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Centrifugal stretching of ^{170}Hf in the Interacting Boson Model

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The prediction of spectra of deformed nuclei remains a challenge to microscopic models, and requires the input of collective models. Common approaches are geometric models characterizing the deformed nucleus by the well-known β- and γ-deformation parameters. Such models typically assume rigid deformations. Using the Bohr Hamiltonian [1] allows the introduction of soft potentials, as for example in the critical point solution X(5) [2], which in turn allow for vibrations. Another approach is offered by bosonic models, especially the interacting boson model (IBM) [3], which is capable to describe a large variety of nuclear structure, including vibrators [within the algebraic U(5) limit], axially-symmetric rotors [corresponding to SU(3) symmetry], and γ-soft rotors [O(6) symmetry]. More importantly, the model allows interpolation between those symmetries, giving access to the description of the spectra and electro-magnetic properties of a wide range of transitional nuclei. A feature of the model is its valence character - only nucleons in the valence space are considered, hence the number of available valence bosons (pairs of nucleons) is limited to $N < 20$ near mid-shell in the case of the rare-earth region, where typically axially-symmetric rotors are found.

Intrinsic excitations, that is vibrations such as the γ-vibrational and the $0^+_{K=0}$ band heads in rotational nuclei, are valence excitations and are well described within the IBM. A problem, however, is the reproduction of electromagnetic properties within a rotational band. New results from a recent plunger experiment on ^{170}Hf at WNSL [4] displays rising transitional quadrupole moments Q_t, similar to previous data on ^{168}Hf [5]. This effect of centrifugal stretching of the nucleus is also predicted within the confined β-soft (CBS) rotor model [6,7]. A standard IBM calculation with $N = 13$ bosons, however, shows a dramatic drop of Q_t values with increasing spin. Large-N calculation within the IBM can resolve this problem, however, at the expense of the description of intrinsic excitations. We suggest a simple procedure to obtain a simultaneous description of electromagnetic properties and energies within the ground state band of deformed nuclei, and their intrinsic excitations, demonstrated in the example of ^{170}Hf.

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