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物質と情報の量子協奏
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Mastering Quantum Complexity: The Path to Scaling and Controlling topological Majorana bound states

研究成果の概要

Twisted bilayer graphene at magic angle hosts flat bands, enabling diverse quantum strongly correlated physics like unconventional superconductivity and Mott physics. Most studies focus on two-fold flat bands (per valley/spin). However, flat bands with higher degeneracy offer a promising platform exhibiting more types of correlated physics. My work reveals moiré flat bands with four-fold degeneracy by introducing a spatially alternating magnetic field in graphene, causing double and quadruple flat bands to appear recursively in the twisted bilayer.

The evolution of Dirac nodes in graphene with varying twist angles is key to band flatness. While Dirac nodes are typical topological nodes, a comprehensive understanding of node conditions for these flat bands is lacking. My other study addresses this gap by classifying topological nodes in distinct twisted bilayer systems, elucidating configurations conducive to flat bands and predicting new twisted bilayers for strongly correlated physics. These flat bands can form on two twisted surfaces of time-reversal symmetric topological superconductors, allowing multiple Majorana zero energy modes to emerge, with suppressed Majorana hybridization leading to dominant Majorana interactions. Additionally, we find higher degeneracies, including four-fold, six-fold, and eight-fold per spin, with six-fold and eight-fold degeneracies discovered for the first time.

These findings offer new platforms with enhanced freedom to enrich exotic correlated and topological physics and to tailor the electronic structure in moiré twistronics.

【代表的な原著論文情報】

1) Classification of High-Ordered Topological Nodes Towards MFBs in Twisted Bilayers, accepted by SCIENCE CHINA Physics, Mechanics & Astronomy, arXiv: 2310.00662, Fan Cui, Congcong Le, Qiang Zhang, Xianxin Wu, Jiangping Hu, Ching-Kai Chiu
2) Double and Quadruple Flat Bands tuned by Alternative magnetic Fluxes in Twisted Bilayer Graphene, accepted by Physical Review Letters, arXiv:2310.00662, Congcong Le, Qiang Zhang, Fan Cui, Xianxin Wu, Ching-Kai Chiu