Association of Korean Physicists in America

AKPA Newsletter

재미 한인 물리학자 협회

Volume 28, Number 3, June 2010

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AKPA Newsletter is edited and published by the 28th AKPA administration (president: Prof. Ji) and AKPA Publicity and Editorial Committee.

KPS, together with AKPA

YoungPak Lee (Hanyang University, President of the KPS)

First of all, greetings to the prestigious members of Association of Korean Physicists in America (AKPA) from the 23rd President of Korean Physical Society (KPS).

As everybody might know, the Korean Physical Society (KPS) was established in 1952 and with 12,378 members as of December 2010, 11 Divisions, 7 Regional Chapters and 17 Committees it is grown to be one of the largest and most influential academic Societies in Korea. The KPS holds many conferences each year with the largest ones being the biannual meetings in April and October, where more than 1000 papers are presented at each meeting. The Society has four main publications: Physics and High Technology, a news magazine for non-specialists, and New Physics, a research journal, are published monthly in Korean; the monthly Journal of the Korean Physical Society (JKPS) and bimonthly Current Applied Physics (CAP) are English-language publications registered with the Science Citation Index.

I have a clear vision for the KPS : One of my main goals during my tenure is to improve the global visibility of the KPS, and I really want the readership of our journals to be truly international. Nurturing future physicists is another major role of the KPS. The Society has been putting considerable effort into reforming physics education at senior high schools in Korea. In addition, we do our utmost to participate in science-related activities in Korea, including the planning of a new science city.

We have also been working with a major television broadcasting company to produce special programs about physics for the general public. April is indicated to be a Month for Science. This was thought to be very good time to broadcast this kind of program. A two-part (1 hour each) Special Project, named “Ben Lee’s Truth,” had been produced for about 1.5 years together with the Korean Broadcasting System (KBS), and was finally revealed on April 30 and May 1, 2010. This might be the biggest physics-related program ever, released by major television broadcasting companies in Korea. Dr. Ben Lee should be a representative member of AKPA in the history. This production reflects strong mutual influence between KPS and AKPA, and tells us simply how greatly the KPS considers the AKPA.

The KPS had the Spring Annual Meeting in Daejeon from 21 to 23 April, 2010. During the Meeting, I was so happy and impressed because of another great AKPA member, Prof. Y. K. Kim at University of Chicago. She came to me suddenly and spontaneously, and intended to donate a big money to the KPS for a new award in the field of experimental high-energy physics. At this moment, strangely I came to remember that the KPS donated a small amount of money (but, the first formal support by the KPS in the history, to my knowledge) for the Annual Meeting of AKPA in March 2010. The AKPA pays back with a much bigger amount nearly immediately, in other words, the AKPA also cares specially about the KPS. I think that such mutual respect and concern is the basis for cooperation. In this view point, the present cooperation between two organizations is considered to be excellent. Nevertheless, there is always a room for further improvement.

Firstly, it should be avoided any fluctuation in the degree of cooperation according to the changes in the leadership of both sides. Instead, the cooperation keeps being deepened and developed.

In a short term, we meet again at the Joint KPS-AKPA Session in US-Korea Conference 2010 coming August in Seattle as in last year, which is organized together to introduce the progresses on each side and to deepen the cooperation. We have to co-organize more and better academic programs in either Korea (for example, at the Annual Meetings of KPS) or U. S. At the Spring Annual Meeting of KPS, the KPS co-organize 4 International Sessions : 1 with the Chinese Physical Society, 2 with Japan Society of Applied Physics, and 1 with the Physical Society located in Taipei. Programs together with Korean physicists in foreign countries, such as the AKPA, can be arranged, in addition.

The KPS should help the AKPA more in both physical and human respects so that the AKPA vitalizes further the various activities. On the other hand, it is suggested that the members of AKPA show more interests in the English academic journals (JKPS and CAP) of KPS, and submit more excellent papers to them for our journals to be truly international sooner or later.

What about trends in the Asia Pacific physics community beyond the matters between the KPS and the AKPA, where both belong to ? I envisage much stronger collaboration between the major physical societies in Asia-Pacific in the next few years. Furthermore, the interaction with smaller physical societies will also increase reflecting advances in physics in those countries.

