Superdeformed rotational band in framework of three parameters rotational formula

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Introduction

The discovery of superdeformation is one of the significant advances in nuclear structure physics. Superdeformed (SD) bands were first observed in fission isomers in the actinide region [1]. The discrete line SD shapes were found in ^{152}Dy nucleus [2]. Since then vast experimental and theoretical studies have been undertaken. At present numerous SD bands have been observed in various mass region A=30,60,80,130,150 and 190 [3-4].

Although a general understanding of SD bands has been achieved, there are still some striking features which remain partially understood. The excitation energy and firm assignment of spin-parity are not known for most of the SD bands because of near absence of information linking transitions between normal deformed (ND) and SD bands except in a few cases.

Several phenomenological formulae have been proposed to fit the transition energies and assign spin angular momentum to the observed levels in SD bands. The transition energies, spins n identical phenomenon for SD bands in the mass 150 and 190 regions have been predicted by various two and three parameters viz. variable moment of inertia, ab formula, Harris expansion [1-6].

In present work, we aim to describe the nuclear properties and SD bands of ^{192}Hg (SD-1), ^{194}Hg(SD-1) and ^{194}Hg(SD-2) nuclei. We have employed the two-parameters *ab* formula and power law to calculate the transition energies of above mentioned bands.

Formulae used

The energies $E(I)$ of the SD nuclear rotational bands as a function of the unknown spin (I) can be expresssed as

$$E(I) = E_0 + a\left[\sqrt{1+bI(I+1)} - 1\right] + cI(I+1). \tag{1}$$

The rotational frequency $\hbar\omega$, defined as the derivative of energy E, with respect to the angular momentum $J = I(I+1)$ is

$$\hbar\omega = \frac{dE}{dJ} = \left[2c + ab\left[1+bI(I+1)\right]^{1/2}\right]\left(I(I+1)\right)^{-1/2}. \tag{2}$$

The two types of possible nuclear moments of inertia have been suggested which reflects two different aspects of nuclear dynamics.
Kinematics moment of inertia:

$$J^1 = \hbar^2 I(I+1)\left(dEdI\right)^{-1} = \frac{\hbar^2}{ab}\left[1+bI(I+1)\right]^{3/2} + \frac{1}{2c} \tag{3}$$

and the dynamic moment of inertia:

$$J^2 = \hbar^2\left(\frac{d^2E}{dI^2}\right) = \frac{\hbar^2}{ab}\left[1+bI(I+1)\right]^{3/2} + \frac{1}{2c} \tag{4}$$

Also the bandhead moment of inertia is

$$J_0 = \hbar^2/(ab + 2c). \tag{5}$$

A. Power Law

By replacing the concept of the arithmetic mean of the two terms used in Bohr-Mottelson expression by the geometric mean, Gupta [10] introduced a two-parameter formula called power law. In general the single-term power law is expressed as

$$E_I = aI^b. \tag{6}$$

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Results and Discussion

Theoretical energies so obtained for the SD-1 bands of ^{192}Hg have been compared with the corresponding experimental values in Table 1 and Table 2. It shows that the theoretical transition energies obtained for SD band of ^{194}Hg by using empirical formula, power law and *ab* formula show good agreement with the experimental values.

TABLE I: Comparison of theoretical (*ab* and Power law) and experimental results on transition energies of SD-1 band of ^{192}Hg nuclei.

Spin	^{192}Hg(SD1)	*ab*	Power Law
12	300.1	300.1	301.2
14	340.4	340.1	339.0
16	381.6	382.5	384.4
18	421.1	423.1	425.4
20	458.8	455.6	459.1
22	496.0	496.4	498.3
24	532.1	531.5	534.3
26	567.4	569.3	568.2
28	601.7	604.5	603.2
30	634.9	632.2	629.2
32	668.1	666.2	667.2

TABLE II: Comparison of theoretical (*ab* and Power law) and experimental results on transition energies of SD-2 band of ^{194}Hg nuclei.

Spin	^{194}Hg(SD2)	*ab*	Power Law
12	283.1	282.1	280.1
14	323.4	324.0	325.0
16	363.1	360.32	366.3
18	402.0	401.2	405.2
20	440.3	443.2	443.2
22	477.7	480.1	479.1
24	514.2	513.3	516.4
26	549.9	547.3	548.3
28	584.9	582.3	586.4
30	619.3	616.3	623.5
32	652.3	650.1	655.1

1. Conclusion

The present work provides a new insight to understand the nuclear structure of the SD-1 band of ^{192}Hg and ^{194}Hg nuclei. In the discussion above, we compared the four formulae: power law, ab, SRF and AHV. The power law and AHV show good accuracy in SD-1 and SD-2 bands.

Acknowledgments

We are grateful to Dr. J. B. Gupta (Ramjas College, Delhi University, Delhi) for constant encouragement. Author also thanks to IET Bhaddal for providing research facility.

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