复旦大学物理系 Colloquium

Time: 14:00, Friday, 2023.5.12

Location: C108, Jiangwan Physics Building（线下报告）

Half Quantum Hall Effect in Metal

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Abstract: The quantum Hall effects refer to a series of peculiar quantum states of matter in the two-dimensional electron system in a strong magnetic field at a very low temperature. Similar phenomena in quasi-two-dimensional materials in the absence of a magnetic field are named the quantum anomalous Hall effect. So far, all the quantum Hall effects occur in insulating phases and are characterized by an integer or rational fraction. These quantum Hall effects occur when the Fermi level lies in the energy gap of the Landau levels or the band gap, and are characterized by the TKNN number or Chern number for the band structure as a topological invariant. The longitudinal conductivity is zero and either the Hall resistivity or conductivity is quantized. The bulk-edge correspondence illustrates that the number corresponds to the number of the localized edge modes around the system boundary, which carries the dissipationless chiral charge current. Here we report a half-quantized Hall effect in a metal or semimetal. The Hall conductance is half quantized and the longitudinal conductance is nonzero, but the Hall resistivity is not quantized. The half quantization occurs when the Fermi surface is invariant under the parity symmetry while the symmetry is broken in the whole system. A recent experiment reports the observation of the half-quantized Hall conductance in a magnetically-doped topological insulator. We discover that a single gapless Dirac cone exists in the band structure and has half-quantized conductance when the Fermi level intercepts the gapless surface states in which the parity symmetry is respected for in a finite regime in the Brillouin zone. As there are no localized chiral edge states in the gapless and metallic system, we find that the chiral edge current is carried by the gapless surface states. The current density peaks at the edge and decays in a power law rather than the exponential decay in the quantum anomalous Hall effect. We term the unexpected and nontrivial quantum phase as “parity anomalous semimetal”. The work opens the door to exploring novel topological states of matter with fractional topological invariant.

Biography: Shun-Qing Shen is a professor in department of physics, The University of Hong Kong. He is an expert in the field of condensed matter physics, and distinguished for his research works on topological insulator, quantum transport, and novel quantum states of condensed matters. He published a single-authored monograph, Topological Insulators (Springer, 2012), which is the first book on the topic. Professor Shen received his PhD in theoretical physics from Fudan University in Shanghai. He was a postdoctorial fellow in China Center of Advanced Science and Technology (CCAST), Beijing, Alexander von Humboldt fellow in Max Planck Institute for Physics of Complex Systems, Dresden, Germany, and JSPS research fellow in Tokyo Institute of Technology, Japan.