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Multifaceted character of shape coexistence phenomena in atomic nuclei

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We present a recent survey of decay properties of excited 0^+ states in regions of the nuclear chart well known for shape coexistence phenomena, focusing, in particular, on even-even nuclei around the Z=20 (Ca), 28 (Ni), 50 (Sn), 82 (Pb) proton shell closures and along the Z=36 (Kr), Z=38 (Sr) and Z=40 (Zr) isotopic chains [1]. The aim is to identify examples of *extreme shape coexistence*, namely, coexisting deformed and spherical (or close-to-spherical) nuclear states, with wave functions well separated in the Potential Energy Surface (PES) with coordinates in the deformation space. Such a wave function separation may result in a substantially hindered transition between the corresponding structures. This is in analogy to the 0^+ fission shape isomers in the actinides region and to the superdeformed (SD) states at the decay-out spin in medium/heavy mass systems. In the survey, the Hindrance Factor (HF) of the E2 transitions de-exciting 0^+ states or SD decay-out states is a primary quantity which is used to differentiate between types of shape coexistence.
It is found that a limited number of 0^+ excitations (in the Ni, Sr, Zr and Cd regions) exhibit large HF values (>10), few of them being associated with a clear separation of coexisting wave functions, while in most cases the decay is not hindered, due to the mixing between different configurations. A brief discussion will be devoted to the case of the relatively light ^{64,66}Ni nuclei, where shape-isomer-like structures, of prolate deformed nature, have been observed at spin zero by performing gamma-spectroscopy investigation with different types of reaction mechanisms (i.e., proton and neutron transfer, neutron capture and Coulomb excitation) [2,3]. An analogous situation is expected to occur in $^{112-116}$Sn isotopes, for which preliminary results will be presented from experiments performed at IFIN-HH (Magurele, Romania) with ROSPHERE, and at Legnaro National Laboratory (Padua, Italy) with the AGATA tracking array. The experimental data will be interpreted in the light of state-of-the-art Monte Carlo Shell Model (MCSM) calculations [4], according to which the action of the monopole tensor force plays a relevant role in stabilizing and deepening isolated, deformed local minima in the PES, thus leading to a significant separation of the wave functions of states residing in these minima and, eventually, to shape isomerism.

References

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