I see a greater international presence for physical societies based in Asia-Pacific. Physicists in this part of the world, including the members of AKPA, are playing an ever-increasing role in the development of physics on a global scale. The Association of Asia Pacific Physical Societies (AAPPS) or a similar organization will be important to promote the activities of physicists in Asia-Pacific internationally.

Dirty Superfluid

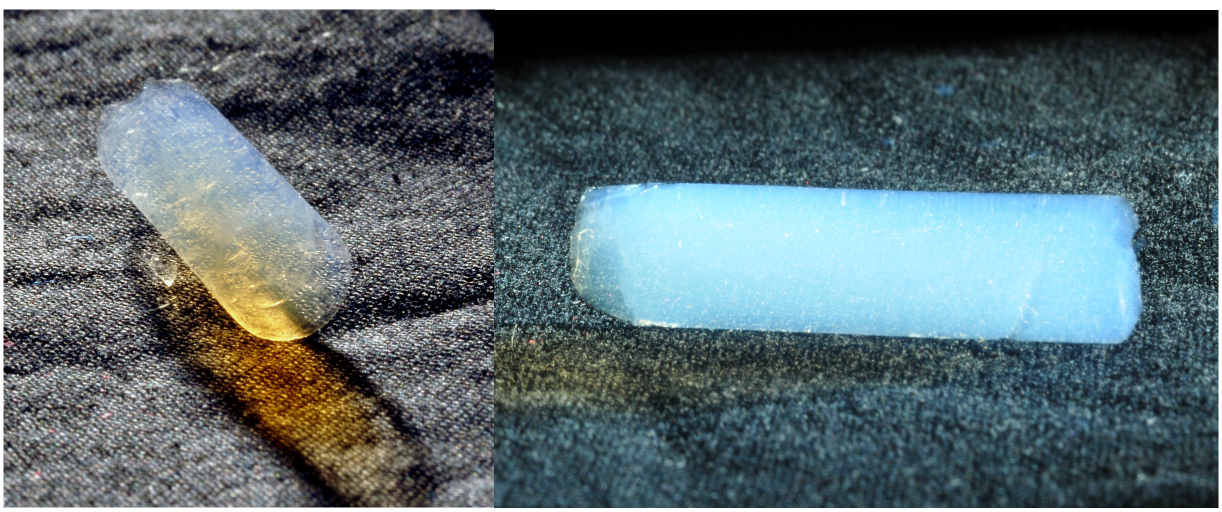
Yoonseok Lee (University of Florida)

Disorder is ubiquitous. In naturally occurring systems, ranging from sedimentary rocks with various types of porous geometry to biological systems such as bones and neural networks, it is essential to understand the role of disorder at least at the classical level. In man-made materials, which largely compose the subjects of modern condensed matter physics and for which we have the ability to tune to a certain degree, disorder poses layers of challenges, especially when the understanding of a system at the quantum mechanical level is required. Physics of disorder is integrated in an extremely large area of science as a common thread, and the impact of research on this subject permeates from the highly practical as in oil extraction and superconducting wires to the purely academic as in zero temperature quantum phase transitions. In condensed matter physics, the metal-insulator transition and the Kondo effect are a few examples of phenomena in which disorder, in the form of various types of impurities, plays a fundamental role and has attracted sustained interest. The influence of disorder on ordered states, such as the magnetic or superconducting phases has also been the subject of intense research for several decades, displaying diverse and dramatic phenomena associated with quantum phase transitions (phase transitions driven by quantum fluctuations rather than thermal fluctuation) and emergence of novel states of matter.

Liquid 3He is an unexpected material that can offer a unique opportunity for a systematic investigation on this subject. In the first half of the last century, successful liquefaction of two helium isotopes (3He and 4He) has provided physicists with arguably the most fascinating liquids in nature. These two isotopes share many unique features such as a low boiling point (3 – 4 K) and lack of both a triple point and a solid phase down to absolute zero below the melting pressure (approximately 2.5 MPa for 4He and 3.4 MPa for 3He). As we lower the temperature, the distinct quantum nature of these isotopes is unveiled, originating from the fact that the two isotopes obey different quantum statistics, and they are rightfully called quantum fluids.

