北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Weekly Seminar

Fractional quantum anomalous Hall effect in anomalous occasions

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Time: 3:00 pm, June.4, 2025 (Wednesday)

时间：2025年6月4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

In this talk, I will discuss fractional quantum anomalous Hall effects in two occasions that are rather unconventional, hosted by lattice models that are variants of the three orbital tight-binding model for twisted $MoTe_2$ [1]. The first is a singular flat band, with a protected touching point with a dispersive one [2]. Such flat band can have some characters of a nearly ideal flat Chern band, except for the absence of a gap, which raises the question of whether fractional QAH state can be compatible with this band touching. I will show numerical evidences of FQAH states from both exact diagonalization and DMRG calculations. An interesting observation is the fractional QAH states exist in the limit of weak interaction strength, where the singular band touching feature is retained, but get quenched when larger interaction gaps the touching point and turn the singular flat band into a flat Chern band. The second occasion is in the opposite limit: an isolated flat band of zero Chern number, gapped from the rest bands that also have zero Chern number [3]. And we will focus on the isolated band limit, namely interaction is always weaker than the gap, so that renormalisation by interaction leaves the flat band quantum geometry and trivial topology unchanged. Starting with the Hartree Fock band of zero Chern number, our ED calculations show unambiguous evidences of fractional QAH effect at its 2/3 filling. The ground state degeneracy rules out the relevance of band folding fractional hall crystal, and we do not expect there can be folded miniband to effectively display nontrivial band topology either. This example suggests that single particle topology is not the prerequisite for fractional quantum Hall state.

References:

[1] Giant magnetic field from moire induced Berry phase in homobilayer semiconductors, Hongyi Yu, Mingxing Chen, Wang Yao, National Science Review 7, 12 (2020).

[2] Fractional Quantum Anomalous Hall Effect in a Singular Flat Band, Wenqi Yang, Dawei Zhai, Tixuan Tan, Feng-Ren Fan, Zuzhang Lin and Wang Yao, Phys. Rev. Lett. 134, 196501 (2025).

[3] Fractional Chern insulator states in an isolated flat band of zero Chern number, Zuzhang Lin, Wenqi Yang, Hongyu Lu, Dawei Zhai, Wang Yao, arXiv preprint arXiv:2505.09009 (2025).

About the speaker

Wang YAO obtained his BSc from Peking University in 2001, and PhD in physics from University of California, San Diego in 2006. He joined the University of Hong Kong in 2008, and rose through the academic ranks to Chair Professor of Physics in 2019. His group works in an interdisciplinary area across condensed matter physics, quantum physics, and optical physics, with current research interest in 2D quantum materials and their twisted structures. He is a New Cornerstone Investigator, and Fellow of American Physical Society and Fellow of Optica.