Two parameter formula for ground band energy spectra for superdeformed ^{194}Hg and $^{192-194}$Pb nuclei

Vidya Devi[1*] and J. B. Gupta[2]
[1] *C T group of Institutions, Partap Pura Road, Shahpur, Jalandhar, Punjab - INDIA and*
[2] *Ramjas College, University of Delhi, Delhi-110007, INDIA*

Introduction

The evolution of the dynamic moment of inertia as a function of rotational frequency for superdeformed (SD) bands in the mass 150 region is characterized by pronounced isotopic and isotonic variations [1]. In contrast, the vast majority of the SD bands in the mass 190 region display the same smooth and rather pronounced increase of $\Im^1$ and $\Im^2$ with $\hbar\omega$ [2]. The ground-state band structure in even-even nuclei developed many phenomenological and theoretical approaches to understand the structure of nucleus and yrast excitation energies. The two parameter *ab* formula was introduced by Holmberg and Lipas [2] which can also be rewritten as

$$E(J) = a[\sqrt{1 + bJ(J+1)} - 1] \quad (1)$$

Das et al. [3, 4] studied the AHV-type approach for the ground band energy

$$E(J) = nE(2_1^+) + \frac{n(n-1)}{2}\epsilon_4 \quad (2)$$

where $\epsilon_4 = E(4_1^+) - 2E(2_1^+)$ and $n = \frac{J}{2}$. If $E(2_1^+)$ and ϵ_4 be assumed as the free parameters. Zamfir and Casten [5] state the need of additional term, and gave next three order AHV expression

$$E(J) = nE(2_1^+) + \frac{n(n-1)}{2}\epsilon_4 + \frac{n(n-1)(n-2)}{6}\epsilon_6.$$

Recently Brentano et al. [6] proposed a new yrast energy formula for soft rotor

$$E(J) = \frac{J(J+1)}{a(1+bJ)} \quad (3)$$

This is also called the soft rotor formula (SRF). However, the concept of an arithmetic mean of the two terms used in these expressions was replaced by the concept of geometric mean in the form of the power law [7]

$$E_J = aJ^b. \quad (4)$$

By using equation (5), one can evaluate the value of index b for different J in any given nucleus. In this paper we compare the two parameter formulae for superdeformed bands. We also compare the Kinetic ($\Im^1$) and Dynamic moment ($\Im^2$) of inertia with rotational frequency ($\hbar\omega$). For this calculation data are taken from [8]

Variation of Static $\Im^1$ and Dynamic Moment Inertia $\Im^2$ with rotational frequency $\hbar\omega$

The behavior of $\Im^1$ and $\Im^2$ for the SD bands in ^{194}Hg is given in Fig. 1. The value of $\Im^1$, $\Im^2$ and $\hbar\omega$ are calculated by

$$\hbar\omega(J) = \frac{E_\gamma((J+2) \to J) + (E_\gamma(J-2) - J))}{4}$$

$$\Im^1(J) = \frac{2J-1}{E_\gamma(J-(J-2))}\hbar^2$$

$$\Im^2(J) = \frac{4}{E_\gamma((J+2) \to J) + (E_\gamma(J-2) - J))}\hbar^2$$

With the addition of these new transitions, two markedly different slopes in the $\Im^1$, $\Im^2$ for the SD-1 and SD-2 bands of ^{194}Hg nuclei are apparent. Kinematic moment of inertia has larger slope, and Dynamic moment of inertia has less slope but vary constantly with rotational frequency. It can be see

Fig.2, shows the ab, AHV-1, AHV-2, SRF and Power law for the SD-1 and SD-2 band of ^{194}Hg nuclei. It can be observed that AHV-1, AHV-2, power law shows good results as compared to the SRF and ab formula. Similarly in Fig. 3, it can be observed that AHV-1, AHV-2 and power law shows good results upto 20^+

*Electronic address: vidyathakur@yahoo.co.in

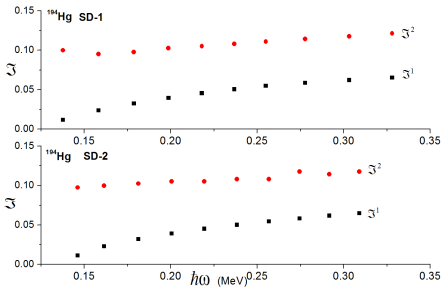

FIG. 1: Static $\Im^1$ and Dynamic $\Im^2$ moments of inertia vs $\hbar\omega$ for the latest data sets on the SD-1, SD-2 bands in ^{194}Hg.

