Systematic study of β-band and correlation with g- band using power law and soft rotor formula

Vikas Katoch[1,*], Reetu Kaushik[2], S. Sharma[3,#] and J. B. Gupta[4]
[1]*Research Scholar, Department of Physics, Singhania University, Jhunjhunu, Rajasthan-333515, India*
[2]*Research Scholar, Department of Physics, Mewar University, Gangrar, Rajasthan-312901, India*
[3]*Panchwati Institute of Engineering & Technology (U.P. Technical University), Meerut-250005, India*
[4]*Ramjas College, University of Delhi, Delhi-110007, India*
[#]ssharma_phy@yahoo.co.uk

Introduction

The nuclear structure of even Z even N medium mass transitional nuclei consist of ground state band, $K^{\pi}=0_1$ β-band, $K^{\pi}=2_1$ γ-band and other higher bands [1]. As we move away from closed shell, energy levels are low lying from spherical to deformed nuclei and energy deviated from ideal rotor behavior. The energy of these transitional nuclei in ground band can also be studied using Bohr Mottelson energy expression [1], Soft Rotor Formula (SRF) [2], Power Law (PL) [3] etc. Recently, Gupta et al. (2013) [4] modified SRF for non zero band head $K^{\pi}=2_1$ γ-band and reproduced the level energies. Here same formula applied for $K^{\pi}=0_1$ β-band and the level energies are reproduced and compared with experimental energies. The power law [3] is also used for recalculation of level energies and for useful comparison.

Method

The SRF of Gupta (1971) and Brentano et al. (2004) [2] for ground state band is:

$$E(I) = \frac{\hbar^2 I(I+1)}{2\theta(1+\sigma I)} \qquad (1)$$

where, σ and θ are softness parameter and moment of inertia (MOI). For β-band, the level energies are $E(0_\beta)$, $E(2_\beta)$, $E(4_\beta)$, $E(6_\beta)$, $E(8_\beta)$ and $E(10_\beta)$ in KeV for spin I=0, 2, 4, 6, 8 and 10. The difference of $[E(2_\beta) - E(0_\beta)]$ and $[E(4_\beta) - E(0_\beta)]$ are denoted as $\Delta E(20_\beta)$ and $\Delta E(40_\beta)$. The Equ. (1) for spin 2 and 4 gives:

$$\Delta E(20_\beta) = \frac{3}{\theta(1+2\sigma)} \qquad (2)$$

and $$\Delta E(40_\beta) = \frac{10}{\theta(1+4\sigma)} \quad . \qquad (3)$$

On dividing equation (3) by equation (2), the θ is cancelled and σ can be calculated. Using σ and θ for different spin the values of level energies is reproduced. Similarly, the PL energy expression $E_I=aI^b$ [3] is used for β-band. The values of 'a' and 'b' parameters are obtained by subtracting band head difference $E(0_\beta)$ and the energy difference of spin 2 and 4. Using these parameters, level energies are reproduced.

Result and Discussion

The values of root mean square deviation (RMSD) of the reproduced level energies are obtained using PL and SRF from experimental level energies [5]. It is observed that the RMSD values are small using power law in comparison to the SRF. Most of the nuclei having RMSD value lie below 40 KeV using power law except N=88 whereas using SRF it is lie below 100 KeV. The variation of RMSD versus N using SRF and PL is shown in Fig. 1(a, b). The MOI from SRF for β-band and ground band is studied with energy ratio of both the bands and shown in Fig. 2(a, b). It is observed from the diagrams that as the energy ratio rises from spherical behavior to deformed limit, the MOI increases except ^{150}Sm in β-band and ^{150}Nd out of the fit of smooth curve. The systematics of softness parameters of both the bands also has same correlation with energy ratios.

Conclusion

It is evident from variation of RMSD vs. R_4 curve that the level energies of β-band are well reproduced in PL and the values of RMSD ≤ 40 KeV except N=88 isotones (RMSD≈ 50 KeV). The variation of MOI (θ)

vs. R_4 for g- band and β- band show a strong correlation.

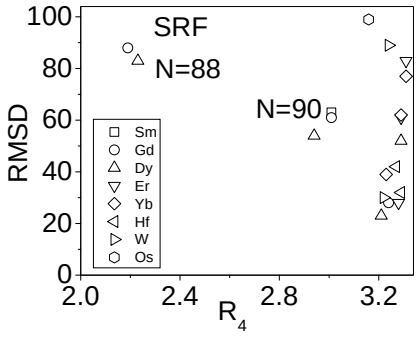

Fig. 1(a) The variation of RMSD vs R_4.

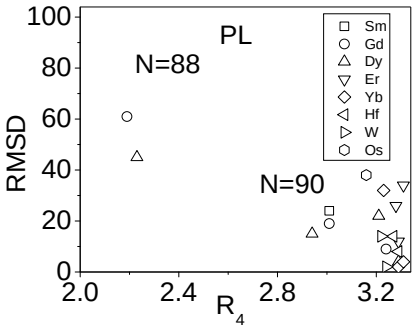

Fig. 1(b) The variation of RMSD vs R_4.

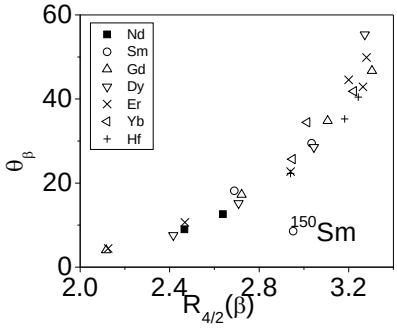

Fig. 2(a) The MOI vs. $R_{4/2}$ for β-band.

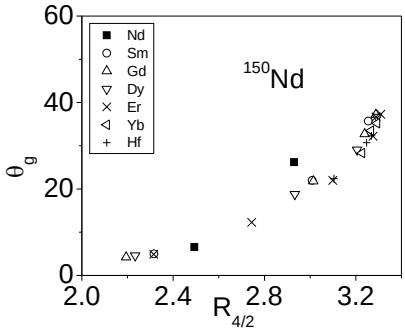

Fig. 2(b) The MOI vs. $R_{4/2}$ for ground band.

Acknowledgement:

One of us SS is thankful to the Shri Pankaj Goel Chairman, Panchwati Institute of Engineering & Technology, Meerut for supporting research facility in the Institute. VK is thankful to the Shri Dinesh Goel, Chairman, Raj Kumar Goel Institute of Technology, Ghaziabad for providing platform for research work. J. B. Gupta appreciates post-retirement association with Ramjas College.

* *Raj Kumar Goel Institute of Technology (Uttar Pradesh Technical University), Ghaziabad.*

References:

[1] A. Bohr & B. R. Mottelson, Nuclear Structure, Vol. II (Benjamin, N.Y) 1975.
[2] R. K. Gupta, Phys. Lett. **36B** (1971) 173 & P von Brentano et al., Phys. Rev. **C69**, (2004) 044314
[3] J. B. Gupta, A. K. Kavathekar and R. Sharma, Physica Scripta **51** (1995) 316.
[4] J. B. Gupta, Satendra Sharma and Vikas Katoch, Pramana J. of Phys. 81(2013) 75-86
[5] www.nndc.gov.bnl, July, 2014