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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.