Systematic study of moment of inertia and softness parameter of superdeformed bands in A ≈ 60-90 mass region

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Introduction

The study of atoms and its constituents has been always fascinating and challenging to all nuclear physicists since their discoveries. The nucleus shape can be oblate, prolate, and triaxial under extreme deformation. Thus the superdeformation has always been an important tool to study the nuclear structure under extreme deformation since it was first discovered in ^{152}Dy by Twin [1]. The superdeformed (SD) bands are regular cascades of gamma ray transitions, have an ellipsoidal shape with an axis ratio around 2:1 and deformation parameter β around 0.5 [1]. Till date the SD bands have been observed in four primary mass regions including A ≈ 190, 150,130, and 100 [2-4]. The study of SD bands in A ≈ 60-90 lower mass region is interesting due to its special characteristics like high frequency range, shape coexistence phenomenon, and onset of triaxiality in Sr, Zr, Mo, and Nb nuclei [5-6]. Therefore, in this manuscript we have studied the softness parameter σ and moment of inertia J_0 of various SD bands in A ≈ 60-90 mass region using nuclear model called Variable Moment of Inertia with its extension based on Nuclear Softness (VMINS3) concept [7].

Brief review of model and Methodology

We have employed VMINS3 model to carry out systematic study of band head moment of inertia J_0 and softness parameter σ of SD bands in A ≈ 60-90 mass region and the complete description of model is given in Ref. [7]. The gamma transition energies and intensities are only two globally available information for SD bands. Therefore, we have used experimental E_γ [8-9], which is written for levels I to I-2 as

$$E_\gamma(\mathrm{I}) = \mathrm{E(I)} - \mathrm{E(I-2)}. \quad (1)$$

Here I is the spin. The energy expression of ground state of VMINS3 model is written as

$$\mathrm{E(I)} = \frac{\hbar^2}{J_0}\frac{I(I+1)}{1+\sigma I} + \frac{1}{2}CJ_0^2 I^2. \quad (2)$$

Using equation (1), the energy expression of ground state of VMINS3 model in terms of E_γ can be written as

$$E_\gamma = \mathrm{A}\left[\frac{I(I+1)}{1+\sigma I} - \frac{(I-2)(I-1)}{1+\sigma(I-2)}\right] + 4\mathrm{B(I-1)}. \quad (3)$$

Here, A= $\hbar^2/2J_0$ and B=$1/2CJ^2_0$, and σ, all these parameters are obtained by performing the least square fitting of experimental gamma transition energies. The variations J_0 with σ and $A^{5/3}$ are investigated.

Results and Discussion

We obtained the variation of band head moment of inertia J_0 with softness parameter σ and $A^{5/3}$. The softness parameter σ lies in the range of 10^{-4} to 10^{-6} for SD bands and lies in the range of 10^{-2} to 10^{-4} for normal deformed (ND) bands [7]. The higher the softness parameter, lower is the rigidity. After extracting σ for SD bands in this mass region, it has been observed that the value of σ for SD bands is unexpectedly more than ND band [8]. The higher values of σ indicate that the SD bands are weakly rigid. We also investigate the behavior of J_0 with σ and observed that the σ found to increase with increasing J_0 as triaxial character seems to increasing in SD nuclei. In addition, we have examined the variation of J_0 with $A^{5/3}$ to confirm that SD bands of this mass region follow $A^{5/3}$ rigid behavior. The SD bands in this mass region follow rigid behavior as they do in primary mass regions but the rigidity is quite weak in this mass region.

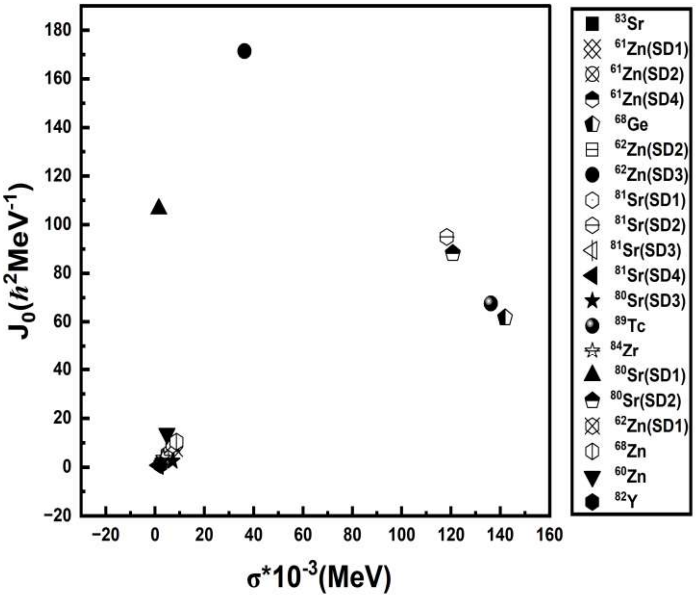

Fig.1: Variation of J_o vs. σ for A ~ 60-90 mass region

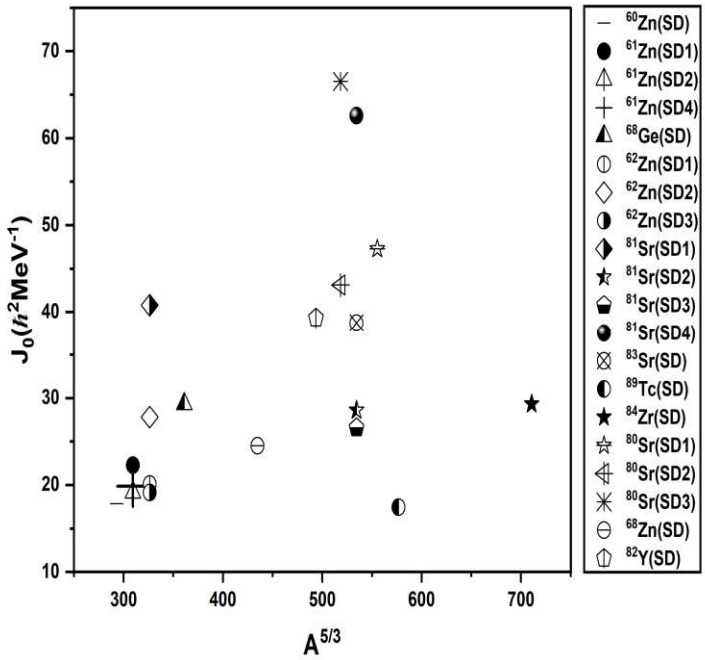

Fig.2: Variation of J_o vs. $A^{5/3}$ for A ~ 60-90 mass region

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