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New formulation of Interacting Boson Model and the structure of exotic nuclei

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Recently, various exotic nuclei with intriguing collectivities have been created, which motivate us to investigate the properties of neutron-rich A$\geq$200 region nuclei far from the stability line. We study the low-lying collective states, especially the quadrupole deformations, of these heavy unstable nuclei within the interacting boson model (IBM). A conventional way for the derivation of the IBM Hamiltonian has been based on the nuclear shell model. However, the effective interaction of the shell model is so sensitive to the precise structure of nuclear force, which is not important to describe quadrupole collective states, that it's difficult to discuss only the properties of quadrupole collective modes robustly. In this study, we demonstrate that constrained Hartree-Fock+BCS method (HF+BCS) is more suitable for constructing a model of Hamiltonian for the description of the low-energy collective excitations. The parameters of the IBM Hamiltonian are determined so that its expectation value reproduces the potential energy surface calculated by HF+BCS with Skyrme-type interaction. This procedure is a new derivation of the IBM Hamiltonian, and quantitatively describes the low-lying states of medium-heavy nuclei in wide area of the nuclear chart, including unstable region at issue. Excitation spectra of several nuclei with U(5), SU(3) and O(6) dynamical symmetries, along with the newly proposed X(5) and E(5) critical-point symmetries, are well described. We suggest the manifestations of transitions from spherical to rotational
shapes in neutron-rich (A$\geq$200) Os and W isotopes and the corresponding critical point. We also discuss the further applications, for instance, to the configuration mixing in light Pb-Hg-Pt region isotopes.

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