PS05

Mechanism of Spontaneous Rotation in One-dimensional Cold Atoms

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Cold-atom systems have been studied intensively for the last decade. In this exciting field, we focus on harmonically-trapped one- dimensional (1D) Bose gases. 1D atom systems have been constructed experimentally by applying a 2D trap potential to 3D cold atoms. From the theoretical viewpoint, the 1D systems are expected to be fabricated as follows: the trap potential makes the spectrum of the 2D trap-plane dynamics discrete, and then almost all the atoms enter in the lowest band. So far, many theoretical works of 1D cold atoms have been done under this assumption. However, if we change the total number of cold atoms, the strength of the potential, etc, we can obtain a situation where atoms occupy the higher bands as well as the lowest one. Following this idea, we consider effects of higher bands in 1D repulsively interacting Bose gases. If we assume that the trap potential is a 2D harmonic type, the angular momentum "L" defined in the 2D plane becomes a good quantum number and the band structure in the remaining 1D direction is followings: the lowest band has L=0, the second lowest ones are doubly degenerate with L=+1 and -1, etc. For simplicity, we suppose that Bose atoms occupy only the lowest three bands. For this situation, we show that when the inter-atom interactions are sufficiently weaker than the trap potential, they and quantum fluctuations make the occupation numbers of L=+1 and -1 bands imbalanced, and as a result, a spontaneously rotating ground state emerges. In this state, the Z_2 reflection symmetry is spontaneously broken. I will talk about the mechanism of this new symmetry breaking in detail.

PS06

Monte Carlo Study of Quantum Phase Transition in the Quasi-One-Dimensional SU(N) model

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In recent numerical studies, it is argued that the Landau-Ginzburg-Wilson (LGW) paradigm of phase transition fails in a number of quantum phase transitions. For example, a quantum phase transition between a Néel phase and a valence bond solid (VBS) phase. According to the LGW paradigm, a direct phase transition between these two phase should be of first order, because both phase break symmetries in distinct spaces: the Néel state breaks the SU(2) symmetry of the Hamiltonian, while the VBS state breaks the rotational symmetry of the lattice. But recent some numerical simulations for the $S = 1/2$ Heisenberg models with four-sites interactions suggest the possibility of a continuous phase transition. This new type of quantum phase transition is called deconfinement critical phenomena (DCP) and the existence of the DCP is in controversy. In this Monte Carlo study, the quantum phase transition of the quasi-one-dimensional SU(N) Heisenberg model is investigated. In the $N = 3$ and 4 cases of this model, the VBS phase present in the one dimension does not survive in the two-dimension and the phase in the isotropic two-dimensional model breaks the SU(N) symmetry of Hamiltonian. In our previous study for the $N = 3$, as the magnitude of the interchain couplings is increased, the direct quantum phase transition between a VBS phase and a SU(3) symmetry breaking phase was observed and the phase transition seems to be continuous or of weak first order. In order to decide if the transition is second or weakly first order, we apply a quantum extended ensemble Monte Carlo algorithm to this model. It gives us precise data at low temperatures in the VBS phase. The numerical results suggest the possibility of an unconventional second-order transition not only in the SU(3) model, but also in the SU(4) model.