SEMINAR

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Abstract

"Excitation dynamics in a lattice Bose gas within the time-dependent Gutzwiller mean-field approach."
Studies of excitations of ultracold atoms in optical lattices play an important role in the understanding of their physical properties and dynamical behavior. For instance, the celebrated quantum phase transition from the superfluid into the Mott-insulator is accompanied by the opening of the gap in the excitation spectrum. We have studied the ground state, stationary excitation modes, as well as the dynamics of the lattice Bose gas using the time-dependent Gutzwiller mean-field approach valid in the superfluid as well as in the Mott-insulator phases.
The modes of collective excitations are calculated within the framework of the linear-response theory considering small perturbations of the many-body ground state. The lowest excitation modes of the Mott-insulator display energy gaps which become smaller when we approach the phase boundary. The lowest-energy excitation of the superfluid is a Goldstone mode that appears due to the spontaneous breaking of the phase symmetry. It has a phonon-like dispersion relation characterized by the sound velocity which is described by the hydrodynamic relation. In this mode, the condensate and the normal fractions oscillate in phase. The second mode of the superfluid has a gap and the oscillations of the condensate and the normal components are out-of-phase. We have performed simulations of the sound-wave propagation in the linear-response regime and beyond.
Dark solitons of ultracold bosons in the vicinity of the Mott-insulator -- superfluid phase transition are studied as well. Making use of the Gutzwiller ansatz we have found antisymmetric eigenstates corresponding to standing solitons, as well as propagating solitons created by phase imprinting. Near the phase boundary, superfluidity has either a particle or a hole character depending on the system parameters, which greatly affects the characteristics of both types of solitons.