Electrons in metals and the core of neutron stars also belong to the class of quantum fluids. One common feature of these systems is the existence of symmetry breaking phase transition to a quantum condensate, superfluid state, at low temperatures - here, one should understand that the word “low” is used in a relative sense. The superfluid phases of 3He appear below ≈ 2 mK as a consequence of unconventional (p-wave spin triplet) BCS (Bardeen-Schrieffer-Cooper) pairing, and one of the peculiar properties is in its extreme sensitivity to disorder. However, at this low temperature, the system remains extremely clean because all other impurities would freeze or be preferentially adsorbed on the container wall. The system also cleanses out the only soluble element, 4He through phase separation – 3He-4He are the only isotopes which spontaneously phase segregate. A calculation indicates that only one 4He atom can be dissolved in 1055 liters of liquid 3He at 2 mK. Because of this extreme intrinsic purity and homogeneity, liquid 3He has been a testing ground for numerous theoretical ideas and we do have quantitative understanding of this system. However, the same virtue hampered the effort for many years in pursuing answers to an overarching question: How does a quantum condensate (p-wave spin-triplet superfluid in this case) respond to an increasing amount of disorder or impurity?

Observation of superfluid transitions in liquid 3He impregnated in high porosity silica aerogel has opened a way to introducing static disorder/impurities in this system and triggered immediate theoretical and experimental activities. Highly porous and transparent silica aerogels were first synthesized in 1931 by Kisler but their practical applications in diverse fields are being explored and realized only in recent years. Silica aerogels are composed of a tenuous network of SiO2 strands and can be synthesized in a wide range of porosities, especially in the high porosity limit up to 99.9%. They are in fact, the lightest solid materials with the lowest refractive index ever manufactured. The structure of aerogel is formed by cluster-cluster aggregation of 3 – 5 nm silica beads. This process results in a fractal geometry in the length scale ranging from 5 to 100 nm. Therefore, aerogel provides randomly distributed almost point-like scattering centers (or quenched disorder) to superfluid 3He whose characteristic size (coherence length) is in the range of 20 – 80 nm.



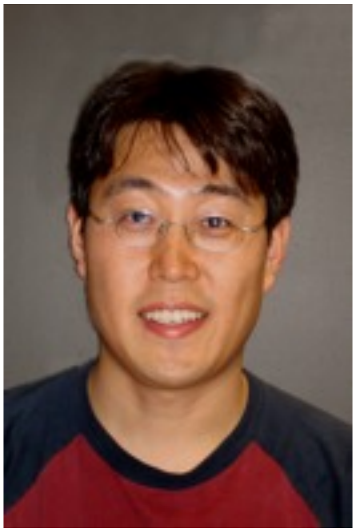
A cylindrical sample of 98% porosity aerogel used in our experiment. Two pictures show the same sample under different lighting. It shows the effect of Rayleigh scattering reminiscent of blue sky and red sunset. More pictures of aerogels can be found at http://eetd.lbl.gov/ecs/aerogels/sa-photos.html.

Fifteen years of investigation has revealed many interesting features. The low temperature phase diagram of this dirty superfluid is significantly different from that of pure liquid. In 95% aerogel, no superfluid phases were observed down to the lowest temperature reached (≈ 0.1 mK). In 98% aerogel, which is studied most extensively, the superfluid transition is substantially depressed to lower temperature leading to a quantum phase transition point where the superfluid transition temperature approaches absolute zero near 0.7 MPa of sample pressure. At low pressures but above 0.7 MPa, the dirty superfluid exhibits gapless superfluidity – superfluid without a characteristic excitation spectrum, superfluid gap. In recent years, researchers started to look at more subtle effects of aerogel. The correlated strand-like structure inevitably introduces local random anisotropy and this anisotropic disorder intricately interacts with anisotropic superfluid 3He with p-wave pairing. Theoretical considerations suggest a possibility of novel quantum phases induced by disorder.

