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Evolution of octupole collectivity in ^{221}Th

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The Ra-Th region around $A\approx 220$ offers some of the best examples of reflection-asymmetric, octupole shapes in nuclei. In odd-A nuclei, this phenomenon is manifested in terms of so-called parity-doublet structures. While several even-even nuclei are well studied, there is not much data on odd-A, proton-rich isotopes. These nuclei are of particular interest due to the coexistence and competition between quadrupole and octupole collectivity. The role of nucleon alignments in influencing shape changes can be studied, in a regime where octupole correlations are substantial. Further, the appearance of novel excitation mechanisms like rotation-induced condensation of octupole phonons [1] can be explored.

Excited states in ^{221}Th were populated through the ^{208}Pb(^{16}O,3n) reaction, at a beam energy of 86 MeV. The Indian National Gamma Array (INGA), consisting of 19 Compton-suppressed clover Ge detectors, was used to record γ rays emitted by the reaction products. The previously reported decay scheme for ^{221}Th [2] has been substantially modified and extended up to spin (39/2) $\hbar$ in the yrast sequence. In addition, a new non-yrast structure, with interleaved positive and negative parity sequences has been identified, with transitions up to spin (25/2) $\hbar$. A number of transitions linking the non-yrast and yrast structures have also been observed. Near-degenerate parity doublet structures similar to those observed in the heavier odd-A Th isotopes ^{223,225}Th are not evident in ^{221}Th (Fig. 1). Several arguments support a $7/2^{+}$ assignment for the ground state in ^{221}Th, with a dominant contribution from a K=1/2 configuration, leading to the absence of parity doublets. The moment of inertia of the positive parity states shows a pronounced increase at higher spins (Fig. 1), while the intensity in the negative parity sequence decreases rapidly, features which can be interpreted as an increase in quadrupole as compared to octupole collectivity. Cranking calculations have been performed, using the universal parameterization of the Woods-Saxon potential, including deformations (β_λ) up to λ=4, which indicate nucleon alignments beyond 0.20 MeV. The intrinsic electric dipole moments (D_0) deduced for the yrast structure (Fig. 1), along with the moments of inertia, suggest a dynamic variation of both quadrupole and octupole collectivity with spin.

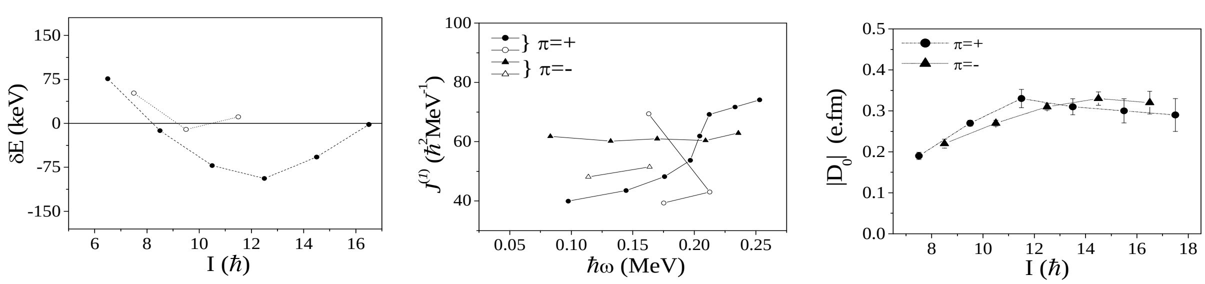

Figure 1: *Energy splitting between positive and negative parity states, kinematic moments of inertia, and intrinsic electric dipole moments (from left to right), deduced from the observed structure of ^{221}Th. The closed and open symbols in the first two panels represent yrast and non-yrast states, respectively.*

[1] S. Frauendorf, Phys. Rev. C 77, 021304(R) (2008);
[2] M. Dahlinger et al., Nucl. Phys. A 484, 337 (1988).