Vortexable Chern Bands in Twisted and Strained Graphene

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Fractional Chern insulators realize the remarkable physics of the fractional quantum Hall effect (FQHE) in crystalline systems with Chern bands. The lowest Landau level (LLL) is known to host the FQHE, but not all Chern bands are suitable for realizing fractional Chern insulators (FCI). Previous approaches to stabilizing FCIs focused on mimicking the LLL through momentum-space criteria. Here instead we take a real-space perspective by introducing the notion of vortexability. Vortexable Chern bands admit a fixed operator that introduces vortices into any band wavefunction while keeping the state entirely within the same band. Vortexable bands admit trial wavefunctions for FCI states, akin to Laughlin states. In the absence of dispersion and for sufficiently short ranged interactions, these FCI states are the ground state — independent of the distribution of Berry curvature. Vortexable bands are much more general than the LLL, and we showcase a recipe for constructing them. We exhibit diverse examples in twisted graphene-based systems with or without magnetic field, and with any Chern number. We will discuss the recent observation of fractional Chern insulators in twisted bilayer graphene in this context. Vortexable bands have a close relationship with momentum-space band geometry that clarifies and expands standard approaches