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Unveiling the shapes of the atomic nucleus

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The intricate nature of nucleon-nucleon interactions within the atomic nucleus gives rise to a rich array of collective phenomena, including the emergence of permanently deformed shapes in the nucleus' intrinsic frame of reference[1]. While spherical shapes are favored near magic numbers, most nuclei exhibit some degree of deformation, and many display shape coexistence within a narrow energy window of a few MeV. Understanding these phenomena is crucial for refining nuclear interaction models, which have significant implications for nucleosynthesis, astronomical r- and s-processes, and neutrino(less) double beta decay[2].

Nuclear spectra, characterized by rotational bands and vibrational states, provide key insights into these deformations. Careful analysis of energy levels and electromagnetic transitions reveals the vast landscape of nuclear shapes. Recent advances have also established connections between high- and low-energy physics, as data from the Large Hadron Collider now offer new ways to probe nuclear deformation. In particular, detailed studies of the quark-gluon plasma produced in heavy-ion collisions provide novel insights into the shape and structure of nuclei under extreme conditions[3].

Finally, I will discuss the challenges in accurately describing nuclear deformations, focusing on particularly intriguing cases of shape coexistence[4]. A key open question is the robustness of these nuclear shapes, as the parameters defining them often exhibit significant fluctuations, leading to mixing between different configurations.

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