Unlike other condensed matter systems, we understand the ground state (vacuum) of the intrinsic pure liquid 3He with high confidence. Now, being able to introduce disorder or impurity in a controlled way in liquid 3He, we are given a special opportunity to systematically investigate the role of disorder in this system and to answer the question posed earlier, How does a quantum condensate (p-wave spin-triplet superfluid in this case) respond to an increasing amount of disorder or impurity?

Ultrafast Terahertz Radiation Generation

Ki-Yong Kim (University of Maryland at College Park)



Sandwiched between the optical and microwave regimes, far infrared or terahertz (THz) frequency (1 THz = 1012 Hz) has recently drawn special attention due to its ubiquitous nature. If looking around yourself, you will find small air molecules such as nitrogen and oxygen molecules rotate at THz frequencies; biomolecules and proteins in your body vibrate at THz frequencies; semiconductors in your computer resonate at THz frequencies. Your body can also emit electromagnetic waves oscillating at THz frequencies (THz radiation) thru black body radiation where the maximum radiation is peaked at ~30 THz (9.5 microns), which lies in mid-infrared, and the radiation tail extends to low THz frequencies. Such THz radiation can easily pass through non-polar materials such as clothing, paper, plastic, wood and ceramics but it can not penetrate metals. These properties allow many potential THz applications in molecular sensing, biomedical imaging and spectroscopy, security scanners, and plasma diagnostics.

In particular, THz spectroscopy holds great promise for molecular sensing. Upon irradiation of light at optical frequencies, molecules can scatter the incident photons non-elastically with a frequency shift determined by their electronic, vibrational, and rotational states. This non-elastic scattering can provide a wealth of information on the molecular energy states, but unfortunately, such phenomenon occurs extremely rarely, typically 1 out of 10 million events. In contrast, the molecular rotational and vibrational states can be directly probed at THz frequencies.

The applications mentioned above provide strong motivation to advance the state of the art in THz source development. In particular, high-energy THz generation is vital for applications in nonlinear THz optics and spectroscopy. Currently, intense THz radiation exceeding tens of micro-Joules can be obtained from large accelerator facilities such as linear accelerators, synchrotrons, and free electron lasers. However, due to large cost to build those facilities and thereby limited access, there is a present and growing demand for high-energy, compact THz sources at a tabletop-scale. One potential approach is using a tabletop ultrafast laser to produce coherent light ranging from X-rays to THz via novel frequency up/down conversion techniques.

It is noteworthy that there are many tabletop methods of generating broadband THz radiation in solids, but THz generation in solids is fundamentally limited by material damage, which is a main obstacle for effective THz energy scaling. For example, to avoid THz saturation and material damage, extremely large (tens of centimeters to meters) samples of THz materials are needed to take full advantage of modern tabletop lasers capable of providing multi-terawatt (1 TW = 1012 W) and even petawatt (1 PW = 1015 W) power. Because of this, plasma is an ideal choice for scalable THz generation because it is already broken down and there is no concern about material damage.

