$\Delta I = 2$ staggering in Ce nuclei

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Introduction

Superdeformed (SD) states have been discovered widely in several mass region. A part from the fission isomers in the actinides, 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 ΔI= 1 staggering was reported in [3], [4]. It was found that some SD bands show an unexpected ΔI = 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 was also interpreted 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].

The discussion on the $\Delta I = 2$ staggering in isotopes ^{131}Ce(SD-1)(SD-2) and ^{132}Ce(SD-1)(SD-2) nuclei are presented in this paper.

Test of $\Delta I = 2$ staggering

Another feature of SD nuclear bands is the $\Delta I = 2$ staggering sequences of states differ by four units of angular momentum. A few theoretical proposals for the possible explanation of this $\Delta I = 4$ bifurcation were made. The deviation of the γ-ray transition energies from the rigid rotor behavior can be measured by the staggering quantity [7]

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

This formula include five consecutive transition energies E_γ and is denoted by five-point formula. It represents the finite difference approximation to the fourth derivative of the transition energies with respect to the spin in a $\Delta I = 2$ band. The experimental $\hbar\omega$ and $\Im^2$ for the SD bands are usually extracted from the observed energies of gamma transition between two consecutive transitions within the band from the following formulae:

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

$$\Im^2 = \frac{4}{E_\gamma(I) + E_\gamma(I+2)} \quad (3)$$

We calculated the staggering quantity $\Delta^4 E_\gamma$ and plotted it as a function of rotational frequency $\hbar\omega$.

Result and Discussion

We calculated the staggering quantity $\Delta^4 E_\gamma$ and plotted it as a function of rotational frequency $\hbar\omega$. Figure 1 shows the staggering pattern $\Delta^4 E\gamma$ for the ^{131}Ce(SD-1) and ^{131}Ce(SD-2) band. For ^{131}Ce(SD-1), staggering values lie from -0.2 to 0.1 and with increasing neutron number the staggering also get increased. For ^{131}Ce(SD-2) staggering index lies between -0.3 to 0.4 . Figure 2 shows the

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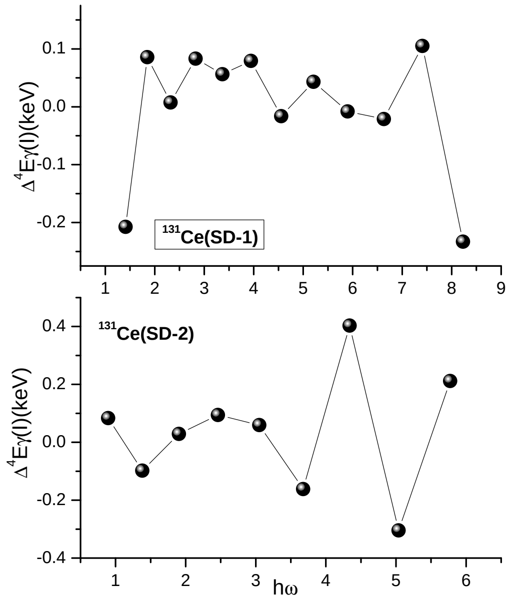

FIG. 1: $\Delta^4 E_\gamma$ staggering pattern for the ^{131}Ce(SD-1) and ^{131}Ce(SD-2).

staggering pattern $\Delta^4 E\gamma$ for the ^{132}Ce(SD-1) and ^{132}Ce(SD-2). The staggering index for ^{132}Ce(SD-1) lies between -0.4 to 0.2 and this band shows large constant staggering and for ^{132}Ce(SD-2) the staggering index lies between -1 to 1.

Conclusion

In summary, the $\Delta I = 2$ staggering of SD bands in Ce nuclei has been investigated thoroughly. A large amplitude of staggering is found in these Ce bands. 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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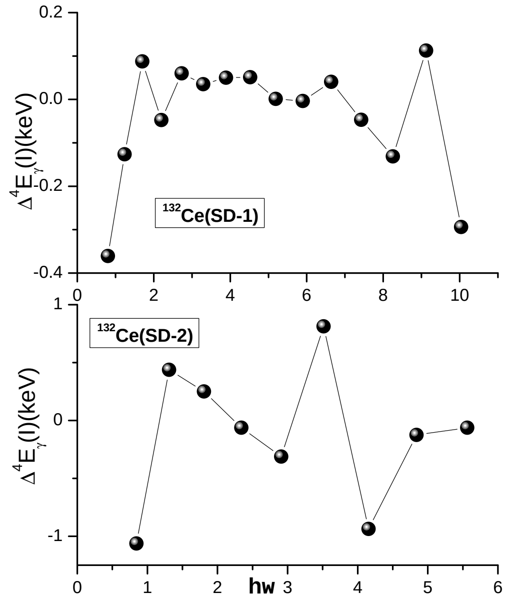

FIG. 2: $\Delta^4 E_\gamma$ staggering pattern for the ^{132}Ce(SD-1) and ^{132}Ce(SD-2).

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