Strongly-correlated lattice bosons in the superfluid phase: a selfenergy-functional cluster approach

Enrico Arrigoni, Michael Knap, and Wolfgang von der Linden

Institute of Theoretical and Computational Physics, Graz University of Technology, 8010 Graz, Austria

We extend the variational cluster approach to deal with strongly-correlated lattice bosons in the superfluid phase. To this end, we reformulate the method within a pseudoparticle formalism, whereby cluster excited states are described in terms of particle-like excitations. The approximation amounts to solving a multi-component noninteracting bosonic system by means of a multi-mode Bogoliubov approximation. A criterion for the stability of the solution is discussed. In order to provide a rigorous background for this approach we provide an extension of the selfenergy functional approach to include the bosonic superfluid phase, and show that the two approaches are equivalent.
We provide expressions for the single-particle normal and anomalous Green's functions, the condensate density, the grand-canonical potential, and other static quantities.
We apply the method to the two-dimensional Bose-Hubbard model and evaluate results in both Mott and superfluid phase. Our approach yields excellent agreement with Quantum Monte-Carlo calculations. The extension to other problems of interest, such as correlated light-matter systems, Fermi-Bose mixtures, as well as systems out of equilibrium is discussed.