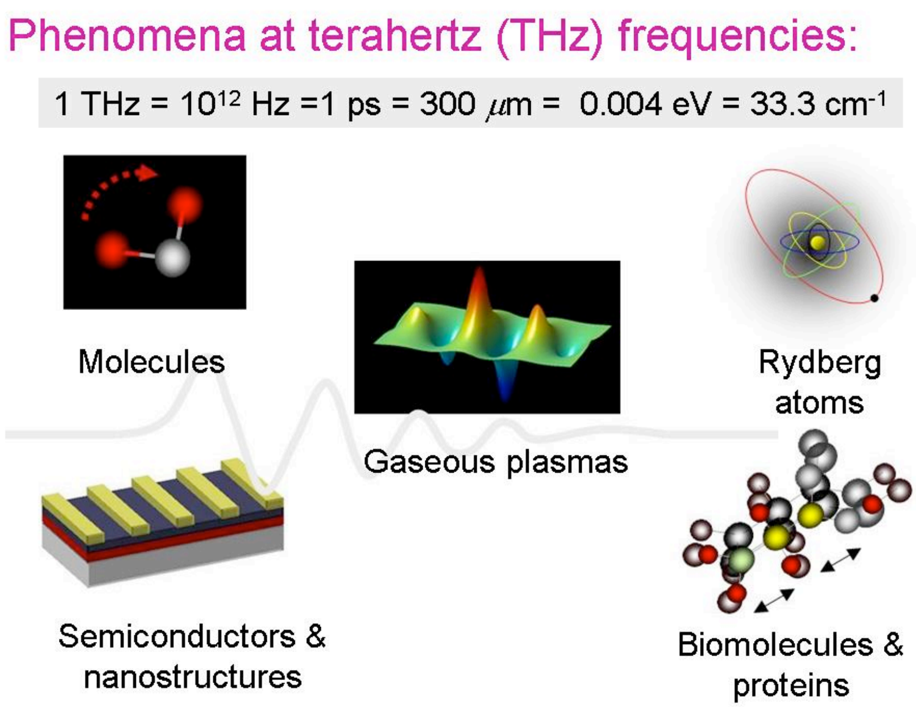


Figure 1. THz phenomena occurring in natural and man-made things—small molecules rotate at THz frequencies; gaseous plasmas oscillate at THz frequencies; highly-excited electrons in Rydberg atoms orbit at THz frequencies; electrons in semiconductors and their nanostructures resonate at THz frequencies; biomolecules such as DNA and proteins vibrate at THz frequencies.

In this effort, we have recently demonstrated a high-energy (>5 microjoule), super-broadband (0.1~75 THz), tabletop THz source via ultrafast photoionization in gases. In this scheme, an ultrafast pulsed laser's fundamental and second harmonic fields are mixed in a gas of atoms or molecules, causing them to ionize (see Fig. 2).

Microscopically, the laser fields act to suppress the atom's or molecule's Coulomb potential barrier, and via rapid tunneling ionization, bound electrons are freed. The electrons, once liberated, oscillate at the laser frequencies, and also drift away from their parent ions at velocities determined by the laser field amplitudes and the relative phase between the two laser fields [see Fig. 2(a)]. Depending on the relative phase, symmetry can be broken to produce a net directional electron current. As this current surge occurs on the timescale of photoionization, for sub-picosecond lasers, it can generate electromagnetic radiation at THz frequencies. In a nutshell, we can generate and control an ultrafast electric current (direction and amplitude) in a plasma system and this can generate coherent THz radiation.

This THz generation mechanism turns out to be closely related to the mechanism used to explain high harmonic generation (HHG) in gases, as both processes originate from a common source, that is, a nonlinear electron current. The electrons re-colliding with the parent ions are responsible for HHG, whereas the electrons drifting away from the ions without experiencing re-scattering ions account for THz generation. As demonstrated experimentally, the generated THz and third-harmonic are strongly correlated in such a way that changing the relative phase can effectively switch the emission between THz and harmonics. This provides the basis to coherently control electromagnetic radiation in a broad spectral range, from THz to extreme ultraviolet.

