北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Seminar

Half Quantized Hall Effect in Metal

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Time: 10:00 am, Sept. 21, 2023 (Thursday)

时间：2023年9月21日 （周四）上午10:00

Venue: Room w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

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 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 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 as in the conventional quantum anomalous Hall effect. We term the unexpected and nontrivial quantum phase as “parity anomalous semimetal”. We also discovered a metallic quantum anomalous Hall effect without chiral edge states in a magnetic sandwich structure of topological insulators. The set of works opens the door to exploring novel topological states of matter with fractional topological invariants.

References:

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• K. Z. Bai, B. Fu, Z. Y. Zhang, and S. Q. Shen, *Metallic quantized anomalous Hall effect without edge states*, arXiv: 2308.05963

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About the speaker

Shun-Qing Shen is a professor in the Department of Physics at the University of Hong Kong. He is an expert in the field of condensed matter physics and is distinguished for his research works on topological insulators, quantum transport, and novel quantum states of condensed matter. He published a single-authored monograph, *Topological Insulators* (Springer, 1st ed., 2012; 2nd ed., 2017), which is the first one on the topic. He received his BS. MS, and Ph.D. in theoretical physics from Fudan University in Shanghai, China. He was a post-doctoral fellow at China Center of Advanced Science and Technology (CCAST), Beijing, an Alexander von Humboldt fellow at Max Planck Institute for Physics of Complex Systems, Dresden, Germany, and a JSPS research fellow at Tokyo Institute of Technology, Japan. He joined The University of Hong Kong in December 1997.