Validity of rotational energy formulae for superdeformed bands in ^{83}Y

H. M. Mittal* and Honey Sharma ‡
*Department of Physics,
Dr. B. R. Ambedkar National Institute of Technology,
Jalandhar, Punjab-144011, India
and
‡Department of Physical Sciences,
Sant Baba Bhag Singh University,
Padhiana, Punjab-144030, India

Introduction

The main advantage of the theoretical model and formalism used to fit SD bands are to make estimated guess/accrediting of angular momentum to the observed experimental transition energy levels in the SD bands. One can inspect SD rotational bands by their transition quadrupole moment, deformation parameter (β = 0.5)and the lifetime measurements. These features very well implies that the SD nuclei are elongated ellipsoids with the axes ratio of 2:1:1. However, the only vital information available for the SD bands are their E_γ transition energies and intensities. The physics of SD bands can be explained by the concept of level spin determination. Due to missing linking transitions between SD and normal deformed (ND) bands the various specific features like spin determination, exact excitation energies and parities remain undiscovered. Therefore, to solve the discrepancy of spin determination many theoretical rotational energy formulae and models was taken into the account [1–4]. The measured spins provide a significant attempt to check the effectiveness of these approaches. As SD bands are high spin bands, so it would be highly interesting to test these formulae/models for the SD bands. One can also obtain the new insight into high spin phenomenon of superdeformation. Sharma and Mittal [5] calculated the band head spin in A∼60-80 mass regions by nuclear softness formula. To test the validity of various rotational energy formulae i.e Nuclear softness formula [6], VMI model [7], VMINS3 model [8], four parameter formula [9] we have calculated the band head spin (I_0) and band head moment of inertia ($\Im_0$) for four SD rotational bands of ^{83}Y in A∼80 mass region. One would also able to know which rotational energy formulae suits more to study the general nature of four SD rotational bands of ^{83}Y in A∼80 mass region.

Formalism

A) Nuclear softness formula [6]

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

B)VMI model [7]

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

C)VMINS3 model [8]

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

*Electronic address: mittalhm@nitj.ac.in

D)Four parameter formula [9]

$$E_\gamma(I \to I-2) = A(I(I+1) - (I-2)(I-1)) \\ +B((I(I+1))^2 - ((I-2)(I-1))^2) \\ +C((I(I+1))^3 - ((I-2)(I-1))^3 \\ +D((I(I+1))^4 - ((I-2)(I-1))^4). \quad (4)$$

TABLE I: The band head spin (I_0) obtained from various rotational energy formulae for 4 SD bands of ^{83}Y. Here 1, 2, 3 and 4 in parenthesis represent band 1, band 2, band 3 and band 4 respectively.Here VMI denoted VMI model, N.S denotes nuclear softness formula, F.P denotes four parameter formula and VMINS3 as VMINS3 model.

SD bands	$E_\gamma(I)$	VMI	N.S	F.P	VMINS3	[10]
$^{83}Y(1)$	1893	28.5	26.5	22.5	22.5	22.5
$^{83}Y(2)$	1757	23.5	24.5	22.5	20.5	21.5
$^{83}Y(3)$	1738	23.5	24.5	18.5	20.5	21.5
$^{83}Y(4)$	1920	29.5	32.5	20.5	21.5	22.5

TABLE II: The band head moment of inertia ($\Im_0$) obtained from various rotational energy formulae for 4 SD bands of ^{83}Y. Here 1, 2, 3 and 4 in parenthesis represent band 1, band 2, band 3 and band 4 respectively.Here VMI denoted VMI model, N.S denotes nuclear softness formula, F.P denotes four parameter formula and VMINS3 as VMINS3 model.

SD bands	$E_\gamma(I)$	VMI	N.S	F.P	VMINS3
$^{83}Y(1)$	1893	24.9	26.6	20.3	19.8
$^{83}Y(2)$	1757	26.5	26.9	27.3	20.9
$^{83}Y(3)$	1738	27.3	28.4	24.7	21.0
$^{83}Y(4)$	1920	25.1	28.4	20.6	17.2

Results and Discussion

The experimentally noticed transition energies of four SD rotational bands of ^{83}Y listed in ENSDF database [10] have been fitted in Nuclear softness formula [6], VMI model [7], VMINS3 model [8] and four parameter formula [9] to obtain the band head spin (I_0) and band head moment of inertia ($\Im_0$). The attained band head spin (I_0) for four SD rotational bands of ^{83}Y computed from various rotational energy formulae are specified in Table I. From all the rotational energy formulae four parameter formula and VMINS3 model is efficient in reproducing the experimental band head spin of $^{83}Y(1,2)$ SD bands (see Table I). VMINS3 model is efficient in reproducing the experimental band head spin of $^{83}Y(3,4)$ SD bands (see Table I). SD bands having same band head moment of inertia ($\Im_0$) are called signature partner pairs. From Table II it is noticed that nuclear softness formula very well depicts the presence of signature partner pairs in ^{83}Y isotope.

Conclusion

In this present work, we have utilized various rotational energy formulae in order to check their validity by deducing the band head spin (I_0) of four SD rotational bands of ^{83}Y. It is concluded from present study that the four parameter formula and VMINS3 model works very well to explain the general nature of $^{83}Y(1,2)$ SD bands. VMINS3 model works very well to explain the general nature of $^{83}Y(3,4)$ SD bands. Similar value of band head moment of inertia ($\Im_0$) obtained by nuclear softness formula indicates the presence of signature partner pairs in ^{83}Y SD isotope.

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