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Symmetries as a framework for understanding signatures of collectivity and shape coexistence

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Abstract

Ab initio nuclear theory provides not only a microscopic framework for quantitative description of the nuclear many-body system, but also a foundation for deeper understanding of collective behavior. When the the low-lying spectra of p-shell nuclei are predicted in no-core configuration interaction (NCCI), or no-core shell model (NCSM), calculations, rotational bands with vastly different structure and deformation are found to appear within the same nucleus [1–4]. To gain insight into the structure and correlations which give rise to this emergent collective behavior and shape coexistence, we decompose the calculated wave functions by symmetry content. In particular, we consider the symmetries associated with Elliott's $\mathrm{SU}(3)$ group, which is tied to nuclear rotation and deformation, and the symplectic group $\mathrm{Sp}(3,\mathbb{R})$, which furthermore incorporates giant monopole and quadrupole resonance degrees of freedom. These decompositions demonstrate that Elliott's $\mathrm{SU}(3)$ rotational model provides a natural framework for understanding the emergence of rotational bands throughout the p-shell.

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