Band head spin determination for superdeformed bands in ^{83}Y

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Introduction

The estimation for very elongated shapes with major to minor axis of 2:1 in nuclei with atomic number Z= 38-40 and N=42-45 led to the discovery of superdeformed bands(SD) in A∼80 mass region [1–6]. Experimentally, these estimations were proved with the observation of SD bands in ^{83}Sr [7, 8]. Since then, the advancement in various detector facilities have allowed one to unravel an island of SD shapes in A∼80 mass region. However, several aspects of SD bands like spin assignments, excitation energies and parities remain undetermined. This is because the linking transitions amid SD and normal deformed bands (ND) are still missing. To interpret, the physics of SD bands, spin determination is a vital asset. Therefore, the theoretical techniques like [9, 10] has been suggested to predict the spin assignments in A∼80 mass region. Band head spin assignment of SD bands in A∼60-80 mass region through nuclear softness formula was calculated by Sharma and Mittal [11]. In this present paper, we have calculated the band head spin for $^{83}Y(1, 2, 3, 4)$ SD bands using VMINS3 model.

Formalism

VMINS3 model

Batra and Gupta [12] calculated the ground state bands in even-even nuclei by redesigning the VMI model in terms of nuclear softness.

$$E_\gamma(I) = A\frac{[I(I+1)]}{1+\sigma I} + BI^2, \quad (1)$$

The only obtainable information about SD bands are the intraband energies and intensities. Therefore, one may choose to fit $E_\gamma(I)$ transition as

$$E_\gamma(I \rightarrow I-2) = E(I) - E(I-2), \quad (2)$$

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

where $A=\frac{1\hbar^2}{2\theta_0}$ and $B=\frac{1}{2}C\theta_0^2\sigma^2$ are the model parameters, which can be found by using the fitting techniques. As the model takes into account the three parameters namely softness parameter σ, the ground state moment of inertia θ_0 and the stretching constant C; so it is called as VMINS3 model.

Results and Discussion

The observed transition energies [13] for $^{83}Y(1, 2, 3, 4)$ SD bands has been fitted to VMINS3 model. The computed and experimental transition energies agrees extremely well whenever accurate band head spin is accredited and the root mean square deviation

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is found to be minimum. By using band head spins and intraband γ transitions, the corresponding fitting parameters i.e. ground state moment of inertia (θ_0), softness parameter (σ) and stretching constant(C) are calculated. The fitting parameters along with deduced band head spin for $^{83}Y(1,2,3,4)$ SD bands using VMINS3 model have been given in Table I and Table II. It is well noticed from the Table II that the band head spin for $^{83}Y(1,2,3,4)$ SD bands obtained using VMINS3 model agrees very well with [13].

TABLE I: Parameters obtained from least-squares fit for $^{83}Y(1,2,3,4)$ SD bands using VMINS3 model. θ_0 is a ground state moment of inertia, C is a stretching constant and σ is a softness parameter.

SD bands	$\theta_0 \times 10^{-3}$	$C \times 10^7$	σ
$^{83}Y(1)$	1.985	1.197	0.397
$^{83}Y(2)$	2.746	1.786	0.321
$^{83}Y(3)$	5.960	8.480	0.148
$^{83}Y(4)$	2.0446	1.328	0.399

TABLE II: The band head spin(I_0) for $^{83}Y(1,2,3,4)$ SD bands using VMINS3 model and its comparison with experimental results [13].

SD bands	$E_\gamma(I \to I-2)$	VMINS3 model	[13]
$^{83}Y(1)$	1893	22.5	22.5
$^{83}Y(2)$	1757	20.5	21.5
$^{83}Y(3)$	1738	20.5	21.5
$^{83}Y(4)$	1920	21.5	22.5

Conclusion

In this present work, VMINS3 model is used to assign the band head spin for $^{83}Y(1,2,3,4)$ SD bands. VMINS3 model proves to be a powerful tool to detect the band head spin for $^{83}Y(1,2,3,4)$ SD bands.

References

[1] W. Nazarewicz et al., Nucl. Phys. A, 435: 397 (1987)
[2] J. Dudek, W. Nazarewicz, and N. Rowley, Phys. Rev. C, 35: 1489 (1987)
[3] T. Bengtsson, I. Ragnarsson, and S. Aberg, Phys. Lett. B, 208: 39 (1988)
[4] P. Bonche, H. Flocard, and P.H. Heenen, Nucl. Phys. A, 523: 300 (1991)
[5] T. Werner and J. Dudek, At. Data Nucl. Data Tables, 50: 176 (1992)
[6] A.V. Afanasjev and I. Ragnarsson, Nucl. Phys. A, 586: 377 (1995)
[7] C. Baktash et al., Phys. Rev. Lett., 74: 1946 (1995)
[8] D.R. LaFosse et al., Phys. Lett. B, 354: 34 (1995)
[9] M. A. J. Marriscotti, G. Scharff-Goldhaber and B. Buck, Phys. Rev., 178: 1864 (1969)
[10] R. K. Gupta, Phys. Lett. B, 36: 173 (1971)
[11] H. Sharma and H. M. Mittal, Int. J. Mod. Phys E, 26: 1750074 (2017)
[12] J. S. Batra and R. K. Gupta, Phys. Rev. C, 43: 1725 (1991)
[13] http://www.nndc.bnl.gov/