Investigation of phase diagram of hard-core boson model allowing for non-ergodic contributions

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Recently, a great rising of interest to quantum lattice gas models, particularly to hard-core boson model, is observed. The latter was applied to description of thermodynamics and energy spectrum of system of ultracold atoms in optical lattices and is used also in the theory of ionic conductors and intercalated compounds. In the pseudospin representation one can consider the equivalent XXZ anisotropic Heisenberg model.

Applying diagrammatic technique for Matsubara Green's functions built on pseudospin operators we investigate the contributions on the zero Matsubara frequency, which manifest the non-ergodicity of system and are responsible for difference between isothermal and isolated susceptibilities. The single-particle Green's function and grand canonical potential are calculated in the random phase approximation. Basing on the instability condition in the $\vec{q} = 0, \omega = 0$ point, the region of existence of the non-ordered (normal) phase is established. The phase boundary, which corresponds to the second-order phase transition to the phase with the non-zero transverse pseudospin component (phase with the off-diagonal long range order, which is of the Bose condensate phase type) is found. The coexistence lines, describing transitions to the phases with the double modulation of the lattice site occupation and the condensate parameter, are also obtained. Changes in the phase diagram connected with the mentioned above non-ergodic contributions are analysed. A comparison with the results obtained in the decoupling approach for the two-time Zubarev Green's functions is made.