Interacting bosons on a two-leg ladder in the presence of gauge fields

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We present the phase diagram of the interacting Bose-Hubbard model defined on a two-leg ladder geometry in the presence of a homogeneous flux. Our work is motivated by recent experiments using laser assisted-tunneling in optical lattices [1] and lattices in synthetic dimensions [2,3], which studied the regime of weak interactions. Based on extensive density matrix renormalization group simulations and a bosonization analysis, we explore the parameter space and calculate experimentally accessible observables.

For hardcore bosons, the phase diagram comprises gapless and gapped Meissner and vortex phases, with the gapped states emerging in Mott-insulating regimes [4]. For moderate interactions, vortex lattices form at certain commensurate vortex densities. We also find the so-called 'biased leg phase', which shows density-imbalance between the two legs [5].

Very interestingly, an enlarged unit cell forms in the vortex lattice phases, which can lead to the reversal of the current circulation-direction. We demonstrate this effect for arbitrarily weak interactions and at sufficiently low temperature, and show that it is significant for intermediate interactions [6].

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