The Department of Physics at Northeastern University, China

WEI-JIANG GONG, QI WANG, AND YONG HU
DEPARTMENT OF PHYSICS, NORTHEASTERN UNIVERSITY

Fig. 1: Northeastern University in China.

Northeastern University

Northeastern University, China (NEU) was founded over 90 years ago, on April 26, 1923. The university's motto is "to strive constantly for improvement and to behave in conformity with the knowledge". NEU is affiliated with a number of high-level scientific research achievements, such as the creation of China's first analog computer, the creation of the first domestically produced computed tomography (CT) scanner, the fabrication of the first piece of super steel, the development of new technology for smelting vanadium titanium magnetite, the development of the controlled rolling and controlled cooling technique, and the development of mixed intelligent optimization control technology. By establishing the first university science park in China, NEU has created a series of high-tech enterprises, such as Neusoft Corporation and Neunn Technology Inc., and has developed unique strengths in the areas of technological innovation, technological transfer, and industry-university cooperation.

NEU is situated in Shenyang, the central city of northeastern China, and NEU also has a campus in Qinhuangdao City, Hebei Province. The university occupies a total area of 2,550,000 square meters, of which the architectural area amounts to 1,680,000 square meters. It has 4,538 faculty members, among whom 2,711 are full-time instructors. The university has four innovation groups of the National Natural Science Foundation and three innovation teams of the Ministry of Education. It has more than 100 research institutes, including three National Key Laboratories, four national engineering (technology) research centers and three national engineering laboratories. In addition, it has two national

collaborative innovation centers and three collaborative innovation centers in Liaoning province.

DEPARTMENT OF PHYSICS

As early as 1958, NEU had instruction in metal physics, semiconductor materials, semiconductor devices and other physics topics. In 1977, the Department of Physics was established, and the department began admissions of undergraduate students in physics. In July 1986, the department began to obtain the right to confer a master's degree in condensed matter physics. In June 2003, NEU established a master's degree program in theoretical physics, and in January 2006, an authorized master's degree program of physics was approved. In 2011, the department was granted the right to confer a doctoral degree in physics. In 2019, it was approved to build a physics postdoctoral mobile station.

The Department of Physics has 47 faculty members, 42 of whom are full-time instructors. Among the teaching staff, there is one awardee of the National Ten Thousand Talents Plan; one winner of the National Excellent Youth Fund; one winner of the special government allowance of the State Council; one "Excellent Talent" awardee of the Ministry of Education in the New Century; one "Hundred Talents Level" awardee and three "Thousand Talents Level" awardees of Liaoning Province; one "Famous Teacher" of Northeastern University; and one "Young Thousand Plan (Xinjiang project)" awardee.

The department attaches great importance to student education, especially undergraduate education, and considers teaching to be its central task. Guided by the motto of the university, the Department of Physics strives to provide a well-rounded education for our students; in particular, we endeavor to have our students master not only the fundamental theories, knowledge and skills of physics (and advanced research and compound application abilities for those students with the requisite capabilities), but we also hope to instill a civic sense and an awareness of social responsibilities to our students. In addition, the Department of Physics aims to foster the experimentalists, theorists and applied engineers who will to contribute to the critical science projects of the present and the future. In parallel with the developments of science and technology and combined with the directions of our discipline, the physics department at NEU works to provide an education that merges applied physics with outstanding academics and business acumen.

Fig. 2: Department of Physics at Northeastern University.

NEU has doctoral level disciplines in physics, and stable research teams in fields including theoretical physics, astroparticle physics and cosmology, condensed matter physics, optics and radio physics. Condensed matter physics is one of Liaoning province's key disciplines. According to the direction of the discipline and the developments of physics, key teachers have been involved in different academic terms, including astroparticle physics and cosmology, nanophysics and nanodevices, condensed matter physics, optics and radio physics.

RESEARCH GROUPS

Astroparticle Physics and Cosmology Group

The members of this group focus on research in cosmology, and in particular, in exploring the fundamental nature of dark energy with cosmological observations, which has always been one of the major subjects of research in cosmology. In recent years, they have been investigating issues such as whether or not dark energy directly interacts with dark matter, how such a subtle interaction influences the evolution of the Universe and how to detect this interaction, how the properties of dark energy influences the cosmological measurements of the total neutrino mass, and how to precisely measure the cosmological parameters relevant to dark energy. Many important research achievements in the studies for these issues have been made, including, e.g., the establishment of a theoretical framework for calculating the cosmological perturbations for the interacting dark energy scenario, the systematic exploration of issues associated with the cosmological weighing of neutrinos and the cosmological search for sterile neutrinos, and a systematic study on the precise measurements of cosmological parameters.

Professor Xin Zhang, the leader of this group, has published more than 120 research papers in peer-reviewed journals, which have been cited more than 5400 times so far by international experts in the same community throughout the world; his H index is now 39. He is also the recipient of numerous awards and honors, including the Natural Science Award of Liaoning Province, and the Special Government Allowance from the State Council. His group currently still focuses on the essential questions of cosmology, including, e.g., systematic studies on the cosmological measurement of the coupling parameter between dark energy and dark matter, issues concerning gravitational-wave multi-messenger astronomy and dark energy, and cosmology studies based on SKA (the Square Kilometre Array project).

