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Coexistence and evolution of shapes: mean-field-based interacting boson model

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The nuclear shapes and collective excitations have been one of the most prominent and studied themes of nuclear structure physics. Experiments using radioactive-ion beams allow to study thus far unknown nuclei and also necessitate timely systematic, as well as reliable, theoretical analyses. The interacting boson model (IBM) has been remarkably successful in phenomenological description of low-lying states in nuclei. Microscopic foundation of the IBM, i.e., derivation of the bosonic Hamiltonian from nucleonic degrees of freedom, has been extensively studied in terms of the shell model, but it has been somewhat limited to nearly spherical nuclei.

In this presentation I will focus on a comprehensive method of deriving the Hamiltonian of the IBM from the energy density functional theory (DFT). We begin with the DFT self-consistent mean-field calculation of the potential energy surface with the relevant shape degrees of freedom. The DFT energy surface is then mapped onto the expectation value of the IBM Hamiltonian in the boson condensate state. This procedure completely determines the strength parameters of the IBM Hamiltonian, which is used to compute the excitation spectra and electromagnetic transition rates. Since the DFT framework allows for a global mean-field description of many nuclear properties over the entire region of the nuclear chart, it has become possible to derive the IBM Hamiltonian for any arbitrary nuclei. This has paved the way and allowed unprecedented opportunities to study the spectroscopy of heavy exotic nuclei in an accurate, systematic, and computationally feasible way.

Interesting applications of the mean-field-based IBM calculations include the shape phase transitions and coexistence in neutron-rich isotopes in the mass A~100 region, the possible intruder states in even-even Cd isotopes, and the spectroscopy in heavy odd-A and odd-odd nuclei, in particular, the influence of odd particles on the nature of shape phase transitions.

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