北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Weekly Seminar

Optical responses of Majorana edge states & superconductor diode effect

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中国科学技术大学合肥微尺度物质科学国家研究中心ICQD

Time: 3:00pm, Sept.21, 2022 (Wednesday)

时间：2022年9月21日 （周三）下午3:00

腾讯会议链接： https://meeting.tencent.com/dm/MICDIHSzkqGU

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Abstract

This talk includes two topics. I will first discuss our research on a new property of Majorana edge states and its application in the detection of such edge modes. In the second part, I will talk about a nonreciprocal transport phenomenon, termed the superconductor diode effect, which has been attracting a lot of attention recently.

Majorana states obey non-Abelian statistics, which makes them a promising candidate for achieving topological quantum computation. The past decade witnessed great progresses in the research on Majorana states. However, in the path to topological qubits, there exist serious difficulties that are yet to be overcome, including the detection of such states. Current detection methods rely a lot on transport measurements where Majorana fermions manifest themselves by inducing electron-pair tunneling, i.e., Andreev reflection. In this talk, I will show that chiral Majorana fermions in topological superconductors can generate optical responses, resulting in a local optical conductivity $\sigma_{xx}(\boldsymbol{r})$ proportional to ω^2 when the photon frequency ω is small. The features of the σ_{xx} distinguish chiral Majorana fermions not only from trivial superconductors or insulators (where $\sigma_{xx} = 0$), but also from normal electronic edge states such as those in quantum Hall systems (where $\sigma_{xx} = e^2/2h$). We further discuss the optical responses of chiral Majorana modes in the Kitaev quantum spin liquids, where the optical signal is a Raman scattering intensity proportional to ω^3, ω beingng the Raman frequency shift.

The superconductor diode effect refers to a phenomenon in which a supercurrent becomes normal when its direction is reversed. It has been reported in various systems in the past couple of years. Here, I will share our understanding of the physics behind this phenomenon in a certain class of systems, i.e., superconductors with strong spin-orbit coupling and Zeeman splitting. We will first discuss a rather general description of this phenomenon with the Ginzburg-Landau theory. And then, Rashba superconductors are taken as an example, for which both the GL theory and numerical calculations based on the Bogoliubov-de Gennes mean field Hamiltonian are given, and the parameter dependences of the nonreciprocal supercurrent are obtained.

相关文章：

[1] James Jun He, Yukio Tanaka, and Naoto Nagaosa, *Phys. Rev. Lett.* 126, 237002 (2021).

[2] James Jun He and Naoto Nagaosa, *Phys. Rev. B* 103, L241109 (2021).

[3] James Jun He, Yukio Tanaka and Naoto Nagaosa, *New J. Phys.* 24 053014 (2022).

About the speaker

何骏2017年博士毕业于香港科技大学物理系，师从K. T. Law教授。毕业后在日本理化学研究所（RIKEN）衍生物质科学研究中心（Center for Emergent Matter Science, or CEMS）的Naoto Nagaosa教授研究组担任博士后研究员。2022年2月份至今担任中国科学技术大学微尺度物质科学国家研究中心国际功能材料量子设计中心（ICQD）特任研究员。他从事凝聚态理论物理研究，主要研究的是物质的拓扑能带理论、自旋轨道耦合的电子系统、超导电系统等，具体方向包括拓扑超导与马约拉纳费米子、非中心对称的超导、约瑟夫森结、Ising超导体（二维transition metal dichalcogenide）、 超导二极管效应等，目前在Physical Review Letters、Nature Communications等期刊发表论文共19篇。