Condensed Matter Physics Group

One research topic of this group is condensed matter theory. The members pay attention to quantum transport phenomena dominated by quantum interference, such as the AB (Aharonov-Bohm) effect, the Fano effect, decoupled state, antiresonance, and the application possibilities of these phenomena in electronic manipulation or thermoelectric conversion. In recent years, the quantum transport behavior driven by the Majorana bound states has become one important research area. They clarified the competition mechanism of Andreev reflection and electron tunneling by considering the coupling of the Majorana bound state with the quantum dot structure or the change of the topological superconductor. In addition, they elucidated the phenomenon of superfluid phase transitions by embedding quantum dots into the Josephson junction.

The group's other main area of research focuses on the fundamental concept of quantum physics. This group studies the underlying physics of non-Hermitian quantum systems. They clarified the influence of Parity-Time-symmetric complex potentials on the transport properties and topological phase transitions of low-dimensional systems. The quantum interference behavior regulated by PT-symmetric complex potential energy has been discussed, and the influence of the existence manners of complex potentials on topological states in different systems has been analyzed. It has been found that changing the ways of introducing complex potentials or considering the coupling mechanisms can lead to the emergence of new topological states and can enrich the phase transition phenomenon of the original topological mediocrity region.

Magnetic Materials and Nanophysics Group

The magnetic materials group studies the preparation and physical properties of various magnetic materials. This includes, mainly, high anisotropic magnetic films and the preparation and processing technologies and physical properties of soft and hard magnetic permanent magnet alloys and amorphous nanocrystals. This area of research provides basic data for exploring and understanding the principle of magnetic memory, understanding the magnetic nature of materials, developing ultrahigh recording density disks, and obtaining magnetic materials with excellent soft or hard magnetic properties.

The nanophysics group pays attention to the self-assembly behavior of nanoparticles in the fields of physics, chemistry and materials science. Based on the theoretical numerical method, the group carried out a qualitative analysis of the self-assembly behavior of nanosystems. The results fully correspond to the experimental process and clearly explain the underlying mechanism. Furthermore, are performing studies on field-driven oscillation and rotation of multifrequency clusters in nanodisks and the magnetothermal effect of nanosystems.

Optics Group

The group focuses on laser technologies and applications. The group carries out systematic research on the cutting-edge issues in the cross-fields of laser technology and materials research. The main research areas include laser surface modification of medical metal materials; laser texturing technology to improve the comprehensive performance of metal surfaces; and, in laser welding, joint dynamic tensile and structural properties of automobile steel plates. The common thread that binds these research areas together is the desire to use laser technology to resolve problems in modern engineering applications. We have established cooperative relationships with the Institute of Laser Application Technology, the School of Materials, the Metal Institute of NEU and many domestic and foreign universities; therefore, we have access to excellent research equipment and research conditions.

Radio Physics

The radio physics group focuses on the applications of superconducting single-photons, optical measurements, and stereoscopic displays. They have successfully developed an excimer laser dioptric correction instrument, a rapid colorimetric optical temperature measurement system and other application equipment. For training tasks such as teaching and applied research, they par-

ticipated in a 0.23T permanent magnetic resonance imaging system developed by the Neusoft company. In high-temperature superconducting magnetic resonance imaging research, they have several domestic and international advanced technologies and have the ability to independently develop high-temperature superconducting magnetic resonance equipment. In addition, they study plasma physics, including the characteristics of electromagnetic fields in low-pressure discharge frequency sources, and the application of radio frequency (RF) discharge in advanced manufacturing fields such as material processing, synthesis and preparation processes.

Wei-Jiang Gong is a professor and is also the dean of the Department of Physics at Northeastern University, China (NEU). In 2008, he works in the Department of Physics after obtaining his doctoral degree from Jilin University. From 2015 to 2016, he worked as a visiting scholar at the University of Texas at Dallas. He carries out research on the electronic structure and quantum transport properties of low dimensional semiconductor systems and the phase transition of strongly correlated systems. He is also interested in the physical properties of topological quantum systems.

Qi Wang is an associate professor and also the vice dean of the College of Science at Northeastern University, China (NEU). Since 2007, he has taught physics experiment courses for more than 10 years, including "college physics experiments" and "modern physics experiments". While teaching, he encourages students to explore new physics phenomena. In 2018, he won the National Virtual Simulation Experiment Teaching Project of China. His research interests are mainly in the field of nanomaterials, and he performs studies regarding the realization and application of nanosensors.

Yong Hu received his undergraduate degree from Northeastern University, China (NEU) in 2005. He obtained his doctoral degree in materials physics and chemistry in April, 2011. In 2011, he joined the faculty of NEU, where he is now an associate professor of physics. In 2016-2017, he worked in the physics department of the University of California, Davis as a visiting professor. His scientific interests mainly focus on nanomagnetism and spintronics. He has worked on the development of a modified Monte Carlo method by which the spin energy can be exactly calculated to consider the influence of energy barriers on the spin reversal. This modified method has been successfully used in simulations to understand the spin glass dynamics and the exchange bias effect for the first time.