The study of triaxial rotor model in A=120-200 mass region nuclei.

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Introduction

The Bohr Mottelson expression has widely used for the description of the low energy spectra of deformed nuclei that satisfy the rotational limit $R_{4/2} \geq 3.3$ [1]. For the shape of transitional nuclei there are several other formulae that describe the properties of ground band energy. The simplest well known expression for rotational spectra is Ejiri et al.[2] tested empirically the expression

$$E(J) = aJ(J+1) + bJ \tag{1}$$

However, this two-parameter expression yields a linear relation of $R_6 (= E(6_1^+)/E(2_1^+)$ with $R_{4/2}$, but the experimental data deviate from this, showing the need of a 3rd term viz

$$E(J) = aJ(J+1) + bJ + cJ^2(J+1) \tag{2}$$

The usefulness of such a split of the total energy level of 2^+ into ROTE+VIBE was illustrated by Gupta et al. [3] for studying the collective nuclear structure variation with N, Z and N_pN_n (product of valence proton and neutron pairs). In this present work we try to understand the effect on the shape transition when mixing angle (τ) is added to the asymmetric parameter (γ_0) and to study correlation of $B(E2)_{cal}$ ratio with N_pN_n.

Calculation

The Hamiltonian for the model can be written as [4]

$$H = A\tilde{I}^2 + F\tilde{I}_3^2 + G(\tilde{I}_+^2 + \tilde{I}_-^2), \tag{3}$$

where

$$A = \frac{1}{2}(A_1+A_2), \quad F = A_3-A, \quad G = \frac{1}{4}(A_1-A_2)$$

and

$$\tan\tau = \frac{\sqrt{F^2+12G^2}-F}{2\sqrt{3G}} \tag{4}$$

Therefore moment of inertia is directly equal to the

$$J_k = 4B\beta^2\sin^2(\gamma_0 - k\frac{2\pi}{3}), k = 1,2,3... \tag{5}$$

where B is mass parameter, therefore

$$F = \frac{3}{8B\beta^2\sin^2 3\gamma_0}(\cos 4\gamma_0 + 2\cos 2\gamma_0) \tag{6}$$

$$G = \frac{\sqrt{3}}{16B\beta^2\sin^2 3\gamma_0}(\sin 4\gamma_0 - 2\sin 2\gamma_0) \tag{7}$$

and

$$\tau = -\frac{1}{2}\cos^{-1}\left(\frac{\cos 4\gamma_0 + 2\cos 2\gamma_0}{\sqrt{9-8\sin^2 3\gamma_0}}\right) \tag{8}$$

From (8) we calculate the value of mixing angle. Here β is calculated from

$$\beta = \beta_G\left(\frac{9-8\sqrt{81-72\sin^2 3\gamma_0}}{4\sin^2(3\gamma_0)}\right) \tag{9}$$

where

$$\beta_G^2 \cong \frac{1224}{E(2_1^+)A^{7/3}} \tag{10}$$

$$B(E2;2_l^+ - 0_1^+) = \frac{Q_0^2}{16\pi}\left[\frac{1}{2} - (-1)^l\frac{1}{2}\frac{3-2\sin^2 3\gamma_0}{\sqrt{9-8\sin^2 3\gamma_0}}\right] \tag{11}$$

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To calculate the γ_0 there are various method. We have derived γ_0 from the R_γ values using the equation that is given by Davydov and Filippov [5]

$$\gamma_0 = \frac{1}{3}\sin^{-1}\left[\frac{9}{8}\left(1-\left(\frac{R_\gamma-1}{R_\gamma+1}\right)^2\right)\right]^{1/2} \tag{12}$$

Result and discussion

In quadrant-IV, containing 66≤ N≤ 82 (Xe-Nd) region of neutron deficient nuclei, lying far from the β - stability line, variation of relative rotational energy ROTE/$E(2_1^+)$ with $\gamma_0+\tau$ is linear (about 70%) and saturation is attained. Next in quadrant-1 of N>82 region

