

Signature dependence of $1/2^+$ bands in rare-earth nuclei: Rotation-alignment of $g_{7/2}$ protons

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Abstract. The origin of the signature splitting of the $K = 1/2^+$ bands in odd Z rare-earth nuclei Ho, Tm and Lu, unexplained in previous models, is studied by angular momentum projection from deformed Hartree-Fock configurations. Energy spectra, $E2$ matrix elements and the rotation-aligned angular momenta of nucleons in $i_{13/2}$, $h_{11/2}$ and $g_{7/2}$ orbits are calculated. Staggering in the rotation-alignment of protons in the $g_{7/2}$ orbit causes signature dependent effects in the $1/2^+$ bands.

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Deformed nuclei have collective rotational bands with energy varying as $I(I + 1)$ (Bohr and Mottelson 1975). However some bands in deformed nuclei show significant deviations from this normal rotational behaviour. Rotation-alignment of nucleons occupying large j orbits not only causes backbending (Stephens 1975) but also gives rise to signature splitting in energy and electromagnetic transition rates (Hagemann *et al* 1982, 1984; Praharaj and Rath 1988). In the latter case a band is split into two branches with different signatures.

The signature quantum number α for a state of angular momentum I is defined as

$$\exp i\pi\alpha = \exp i\pi I. \quad (1)$$

Thus for an odd mass nucleus

$$\begin{aligned} \alpha &= +1/2 \quad \text{for } I = 1/2, 5/2, 9/2, \dots \\ \alpha &= -1/2 \quad \text{for } I = 3/2, 7/2, 11/2, \dots \end{aligned} \quad (2)$$

In the extreme rotation-aligned (RAL) limit, a rotational band built on a nucleonic state with the half-integral rotation-alignment “a” has the angular momentum sequence

$$I = a, a + 2, a + 4, a + 6, \dots \quad (3)$$

which is essentially the addition to “a” of an even-even core rotational band. In many nuclei the branch

$$I_{\text{favoured}} = a, a + 2, a + 4, \dots \quad (4)$$