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Quantum phases in an asymmetric double-well optical lattice[1]

SAURABH PAUL, EITE TIESINGA, Joint Quantum Institute — We study the superfluid (SF) and Mott insulator phases of ultracold atoms trapped in a double-well optical lattice. The lattice has an asymmetric double-well geometry along the x axis and single wells along the other axes. We set up the Bose-Hubbard model and evaluate tunneling and atom-atom interaction energies from exact band-structure calculations. Only nearest-neighbor tunneling is considered. This leads to two tunneling energies, t and J, to describe hopping along the x axis, and $J_\perp$ along the other directions. We assume that the barrier between the double wells is low compared to that between double-well pairs and nearest-neighbor atom-atom interaction can not be ignored. A mean field calculation determines the SF and Mott phase boundaries as a function of lattice parameters and chemical potential μ. The boundary is characterized by an effective tunneling $t_{\text{eff}} = t + J$ along the x axis. Moreover, we show that the Mott lobes within the $\mu - t_{\text{eff}}$ plane are completely surrounded by SF regions. In future, we will use the results of these simulations to construct effective lattice models where the atom-atom interaction is zero and the interactions are governed by a three-body potential. Such systems might lead to unique many-body ground states.

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