Analysis of many-body effects on flat band with nontrivial topology

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We investigate the electron-electron interactions on a topologically nontrivial flat band in Emery model (Lieb lattice). It was shown that systems with flat bands with nontrivial topology can exhibit fractional quantum Hall effect (FQHE) without Landau levels. These bands are obtained by right choice of parameters in he tight-binding model. Existence of fractional quantum Hall states was confirmed for several model systems, called "fractional Chern insulators", for example Haldane model and checkerboard lattice [1-5].

Lieb lattice can also be considered as a potential candidate for fractional Chern insulator. In tight-binding approximation it has a flat band at the Fermi level. This band is topologically trivial, but adding staggered potential and spin-orbit coupling can induce a topological phase transition and make it topologically nontrivial [6]. Also, these parameters open energy gaps between the flat band and the conduction and valence bands.

In this work, we investigate the many-body states on a flat band in Lieb lattice. We perform exact-diagonalization calculation for finite Lieb lattice plaquettes with periodic boundary conditions and find the 3-fold degeneracy of ground state for 1/3 filling - a necessary condition for existence of FQHE. We analyze the ground state and energy gap for different plaquette sizes. Finally, we perform flux insertion using twisted boundary conditions to determine if the observed states are true fractional quantum Hall states.

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