA sequence, but in a way that cannot be understood based on local base pairing interactions only.

Prof. Seok Cheol Hong from Korea University presented a study about structural transitions of DNA from B- to

Group Photo from UKC 2017 Emergent Physics Session

Z-form. Although B-DNA is the canonical right-handed double helix, other non B-DNA conformations do occur inside the cell, implicating an unknown biological significance. Prof. Hong explained how one can measure the energetics and dynamics of B-Z transitions in various conditions using a combination of magnetic tweezers and single-molecule fluorescence.

Dr. Hyeongjun Kim from Harvard Medical School presented his recent discovery of a new role of a DNA binding protein called SMC. Using a combination of flow-induced stretching and fluorescence microscopy, Dr. Park was able to observe that SMC proteins can shorten DNA even in the absence of chemical energy. He also found that SMCs shorten DNA in a pattern similar to other proteins that can bend or bridge DNA, suggesting that SMCs can employ both wrapping and bridging mechanisms to compact DNA.

Prof. Byung Mook Weon from Sungkyunkwan University presented recent progress in our understanding of the coffee ring effect which refers to the ring-like pattern of stain left behind by an evaporating colloidal suspension. Prof. Weon explained the importance of this phenomenon in relation to developing a crack-free film deposition technique for inkjet printing. He showed that the coffee ring effect can be controlled or even reversed by varying the size of the colloidal particle and the concentration of medium viscosity.

Prof. Seongshik Oh from Rutgers University treated us to a general introduction to topological insulators. Topological insulators are a special type of insulators that are insulating in the bulk, but conducting on the surface. The conducting state on the surface is related to the quantum hall effect which we now understand to arise from the momentum space topology of a two dimensional electron gas under an external magnetic field. This realization of the effect of topology on the state of matter led to the 2016 Nobel Prize in Physics. Prof. Oh explained his research effort to create resistance-free conductors using these ideas.

Prof. Jayil Lee from UNIST presented a comparative experimental study on a family of proteins that catalyze pairing of homologous DNA strand. Using a DNA curtain assay that stretches many DNA molecules in parallel, Prof. Lee was able to show that all these proteins enable DNA strand invasion in three base steps. However, he showed that this universal base triplet stepping mechanism of different proteins was differentially perturbed in the presence of DNA sequence mismatches.

Group Photo at the Physics Networking Dinner

UKC 2017
RISP Particle Accelerator Forum

Young-Kee Kim
University of Chicago

Kang Seog Lee
Chonnam National University

About the SYMPOSIUM:

World-renowned accelerators are the discovery and innovation engines of scientific enterprise and are where the Korean particle accelerator communities are steadily forwarded for. It is imperative that the critical value-added role of particle accelerator facility in the areas of fundamental science and application to be sustained. In Korea, Pohang Accelerator Laboratory (PAL) and Korea Multi-purpose Accelerator Complex (KOMAC) are successfully operating and a rare isotope accelerator facility, RAON, to be commissioned on 2021, will provide the considerable values to the particle accelerator community. This forum brought the researchers from Korea and U.S. to discuss the status and future of the particle accelerators and related fields of science and technology.

KEY MESSAGES:

Accelerators are "engines of discovery," essential scientific instruments for advancing science and technology of the 21st century. International collaboration is the norm of the accelerator projects. If successfully managed, the collaboration can lead to substantial savings in cost and time, to the mutual benefits of the collaborating laboratories. The forum reviewed three accelerator projects in Korea, the PLS-II and PAL-XFEL at PAL (Pohang Accelerator laboratory), ROAN accelerator system for RISP (Rare Isotope Science Project) at IBS, and the KOMAC (Korea Multipurpose Accelerator Complex). The first two are of B$ class and the third a few hundreds M$. These projects have all benefitted from various forms of collaborations with laboratories in US and other countries. Eric Colby gave a presentation on the management by DOE of accelerator laboratories in US.