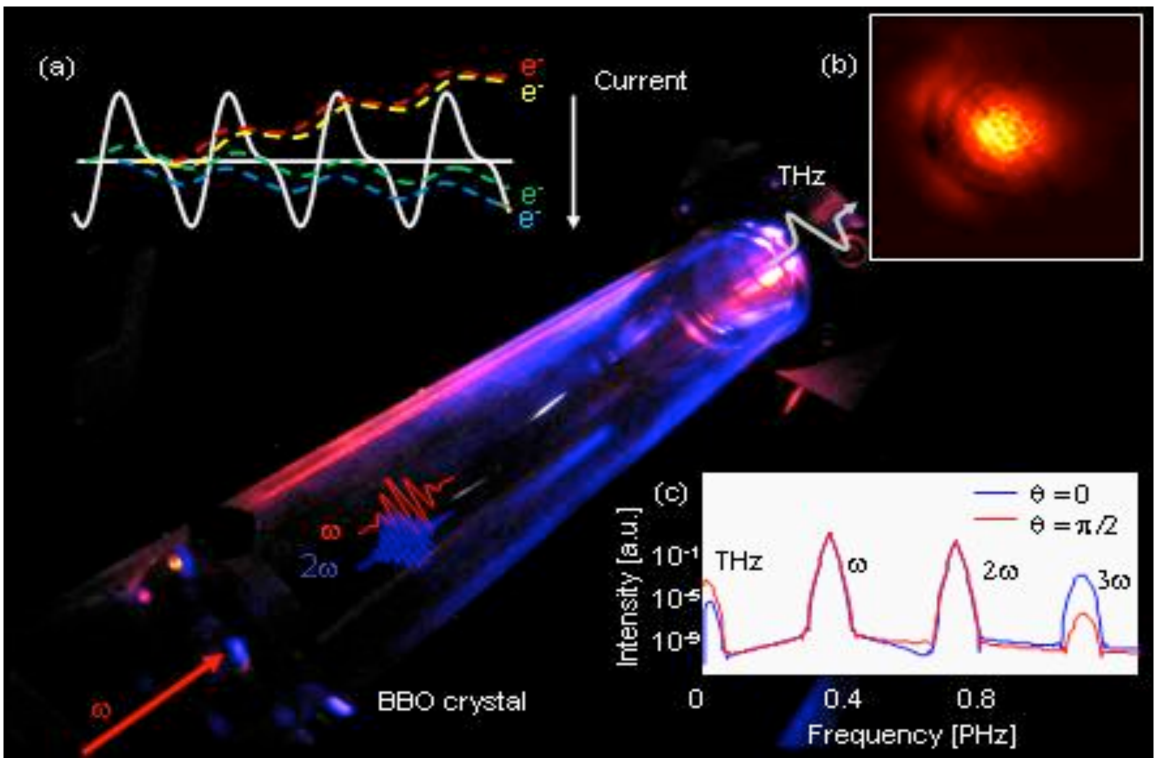


Figure 2. THz generation via two-color photoionization in a gas by mixing the fundamental and second harmonic of ultrafast laser pulses. (a) Combined two-color laser field (solid line) and the trajectories of electrons (dotted lines) liberated at four different phases. (b) THz beam profile imaged by a two-dimensional electro-optic technique. (c) Computed radiation spectra of anti-correlated THz and third harmonic with two different relative phases.

The next plan is to scale up the laser power to produce even more powerful THz radiation. Using a 30 terawatt (TW) laser at the University of Maryland, we anticipate producing an unprecedented millijoule level of THz radiation. Such radiation may allow us to observe extreme nonlinear THz phenomena in a university laboratory. In addition, the THz generation model described above is now widely accepted by the community, but there is still an important piece of the physics that needs to be verified—the direct detection of the asymmetric photocurrent and its correlation with THz radiation. This will conclusively determine the THz generation process, necessary for understanding and enhancing the THz energy even further.

The First 7 TeV Proton-Proton Collisions at LHC

Sung-Won Lee (Texas Tech University) and Jaehoon Yu (Univ of Texas at Arlington)

A few months ago the Large Hadron Collider (LHC) circulated its first beams, and the first collisions at 900 GeV were recorded on 23 November 2009. Soon after that the record-breaking 2.36 TeV collisions took place, leading to publications of the first experimental results using the real LHC data.

At 12:58pm on the 30 March 2010, the LHC has, for the first time, collided two stable beams protons at the energy of 3.5 TeV each – the highest energy human has ever accomplished. All LHC experiments immediately detected these collisions successfully, signifying the beginning of the "First Physics" at the LHC in a brand new kinematic regime. A few seconds later the enormous computing power of each LHC detector had analyzed the first 7 TeV collision data and produced fully reconstructed first images of particles created in 7 TeV collisions. Two general-purpose experiments, ATLAS and CMS, were fully operational and observed around 200,000 collisions in the first hour. The data were quickly stored and processed by a huge farm of computers at CERN before transported to collaborating particle physicists all over the world for further analysis.

