Prediction of TSD band-head spin of ^{164}Lu using VMI model

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Introduction

The Study of Triaxial Super-Deformed (TSD) nuclei has become an exciting field in nuclear structure. The nuclei which has large γ deformation and large quadrupole deformation known as Triaxial Super-Deformed (TSD) nuclei [1].

Until now, enough data for axial superdeformed nuclei are accumulated but the data for TSD nuclei are quite few like ^{163}Lu, ^{164}Lu, ^{165}Lu, ^{167}Lu, ^{171}Ta, ^{86}Zr etc. were identified experimentally. The prediction of TSD nuclei in A ∼ 160 region has been reported in Ref. [2]. However, Bohr and Mottelson predicted the existence of the nuclear wobbling motion in rapidly rotating triaxially deformed systems [3]. The TSD nuclei has the configuration with $\varepsilon_2 \sim 0.4$ and $|\gamma| \sim 20^\circ$ has been well known in a Lu isotope since long [4]. For the first time, an excited TSD band was reported in ^{163}Lu [5].

Various empirical or semi-empirical models have been proposed for the spin assignments in SD bands. Unfortunately, very few experiments could perfectly assign spins of SD bands. The theoretical modeling is only technique to calculate the spin values. Several efforts for assigning spins of SD states have been proposed in A∼190 mass region.

Further some of the methods were proposed to assign band-head spins and transition energies as a function of spin or rotational frequency ω. However, the spin assignments in these studies were not in good agreement with the experimental values.

In this paper a simple Variable Moment of Inertia (VMI) model is used to assign band-head spin directly from experimentally observed transition energy ratio which requires less computation time [6,7].

A brief description of the VMI model

Here we use VMI model to explain the rotational energy in relation with angular momentum (I) of each level. It gives as the sum of the potential energy term $(J_I - J_o)^2$ and rotational energy term $[\hbar^2.I(I+1)/J_I]$. The parameters depend on the difference in moment of inertia (J_I) from that of the ground-state moment of inertia (J_o). However, VMI model is a two-parameter formula which characterizes each nucleus by band-head moment of inertia (J_o) and restoring force constant (C) [8].

In VMI model, the transition energy for SD bands is defined as [8]:

$$E_\gamma(I \rightarrow I-2) = \frac{1}{2J_0}\left[I(I+1)-(I-2)(I-1)\right] + \frac{1}{8CJ_0^4}\left\{[I(I+1)]^2 - [(I-2)(I-1)]^2\right\} \quad (1)$$

In this equation, the parameters J_o and C are determined by fitting the experimentally known transition energies using the Best-Fit Method (BFM). The extension of the VMI model to an asymmetric (γ≠0) rotator can only be done by an additional assumption. The method given is reasonable, since it reduces to the usual VMI model for (γ=0). But the results are not changed appreciably with respect to the procedure given. [9]. The root mean square deviations (rms) of calculated transition energies for different I_o values are calculated. The rms value is least for band-head spin value of a band. If I_o shifts away from the accurate value by ±1, rapid shift in rms deviation (χ) can be observed.

The rms deviation is taken as [8,10],

$$\chi = \left[\frac{1}{n}\sum_{i=1}^{n}\left|\frac{E_\gamma^{cal}(I_i) - E_\gamma^{exp}(I_i)}{E_\gamma^{exp}(I_i)}\right|^2\right]^{\frac{1}{2}} \quad (2)$$

Where n is the total number of transitions involved in the fitting.

Lowest spin I_o is predicted, as I_o is known all the spin values of the SD band levels can be determined. It is clear that the fitting procedure is quite simple and straightforward [8,10]. Therefore, the experimentally observed band head spins for TSD bands are well verified with the I_o predicted from rms deviation. The experimental transition energy and the band head spin I_o of TSD band is given in the tabular form.

SD band	E_γ ($I_o \rightarrow$ (I_o-2) Exp. (keV)	E_γ ($I_o \rightarrow$ (I_o-2) VMI (keV)	Band head spin (I_o) Exp. [11]	Assig -ned I_o from rms devia - tion	rms devia -tion (χ)
^{164}Lu (b1)	373	382	14^-	14^-	.0345
^{164}Lu (b2)	565	555	18^+	18^+	.0208
^{164}Lu (b3)	353	364	13^+	13^+	.0374

Table 1: Band head spin I_o and calculated transition energy of TSD ^{164}Lu.

Results and discussion

We discuss the results of TSD ^{164}Lu using VMI model. In this work, the band-head spin (I_o) of TSD rotational bands in ^{164}Lu is predicted using the VMI model. The obtained gamma energies are in good agreement with the observed spectra. The predicted band head spin is compared with experimentally known spin values which provide a significant validity of this approach. The results are given in table 1 where the spin value is observed experimentally and compared with calculated rms deviation [11].

In Figure, we plot rms deviation to obtain the band head spin. The rms plots show the minimum value for spin which is in agreement with the experimentally observed spin [11].

Overall the obtained spin values are well justified by the calculation of rms deviation.

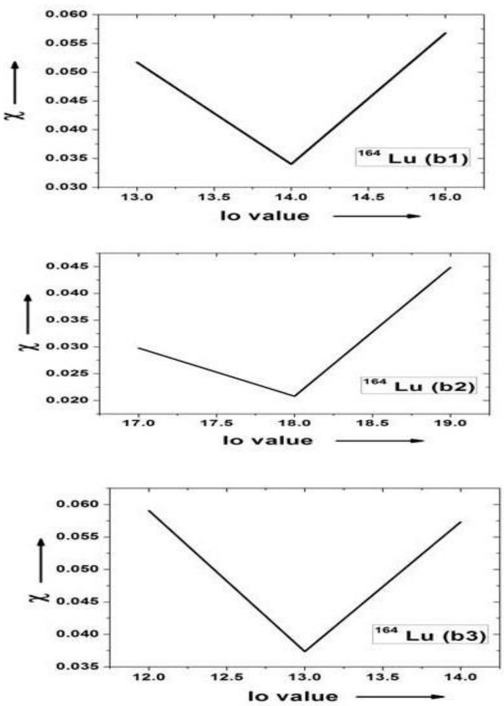

Fig. 1: Plots for rms deviation of TSD ^{164}Lu.

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