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The shape of the nucleus: shape invariants and connection to $2\nu\beta\beta$

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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 perform shell-model calculations [2] to infer shape coexistence from multiple electric observables such as: quadrupole moments, $E2$ transitions, 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. We also compare these traditional low-energy methods with novel nuclear-imaging techniques based on heavy-ion collisions [3].

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 [5]. 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 [6]. We analyze the fluctuations of the deformation parameters associated to these states.

Additionally, we study the impact of differences in shapes of the initial and final nuclei for double-beta decay, including triaxiality. We find that larger deformation differences between the initial and final states lead to smaller nuclear matrix elements [7].

[1] P. E. Garrett, M. Zielińska, and E. Clément, Prog. Part. Nucl. Phys. 124, 103931 (2022).

[2] E. Caurier and F. Nowacki, Acta Phys. Pol. B 30, 705 (1999).

[3] STAR Collaboration, Nature 635, 67 (2024).

[4] A. Poves, F. Nowacki, Y. Alhassid, Phys. Rev. C 101, 054307 (2020).

[5] D. Frycz, A. Poves, J. Menéndez, in preparation

[6] D. Frycz, J. Menéndez, A. Rios, B. Bally, T. R. Rodríguez, and A. M. Romero, Phys. Rev. C 110, 054326 (2024).

[7] D. Castillo, D. Frycz, B. Benavente, J. Menéndez, arXiv:2507.21868

Author: FRYCZ, Dorian (University of Barcelona)

Co-authors: POVES, Alfredo (Universidad Autónoma de Madrid); MENÉNDEZ, Javier; CASTILLO GARCIA, Daniel (University of Barcelona/ICCUB); RIOS HUGUET, Arnau (University of Barcelona)

Presenter: FRYCZ, Dorian (University of Barcelona)