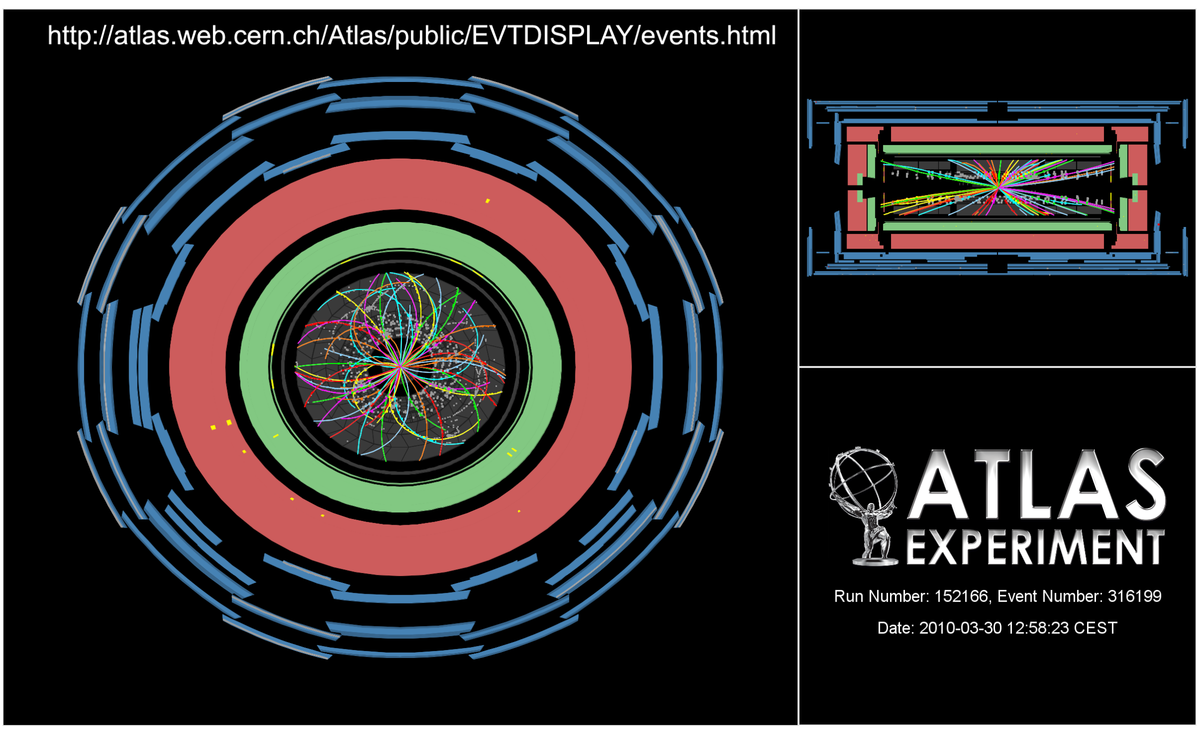


Figure 1. A display of the first 7 TeV collision event in the ATLAS detector.

Both ATLAS and CMS were built to search for new physics. They were designed to detect a wide range of particles and phenomena produced in the LHC's high-energy proton-proton collisions, and will help answering some of the most profound questions in our current understanding of the structure of matter and the evolution of the early universe.

The current run of the LHC at 7TeV is expected to last 18 to 24 months. This should enable the LHC experiments to accumulate enough data to make significant advances across a wide range of physics channels and to explore a new territory in all areas where new physics can be expected. The LHC experiments will "re-discover" the Standard Model particles, a necessary precursor to looking for new physics, and start systematic searches for the Higgs boson, the illusive particle responsible for particle mass. With the amount of data expected, combined analyses of ATLAS and CMS will explore a wide mass range, and possibly discover it if the Higgs has a mass near 160 GeV/c^2.

For supersymmetry, ATLAS and CMS will each have enough data to double today's sensitivity to certain new discoveries. The existing experiments are sensitive to some supersymmetric particles with masses up to 400 GeV/c^2. The expected amount of data at the LHC in the next two years will expand the search range up to 800 GeV/c^2.

