The Department of Physics at Chonbuk National University

HEESUK RHO
DEPARTMENT OF PHYSICS, CHONBUK NATIONAL UNIVERSITY

UNIVERSITY

Since its founding in 1947, Chonbuk National University (CBNU) has become one of the best national universities in South Korea and has offered students excellence in education and research. With more than 1,000 faculty members, CBNU strives for excellence in teaching and research, and keeps growing in its academic reputation. CBNU was ranked second in national universities and 15th in all universities in South Korea, according to the QS World University Rankings 2018. The university consists of seven campuses, including a main campus in Jeonju, a famous city known for traditional architecture and arts in Korea. CBNU offers more than 100 undergraduate and 140 graduate and professional programs in 15 colleges with an enrollment of more than 18,000 undergraduate and 4,000 graduate students. CBNU offers international admission to both undergraduate and graduate programs. Currently, approximately 1,000 foreign students are enrolled at the university.

Fig. 1: Overview of the CBNU campus in Jeonju.

DEPARTMENT OF PHYSICS

The Department of Physics, founded in 1952, offers various undergraduate and graduate curricula and strives for excellence in training experts not only in fundamental and applied physics research areas but also in areas relevant to modern technology societies. Our department offers BS, MS, PhD, and MS/PhD combined degrees in undergraduate and graduate programs. Currently, there are approximately 120 undergraduate students and 30 graduate students enrolled in the department. The physics program is ranked 14th in South Korea, according to the QS World University Rankings by Subject 2018.

We provide fully-developed and creative learning environments and research opportunities for undergraduate students and, particularly, for graduate students. Many undergraduate students are supported by scholarships through various funding programs. All of the graduate students are fully supported by teaching and research assistantships.

Faculty members in the department, consisting of 16 professors, are involved in both experimental and theoretical studies covering most of the central topics of modern physics. At present, we are running two research centers: the Institute of Photonics and Information Technology, and the Research Institute of Physics and Chemistry.

RESEARCH AREAS

Condensed Matter Physics Group

There are 11 faculty members in the condensed matter physics group. Individual research interests are the following.

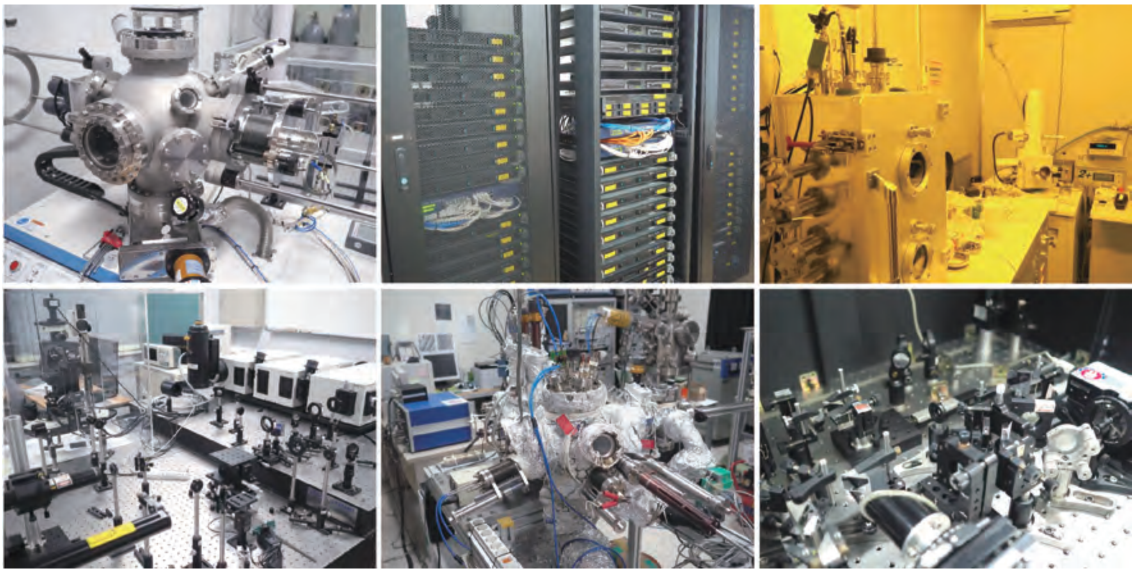

Fig. 2: Clockwise from top left: a pulsed laser deposition system, computer clusters, cleanroom facilities, an ultrashort laser pulse pump-probe system, a scanning tunneling microscope, and a tip-enhanced Raman scattering system with a triple-stage spectrometer.

Sang Don Bu's research has spanned areas of epitaxy of complex oxides and nanostructure fabrication, from thin film synthesis to characterization and device application of various novel materials. Complex oxide materials possess an enormous range of electrical, optical, and magnetic properties. Dielectrics, ferroelectrics, piezoelectrics, ferromagnetics, and superconductors have all been produced using oxide materials. A major challenge is to prepare these materials with a thin film form and to integrate them so that these properties can be fully utilized in electronic devices.

