Systematic study of superdeformed bands in ^{152}Tb

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Introduction

The evidence for the existence of superdeformation was given experimentally by Twin et al. [1]. Afterwards, number of superdeformed (SD) bands are observed in different mass regions i.e. $A \sim 190, 150, 130, 80, 60$. The linking transitions between SD bands and the normal deformed bands (ND) remain unrevealed. Therefore, many of the aspects like spin assignments, parities and excitation energies remain unknown. Many different methods are suggested to calculate the spin assignments [2–5]. The existence of identical bands in $A \sim 150$ mass region i. e. ($^{151}Tb(2)$ and $^{152}Dy(1)$) proves to be one of the incredible discoveries. The energies are almost same for the 16 transitions (within 2 keV) [6]. The response of dynamic moment of inertia ($J^{(2)}$) versus the rotational frequency proves to very useful in understanding the general properties of SD bands. In $A \sim 150$ mass region, ($J^{(2)}$) decreases with the increase of rotational frequency [7]. Sharma et al. [8] studied the systematics of $J^{(1)}$ and $J^{(2)}$ of SD bands with N_pN_n scheme In this present paper we have studied the $E_\gamma$transition energies of $^{152}Tb(1,2)$ SD bands. To do this work we have employed the two parameter formulae i. e. VMI model, nuclear softness formula and the power index formula.

Formalism

VMI Model

Mariscotti et al. [9] suggested a model in which angular momentum of energy levels are given by the sum of potential energy term and the rotational energy term. The transition energies of SD bands can be expressed as

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

where $\Im_0$ and C are the model parameter and can be found by the fitting techniques.

Nuclear softness formula

Nuclear softness formula was designed by Gupta [10]. In this work, energy levels of ground state bands in even-even nuclei have been taken into the account. Similar expression was given for transitional and well deformed nuclei called as soft rotor formula. The transition energies for the SD bands can be expressed as

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

where $\Im_0$ and σ are the model parameter, which can be found by the fitting procedures.

Power index formula

The single term expression for the ground band level energies of soft rotor was proposed by Gupta et al. [11] In this work the arithmetic mean approach of Bohr-Mottelson formula was replaced by the geometric mean and was called as the Power index formula.

$$E_\gamma(I) = a(I^b - (I-2)^b), \quad (3)$$

where a and b are obtained by the least square fitting of the observed transition energies.

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Results and Discussion

VMI model, nuclear softness formula and power index formula have been applied on $^{152}Tb(1,2)$ SD bands to calculate the $E_\gamma$transition energies. The data has been taken from the tables of SD bands given by Singh et al. [12]. The calculated results of transition energies obtained for $^{152}Tb(1,2)$ SD bands have been compared with the experimental results (see Table I and II).

TABLE I: Comparison of the theoretical result(VMI model, Nuclear softness formula (N.S) and Power index formula (P.I)) and experimental results of transition energies E_γ of $^{152}Tb(1)$ SD band in (keV).

Spin I	Expt	VMI	N.S	P.I
31	823	819.4	820.2	820.6
33	864	866	865.9	865.8
35	909	911.4	910.8	910.4
37	954	955.3	954.8	954.6
39	1000	997.6	998.0	998.4

TABLE II: Comparison of the theoretical result(VMI model, Nuclear softness formula (N.S) and Power index formula (P.I)) and experimental results of transition energies E_γ of $^{152}Tb(2)$ SD band in (keV).

Spin I	Expt	VMI	N.S	P.I
32	801	799.0	799.5	799.8
34	844	844.7	844.6	844.5
36	888	889.5	889.1	888.9
38	932	933.4	933.1	932.9
40	978	976.2	976.4	976.7

Conclusion

In this present work we have compared the values of transition energies of $^{152}Tb(1,2)$ SD bands by using the VMI model, nuclear softness formula and the power index formula with the experimental data. A good agreement is shown by the power index formula for $^{152}Tb(1,2)$ SD bands.

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