Interplay of magnetic field and spin orbit interaction for Lieb lattice

Błażej Jaworowski, Paweł Potasz, and Arkadiusz Wójs

Wrocław University of Technology, Wybrzeże Wyspiańskiego 24, Wrocław, Poland

We study the combined effect of spin-orbit interaction and magnetic field on the Lieb lattice. The Lieb lattice is a system in which spin-orbit interaction gives rise to a topologically nontrivial energy band [1]. Such a band can be made nearly flat, which allows for existence of Fractional Quantum Hall Effect (FQHE) - like state, the Fractional Chern Insulator (FCI), similarily to e.g. Haldane or checkerboard models [2]. Including magnetic field in spinless single-particle regime allows to investigate interplay of two integer quantum Hall effect (IQHE) coming from two sources [3,4]. If both spins are included, we can observe the interplay of ordinary IQHE and spin quantum Hall efect (SQHE) [5]. Including interaction would allow us to explore the FQHE/FCI regime.

For a noninteracting system (in both spinless and spinful versions) we investigate the band structure and Chern number of the bulk system and the edge states of system in the ribbon geometry. Then, for the spinless system, we include electron-electron interaction by exact diagonalization technique. By investigation of energy spectrum, spectral flow, many-body Chern number and quasihole spectrum we check if the system exhibits fractional quantum Hall effect. Exact diagonalization in ribbon geometry allows us to investigate the edge properties also.

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