Materials for Synchrotron Experiment Laboratory, led by Deok-Yong Cho, aims to explore local structures and electronic structures in various functional materials using synchrotron X-rays in synchrotron radiation facilities including the Pohang Light Source. Using soft/hard X-ray absorption spectroscopy and photoemission spectroscopy along with their theoretical simulations, various phenomena in functional systems have been explored, including the nanodiffusions in active interfaces of resistive switching materials or generalized metal-nonmetal contacts, the structural evolutions in amorphous oxide thin films, and the strong electron correlation effects in transition metal oxides.

Hyungkook Choi's research group is working toward a better understanding of mesoscopic electronic systems, where coherent behavior of electrons plays an important role, using low temperature transport measurements. By utilizing general mesoscopic devices, like quantum point contacts, quantum dots, and an electronic interferometer, the group aims to study fundamental quantum physics issues, such as decoherence and entanglement, and to observe a new type of quasiparticle due to the interactive nature of electrons. Starting from a conventional two-dimensional electron system, this research area has now been extended to other low-dimensional systems as well.

Sukmin Jeong leads a computational electronic structure group that includes two PhD students. He mainly concentrates on first-principles calculations of nanostructures, their electronic structures, and dynamics. His research topics include the computational tuning of the electronic structures of materials, the growth of two-dimensional materials on metal surfaces, the formation of organic functional groups on semiconductor surfaces, and atomic or molecular behaviors on solid surfaces.

Ju-Jin Kim's laboratory focuses on quantum transports in low-dimensional nanostructures and electrical properties of nanomaterials. In recent years, Kim's group has investigated electrical property control by work function engineering and tunneling spectroscopy in the contact between nanosized metals and nanostructures such as carbon nanotubes, nanowires, and two-dimensional layered materials with well-defined nano-fabrication facilities. His group is developing novel nanodevices based on these materials, such as high mobility transistors, high sensitivity sensors, and quantum nanodevices.

Hong Seok Lee leads the Compound Semiconductor Laboratory. The group studies fabrications and characterizations of epitaxial semiconductor nanostructures (quantum dots, quantum wells, and quantum wires) and colloidal nanostructures (nanoparticles, core-shells, and tetrapods). In particular, the group focuses on tuning structural and optical properties of nanostructures, on understanding the carrier dynamics of nanostructures, and on applications in optoelectronic devices.

In Jae Lee's research pursues the fundamental understanding of growth dynamics and interfaces on polymer films, and electronic and optical structures of molecular organic semiconductors. Research interests include dynamic scaling applications on morphological characteristics of polymer films produced under a far-from equilibrium condition such as molecular beam epitaxy, chemical vapor deposition, and plasma/ion-beam etching. The charge transports/optical properties of organic molecular single crystal semiconductors known to limit the performance of the electron/optoelectronic devices have been one of the active research areas in the lab. Some of the experimental techniques involved in his studies are atomic force microscopy, x-ray diffraction, x-ray photoelectron spectroscopy, photoluminescence spectroscopy, photolithography for fabrication of electronic devices, and the growth/synthesis of organic films and single crystals.

Jung-Keun Lee's research is focused on finding and understanding optical and spintronic properties in hybrid perovskite systems. In particular, the group studies electron spin resonance, transient photocurrent, and spin control systems. This work is also directly connected to perovskite solar cells, quantum information storage, and quantum computing applications.

The research efforts of Heesuk Rho's Nano Optics Laboratory are mainly focused on understanding optical and electronic properties of two-dimensional layered materials such as graphene and transition metal dichalcogenides. Particularly, he is interested in the in situ optoelectronic studies of nanoscale devices. The experimental facilities that are equipped in his laboratory include a triple-stage spectrometer system integrated with an optical microscope, a low-temperature cryostat operating in the range of 4-500 K, and a tip-enhanced Raman scattering (TERS) setup.

Jae Myung Seo's research group has studied structural and electronic properties of semiconductor interfaces since 1991. Two main research topics are (i) atomic structures of self-assembled nanowires on high-Miller-index or vicinal Si surfaces and (ii) intercalation studies for modulating electrical properties of quasi-free standing monolayer graphene formed on a SiC substrate. Major experimental tools are surface science techniques, including scanning tunneling microscopy and synchrotron photoemission under an ultra-high vacuum.

