Systematic dependence of $SFE * B(E2) \uparrow$ and $ROTE * B(E2) \uparrow$ on N_pN_n in A = 100-200 mass region.

Amit Bindra* and H.M. Mittal
Department of Physics, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar-144011, India

Introduction

The study of deformation and evolution of collectivity is the ongoing and active issue in the study of nuclear structure. Long ago, Satpathy and Satpathy [1] proposed a shape fluctuation model for the energy levels of a ground state bands in even even nuclei. The energy expression is given by

$$E(J) = B_0J(J+1) + J\phi^{'}E^{'} + J\phi^{'}B^{'}J(J+1) \quad (1)$$

where ϕ is the intrinsic wave function, E is the intrinsic energy of the core. In eq. (1) the first term gives the energy due to the rotation of the unfluctuated core. The second and third term respectively gives the excess in the intrinsic energy and rotational energy due to fluctuation of the core. Based on the assumptions of shape fluctuation model Gupta *et al.* [2] assumes the sum of last two terms - the intrinsic energy and interaction term as the shape fluctuation energy (SFE) and the first term being the rotational energy (ROTE).

$$E(J) = aJ(J+1) + bJ + cJ^2(J+1) \quad (2)$$

where a, b and c are the constants can be calculated by least squares fit method.The IBM-I [3] Hamiltonian, represent O(5) and O(3) symmetries written in terms of Casimir operators have the same split of energy of $E(2_1^+)$ into vibrational and rotational part as written in eq. (2) in their contribution to g-band energies. It was recently suggested [4] that a simplified parametrization of nuclear structure could be obtained by plotting the Grodzins product $E(2_1^+) * B(E2) \uparrow$ as a function of product N_pN_n. Following Satpathy and Satpathy [1], we have splitted the energy term in Grodzins product $E(2_1^+) * B(E2) \uparrow$ as $SFE * B(E2) \uparrow$ and $ROTE * B(E2) \uparrow$ and studied its systematic dependence on N_pN_n for A = 100-200 mass region.

Results and discussion

We adopt a grouping based on valance particle and hole pair consideration [5]. Thus the Z = 50-82, N =82-126 major shell space is partitioned into four subspaces: p-p, h-p, h-h and p-h quadrants (p = valance particle, proton or neutron, h = hole). The last quadrant is empty. The data is taken for $E(2_1^+)$ and $B(E2) \uparrow$ values from National Nuclear Data Centre [6] and S. Raman *et al.* [7]

Figure 1 shows $SFE*B(E2) \uparrow$ and $ROTE* B(E2) \uparrow$ are plotted against N_pN_n for all nuclei in Z =50-82 and N = 82-126. The product $SFE * B(E2) \uparrow$ and $ROTE * B(E2) \uparrow$ are a convenient indicator of structure. The product $SFE * B(E2) \uparrow$ is smoothly decreasing with N_pN_n. For shape transistional nuclei *Nd*,*Sm* and *Gd*, the product $SFE * B(E2) \uparrow$ falls to minimum almost zero and becomes negative for $N_pN_n > 120$. Casten[8] also observed a similar change as the data points of ground state energy ($E(2_1^+)$) shifted from the regular trend (Fig. 12 Ref. 8) plotted as a function of N_pN_n for shape transitional nuclei. However, in case of *Pt* and *Hg* spherical nuclei large positive values for the product $SFE * B(E2) \uparrow$ are observed. It is due to the proximity of closed proton shell and loss of collectivity. Casten [8] observed as Z increases beyond 76 the last protons enters strongly upsloping $\frac{11}{2}[505]$ and $\frac{7}{2}[402]$ orbits.

