Systematics of band moment of inertia of excited SD bands of even-even nuclei in A=150 mass region

Neha Sharma[1],* H.M. Mittal[2], and A.K. Jain[3]
[1] CT Institute of Engineering Management and Technology, Jalandhar-144020, INDIA
[2] Dr. B.R. Ambedkar National Institute of Technology, Jalandhar-144011, INDIA and
[3] Deptartment of Physics, Indian Institute of Technology, Roorkee-247667, INDIA

Introduction

The superdeformed (SD) shapes whose existence was predicted first by V.M. Strutinsky [1] have been observed experimentally by Twin et al., [2]. They are manifestation of strong deformed shell effects which remain in close analogy to the well known spherical shell closures. The phenomenon of high spin deformation represents one of the most remarkable discoveries in nuclear physics made during the last decade of 20th century. A large number of SD bands have been observed in the mass region A=60, 80, 130, 150, 190 [3, 4]. Also Ideguchi et al., [5, 6] observed SD bands in A=40 mass region. The cascades of SD bands are known to be connected by electric quadruple (E2) transitions. There is no linking transition to normal levels so spin assignments of most of these bands carry a minimum uncertainty 1-2 $\hbar$. Recently a link has been observed in A=190 mass region [7]. It may be pointed out that a lack of knowledge of the spins has led to an emphasis on the study of dynamical moment of inertia of SD bands and the systematics of the kinetic moment of inertia have not been examined in a detailed manner.

In this paper, we extract the band moment of inertia J_0 of all the known excited SD bands in A=150 mass region corresponding to 2:1 deformation and present their systematics.

Results and Discussion

First of all, we classify the bands into excited SD bands of even-even nuclei in A=150 mass region by using the feeding intensities from the experiments and reported in ref. [3, 4]. We have calculated the band moment of inertia J_0 by fitting the E2 gamma ray energies of all the excited SD bands of even-even nuclei in A=150 mass region [3, 4] by using a 4-parameter formula [10]. In these bands, some kind of spin assignments is available. The fits are very good because the SD bands are very good rotors. The root mean square deviation has been calculated and shown in the results for each band. For a prolate ellipsoid, the transition quadrupole moment (Q_t) can be related to the major-to-minor axis ratio, x, by [11]

$$Q_t = \frac{2}{5} Z R^2 \frac{x^2 - 1}{x^{2/3}} \times 10^{-2} eb. \quad (1)$$

So, the axes ratio can be estimated from Q_t in this way. For a prolate ellipsoid which give rigid rotation, it is possible to estimate the rigid body moment of inertia as [12]

$$J_{prolate} = \{\frac{A^{5/3}}{72} \frac{1 + x^2}{2x^{2/3}}\}[\hbar^2 MeV^{-1}]. \quad (2)$$

Higher order shape degrees of freedom and effect of triaxiality or necking have been ignored here.

We compared the fitted values of J_0 of excited SD bands of even-even nuclei in A=150 mass region with the rigid rotor values of moment of inertia obtained from the measured-Q_t values. Those SD bands in which the Q_t measurements are not available, we have compared the fitted J_0 values with those obtained from the corresponding prolate shape of the SD nuclei. It is highly interesting to note in Table I that J_0 values of all the excited SD bands of even-even nuclei are almost identical. It means all the excited SD bands of even-even nuclei in A=150 mass region are signature partner SD bands. The value J_0 of all the

*Electronic address: nsharma.nitj@gmail.com

TABLE I: Table of band moment of inertia $J_0(\hbar^2 MeV^{-1})$ and softness parameter σ with RMSD (keV) for signature partner excited SD bands of even-even nuclei having 2:1 deformation.

Nuclei	J_0 (4-para)	$\sigma\times 10^{-5}$	$J_0(Q_t)$	J_0 (2:1)	J_0 (1:1)	RMSD
$^{150}Gd(2)$	78.1	6.326	86.3	92.6	58.8	2.7
$^{150}Gd(3)$	79.4	8.2	87.5	92.6	58.8	0.7
$^{150}Gd(4)$	83.2	0.7	82.7	92.6	58.8	2.9
$^{150}Gd(5)$	82.6	1.7	85.1	92.6	58.8	4.3
$^{150}Gd(7)$	83.2	0.85		92.6	58.8	4.3
$^{150}Gd(8)$	82.6	2.2		92.6	58.8	2.3
$^{150}Gd(10)$	82.5	2.7		92.6	58.8	0.91
$^{150}Gd(11)$	81.7	4.2		92.6	58.8	3.8
$^{150}Gd(13)$	77.3	9.4		92.6	58.8	2.5
$^{150}Gd(14)$	78.2	7.8		92.6	58.8	2.7
$^{152}Dy(4)$	90.8	11.3		94.7	60.1	0.82
$^{152}Dy(5)$	91.2	14.3		94.7	60.1	0.49
$^{154}Dy(5)$	89.7	2.3		96.8	61.4	0.67
$^{154}Dy(6)$	88.9	2.9		96.8	61.4	0.15
$^{154}Er(1)$	66.4	23.0		96.8	61.4	1.05
$^{154}Er(2)$	66.9	17.5		96.8	61.4	1.15

signature partner SD bands of A=190 mass region is found to be the same [13]. Among all these excited SD bands, J_0 value of $^{150}Gd(4)$ is found to be larger than that observed from the measured Q_t-value. This band is found to be super-rigid in nature.

Conclusions

The 4-parameter formula has been used to obtain the band moment of inertia J_0 for the excited SD bands of even-even nuclei in A=150 mass region. It is very interesting to note that the excited SD bands of even-even nuclei in A=150 mass region are signature partner SD bands as the J_0 values of all the excited SD bands of even-even nuclei are almost identical. Among all the excited SD bands of even-even nuclei of A=150 mass region, $^{150}Gd(4)$ is found to be super rigid rotor band as the value of band moment of inertia J_0 of this band is larger that of the measured Q_t - value.

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