Triaxial nuclei: Change in axis of rotation at high spin

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Introduction

Most deformed nuclei are axially symmetric at low spins. The collective rotation is then possible only about the axis perpendicular to the symmetry axis. However, some nuclei are found to have triaxial shapes. For a triaxial nucleus, there is a possibility of rotation around any of the principal axes. There has been lot of interest in understanding the role of triaxiality on the interesting phenomena like signature inversion and chirality. We have explained the cause of signature inversion in ^{126}I [1] to be the change in the axis of rotation from the shortest axis to intermediate axis of the triaxial nucleus. Conceptually, the rotational axes involved at low and high spins seemed to be in reverse order. Nonetheless, our explanation was supported by the classical arguments presented by Ikeda *et al.* [2]. Here I present our result on signature inversion observed in ^{126}I and discuss it in the light of existing theories.

Experiment and results

The experiment was performed using the heavy-ion fusion reaction ^{124}Sn(^{7}Li, 5n)^{126}I at the Pelletron accelerator facility at the Inter University Accelerator Center, New Delhi, India. The Indian National Gamma Array (INGA), consisting of 15 Compton suppressed clover HPGe detectors, was used. Other details of the experiment, data analysis and results were given in Ref. [1]. As shown in Fig. 1, signature splitting and signature inversion was observed at $13\hbar$ in the yrast negative-parity band based on the valence particle configuration $\pi d_{5/2} \otimes \nu h_{11/2}$.

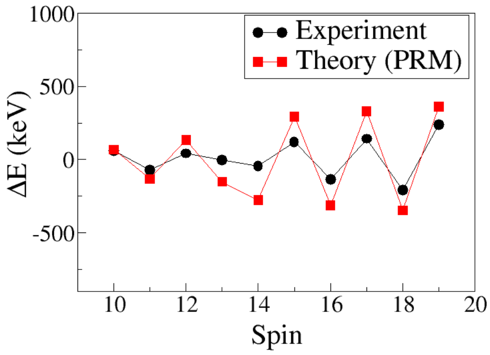

FIG. 1: Signature splitting and signature inversion in the yrast band of ^{126}I [1]

Theoretical discussion

We performed the calculation of total Routhian surface (TRS) using the computer code Ultimate Cranker [3]. The quadrupole deformation parameter ϵ_2 and the triaxiality parameter γ were defined in the Lund convention; wherein the positive and negative values of γ correspond to the rotation around the shortest and intermediate axes, respectively. The energy contour plots using TRS calculation were generated at the low rotational frequency $\hbar\omega = 0.16$ MeV and above the signature inversion $\hbar\omega = 0.33$ MeV. At these frequencies the energy minima, shown by a dot in Fig, 2(a) and Fig. 2(b), correspond to $\epsilon_2 \simeq 0.15, \gamma \simeq +55°$ and $\epsilon_2 \simeq 0.15, \gamma \simeq -38°$, respectively. Using these values of the deformation parameters, we preformed the particle rotor model (PRM) calculation. A near agreement with the experimental data was obtained for the valence particle configuration $\pi d_{5/2} \otimes \nu h_{11/2}$ as seen in Fig. 1. In this figure $\Delta E(\equiv[E(I)-E(I-1)]-1/2[E(I+1)-E(I)+E(I-1)-E(I-2)])$ is plotted as a function of spin. For the odd-odd nuclei, the signature quan-

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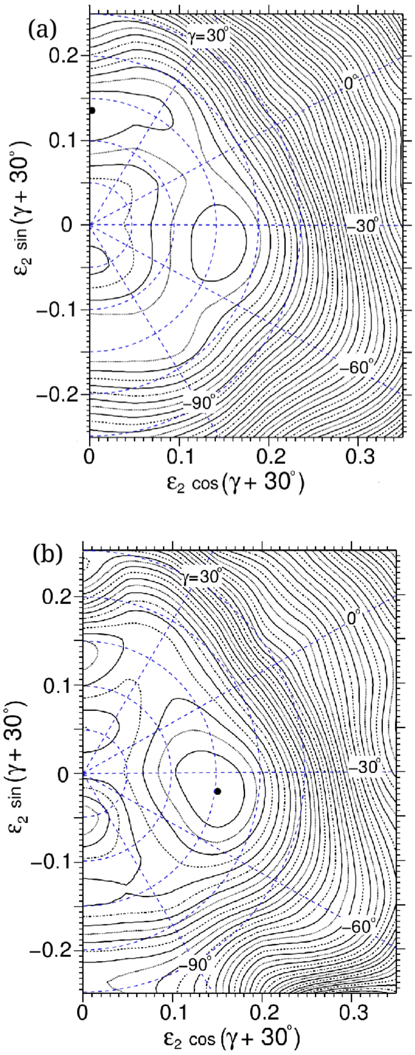

FIG. 2: Contour plot of the TRS calculation for the yrast band at the rotational frequency (a) $\hbar\omega = 0.16$ MeV and (b) $\hbar\omega = 0.33$ MeV [1].

tum number for the favored state is $\alpha_f = \frac{1}{2}[(-1)^{j_p-\frac{1}{2}} + (-1)^{j_n-\frac{1}{2}}]$. We observed the unfavored states to be lower in energy as compared to favored states below the signature inversion; and reverse was the case above the signature inversion. Thus, in ^{126}I we found the change from the anomalous signature splitting to normal signature splitting with increasing angular momentum for nuclei with high degree of triaxiality. Furthermore, the corresponding change was also observed in the rotational axis from the shortest axis to the intermediate axis. The same change in the axis of rotation was understood by Gao *et al.* [4] on the basis of a completely different theoretical approach, the calculation of projected shell model.

Many nuclei show the opposite behavior, *i.e.* the change from the normal to anomalous signature splitting at the inversion point. The question which needs to be addressed is whether the rotational axis shifts from intermediate axis to shortest axis, if all these nuclei are triaxial. Hamamoto [5] suggested that signature inversion should not be taken as the evidence for the triaxial shape because some nuclei with symmetric shape also show signature inversion.

References

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