



Weekly Seminar

Josephson diode effect and flat band superconductivity with quantum metric in moiré materials

Kam Tuen Law

Department of Physics, The Hong Kong University of Science and Technology

Time: 3:00 pm, May. 15, 2024 (Wednesday)

时间: 2024年5月15日 (周三) 下午3:00

Venue: Room w563, Physics building, Peking University

地点: 北京大学物理楼, 西563会议室

Abstract

Recently, it has been observed that superconducting and interaction-driven quantum anomalous Hall states can appear simultaneously in gate-defined Josephson junctions in twisted bilayer graphene [1]. The interaction-driven state serves as the weak link in the superconductor/correlated state/superconductor Josephson junction. In this talk, we will discuss how the interaction-driven valley polarization is essential for the Josephson diode effect observed in experiments [2]. Moreover, many of the superconducting properties of moiré superconductors with ultra-flat bands deviate greatly from conventional BCS theory predictions [3]. In the second half of the talk, I would like to present a Ginzburg-Landau theory derived from a microscopic flat band Hamiltonian, which incorporates the quantum metric effects of moiré flat band superconductors [4,5,6]. The theory explains how the length scale defined by quantum metric, which we call the quantum metric length, is critically important in determining the properties of moiré flat band superconductors.

[1] J D éz-M érida, A D éz-Carl ón, SY Yang, Y-M Xie, X-J Gao, J Senior, K Watanabe, T Taniguchi, X Lu, AP Higginbotham, KT Law, Dmitri K Efetov, Nature Communications 14: 2396 (2023).

[2] Jin-Xin Hu, Zi-Ting Sun, Ying-Ming Xie, K. T. Law, Physical Review Letters 130, 266003 (2023).

[3] Haidong Tian, et al. Nature 614, 440 (2023).

[4] Shuai A Chen, KT Law, Phys. Rev. Lett. 132, 026002 (2024).

[5] Jin-Xin Hu, Shuai A Chen, KT Law, arXiv:2308.05686.

[6] Zhong CF Li, Yuxuan Deng, Shuai A Chen, Dmitri K Efetov, KT Law, arXiv:2404.09211.

About the speaker

Prof. Kam Tuen Law is a Professor at The Hong Kong University of Science and Technology. He received his BSc degree from HKUST in 2003 and completed his PhD degree at Brown University in 2008. He then worked as a Croucher Postdoctoral Fellow at MIT with Prof. Patrick Lee. He joined HKUST as an assistant Professor in 2011. Prof. Law did pioneer works on the study of Majorana fermions in topological superconductors, including predicting the quantized tunnelling conductance and spin-selective Andreev reflections induced by Majorana fermions. He co-discovered Ising superconductivity in transition metal dichalcogenides with two experimental groups in 2015 and has since uncovered many novel properties of Ising superconductors theoretically. Recently, he predicted new classes of materials called Kramers nodal line metals and spin-orbit-parity-coupled superconductors. Many of his theoretical predictions were verified experimentally. Prof. Law received the Croucher Innovation Award in 2015 and the Achievement in Asia Award by the International Organization of Chinese Physicists and Astronomers in 2024. He is a Hong Kong Research Grants Council Research Fellow (2020) and the Founding President (2018-2021) of the Hong Kong Young Academy of Sciences.