Department of Physics, Renmin University of China

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Overview

The Department of Physics at Renmin University of China was established in 2005. The faculty is intended to number 40 when the department has grown to full strength and consists currently of 30 members. Their orientation is high-quality research combined with physics instruction across the full spectrum of core subjects. The activities of the department are designed to exploit the intrinsic synergy of innovative research, teaching, and academic exchanges in physics and related disciplines, all of which are pursued at an internationally recognized standard. The department is located on the west campus of Renmin University in northwestern Beijing at the core of the "Zhongguancun Science and Technology Zone", also known as China's Silicon Valley. New laboratories are located on the east campus of Renmin University in Tongzhou City. The department's research consists of experimental, theoretical, and computational studies, each involving similar numbers of faculty members. Research in the department is supported by three major platforms, the laboratory for condensed matter physics, the laboratory for parallel high-performance computational physics, and the advanced functional materials laboratory. Faculty members are also involved intensively with the ongoing development of large-scale user facilities in China, including the national synchrotron radiation source, high-magnetic-field facility, nuclear reactor and spallation neutron source. The department houses and administers the Beijing Key Laboratory of Optoelectronic Functional Materials & Micro-Nano Devices.

Research Foci

Experimental Condensed Matter Physics: The laboratory utilizes advanced spectroscopic methods, including angle-resolved photoemission (ARPES), electronic Raman Scattering, nuclear magnetic resonance (NMR), and neutron scattering, in combination with materials synthesis, high-field, and high-pressure techniques, to perform broad investigation of physical properties of materials and of the mechanisms for unconventional superconductivity, quantum magnetism, and other novel quantum phases. Recent research is focused on pnictide superconductors, triangular-lattice quantum magnets, and monolayer electronic materials.

Crystal Growth and Functional Materials Synthesis: This team synthesizes functional materials and single crystals by solid-state, self-flux, Bridgman, floating-zone, chemical-vapor-transport, and hydrothermal techniques, also studies basic transport and magnetic properties. Recent research concerns pnictide superconductors and correlated materials with the

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$ThCr_2Si_2$ structure.

Condensed Matter Theory: The group studies a range of connected topics in unconventional superconductivity, quantum and frustrated magnetism, quantum impurity problems, and fractional quantum Hall systems, all with a view to quantitative experimental comparison. Recent achievements include detailed studies of quantum criticality, correlated multi-orbital models for pnictide superconductors, and powerful new numerical approaches to quantum spin liquids.

Multiscale Modeling of Materials: This laboratory develops and applies numerical techniques for modeling strongly correlated electronic materials, superconductors, low-dimensional systems, molecular complexes at surfaces and interfaces, and metallic liquids and glasses. Methods include numerical renormalization group (NRG), dynamical mean-field theory, density functional theory, molecular mechanisms and pair wise potentials, *abinitio* and classical molecular dynamics. Recent projects include using graph theory to characterize structural topology in metallic glass-forming alloys, extended NRG methods for studying dissipative quantum two-level systems and multi-orbital impurity systems, new theories of atomic force microscopy (AFM) imagery including the application to intermolecular hydrogen bonds, the first calculations for the electronic and optical properties of the emerging two-dimensional material black phosphorus, first-principles studies on bulk and epitaxial film of iron-based superconductors, and molecular dynamics simulation of metallic glass.

Advanced Electronic and Optoelectronic Materials: The electronic materials laboratory exercises quantum control over electrical transport in novel nanomaterials, including graphene, nanowires, heterojunctions, and nanoscale magnetic systems. Recent results include establishing the phase diagram of the metal-insulator transition in the $N = 0$ Landau level in graphene and finding $l = 3$ chiral quasiparticles with cubic dispersion. The optoelectronic laboratory develops new materials and packaging technology for white LEDs, including fluorescent transparent ceramics (FTCs) and new-generation phosphors. FTCs have extremely high external quantum efficiency (EQE) for emission and high transparencies. Recent research produced an LED with an EQE over 300 lm/W based on a new sandwich structure involving finely tailored FTCs. The group is also focused on developing new technologies for fabricating phosphors with high efficiency and at low cost.

Ultracold Atoms and Quantum Information: This group studies both few- and many-body theory of ultracold atomic gases. Few-body problems are important due to the diluteness condition and for being (numerically) exact. Recent studies include two-body problems in spin-orbital-coupled ultra-cold gases, where the interaction between Bose and Fermi superfluids is calibrated via a three-body calculation of atom-dimer scattering lengths. From exact few-body solutions, a many-body description of strongly correlated Fermi systems was developed and applied to the exotic phases of ultra-cold Bose and Fermi gases under synthetic gauge fields and spin-orbit coupling.

Interdisciplinary Physics: The team applies concepts from statistical physics to the description of a range of systems in nature and society, including transport in nanoscale materials, stock markets, the internet, and traffic flow. Recently, numerical simulations of heat transport in low-dimensional systems suggest a new approach to problems of anomalous conduction and super heat diffusion.