Study of dynamic moment of inertia versus rotational frequency for superdeformed bands in ^{83}Y

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Introduction

The study of spin determination is an essential step towards characterizing the overall nature of superdeformed (SD) bands in various mass regions. The kinematic moment of inertia ($J^{(1)}$) and dynamic moment of inertia ($J^{(2)}$) are the critical parameters to investigate the spectroscopy of SD bands in further detail. $J^{(1)}$ completely depend upon spins, in contrast to $J^{(2)}$. Because the spin assignments of the SD bands in various mass regions are still up for debate, $J^{(2)}$ is primarily considered. In the context of the N_pN_n scheme, Sharma et al. [1] examined the systematics of $J^{(1)}$ and $J^{(2)}$ in A∼190, 150, and 130 mass regions. There is a continuous increase of $J^{(2)}$ with rotational frequency ($\hbar\omega$) for the mass region A∼190 and a continuous decrease of $J^{(2)}$ with rise of $\hbar\omega$ for A∼150,130. SD bands were seen in the A∼80 mass region up to $\hbar\omega$ of approximately 1.3 $MeV/\hbar$ [2], in contrast to A∼190, 150, and 130 mass regions. In nuclei with atomic numbers Z=38 − 40 and N=42 − 45, the estimate for extremely elongated forms with an axis ratio of 2:1 was discovered in the A∼80 mass region [3–8]. Baktash et al. [9] observed similar estimates experimentally in $^{83}Sr(1)$. In this present work, the calculated transition energies of ^{83}Y(1,2,3,4)SD bands obtained from various rotational energy formulae i.e nuclear softness formula [10], VMI model [11] , VMINS3 model [12], four parameter formula [13] are used to calculate $J^{(2)}$ and its variation with $\hbar\omega$ is investigated.

Formalism

A) Nuclear softness formula [10]

$$E_\gamma(I) = \frac{\hbar^2}{2\Im_0} \times \left[\frac{I(I+1)}{(I+\sigma I)} - \frac{(I-2)(I-1)}{1+\sigma(I-2)}\right]. \quad (1)$$

B)VMI model [11]

$$E_\gamma(I \to I-2) = \frac{[I(I+1)-(I-2)(I-1)]}{2\Im_0} + \frac{[I(I+1)]^2 - [(I-2)(I-1)]^2}{8C(\Im_0)^4}. \quad (2)$$

C)VMINS3 model [12]

$$E_I = \frac{\hbar^2}{2\Im_0}\frac{I(I+1)}{(1+\sigma_1 I)} + \frac{1}{2}C\Im_0^2 I^2 \sigma_1. \quad (3)$$

D)Four parameter formula [13]

$$\begin{aligned} E_\gamma(I \to I-2) &= A(I(I+1) - (I-2)(I-1)) \\ &+ B((I(I+1))^2 - ((I-2)(I-1))^2) \\ &+ C((I(I+1))^3 - ((I-2)(I-1))^3 \\ &+ D((I(I+1))^4 - ((I-2)(I-1))^4). \end{aligned} \quad (4)$$

E)Dynamic Moment of Inertia ($J^{(2)}$)

$$\Im^{(2)}(I) = 4000/[E_\gamma(I+2) - E_\gamma(I)]. \quad (5)$$

F) Rotational Frequency ($\hbar\omega$)

$$\hbar\omega = \frac{E_\gamma(I) + E_\gamma(I+2)}{4}. \quad (6)$$

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Results and Discussion

The $J^{(2)}$ scatters at around $25\hbar^2/MeV$ in A∼80 mass region. Upbends are visible in the SD bands at high rotational frequencies in the ^{83}Y nucleus [2] due to a rotational alignment of a pair of nucleons. Hence, it is observed from Fig. 1 that this type of trend is well reproduced by four parameter formula for all the ^{83}Y(1,2,3,4) SD bands.

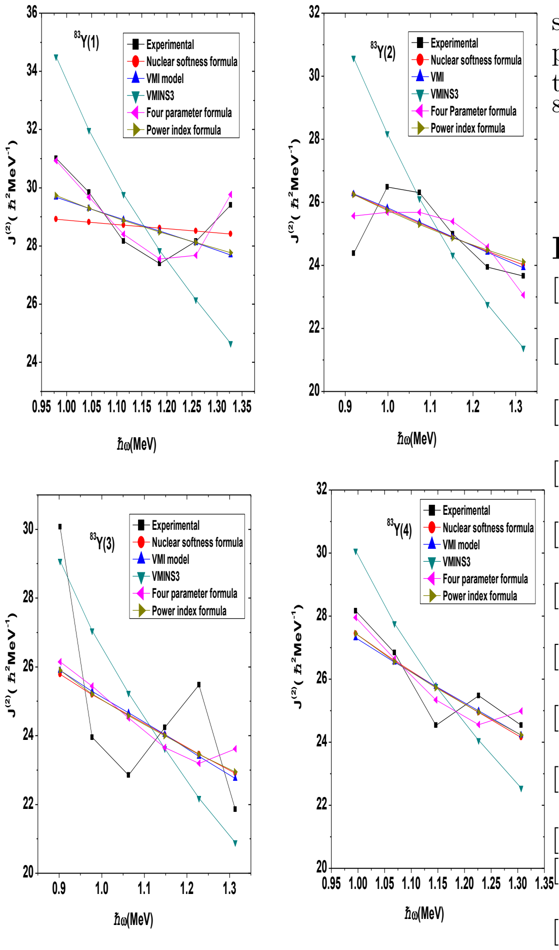

FIG. 1: Variation of calculated result of dynamic moment of inertia $J^{(2)}$ with rotational frequency for ^{83}Y(1,2,3,4) SD bands in $A \sim 80$ mass region and comparison with experimental data.

Conclusion

To study the behaviour of SD bands the dynamic moment of inertia $J^{(2)}$ is a vital quantity. The change of $J^{(2)}$ with $\hbar\omega$ for ^{83}Y(1,2,3,4) SD bands is investigated in present study. As reported in Ref.[2] $J^{(2)}$ with $\hbar\omega$ for ^{83}Y SD nuclei show upbends at high rotational frequency due to a rotational alignment of a pair of nucleons. In the present study also it is well noticed that the same experimental trend is followed by four parameter formula for all four SD rotational bands in ^{83}Y.

References

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