The correspondence of kinetic MoI with power formula index

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In the heavy ion induced reactions with medium mass nuclei, the nucleus is excited to high spins. From the regular γ-ray peak spectra one deduces the kinetic moment of inertia. $J^{(1)}$.

$$J^{(1)} = (2I-1)/E_\gamma \tag{1}$$

based on the rotation model (RM) formula. The slope of the MoI curve varies nucleus to nucleus. Further information is obtained by calculating the dynamic MoI $J^{(2)} = 4/(E_{\gamma 1} - E_{\gamma 2})$.

To express the level energy in ground band, a power index formula

$$E = a\, I^b \tag{2}$$

was proposed earlier by Gupta et al. [1]. It was demonstrated therein that this formula reproduces the energy spectra of deformed nuclei and of the shape transitional nuclei in the medium mass region equally well.

Recently, Gupta and Hamilton [2] have pointed out that the absolute slopes of the kinetic MoI versus spin I, using expression (1), represents only the deformation of the core, not the change in nuclear structure with spin. This is important, especially for near spherical nuclei. Instead, it is the change in slope with spin I, which represents the variation of nuclear structure with spin. Here we illustrate this aspect of nuclear structure by looking at the correspondence of the variation of kinetic MoI with spin and the value of 'b' in the power index formula.

We illustrate this correspondence in two nuclei ^{148}Ce and ^{148}Nd, (N=90, 88), of different deformation, through the plots of Moment of Inertia and of index 'b' versus I. In Fig. (1, 2), we have plotted MoI $J^{(1)}$ and index 'b' against the level spins of the ground band in ^{148}Ce.. The plot of $J^{(1)}$ versus I for ^{148}Ce shows a 300 % rise in value from 20 to 60 up to I=20 and the slope is almost constant, except a small rise at I=14. This small rise reflects slight move to more vibrational. A constant slope of $J^{(1)}$ corresponds to a constant magnitude of index 'b' [2]. The same is approximately realized in the plot (Fig. 2) of index 'b' versus spin I. Its magnitude varies less than 3 % from 1.52 to 1.47 only. Note the highly magnified scale of 'b'. This slight decrease corresponds to slight move towards vibrational. Same features are reflected in ^{148}Nd (Fig. 3 and 4). Here the $J^{(1)}$ increases by 350 % (more vibrational). Again 'b' is almost constant (within 2%). This clearly illustrates that the constant slope of $J^{(1)}$ implies a structure, constant with spin. The absolute rise is due to the use of rotational model expression (2I-1) in the numerator, as pointed out in Ref. [2].

To further test the above hypothesis, in Fig. 5, 6, we present the differentials of MoI and index 'b'.

The slight change in slope of MoI with spin corresponds to the slight reduction in 'b' (Fig. 6). Note that the increase in slope of MoI corresponds to decrease in index 'b'.

Conclusion

The close relation of slope of MoI versus spin with index 'b' is clearly demonstrated in this study. The latter provides a quantitative measure.

References

[1] J.B. Gupta, A.K. Kavathekar and R. Sharma Phys. Scr. **51**, 316 (1995).
]2] J.B. Gupta and J H Hamilton, Phys. Rev. C**83**, 06 4312 (2011).

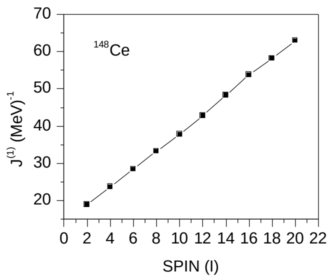

Fig. 1. Plot of MoI $J^{(1)}$ vs I for ^{148}Ce.

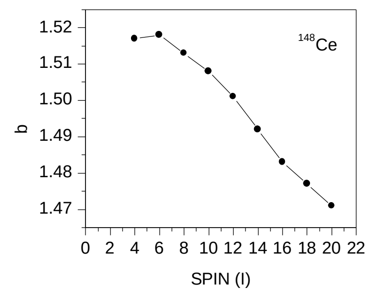

Fig. 2. Plot of index ‘b’ vs I for ^{148}Ce..

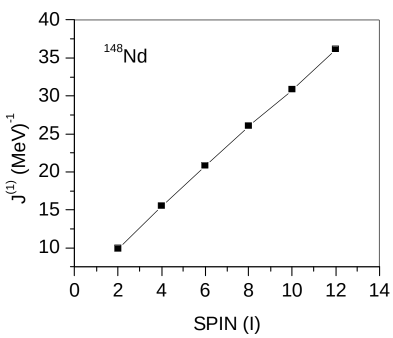

Fig. 3. Plot of MoI $J^{(1)}$ vs I for ^{148}Nd,

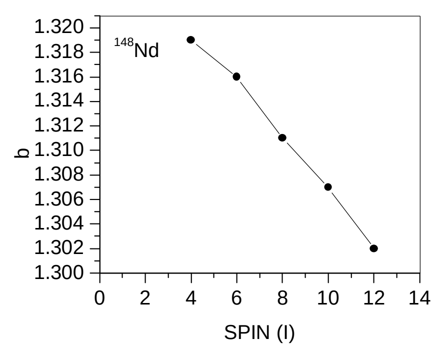

Fig. 4. Plot of index ‘b’ vs I for ^{148}Nd.

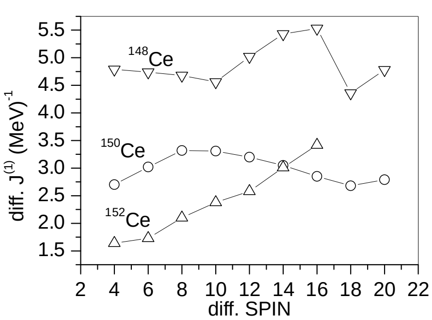

Fig. 5. The differential slope of MoI in Ce.

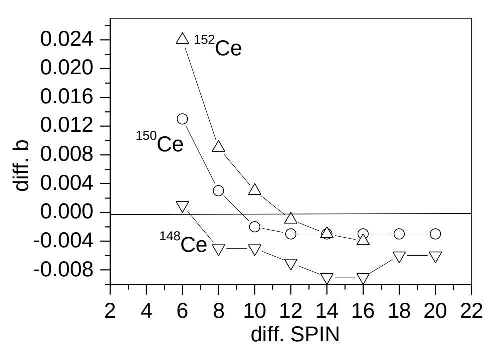

Fig. 6. The differential of index ‘b’ in Ce.