Laser Optics Group

Jin Seung Kim and Myung-Whun Kim work together in the Laser Optics Group. This group is conducting research to enhance the performance of lasers and to utilize lasers as a tool to measure the optical properties of materials. Members of the group fabricated a Ti-Sapphire pulsed laser system of sub-10 femtosecond pulse duration and 140 MHz repetition rate. The team also developed the software as well as the hardware for FROG (frequency resolved optical gating) and SPIDER (spectral interferometry for the direct electric field reconstruction) systems to measure the amplitude and phase characteristics of ultra-short laser pulses. Members of the group also developed a pump-probe system using ultra-short laser pulses and are studying ultra-fast spectroscopic characteristics of solid samples such as stimulated Raman scattering signals in metal-oxides. Members of this group have been developing a system of a quantum-entangled photon source by harnessing a nonlinear optical effect. They are measuring the characteristics of entangled photon-pairs using an interferometer, and they are trying to fabricate a microscope and a spectrometer using the photon source.

Particle Physics Group

Seong Youl Choi, together with two PhD students, is working on particle physics phenomenology, forming a bridge between various models of theoretical physics and the experimental results from high-energy particle colliders such as the Large Hadron Collider (LHC) and International Linear Collider (ILC). The main research topics are precision studies of Higgs particle properties, model-independent search methods of new particles and interactions beyond the Standard Model, and efficient characterizations of various supersymmetric models. One of our key research achievements is to have developed a general theoretical framework in 2003 which was implemented in the simulation programs for unambiguously identifying the spin and parity of the Higgs boson discovered in 2012 at the LHC. We have been actively involved in the global efforts for the realization of the ILC project in the near future and are members of the Korea-CERN theory collaboration. In addition, we are interested in new physics models for explaining neutrino mass and mixing, dark matter particles and matter-antimatter asymmetry.

Statistical Physics Group

The statistical physics group (Young Sul Cho and Hyunsuk Hong) studies the emergence of macroscopic behavior in systems composed of a large number of interacting elements. By using the theoretical framework of statistical physics and numerical computations, this group has understood the dynamics in diverse complex systems. To be specific, current research topics in this group can be categorized into synchronization and percolation. Synchronization is a phenomenon where phases or states of interacting elements change in the same frequency. This phenomenon has been widely observed in diverse real systems such as flashing flies, firing neurons, and power grids. People are interested in the underlying mechanism of spontaneous synchronizations. To answer this question, this group has established a theoretical basis to understand the spontaneous synchronization by analyzing dynamical models on the given complex network structures. Percolation is an emergence of a giant cluster as the number of connections between pairs increase. Emergence of giant clusters in social networks and metal-insulator transitions can be real systems showing percolation. This group is interested in the pattern of the emergence of giant clusters depending on the link attachment rules and the underlying lattice structures.

RESEARCH CENTERS

Institute of Photonics and Information Technology

Since its establishment in November 1998, the Institute of Photonics and Information Technology (IPIT) has aimed to raise the level of education and research at the university through interdisciplinary cooperation between natural science and engineering, thereby contributing to the development of industrial technology in the region and the country. Since 1999, IPIT has established a multimedia classroom that is equipped to handle lectures and experiments for undergraduate physics courses. Members of IPIT have collaborated to improve lecture notes and to renew the content of the undergraduate experiments for the physics department. IPIT has been also trying to improve research activities. In 2002, IPIT was selected as one of the national research centers by the Korean National Research Foundation (NRF). Thanks to the 6-years of financial support from the NRF, IPIT has established cutting-edge experimental facilities in order to study the electronic and optical characteristics of semiconductor quantum structures. Members of IPIT have developed ultra-precise and high-speed measurement devices, including a scanning tunneling microscope and a femtosecond pulsed-laser system, which have become the core research infrastructures of IPIT. By utilizing the infrastructures, the members are now exploring the novel phenomena of alloys, insulators, and semiconductors which can be harnessed in the next generation electronic devices.

Research Institute of Physics and Chemistry

The Research Institute of Physics and Chemistry was established on June 10, 2005 to conduct basic science research based on physics and chemistry. Since its establishment, theoretical and experimental studies have been conducted for the development of new quantum and functional molecular materials and the fabrication of functional devices through close cooperation between physics and chemistry faculty members. Based on experimental and theoretical research, we are also developing eco-friendly materials, securing source technologies for future energy sources, and studying energy saving materials and devices. Six research groups have been organized to accomplish the collaborative research projects successfully: (1) Nano-Bio Convergence Devices (Environmental Sensors), (2) Nano-Bio Materials, (3) Catalyst Development (Environmental Improvement), (4) Next Generation Energy Theory, (5) Single Molecules, and (6) Nano-Luminescence Materials Research Groups.

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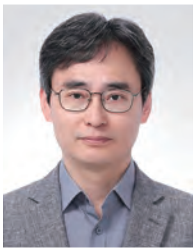

Heesuk Rho is the chair of the Department of Physics. He received a PhD degree in physics from the University of Cincinnati, USA in 1999. He worked as a postdoctoral researcher in physics at the University of Illinois at Urbana-Champaign, USA. He joined the faculty of Chonbuk National University in 2002.