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Mott-insulator phases of coupled two-component Bose gases[1]

LUIS SANTOS, Institut fuer Theoretische Physik, Universitaet Hannover, Appelstr.2, 30167, Hannover (GERMANY)

In recent years, strongly-correlated atomic gases have attracted a rapidly-growing attention, mostly motivated by the impressive developments in the manipulation of atoms in optical lattices. In particular, if cold bosons in lattices occupy just the lowest band of the corresponding band structure, the physics is then described by the Bose-Hubbard model, which presents two different types of ground states, namely a superfluid phase and a gaped incompressible insulator phase known as Mott-insulator, characterized by a commensurate occupation per lattice site. For the case of Bose-Bose mixtures, an even richer physics occurs, and in particular a pair superfluid phase, i.e. a superfluid of boson-boson (or hole-hole) composites [1], can occur. In this work we analyze how the formation of a pair-superfluid may significantly influence the qualitative shape of the boundaries of the Mott-insulator regions. We discuss first that our results are relevant for both binary Boson-Boson mixtures, as well as for the case of dipolar gases placed in two unconnected neighboring one-dimensional wires. By combining strong-coupling-expansion calculations, and one-dimensional numerical results based on Matrix-Product-state techniques, we show that the Mott-boundaries strongly modify their shape, acquiring a marked re-entrant character even for low tunneling, which persists even for two-dimensional systems. Finally, we comment on the consequences that this effect may have in the spatial extension of the Mott-insulator plateaux in experiments with an inhomogeneous harmonic trapping in addition to the lattice potential. [1] A. Kuklov, N. Prokof'ev, and B. Svistunov, Phys. Rev. Lett. 92, 050402 (2004).

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