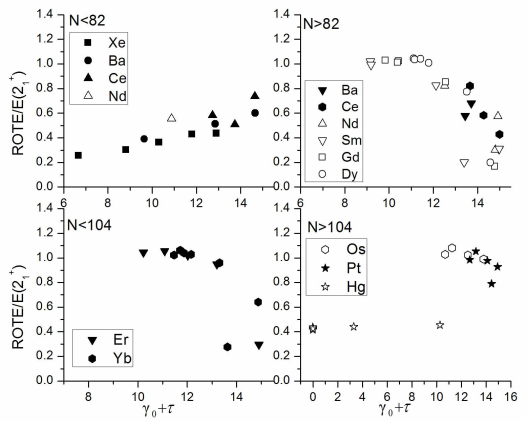

FIG. 1: Variation of ROTE/$E(2_1^+)$ with $\gamma_0+\tau$ for A=120-200 mass region nuclei.

minimum value of $\gamma_0+\ \tau=9^o$, therefore those nuclei having low value of $\gamma_0+\ \tau$ and behave as axially symmetric in nature (see Fig.1). In quadrant-II value of $\gamma_0+\ \tau$ lie between 10^o to 15^o. For $^{156-160}$Er and $^{160-164}$Er nuclei value of $\gamma_0+\ \tau$ is maximum but relative ROTE energy is small i.e. 20-80% but at low value of $\gamma_0+\ \tau$ the relative ROTE energy is maximum i.e. 100%. For N>104 (quadrant-III) the datum of Hg nuclei lies below the curve because these nuclei do not get deformed below 16^o, hence behave axially symmetric.

In Fig. 2 we study see the variation of $B(E2)_{cal.}$ ratio (0.18 for $N<82$,$N.82$ nuclei

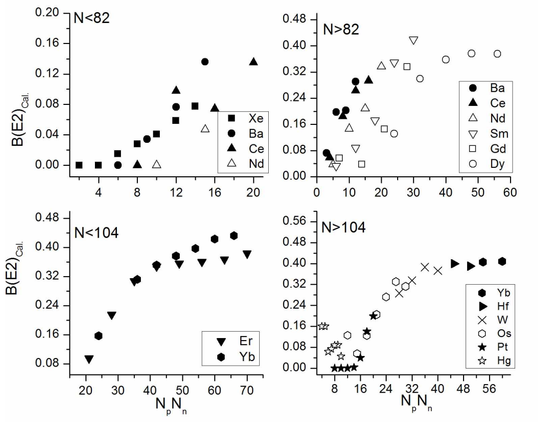

FIG. 2: Variation of $B(E2)_{cal.}$ with (N_pN_n) for A=120-200 mass region nuclei.

and 0.40 for $N>104$, $N<104$ nuclei)with N_pN_n. The $B(E2)_{cal.}$ ratio rise with increasing N_pN_n. Scattering of the data also increases. In quadrant (I, II)(N>82) $B(E2)_{cal.}$ ratio shows exponential rise with the number of valence proton and number of valence neutron number. In quadrant III(N<104) the B(E2)cal ratio for Er and Yb nuclei show smooth rise with the N_pN_n and attained maximum value ($\simeq$ 48%). Next in quadrant IV at low value of N_pN_n the datum of Os, Pt and Hg nuclei have minimum value of $B(E2)_{cal.}$

References

[1] A. Bohr and B. R. Mottelson, *Nuclear Structure W. A. Benjamin, Inc., New York*, **II**, 145 (1975).

[2] H. Ejiri, M. Ishihara, M. Sakai, K. Katori and T. Inamura, J. Phys. Soc. Jpn. **24**, 1189 (1968).

[3] J. B. Gupta, H. M. Mittal and S. Sharma, Phys. Scr. **41**, 660 (1990).

[4] J. L. Wood, A-M. Oros-Peusquens, R. Zaballa, J. M. Allmond and W. D. Kulp, Phys. Rev. **C70**, 024308 (2004).

[5] A. S. Davydov and G. F. Filippov, *Nucl. Phys.*, **8**, 237 (1958).