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Exploring Dynamic Symmetry in the Transitional A~ 70 Region

Nuclear shapes, or deformations, range from spherical harmonic vibrators to axially symmetric and γ-unstable (axially asymmetric) rotors, which represent the idealized limits of nuclear structure. These configurations correspond to distinct dynamical symmetries encoded within the interacting boson approximation (IBA): the spherical vibrator is associated with U(5), the axially symmetric rotor with SU(3), and the γ-soft rotor with O(6). Each symmetry is characterized by unique experimental signatures, such as the ratio of excitation energies of the first 4+ and 2+ states (R4/2), with values of 2.0 for U(5), 3.33 for SU(3), and 2.5 for O(6). These properties provide key insights into the underlying dynamics symmetries of nuclear structure. Transitions between these symmetry paradigms are governed by critical point symmetries (CPS), introduced by Iachello as a parameter-free analytical framework for transitional nuclei. The CPS framework includes X(5), associated with the transition from a spherical vibrator to an axially symmetric rotor, and E(5), which describes the transition from a spherical vibrator to a γ-soft rotor. The Z(4) symmetry further characterizes the transition between U (5) and O(6) with a fixed γ-parameter. While X(5) and E(5) symmetries have been explored in heavier nuclei such as 148,150,152Sm and Ti isotopes, evidence of Z(4) symmetry has remained scarce. Notably, most CPS studies have focused on nuclei with A > 100, with only 82Kr providing experimental support for E(5) in the lighter mass region.

In this study, we investigate the 68Ge nucleus to probe dynamic symmetries in the transitional A ~ 70 region. The low-spin structure of 68Ge was studied using a fusion-evaporation reaction performed at the Indian National Gamma Array (INGA) facility in the Tata Institute of Fundamental Research (TIFR), India. The advanced spectroscopic techniques, including RDCO, gated angular distribution, and linear polarization methods have been used to assign spin and parity to states, analyze mixing probabilities for $\Delta I = 0$ and $\Delta I = 1$ transitions, and extract B(E2) ratios for excited states. The comparisons of these experimental findings with theoretical predictions from the Z(4), E(5), and IBA models, suggest that the 68Ge exhibits Z(4) symmetry at low spins while at higher spins, the structure transitions toward E(5) symmetry, indicating a coexistence of both symmetries. This study represents the unique example of the first possible coexistence of Z(4) and E(5) symmetries in the light-mass A ~ 70 region. This work underscores the importance of spectroscopic investigations in uncovering the rich interplay of nuclear shapes and symmetries, contributing significantly to the broader understanding of nuclear structure in transitional regions.

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