Pusiau sintetinė zigzago optinė gardelė

Semi-synthetic zigzag optical lattice for ultracold atoms

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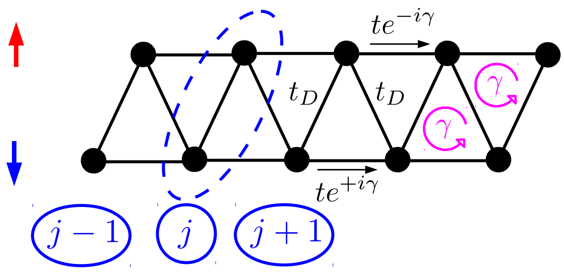
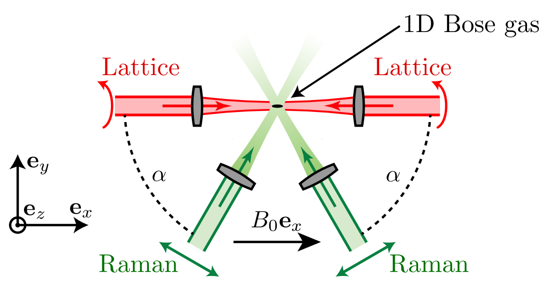
Optical lattices provide a unique tool for simulating quantum condensed matter physics using ultracold atoms [1]. These lattices can be enriched by introducing laser-coupled internal atomic states that can play the role of an extra "synthetic" dimension. For example, a semi-synthetic square lattice results from the combination of the interlayer tunneling among the sites of a one-dimensional optical lattice and laser-assisted transitions between the onsite atomic levels. If the laser coupling is accompanied by a recoil in the lattice direction, the semi-synthetic lattice acquires a uniform magnetic flux traversing the square plaquettes [2]. This leads to the formation of chiral edge states in the resulting quantum Hall ribbon [3]. A characteristic feature of the square geometry is that the atom-atom interaction is long-ranged in the synthetic dimension but short-ranged in the real dimension.

In this work, we depart from the square geometry and find the ground states of a semi-synthetic optical *zigzag* lattice which can be created combining a spin-dependent one-dimensional optical lattice with laser-induced transitions between the atomic internal states. Lattice geometry and experimental layout is shown below:





The lattice is affected by a tunable homogeneous magnetic flux, and furthermore features nonlocal interactions along the semi-synthetic directions that connect different internal states situated at different spatial locations. Generation of magnetic fluxes in an effectively one-dimensional setting is intriguing. Nonlocal interactions are also an important goal in recent experiments, and such interactions have been engineered via superexchange dipole-dipole coupling or Rydberg dressing.

We investigate the ground-state properties of the proposed system for the case of bosonic atoms with strong interactions using the density-matrix renormalization group calculations. We found that the interplay between the frustration induced by the magnetic flux and the interactions gives rise to an interesting gapped phase at fractional per-site filling fractions corresponding to one particle per magnetic unit cell.

Keywords: optical lattice, zigzag lattice, semi-synthetic lattice, ultracold atoms

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