On the contrary relative rise is seen in the product $ROTE * B(E2) \uparrow$ plotted against N_pN_n for all nuclei in Z =50-82 and N = 82-126. Gupta *et al.*[2] suggested that the rota-

*Electronic address: amitbindra@ymail.com

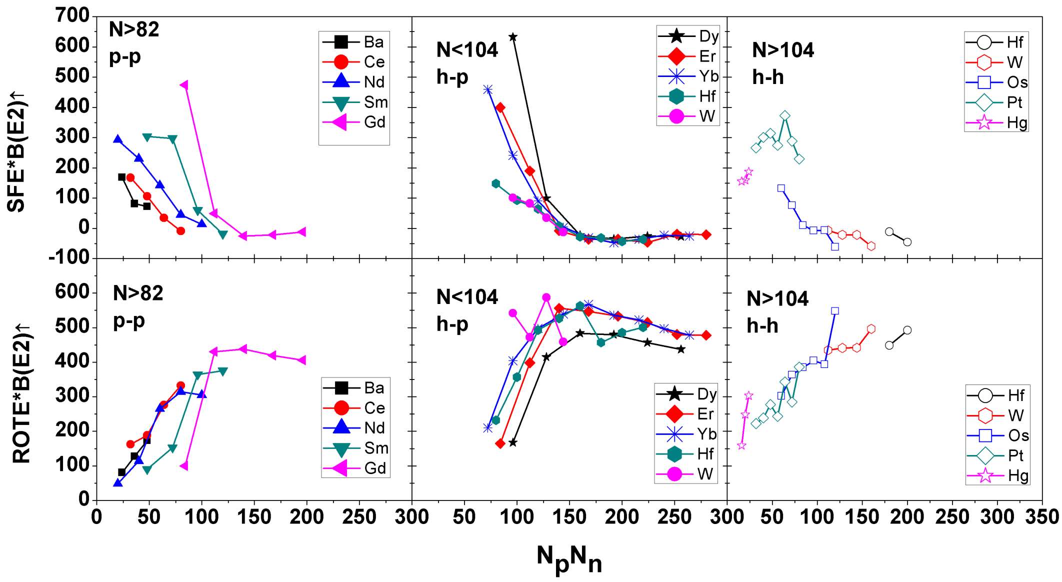

FIG. 1: Plots of $SFE * B(E2) \uparrow$ and $ROTE * B(E2) \uparrow$ in keV e^2b^2 as a function N_pN_n for all nuclei in Z =50-82 and N = 82-126 .

tional energy decreases with increase in deformation (see Fig. 6 of Ref. 2) so that realistic picture of rotational energy in collective state $E(2_1^+)$ is not justified. Here, the plots are vividly highlight the rotational contribution along with $B(E2) \uparrow$ as both N_p and N_n increases simultaneously. It indicates the rotational content and excitation strength represents the coherent motion. In $N > 104$ region the difference between *Pt* and *Hg* nuclei are more highlighted while observing the $ROTE * B(E2) \uparrow$ plot as a function N_pN_n. The data points of *Pt* overlaps with *Os* but *Hg* lie far off. This shows the *Pt* has possibility to deform for large N_pN_n values.

Conclusion

In the well deformed region studied above the product $SFE * B(E2) \uparrow$ decreases and give negative values, becomes independent of N_pN_n product. On the contrary the large contribution of rotational product $ROTE * B(E2) \uparrow$ is significantly highlighted in this split which was missing in previous work.

References

[1] M. Satpathy and L. Satpathy, *Phys. Lett. B* **34** 377 (1971).
[2] J.B Gupta, H.M. Mittal and S. Sharma, *Phys. Scrp.* **41** 660 (1990).
[3] F. Iachello and A. Arima, *The Interacting Boson Model* (1987).
[4] P. Kumari and H. M. Mittal, *Int. J. Mod. Phys. E* **24** 1550033 (2015).
[5] J.B. Gupta, *Int. J. Mod. Phys. A* **5** 6(1990).
[6] www.nndc.gov.in
[7] S. Raman, C. W. Nestor, Jr. and P. Tikkanen, *At. Data Nucl. Data Tables* **78** 1 (2001).
[8] R.F. Casten, *Nucl.Phys.A* **443** 1 (1985).