ΔI=2 staggering in superdeformed bands of different mass regions

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Introduction

The discovery of superdeformation is a remarkable advent in the field of nuclear structure physics. In comparison to the fission isomers in the actinides; many SD bands have now been established in different A∼60,80,130,150,190 mass regions. Many attempts are made to understand the unresolved physics of the SD bands and number of fascinating unique features such as identical bands and ΔI=2 staggering. It was observed that some cases of SD bands display unexpected ΔI=2 staggering in their transition energies cascades. The E_γ transition energies of SD bands are therefore gets splitted into two cascades with the varying spin values i.e. $I, I+4, I+8, ...$ and $I+2, I+6, I+10, ...$ repectively. The magnitude of separation is observed to be in the range of eV to a few keV. Many theoretical interpretation about the ΔI=2 staggering has been made. One of the viewpoint being based on the C_4 symmetry [1]. The staggering is linked with the adjustment of the total angular momentum along the axis perpendicular to the long deformation axis of a prolate nucleus [2]. The phenomenon can also be defined as the mixing of the SD rotational bands differ by ΔI=4 or originates from the mixing of two SD rotational bands situated near the yrast line.

The search of ΔI=2 staggering in SD bands possessing same F_0 symmetry in different mass regions are presented in this paper.

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Formalism

The presence of ΔI=2 staggering is determine by computing the fourth derivative of the transition energies E_γ at given spin [3] by

$$\Delta^4 E_\gamma(I) = 1/16\Big[E_\gamma(I-4) - 4E_\gamma(I-2) + 6E_\gamma(I) - 4E_\gamma(I-2) + E_\gamma(I+4)\Big] \quad (1)$$

The above formula involved five consecutive E_γ transition energies and hence it is denoted as five point formula. The formula shows the finite difference approximation to the fourth derivative of E_γ transition energies w.r.t spin. The experimentally observed rotational frequency ($\hbar\omega$) for SD bands are generally detected from the observed E_γ transition energies between two consecutive transitions of the corresponding SD bands.

$$\hbar\omega = \frac{E_\gamma(I) + E_\gamma(I+2)}{4} \quad (2)$$

Here, we have calculated the $\Delta^4 E_\gamma(I)$ for SD bands possessing same F_0 symmetry in different mass regions and plotted as the function of $\hbar\omega$.

Results and Discussion

Here, we have chosen the pairs of SD bands i.e.($^{134}Nd(1)$ and $^{130}Ce(1)$, $^{144}Gd(1)$ and $^{148}Gd(1)$, $^{195}Tl(1)$ and ^{197}Bi) possessing same F_0 symmetry from different mass regions. The $\Delta^4 E_\gamma(I)$ is calculated for all the chosen pairs of SD bands and plotted as the function of $\hbar\omega$. A large amplitude staggering patterns are observed for all the chosen pairs of SD bands (see Figs. 1, 2 and 3).

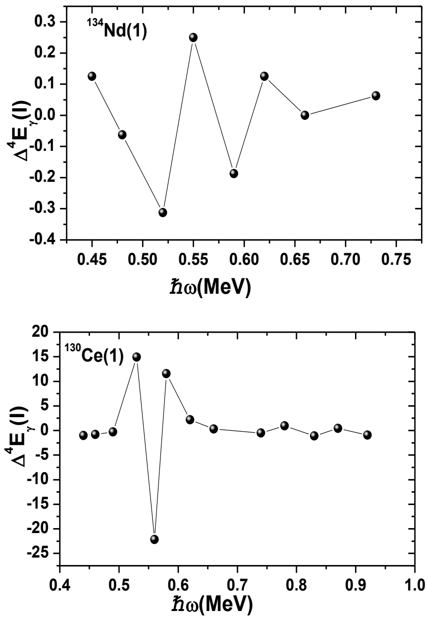

FIG. 1: ΔI=2 staggering pattern of SD nuclei pairs in A∼130 mass region.

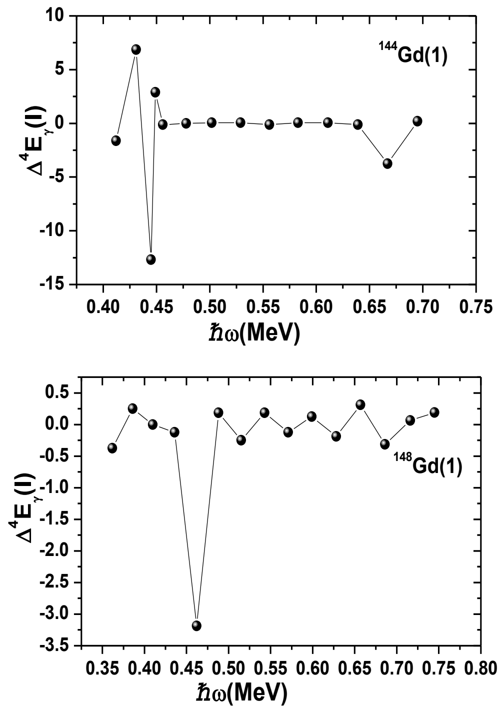

FIG. 2: ΔI=2 staggering pattern of SD nuclei pairs in A∼150 mass region.

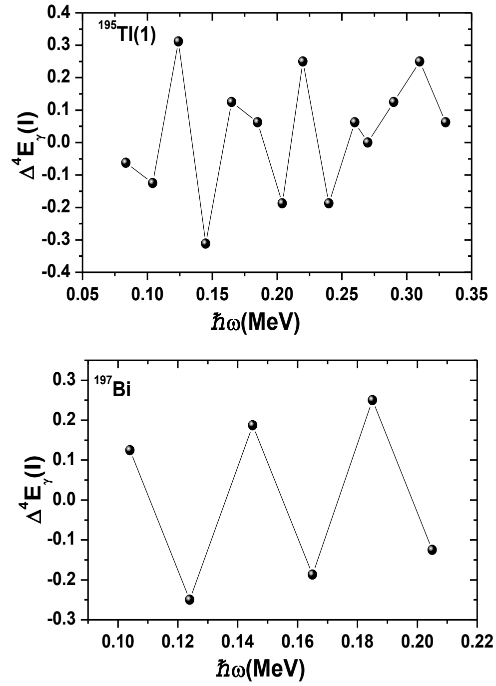

FIG. 3: ΔI=2 staggering pattern of SD nuclei pairs in A∼190 mass region.

Conclusion

In this present work, we have search the ΔI=2 staggering in SD bands possessing same F_0 symmetry in different mass regions. A large amplitude staggering patterns starting from low values and gradually increasing with spin values are observed for all the chosen pairs of SD bands.

References

[1] S. Flibotte et al., Phys. Rev. Lett., 71 (1993) 4299.

[2] I. M. Pavlichenkov and S. Flibotte, Phys. Rev. C, 51 (1995) R460(R).

[3] B. Cederwall et al., Phys. Rev. Lett. 72, (1994) 3150.