Two-band Fractional Chern Insulators approaching the thin-torus limit

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Fractional Chern Insulators (FCIs) [1, 2, 3] are lattice counterparts of Fractional Quantum Hall states. Theoretical and numerical works predict their existence in fractionally filled, topologically nontrivial energy bands of 2D crystals with nearly-flat dispersion. An intuitive way of understanding of Fractional Quantum Hall Effect can be gained from so-called Tao-Thouless (or thin-torus) limit [4], in which FQHE states on a torus transform continuously into charge density wave (CDW) states when one of its circumferences tends to zero and the system becomes one-dimensional. There are several works who attempt to use this approach in FCI [5, 6, 7]. Although topological order is impossible in strictly 1D systems, it was found that the thin-torus CDW states reproduce some properties of FCI states, including quasi-degeneracy and spectral flow (while others, e.g. momentum counting in entanglement spectrum, are not present).

In this work, we study the behaviour of fractionally filled topological flat bands approaching the 1D limit. We calculate the properties of narrow quasi-1D ribbons of width $N_y = 1, 2, 3$ using exact-diagonalization and Density Matrix Renormalization Group methods. FCI states are identified by analysis of ground state degeneracy, spectral flow and momentum counting in quasihole spectrum and entanglement spectrum. The edge properties of finite systems are studied. Finally, the connection between strictly 1D CDW and quasi-1D FCI-like states is analyzed by considering coupled 1D chain and varying the coupling strength.

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