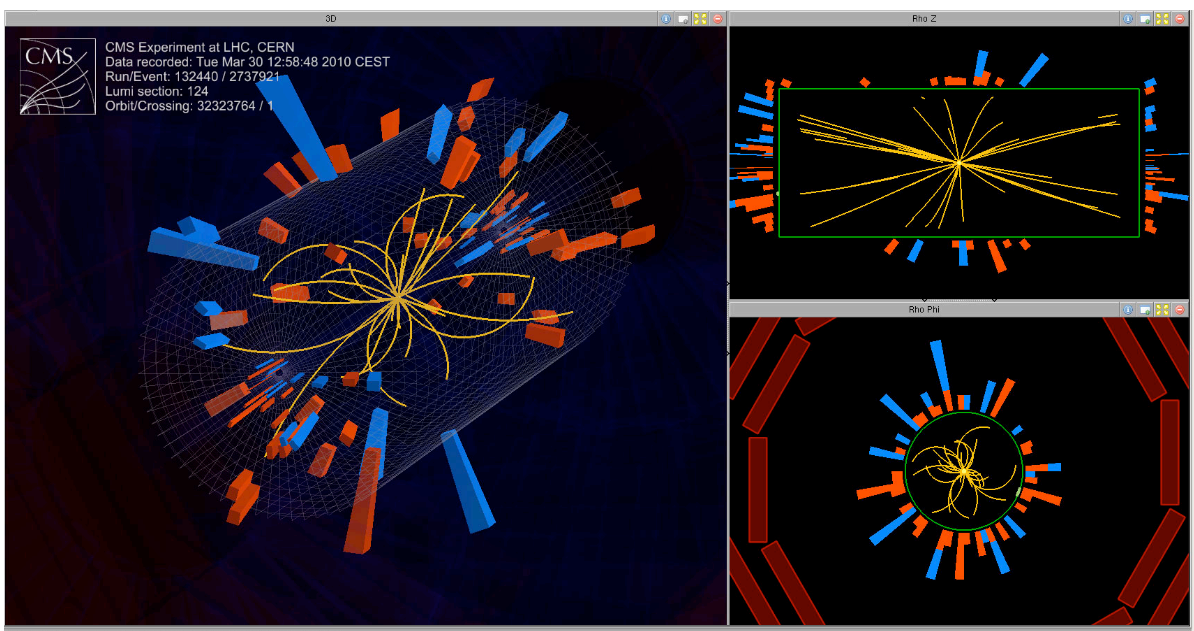


Figure 2. A display of the first 7 TeV collision event in the CMS detector

Following this run at 7TeV, the LHC will shut down for about 18 months for routine maintenance and the completion the repairs and consolidation work needed for its superconducting magnets to reach the LHC's design energy of 14 TeV.

With the excitement of the 30th of March over, the LHC experiments are now settling down into routine operation of the detector and amassing 7 TeV collision data. In the coming weeks and months the Standard Model will be "re-discovered", enhancing our understanding of the nature and the intricacies of the LHC and the detectors. And perhaps, in not so distant future, hints of the Higgs particle and/or that of new physics will appear. We are confident that the LHC experiments are ready to uncover what nature has in her store for us. The LHC era has truly begun.

Report on annual AKPA meeting

Myungkee Sung ? (Lousiana State University)

Upcoming events and meetings

1. UKC 2010

Taek Soo Hahm (Princeton Plasma Physics Lab)

The US-Korea Conference (UKC) 2010 on Science, Technology, and Entrepreneurship will be held on Aug 12-15, 2010 at the Hyatt Regency Bellevue, Bellevue (near Seattle), Washington. A symposium on Pure and Applied Science (PAS) as a part of UKC 2010, covers pure and applied sciences including physics, chemistry, mathematics, and statistics. By broadening the fields covered by this symposium, we would like to facilitate participants to learn the status of other related fields. Invited speakers include: Choong Seok Chang (NYU, KAIST), Sung Won Lee (Texas Tech), S.Y. Jeong (Pusan National Univ), W. Jo (Ewha Womans Univ.), and H.G. Park (KIAS) in physics, Hyung J. Kim (Carnegie Melon) and Chul Hee Kang (Washington State Univ.) in chemistry, and Bong Dai Choi (Korea Univ.) in Mathematics. In addition, there will be contributed presentations selected from thirty five submitted abstracts. The PAS symposium is tentatively scheduled to occur on Aug 13-14 (Friday and Saturday). A preliminary schedule will be available shortly. You can find more about UKC 2010 from the following web site.
http://ukc.ksea.org/ukc2010/cfp.asp

AKPA membership registration information