CRITICAL CHALLENGES:

International collaboration can sometimes be hampered by government regulations and competitive tendency. The issue would be more pronounced when the technical abilities are lopsided between two partners. Such was the case a few decade ago in Korea when accelerator science and technology in Korea was practically non-existing. The trend is changing recently and we see cases of successful equal-partner collaborative arrangements. However, it is piecemeal and case-by-case basis, lacking a coherent overall plan integrated to the project. In addition, there are several cases where the response of the US laboratories to the MOU inquiries are unacceptably slow. Currently, there is no organization in Korea equivalent to the DOE-BES providing oversight of all major accelerator projects. Such an office is essential for coordinating the accelerator projects. It should also help to pursue international collaboration by establishing an overarching MOU with US DOE. We are happy to hear that Korea is in fact moving in that direction—the IBS will take up the oversight role in two to three years.

FUTURE DIRECTIONS:

An excellent example of successful international collaboration in accelerator projects is the SLAC-KEK collaboration on B-factory construction. It was technically a very challenging project with the performance goals beyond the conventional wisdom. However, the project succeeded spectacularly both as the PEP-II at SLAC and B-factory at KEK because accelerator scientists at both laboratories collaborated and competed at the same time. The characters of accelerator physicists in both laboratories were different —more experienced senior staff at SLAC versus competent and younger staff at KEK. On the balance, however, their accelerator physics capabilities were of similar level and that is why the collaboration became so successful. Such is the direction the accelerator science community in Korea should strive for in order for Korea to become a strong international center for advanced accelerator—the engines of discovery.

PROGRAM:

15:40 – 17:40, Thursday, August 10, Lincoln Room

Time	Title and Speaker
15:40 – 16:00	Status of Pohang Accelerator Laboratory: PLS-II and PAL-XFEL Ki Bong Lee, Director of Pohang Accelerator Laboratory
16:00 – 16:20	The KOMAC, its Status and Plan Ky Kim, Director of KOMAC
16:20 – 16:40	Status of RAON Accelerator Facility Taeksu Shin, Rare Isotope Science Project (RISP), IB
16:40 – 17:05	Accelerator Facilities, Technologies and Research in U.S. Eric Colby, U.S. Department of Energy
17:05 – 17:40	Panel Discussion: International Collaborations on Accelerator R&D Facilitator: Kwang-Je Kim, Argonne National Lab. and University of Chicago Panel members: Ki Bong Lee, PAL Ky Kim, KOMAC Taeksu Shin, RISP, IBS Eric Colby, U.S. Department of Energy

Group Photo from UKC 2017 Particle Accelerator Forum

Exploring Hadrons with Electromagnetic Probes: Structure, Excitations, Interactions

by Kyungseon Joo, University of Connecticut

The 2-day workshop co-chaired by Professor Cheung-Rong Ji (North Carolina State U.) and Professor Kyungseon Joo (U. of Connecticut), took place at Jefferson Lab in Newport News, VA, from November 2 through November 3, 2017. One of the main objectives of the workshop was to foster a new potential international collaboration with South Korean physicists in exploring the short-range structure of hadrons, the excitation spectrum, and hadron interactions with the nuclear medium, and developing a framework of the phenomenology for the unified description of electroproduction processes in the resonance and hard process regions. An emphasis was placed on identifying connections between the different areas at the conceptual and methodological level, and discussing the experimental opportunities with the JLab 12 GeV Upgrade and a future Electron Ion Collider (EIC).

The workshop consisted of 27 talks and 4 discussion sessions. 44 participants from 8 countries attended the workshop. It was remarkable that 8 physicists participated all the way from South Korea to promote the international collaborations on the topics discussed in this workshop. A detailed list of the talks and participants can be found on the workshop web page (https://www.jlab.org/conferences/electroproduction2017/). The workshop began on Monday morning, and finished on Wednesday afternoon. The workshop was designed to have an agenda to allow ample discussions after each of the presentations. We also had a session in Wednesday afternoon, which was dedicated to discussions of the path forward to facilitate bringing the communities of theorists, phenomenologists, and experimentalists together to ensure the greatest physics outcomes. The workshop brought together experts in perturbative QCD, phenomenology of electromagnetic processes, and dynamical models of hadron structure, to discuss the impact of present and future experiments (particularly with the JLab 12 GeV upgrade), assess the reach of present theoretical methods, identify directions for further development, and enable joint approaches to the study of GPDs and N* physics. Topics included:

