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# Shape coexistence in medium-mass nuclei

## Content

The complex nature of the nucleon-nucleon interaction allows for spherical, oblate and prolate deformations to appear at similar energies within the same nucleus. This phenomenon, known as shape coexistence, is widespread across the nuclear chart and it provides a crucial role in understanding nuclear structure [1].

In our study we complement shell-model calculations [2] with beyond-mean-field Hartree-Fock-Bogoliubov techniques [3] to shed light on the rich coexistence of differently deformed structures. We infer shape coexistence from multiple observables such as: quadrupole moments, $E2$ transitions, collective wavefunctions, and shape invariants. The combination of all these hints allows us to understand the complexities of shape coexistence and the notion of nuclear shape itself.

Particularly, the shape invariants provide a model-independent framework to quantify the deformation parameters and their fluctuations [4], which are significant in most nuclei. We analyze how nuclear shapes evolve across the band using an extended sum-rule method to compute the shape invariants for $J \neq 0$ states. This method sheds light on long-standing questions, such as whether doubly-magic nuclei are truly spherical, whether rigid triaxial nuclei exist, and how axially symmetric prolate and oblate nuclei really are.

For instance, $^{28}$Si presents a competition between the oblate ground state and the excited prolate rotational band (6.5 MeV), with a possible superdeformed structure at higher energies ($\sim$ 10-20 MeV). We find that $sdpf$ excitations are needed to correctly describe $^{28}$Si and that superdeformed shapes appear at 18-20 MeV [5].

The doubly-magic nucleus $^{40}$Ca also presents shape coexistence between the spherical ground state, the normal deformed rotational band (3.4 MeV) and the superdeformed rotational band (5.2 MeV) [6]. We analyze the fluctuations of the deformation parameters associated to these states.

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