Correlation of β -band with ground state band in medium mass nuclei

J. B. Gupta[1+], Vikas Katoch[2*], S. Sharma
[1]Ramjas College, University of Delhi, Delhi-110007
[2]Raj Kumar Institute of Technology (Mahamaya Technical University), Ghaziabad, India
Panchwati Institute of Engineering & Technology (Mahamaya Technical University), Meerut, India
Email: vkatoch007@yahoo.co.in

The low energy levels of even Z even N nuclei in medium mass region A = 150 - 200 away from closed shells develop collective characteristics. The lowest levels can be grouped into three K - bands. The lowest one based on the ground state forms the ground state rotational band. The rotational band, based on the axially symmetric vibration of the nuclear core with K= 0_2 is called the beta vibrational band. The one based on the axially asymmetric vibration of the nuclear core with K = 2 projection on the symmetry axis is called the K = 2, γ- vibrational band. There is interest in the nature of the K= 0_2 band. This is called the geometric view of the Bohr Mottelson unified collective model [1]. In the algebraic Interacting Boson model [2], the K= 0_2 and K= 2 bands belong to the (2N- 4, 2) family of states. In IBM, strong β-γ E2 transitions comparable to γ- g are predicted. This led to a possibility of interpreting the K = 0_2 band as γγ vibration [3]. Whether, this is applicable to all nuclei or to only a few special ones led to an extensive study of the characteristics of the K = 0_2 bands [4,5]. The problem seems to be still unresolved. In the present work, we study the nature of the K=0_2 bands by studying the correlations of some collective observable of the K = 0_2 band and the ground state band.

If the quadrupole deformation of the nuclear core is unchanged in the intrinsic K=0_2 vibrations, then the energy separation $E(2_\beta)$-$E(0_\beta)$ should be same as $E(2_g)$. So we plot the former against the latter in Figure 1, for the Sm-Hf nuclei with N < 104. The N = 88 isotones of Sm, Gd, Dy, Er lie at the right top corner. At N= 90, there is a sharp drop in $E(2_g)$ energy. The same is true for K=0_2 band. This drop increases progressively with decreasing Z, for Er to Sm. (see the data at about 150 keV). For N > 90, the data lie condensed within a short span of 80 - 120 keV on account of saturation phenomenon of the deformation effect of the valence nucleons. However, the $E(2_\beta)$ - $E(0_\beta)$ remain almost equal to $E(2_g)$.

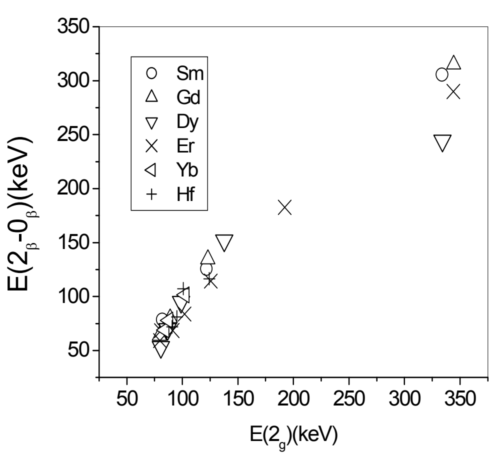

Fig. 1: The energy difference of $E(2_\beta)/E(0_\beta)$ versus $E(2_g)$.

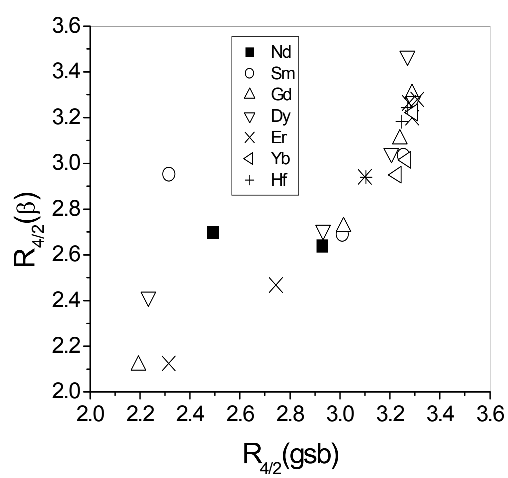

Fig. 2: $R_{4/2}$ (β-band) vs. $R_{4/2}$(ground band).

The energy ratio $R_{4/2}$ = E(4)/E(2) is a good measure of the deformation of a nucleus. With the variation in N, Z it can assume a value of 2.0 for the spherical vibrator to 3.33 for the deformed rotor. For a collective rotation based on the intrinsic axial vibration the value of $R_{4/2}$ is expected to be the same for the K = 0_2 band and the ground state band. In Fig. 2, $R_{4/2}$ for K = 0_2 band is plotted against $R_{4/2}$ of ground band for the nuclei of Nd - Hf, N < 104. Except for ^{150}Sm ($R_{4/2}$ = 2.32) and ^{148}Nd (filled square), all other data form a single smooth curve, indicating a close relationship of the two bands for all nuclei in the spherical to deformed region.

To further explore this relationship, we obtained the ratio r of $R_{4/2}$ for the K= 0_2 band and the ground band and plot it versus neutron number N (Fig. 3). If these are equal, the ratio should be one. In Fig. 3, most points lie below r = 1.0. There is a pattern of the deviation from ideal value of 1.0, versus N and Z. Most points lie within r = 0.9 - 1.0, except N = 88 Sm and Dy. To within 10% deviation, the two bands are correlated. This smaller $R_{4/2}(\beta)$ provides a challenge for nuclear theory.

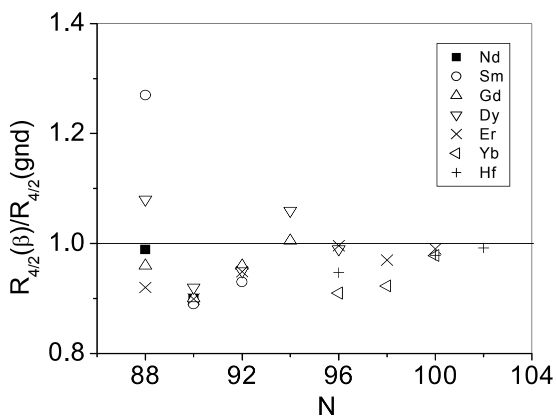

Fig 3: Variation of $R_{4/2}$ (β-band) /($R_{4/2}$ ground) with N.

Conclusion:

A close correlation of the collective characteristics of the K=0_2 β- band and ground band in A=150-200 region of Nd- Hf is demonstrated**.**

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[+]Associated GT.
*Singhania University student, Rajasthan

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