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Collective Excitations in Rare-Earth Nuclei: Insights from Isoscalar Giant Resonances

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The strength distributions of Isoscalar Giant Resonances have been investigated via inelastic alpha- particle scattering on $^{142,146-150}$Nd and ^{172}Yb. All nuclei, except ^{142}Nd, exhibit deformed characteristics, with ^{172}Yb having the largest deformation with its quadrupole deformation parameter exceeds 0.3. The Isoscalar Giant Monopole Resonance (ISGMR) strength distributions reveal a characteristic splitting into two components in the deformed nuclei, while the nearly spherical ^{142}Nd exhibits a single ISGMR peak. This splitting arises from the coupling of the ISGMR with the $K = 0$ component of the Isoscalar Giant Quadrupole Resonance (ISGQR) [1]. A significant outcome of this study is the first-time observation of overtone structures in the ISGQR strength distributions of Nd isotopes, appearing around 25 MeV, as extracted using Multipole Decomposition Analysis (MDA). Overtones are well-known in the ISGMR and Isoscalar Giant Dipole Resonance (ISGDR) and they are related to the nuclear incompressibility in finite nucleus, which is in turn related to the incompressibility of nuclear matter. The observation of an overtone in the ISGQR suggests that this mode may also carry information about the incompressibility of nuclear matter. Notably, the first evidence for a high-lying E2 resonance near 27 MeV was reported in the proton decay of the ISGDR in ^{208}Pb [2].
In this talk, I will show how nuclear deformation influences these strength distributions as we transit from spherical to prolate shapes. Furthermore, I will discuss the first-ever observation of overtone signatures in the ISGQR strength distributions within Nd isotopes. The present experimental results will be compared with predictions from theoretical models.

References

[1] U. Garg et al., Phys. Rev. Lett. 45, 1670 (1980).
[2] M. Hunyadi et al., Phys. Lett. B 576, 253 (2003).
[3] M. Abdullah, S. Bagchi, M. N. Harakeh et al., Phys. Lett. B 855, 138852 (2024).

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