- Status and perspectives of GPD analysis
- Chiral-even GPDs and DVCS
- Chiral-odd GPDs and pseudoscalar mesons
- Gluon GPDs and vector mesons
- Reaction models for N* production
- QCD-based approaches to N* transition form factors
- Transverse densities of baryon resonances
- Dispersion relations for exclusive processes
- Joint simulation tools for GPDs and N* physics

The outcome of the workshop will be the establishment of international collaborative effort aimed at tackling various challenges discussed during the workshop, and ensuring that the resultant framework can be applied across the emerging nuclear experimental and theoretical programs, including at a future EIC.

Joint KPS-AKPA Symposium on New Frontiers in Physics

When: March 4, 2018
Where: Los Angeles Convention Center, Los Angeles, California
Organizers: Jae Il Lee (President of KPS) and Young-Kee Kim (President of AKPA)

We are pleased to inform you that KPS (Korean Physical Society) and AKPA (Association of Korean Physicists in America) will host a Joint Symposium on New Frontiers in Physics from 1:00 pm to 8:00 pm on Sunday, March 4, 2018, in Los Angeles, California, prior to the APS March Meeting (https://www.aps.org/meetings/march/about.cfm). This is to support young ethnic Korean physicists in Korea and North America. It will provide an opportunity for postdocs and students who will attend the APS March Meeting to present their work to the KPS-AKPA community and for the community to understand current concerns and needs of young Korean scientists in this global and rapidly changing society. We will also have an opportunity to congratulate and celebrate the 50th anniversary of Journal of the KPS (JKPS).

If you plan to attend this Symposium, please register at https://indico.cern.ch/event/690003/ . There is no fee for registration. Symposium dinner will be provided.

If you would like to give a talk (this could be the talk that you will be giving at the APS March Meeting), please send one of the organizing committee members via e-mail.

The organizing committee consists of
- Takhee Lee, Seoul National University [tlee@snu.ac.kr]
- SangMin Lee, Seoul National University [sangmin@snu.ac.kr]
- Young-Kee Kim, the University of Chicago [ykkim@hep.uchicago.edu]
- Kyungseon Joo, the University of Connecticut [kyungseon.joo@uconn.edu]

The Symposium is sponsored and supported by Springer (the publisher of JKPS), APS, KPS, and AKPA.

List of the 32nd AKPA Officers and Committee

President
Prof. Young-Kee Kim, ykkim@hep.uchicago.edu (773) 702-7006
Department of Physics, University of Chicago, IL 60637

President Elect and Vice President
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Department of Physics, University of Connecticut, Storrs, CT 06269

Auditor
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Fermi National Accelerator Laboratory, Batavia, IL 60510

Publication Secretary
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Prof. Kwang-Je Kim (Argonne National Lab and U.Chicago), kwangje@anl.gov (630)252-4647
Prof. Harold Kim (Georgia Tech), harold.kim@physics.gatech.edu (404) 894-0080

E-Link Committee
Dr. Jooseop Lee (Cornell University), jl3536@cornell.edu (865) 387-0980

Newsletter Editorial Board
Prof. Sung-Won Lee (Texas Tech U.), Editor-in-chief, sungwon.lee@ttu.edu (808) 742-3730
Dr. Daegene Koh (Stanford University/SLAC), Editor, kdaegen@stanford.edu

Election Committee
Prof. Kyungseon Joo (UConn), Chair, kjoo@phys.uconn.edu

Nomination Committee
Prof. Chueng-Ryong Ji (NC State), Chair, ji@ncsu.edu
Prof. Ki-Hyon Kim (NC Central), khk@nccu.edu
Prof. Eun-Suk Seo (U. of Maryland), seo@umd.edu

Fund Raising Committee
Prof. Jaehoon Yu (UT Arlington), Chair, jaehoonyu@uta.edu

National High School Physics Competition
Prof. Chueng-Ryong Ji (NC State), crji@ncsu.edu

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