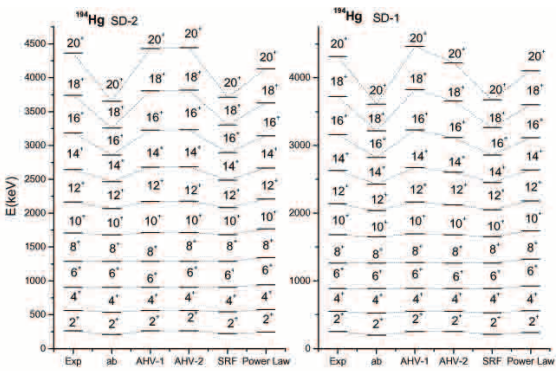

FIG. 2: Comparison between experimental energy with ab, AHV, SRF and power law formulae.

energy level as compared to the SRF and ab formula for the ^{192}Pb,^{194}Pb nuclei.
In Table 1,we present the root mean square deviation (RMSD) for the two parameter formula such as ab, AHV-1, AHV-2, SRF and power law

Conclusion

The present work provides a new insight to understand the nuclear structure of the SD-1 and SD-2 band of ^{194}Hg and ^{192}Pb,^{194}Pb 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 band of ^{194}Hg and ^{192}Pb,^{194}Pb nuclei.

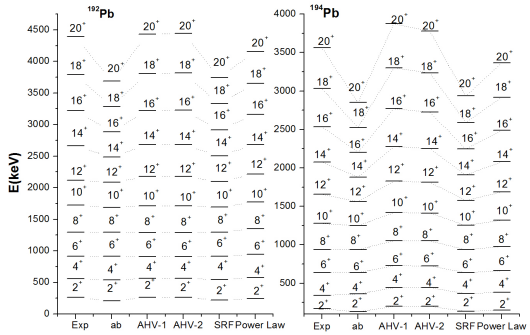

FIG. 3: Comparison between experimental energy with ab, AHV, SRF and power law formulae.

TABLE I: The root mean square deviation(RMSD) value for ab, AHV, SRF and power law formulae.

Nuclei	ab	AHV-1	AHV-2	SRF	P. Law
^{194}Hg(1)	0.105	0.015	0.001	0.041	0.036
^{194}Hg (2)	0.117	0.009	0.001	0.040	0.036
^{192}Pb	0.010	0.027	0.220	0.044	0.039
^{194}Pb	0.267	0.033	0.073	0.360	0.060

References

[1] R. V. F. Janssens and T. L. Khoo, Ann. Rev. Nucl. Part. Sci. **41** (1991).
[2] P. Holmberg and P. O. Lipas, Nucl. Phys. A **117** 552 (1968).
[3] T. K. Das, R.M. Dreizler, A. Klein, Phys. Rev. C **2**, 632 (1970).
[4] R. F. Casten, N.V. Zamfir, D.S. Brenner, Phys. Rev. Lett. **72**, 227 (1993).
[5] N. V. Zamfir and R. F. Casten, Phys. Rev. Lett. **75** 1280 (1995).
[6] P. von Brentano et al., Phys. Rev. C **69** 1 (2004).
[7] J. B. Gupta, A. K. Kavathekar and R. Sharma, Phys. Scr. **51** 316 (1995).
[8] B. Richard, B. Firestone and B. Singh, Lawrence Berkeley Laboratory, Berkeley, 35916 (1994).