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Superfluid-Mott-Insulator Phase Transition of Bosons in an Optical Lattice

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Abstract: The Bose-Hubbard model describing interacting bosons in an optical lattice is reduced to a simple spin-1 XY model with single-ion anisotropy in the vicinity of the Mott phase. We propose a mean-field theory based on a constraint SU(3) pseudo-boson representation on the effective model to study the properties of the superfluid-Mott-insulator phase transition. By calculating the elementary excitation spectra and the average particle number fluctuation in the Brillouin zone center, we find that the energy gaps vanish continuously around $(J_{XY}/J_z)_c \approx 0.175$ and $(J_{XY}/J_z)_c \approx 0.094$ for 2D and 3D cubic lattices respectively, where the superfluid order parameters come up from zero and the Mott insulator state changes into a superfluid state.

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Key words: superfluid, Mott insulator, cold atom, optical lattice

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