Seminar

Ancilla theory of Mott physics and its application to topological bands in moiré systems

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Time: 3:00 pm, June.30, 2025 (Monday)

时间：2025年6月30日（周一）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

The observation of correlated insulators in moiré systems raises a fundamental question: how do we understand Mott localization in a topological band? In this talk, I will introduce the ancilla fermion theory as a framework for understanding Mott localization in both trivial and topological bands. Originally developed for cuprates, this approach introduces two hidden ancilla layers to describe charge and spin degrees of freedom in doped Mott insulators: the Mott gap arises from hybridization between physical electrons and the first ancilla fermions, while the spin sector is described via quantum teleportation from the second layer. Upon doping, the theory captures both conventional and fractionalized Fermi liquids (FL*), the latter has hole pockets with quasiparticle weight large only on Fermi arcs.

I will then discuss our recent application of this theory to understand Mott localization in the twisted bilayer graphene (TBG) system, where the topological band structure enforces a momentum-dependent $p \pm ip$-like Mott hybridization. At charge neutrality point $\nu=0$, we find a topological Mott semimetal with low-energy structure resembling an untwisted bilayer graphene. For other integer fillings, we observe transitions from correlated insulators to semimetals as interactions U weaken. In the most intriguing regime near $\nu = -2 - x$, we propose a symmetric pseudogap metal that violates the perturbative Luttinger theorem, with quasiparticles interpreted as composite fermions formed from ancilla degrees of freedom.

I will conclude with a brief discussion of our most recent slave particle formulation, which reproduces key features of the ancilla theory and provides a complementary trion interpretation of the low-energy excitations. These results together offer a unified perspective on Mott physics across cuprates and moiré systems, and open new directions for exploring strongly correlated phases in the presence of topological band structures.

About the speaker

Jing-Yu Zhao received his Ph.D. in Physics from Institute for Advanced Study, Tsinghua University in 2024. He is currently a postdoctoral fellow at Johns Hopkins University, working on strongly correlated quantum systems and topological phases of matter.