Systematic study of anomalous features of ^{241}Am

Poonam Jain[1],* Alpana Goel[2], and S. K. Mandal[3]
[1,2]*Amity Institute of Nuclear Science and Technology (AINST), Amity University, Noida - 201303, INDIA and*
[3]*Department of Physics and Astrophysics, University of Delhi, Delhi - 110007, INDIA*

Introduction

Signature is a quantum number related to the invariance of a system with deformation under its rotation by 180 degree quadrupole around a principal axis. Thus we can call the symmetry turn about invariance. When the system is axially symmetric, only the turn about around principal axes other than the symmetry axis can be used to define the signature quantum number. Signature takes on only two different values in odd-A nuclei, according to the total spin. It is customary to assign,

$$\alpha_I = \frac{1}{2}(-1)^{I-\frac{1}{2}} \tag{1}$$

as the signature quantum number to a state of spin of an odd-A nucleus. In Bohr and Mottelson's strong coupling model, a rotational band is characterized by its intrinsic structure and is a sequence of levels differing in spin by $1\hbar$ [1]. Signature now splits such a rotational band into two families, I≡j(mod2) and I≡j+1(mod2) each consisting of levels differing in spin by $2\hbar$ according to Eq. (1). The I≡j(mod2) sequence is shifted downward in energy against the other [2]. This is why the I≡j(mod2) sequence is customarily called the favored signature and the other, unfavored signature partner. The difference in energies between the favored and unfavored partners at a given rotational frequency is called the signature splitting and this can be characterized by energy staggering.

As the rotational band increases in spin the favored and unfavored signatures of the band may cross each other resulting in so called signature inversion which can be seen by plotting ΔE(I⟶I-1)/2I vs I. The authors Jain, Goel and Jain et al. demonstrated that in case of odd-odd nuclei [3–5], the signature inversion is a result of coriolis mixing arising from the coupling of the πh11/2 proton orbitals and νi13/2 neutron orbitals. A large amount of experimental information has been collected showing that the πg9/2⊗νg9/2 bands in $A = 80$, as well as, the πh11/2⊗νh11/2 bands in $A = 130$ and the πh11/2⊗νi13/2 bands in $A = 160$ mass regions systematically show signature inversion [6].

In this work, rotational bands of ^{241}Am are examined. The signature reversal are observed in high-j (πf7/2, πh9/2 and πi13/2 proton) bands in odd-A nuclei. We have analysed the experimental data for πf7/2, πh9/2 and πi13/2 configurations for actinide region for ^{241}Am nuclei. For (πh9/2) configuration, $\alpha = +1/2$, the even members should lie lower in energy. It has been observed that the odd-spin members are lying in lower energy; this is anomalous feature; the normal signature dependence is restored before it and after high spin (55/2). For (πi13/2) configuration, $\alpha = +1/2$, again the even members should lie lower in energy but as per observation odd spin members are lying in lower energy.

For (πf7/2) configuration, $\alpha = -1/2$, the odd members should lie lower in energy. It has been observed that the even-spin members lie in lower energy during signature splitting. This anomalous effect is known as signature reversal. In the experimental plot, anomalous effect is shown by arrowhead. These features are well explained by two quasi particle plus rotor model (TQPRM) model in odd-odd and even-even nuclei [7]. We are now in process

*Electronic address: poonam.jn1@gmail.com

of developing a model for one quasi particle. The results are expected in near future from our theoretical model calculations.

Result and Discussion

We have analyzed the experimental data for πf7/2, πh9/2 and πi13/2 configurations for ^{241}Am nuclei. In figure, we summarize the trend for signature reversal in rotational bands of ^{241}Am nuclei. In this figure, we plot the ratio of ΔE(I$\longrightarrow$I-1)/2I vs I.

The experimental observation has revealed the following: (1) For configuration $K^{\pi} = 5/2^{-}$[523], the nomal behaviour is observed before spin (31/2). The inversion takes place at high spin (31/2) represented by arrowhead and termed as anomalous feature and the normal feature is restored again at higher spin (61/2) shown by circle. (2) For configuration $K^{\pi} = 5/2^{+}$[642], the anomaly observed at low spin (9/2). (3) For configuration $K^{\pi} = 3/2^{-}$[521], the signature splitting is clearly observed and the reversal is present for the complete band. (4) The behaviour of $K^{\pi} = 5/2^{+}$[642] and $K^{\pi} = 3/2^{-}$[521] are opposite to each other.

An analysis of the results revealed that the mechanisms, which may be responsible for the signature reversal, is coriolis force that plays an important role in influencing the structure of deformed nuclei both at low and high spins. Although many coriolis band-mixing calculations have been carried out in the past for rotational bands in odd-odd/even-even nuclei, (Goel et al.) same we are expecting for the ^{241}Am Odd-A nuclei [4].

Overall, systemetic study have been analysed and more precise future calculations are expected to tighten the same results from the theoretical model.

References

[1] A. Bohr and B. R. Mottelson, Nuclear Structure (Benjamin, Reading, MA) **Vol. II**, (1975).

[2] A. Ikeda and T. Shimano, Phys. Rev. C **40**, 149 (1990).

[3] A. K. Jain et al., Rev. Mod. Phys. **62**, 2 (1990).

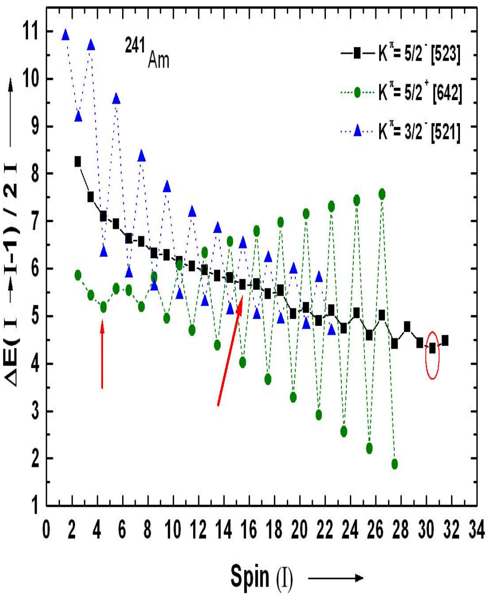

FIG. 1: Experimental energy spectrum of ^{241}Am bands.

[4] A. Goel et al., Phys. Lett. B **277**, 233 (1992).

[5] K. Jain et al., At. Data and Nucl. Data Tab. **50**, 269 (1992)

[6] V. Kumar et al., Int. J. Mod. Phys. E **20**, 1455 (2011).

[7] A. Goel and A. K. Jain, Phys. Lett. B **337**, 240 (1994).