Study of $\Delta I = 2$ staggering in Eu and Dy isotopes

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Introduction

The superdeformed band (SD) in A≈190 mass region have been observed down to quite low spin. Also many bands show the smooth rise in the dynamical moment of inertia as rotational frequency increases. A zigzag behavior of the SD nucleus was observed as a function of spin which was unexpected in transition energies of superdeformed nuclei.

Superdeformed (SD) states have been discovered widely in several mass region. More than 200 SD bands well established in the A=60; 80; 130; 150 and 190 regions. In the past years much effort has been devoted to the study of underlying physics of SD bands and a number of interesting issues such as the identical bands [1], the $\Delta I = 2$ staggering [2] etc have been raised. In addition, the $\Delta I = 1$ staggering was reported in [3], [4]. It was found that some SD bands show an unexpected $\Delta I = 2$ staggering in their γ-ray transition energies. The SD energy levels are consequently separated into two sequences with spin values $I, I+4, I+8, \ldots$ and $I+2, I+6, I+10 \ldots$ respectively. The magnitude of splitting is found to be of some hundred eV to a few keV.
Several theoretical explanation have been made. One of the earliest ones being based on the assumption of a C4 symmetry. Also it was suggested that the staggering is associated with the alignment of the total angular momentum along the axis perpendicular to the long deformation axis of a prolate nucleus. The staggering phenomenon also interpret as the mixing of a series of rotational bands differ by $\Delta I = 4$ or arise from the mixing of two bands near yrast line or by proposing phenomenological model [5], [6].
In this paper we are calculating the staggering in Eu and Dy SD bands nuclei.

Study of $\Delta I = 2$ staggering

Another interesting feature of SD nuclear bands is that $\Delta I = 2$ staggering sequences of states, differ by four units of angular momentum, are delocated with respect to each other. Many theoretical proposals were put forward for the possible clarification of the $\Delta I = 4$ bifurcation [9, 10].
The variation of the γ-ray transition energies from the rigid rotor behavior can be calculated by the staggering quantity [11]. $\Delta I = 2$ staggering is determined by the fourth derivative of the transition energies $E_\gamma(I)$ at a given spin (I) by:

$$\Delta^4 E_\gamma(J) = \frac{1}{16}\,[6E_\gamma(J) - 4E_\gamma(J-2) - 4E_\gamma (J+2) + E_\gamma(J-4) + E_\gamma(J+4). \quad (1)$$

The formula involves five consecutive transition energies E_γ and hence called five point formula. The expression for the rotational frequency $\hbar\omega(I)$ of the nuclei is

$$\hbar\omega(I) = E_\gamma(J+1 \to J-1). \quad (2)$$

Result and Discussion

Figure 1 shows the variation of staggering index with $\hbar\omega$ for ^{142}Eu(SD), ^{143}Eu(SD), ^{144}Eu(SD-2) and ^{144}Eu(SD-3). The SD nuclei ^{142}Eu(SD), ^{143}Eu(SD), and ^{144}Eu(SD-3) show large amplitude of staggering index while ^{144}Eu(SD-2) shows low amplitude of staggering index at low value of $\hbar\omega$. But with increase in $\hbar\omega$ the amplitude of staggering index get increased. Figure 2 shows the large amplitude

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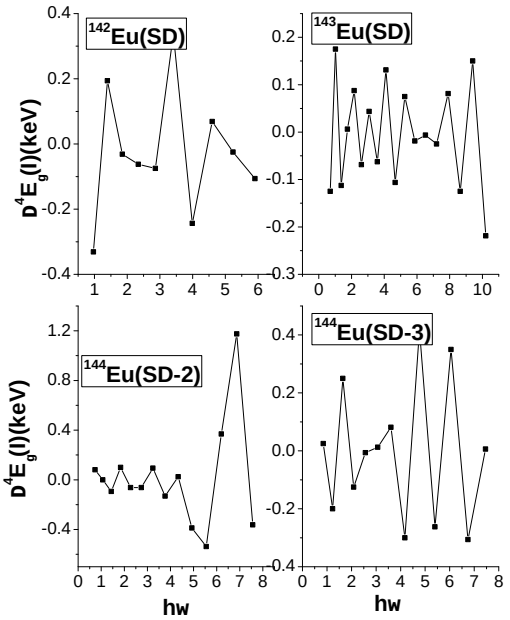

FIG. 1: $\Delta^4 E_\gamma$ staggering pattern for the ^{142}Eu(SD), ^{143}Eu(SD), ^{144}Eu(SD-2) and ^{144}Eu(SD-3).

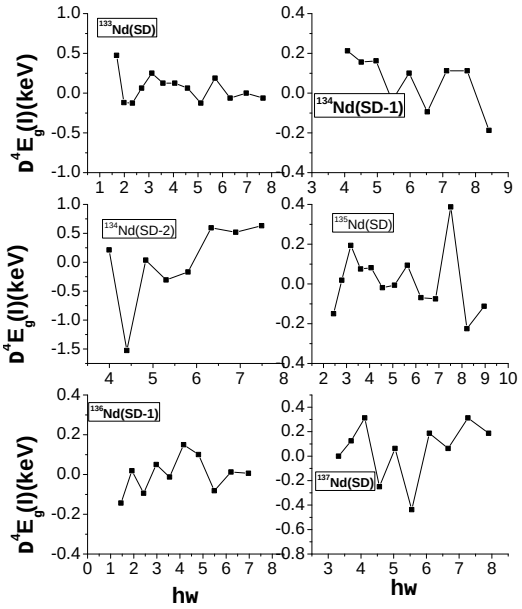

FIG. 2: $\Delta^4 E_\gamma$ staggering pattern for the ^{133}Nd(SD), ^{134}Nd(SD-1), ^{134}Nd(SD-2), ^{135}Nd(SD),^{136}Nd(SD-1) and ^{137}Nd(SD).

of staggering index for ^{133}Nd(SD), ^{134}Nd(SD-1), ^{134}Nd(SD-2), ^{135}Nd(SD), ^{136}Nd(SD-1) and ^{137}Nd(SD).

Conclusion

The Figure 1-2 show the $\Delta I = 2$ staggering in some selected SD nuclei. The isotopes of Eu nuclei show the large amplitude of staggering than Nd isotopes. The nuclear staggering effects in the transitions energies of some SD nuclei have been examined. Transition energies of many SD bands have been calculated.

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