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Title:

Band geometry and topology in correlated quantum materials

Abstract:

Band geometry (or quantum geometry) and band topology describe, respectively, the local and global properties of Bloch electron wavefunctions in quantum materials. These concepts have already triggered a revolution in quantum materials based on single-particle physics, but their significance in interacting systems is much less explored. In this talk, I will discuss two recent advances in this direction for the two major interactions in solids: electron-phonon interaction and electron-electron Coulomb interaction. First, I will explain how band geometry contributes crucially to the electron-phonon interaction, potentially offering a new design principle for higher-temperature superconductors. Second, we show that band topology and band mixing are key to explaining various experimental puzzles centered around fractional Chern insulators (FCIs), which were recently observed in twisted $MoTe_2$ and graphene-hBN superlattices. FCIs, the zero-field analogs of the fractional quantum Hall effect, are induced by the Coulomb interaction in fractionally filled, (nearly-)flat topological bands, and their discovery heralds the discovery of more exotic topologically ordered phases, which will be discussed.