Energy ratio of β-band and co-relation with ground band

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Introduction

The energy levels of medium mass nuclei generally consist of collective and non-collective bands. The collective energy levels are arranged into $K^{\pi}=0_1^+$ ground state band, $K^{\pi}=0_2^+$ β-band and $K^{\pi}=2_1^+$ γ-band as well as other higher bands [1]. The energy levels of well deformed ground state band are expressed by rotor energy expression $E_I= AI(I+1)$, but this expression is not sufficient for shape transitional nuclei, which lie on transition from spherical and deformed shape. For transitional nuclei various energy expressions were suggested e.g., Bohr-Mottelson's energy expression[1], nuclear softness model [2], soft rotor formula (SRF)[3], Ejiri expression [4], and power law [5].

For transitional nuclei of medium mass region, Gupta *et. al*. [5] illustrated a single term energy formula known as Power Law, where $E_I = aI^b$; where a and b are two unknown parameters called scaling coefficient and power index. Here the systematic of energy ratio of β-band is studied and related with ground state band. The energy ratios ($R_I = E_I / E_2$) gives the power index b and the energy ratio R_4 is equal 2 and 10/3 for spherical and deformed nuclei, respectively. The R_I for spin I=6 is $R_6 = 3^b$. For higher spins, I = 8, 10 and 12, the R_I is:

$$R_I = \left(\frac{I}{2}\right)^b , \qquad (1)$$

where, $b = \frac{\log(R_4)}{\log(2)}$.

The R_I from SRF [2, 3] is:

$$R_I = \frac{I(I+1)R_4}{[3R_4(4-I)+10(I-2)]} . \qquad (2)$$

From the Bohr–Mottelson's energy expression [1], the R_I in terms of X = I(I+1) is:

$$R_I = \frac{X}{840}\{10[20-X]+3R_4[X-6\}. \qquad (3)$$

The energy ratio, R_I from Ejiri [4] is:

$$R_I = \frac{I(I-2)R_4}{8} - \frac{I(I-4)}{4}. \qquad (4)$$

The R_I is calculated for R_4 = 2 to 10/3, using the equ. (1), (2), (3) and (4) for spin I=6, 8, 10 and 12 for medium mass region. The experimental values of energies of g- and β-band are taken from [6].

The variation of R_6 vs. R_4 is shown in Fig. 1(a) for Nd to Pt nuclei. Different symbols are used for different series of isotopes for proper identification. BM curve deviates from the observed trend for $R_4 \leq 3.2$. The experimental data points lie above the SRF curve and below the EJIRI curve. For R_4 equal to 2 to 2.9, the power law (PL) curve lies above the SRF curve and close to the experimental points (scattered points) and for the nuclei having $R_4>2.9$, the PL curve lies below the experimental points. It indicates that the PL energy expression is better than SRF, EJIRI and BM energy expressions.

The similar trend is observed for R_8, R_{10} and R_{12} with respect to R_4 for g- band (see Fig. 1.(b) for R_8 vs. R4). Here PL shows better closeness with experimental points due to non integer power of spin I, i.e., b. The b lies between 1 for spherical to 2 for deformed nuclei. Whereas for other energy expressions, the R_I includes the integer power of spin, I i.e., 1 or 2. The variation of R_6 and R_{10} versus R_4 was studied earlier by Gupta et al. [7] for g- band. But in the present work up to date energy data [6] is incorporated. The power law gives better fitting than SRF for transitional nuclei i.e., $R_4 \leq 2.9$. For R4 > 2.9, the PL curve lies; below the curve of EJIRI, SRF and BM; as well as experimental data points because in PL there is power of spin (I) instead of I(I+1) in other energy expressions.

The behavior of energy ratio $R_6(\beta)$ verses $R_4(\beta)$ is also studied in β-band. But the β-band is available only in few nuclei in this region. The variation of energy ratio $R_6(g)$ verses $R_4(g)$ is shown in Fig. 2 (a) and variation of

$R_6(\beta)$ verses $R_4(\beta)$ is shown in Fig. 2 (a) for same nuclei for proper comparison. Here the energy ratio is calculated in similar trend of ground by subtracting the $E_2(0)$ band head [8].

Conclusion

The energy ratio of $R_6(\beta)$ versus $R_4(\beta)$ gives a smooth co-relation with the energy ratio of ground band with Bohr Mottelson, Ejiri, SRF and Power law.

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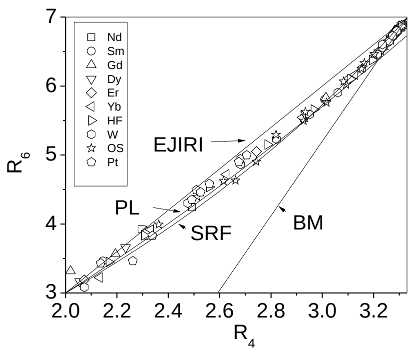

Fig. 1 (a) The plot of R_6 vs. R_4 for g-band.

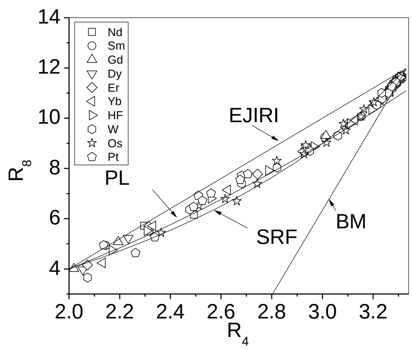

Fig. 1(b) The plot of R_8 vs. R_4 for g-band.

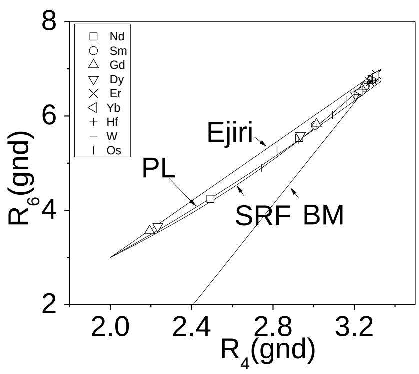

Fig. 2 (a) The plot of R_6 vs. R_4 in g-band.

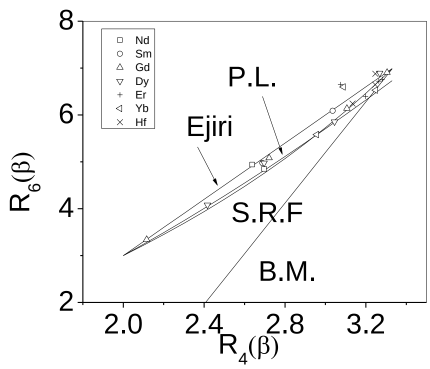

Fig. 2(b) The plot of R_6 vs. R_4 for β- band.