Odd-even staggering of superdeformed band of ^{80,81,83}Sr and ^{89,91}Tc nuclei

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Introduction

Despite the rather large amount of experimental information on Superdeformed bands, still there are a number of very interesting properties, which have not yet been measured. For example, the spin, parity and excitation energy relative to the ground state of the SD-bands. The difficulty lies with observing the very weak discrete transitions which link SD levels with levels of normal deformation (ND). Several related approaches to assign the spins Superdeformed bands in terms of their observed γ-ray transition energies were proposed [1].
Superdeformed (SD) nuclei are some of the best quantum rotors known. Their characteristic long sequences of equally spaced transition energies provide a unique opportunity to search for unexpected effects on an energy scale rarely achieved elsewhere in nuclear physics.
In this context the recent observation of a regular staggering pattern of the transition energies in the yrast SD band in ^{149}Gd [2], where states differing by four units of angular momentum show a similar energy shift of about 60 eV relative to a (smooth) rotational sequence, is particularly intriguing.
The $\Delta I = 2$ staggering was also observed in some SD bands [3, 4]. It manifests itself in systematic shifts of the energy levels, which are alternately pushed down and up with respect to a purely rotational sequence. To date, some models have been proposed to explain the experimental results [4].

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Study of $\Delta I = 2$ staggering effect

Another interesting feature of SD nuclear bands is that ΔI= 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 ΔI= 4 bifurcation [5].

The $\Delta I = 2$ staggering effect is one of the engrossing feature of the SD bands where SD energy levels split into a zigzag sequence separated by $\Delta I = 4$ (bifurcation) shifting up in energy and intermediate shifting down in energy. Some theoretical proposal were taken into account for possible explanation of $\Delta I = 4$ bifurcation [6].
For each SD band, the deviation of gamma-tarnsition energies from a rigid rotor behaviour is determined by calculating the staggering quantity [7].

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

where $\Delta^4 E_\gamma$ is the fourth derivative of the γ-ray transition energies at given spin. This formula is denoted as the five point formula due to the collusion of five consecutive γ-ray transition energies.

The Figure 1 and 2 show the experimental and calculated staggering parameter for ^{80}Sr(SD-1), ^{81}Sr(SD-1), ^{83}Sr(SD) and ^{89}Tc(SD), ^{91}Tc(SD). The calculated staggering parameter show large amplitude for ^{80}Sr(SD-1) while experimental one shows small amplitude and decreases with increase in spin value. The SD nucleus ^{81}Sr(SD-1)

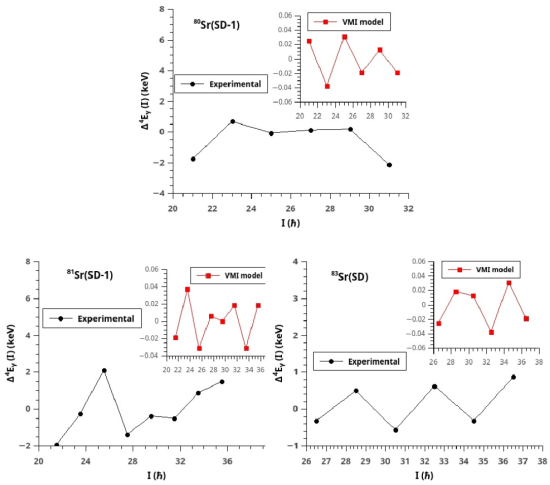

FIG. 1: Variation of calculated and experimental $\Delta^4 E_\gamma$ staggering parameter as function spin for ^{80}Sr(SD-1), ^{81}Sr(SD-1) and ^{83}Sr(SD)

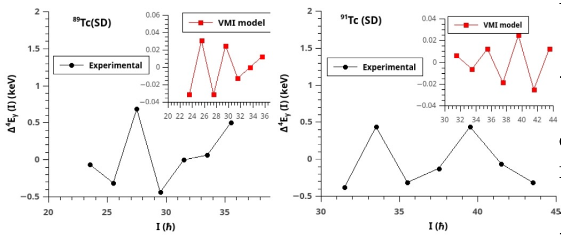

FIG. 2: Variation of calculated and experimental $\Delta^4 E_\gamma$ staggering parameter as function spin for ^{89}Tc(SD) and ^{91}Tc(SD)

show small amplitude for both experimental and calculated staggering parameter at low spin value which further get increased with increase in spin.
For ^{83}Sr(SD), the experimental staggering index shows large amplitude while the calculated one shows small amplitude which directly vary with spin values. For ^{89}Tc(SD), the experimental staggering index shows low amplitude at low spin value but later get increased with increasing spin value. The calculated staggering index show small amplitude for both ^{83}Zr(SD-1)and ^{89}Tc(SD) which decrease with increasing spin. The SD nucleus ^{87}Nb(SD-2) have large amplitude for calculated staggering index but small for experimental.
For ^{91}Tc(SD), both calculated and experimental staggering parameter show same amplitude. But experimental amplitude get decreased while the calculated get increased with spin value

Conclusion

The $\Delta I = 2$ staggering effect is investigated experimentally and theoretically for ^{80}Sr(SD-1), ^{81}Sr(SD-1), ^{83}Sr(SD), ^{89}Tc(SD), ^{91}Tc(SD) using five point formula. The staggering patterns well reproduce by VMI model. All these discussions indicate the VMI model as a suitable tool to study the spectroscopy of SD bands in low mass regions.

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