Moore-Read fractional Chern insulators in the thin torus limit

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Intuitive understanding of the fractional quantum Hall effect (FQHE) can be achieved via the thin-torus limit, in which the system becomes one-dimensional, and the ground states become charge density wave [1]. A similar approach was recently developed for fractional Chern insulators (FCI) – the lattice analogs of quantum Hall states [2, 3]. FCIs arise in topological flat bands, whose properties are similar to the ones of Landau levels [4, 5]. The existence of such bands can be possible even with zero net magnetic field.

In this work, we study a Thouless pump implemented in the Rice-Mele model. Such a system can be regarded as a 1D limit of a 2D lattice model with topological flat bands. We consider lower band, populated by spinless fermions with the filling factor $\nu = 1/2$. For certain model interactions, this filling factor gives rise to the non-Abelian Moore-Read state [6]. We show that the Rice-Mele model considered by us can host the 1D versions of these states. The existence of such states is confirmed by investigating their signatures: the spectral flow and quasihole spectrum. At the limit of exactly flat band, the Wannier functions are decoupled from each other and the ground state can be obtained analytically. The departure from this limit is studied using the numerical methods: exact diagonalization and density matrix renormalization group. Two model interactions are considered: the two- and three-body one. When the interaction strength is small compared to the band gap, both types yield the Moore-Read-like states as the ground states. However, when the strength is increased, such states are destroyed by the interband excitations in the former case, while in the latter they remain stable for arbitrarily strong interactions. This effect can be explained analytically in the limit of exactly flat bands.

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