Finite size effects and Hofstadter butterfly in a bosonic Mott insulator with relativistic dispersion background

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Gauge potentials with different configurations have been recently realized in the optical lattice experiments. It is remarkable that one of the simplest gauge can generate particle energy spectrum with the self-similar structure known as a Hofstadter butterfly. We investigate theoretically the impact of strong on-site interaction on such a spectrum in the Bose-Hubbard model. In particular, it is shown that the fractal structure is encoded in the quasi-particle and hole bosonic branches. A square lattice and other structures (brick-wall and staggered magnetic flux lattice) with relativistic energy dispersions which are currently accessible in the experiments are considered. Moreover, although in brick-wall and staggered flux lattices the quasi-particle densities of states looks qualitatively similar, the corresponding Hofstadter butterfly assumes different forms. In particular, we use a superposition of two different synthetic gauge fields which appears to be a generator of non-trivial phenomena in the optical lattice systems.

This work was supported by the National Science Centre, Poland, project no. 2014/15/N/ST2/03459 (A. S. S.).