Study of triaxial rotor model and correlation of deformation parameter β and γ_0 in A=120-200 mass region

H. M. Mittal* and Vidya Devi
[1] Dr B. R. Ambedkar, National Institute of Technology Jalandhar-144011, INDIA

Introduction

One basic property of the nucleus is its geometric shape. To describe the nuclear structure we turns into the two well known parameter asymmetric parameter (γ_0) and deformation parameter (β), which can be obtained by one of the simplest model for the nuclear collectivity, the rigid triaxial rotor model of Davydov and Fillipov [1]. The triaxiality is the key property of the ground state, as well as the excited states of nucleus. To understand the triaxiality features the gamma degree of freedom plays an important role in the description of these nuclei. The β and γ_0 of the collective model are the basic descriptor of the nuclear equilibrium shape and structure. The anharmonic vibrator (AHV) expression [2],

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

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

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

which gives a non-linear relationship of $R_{6/2}$ with $R_{4/2}$. The variation of ROTE/$E(2_g^+)$ with asymmetric parameter (γ_0) in all the four quadrants is already studied by [3]. We extended this work here, to understand the shape phase transition when mixing angle (τ) is added to the γ_0. We also study the variation of γ_0 and β.

*Electronic address: mittalhm@nitj.ac.in

Calculation and Results

According to the J. L Wood [4] the Hamiltonian for the model is

$$H = A_1\tilde{I}_1^2 + A_2\tilde{I}_2^2 + A_3\tilde{I}_3^2 \tag{3}$$

The Hamiltonian can be written as

$$H = A\tilde{I}^2 + F\tilde{I}_3^2 + G(\tilde{I}_+^2 + \tilde{I}_-^2) \tag{4}$$

where

$$A = \frac{1}{2}(A_1 + A_2),\ F = A_3 - A,\ G = \frac{1}{4}(A_1 - A_2) \tag{5}$$

and for $I = 2$

$$\begin{pmatrix} 6A & 4\sqrt{3}G \\ 4\sqrt{3}G & 6A + 4F \end{pmatrix} \tag{6}$$

therefore

$$\tan\tau = \frac{\sqrt{F^2 + 12G^2} - F}{2\sqrt{3G}} \tag{7}$$

Therefore moment of inertia is directly equal to the

$$J_k = 4B\beta^2 \sin^2(\gamma_0 - k\frac{2\pi}{3}), k = 1, 2, 3... \tag{8}$$

where B is mass parameter, therefore [4]

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

From (9) we calculate the value of mixing angle. To calculate the γ_0 there are various methods, but the γ_0 derived from $R_\gamma(= E(2_\gamma^+)/E(2_g^+))$ is more relevant [5]

$$\gamma_0 = \frac{1}{3}\sin^{-1}\left[\frac{9}{8}\left(1-\left(\frac{R_\gamma - 1}{R_\gamma + 1}\right)^2\right)\right]^{1/2} \tag{10}$$

Here β is calculated from [6]

$$\beta = \beta_G \left(\frac{9 - 8\sqrt{81 - 72\sin^2 3\gamma_0}}{4\sin^2(3\gamma_0)}\right) \tag{11}$$

where

$$\beta_G^2 \cong \frac{1224}{E_{2_g^+} A^{7/3}}. \tag{12}$$

For above calculation the experimental data is taken from [7].

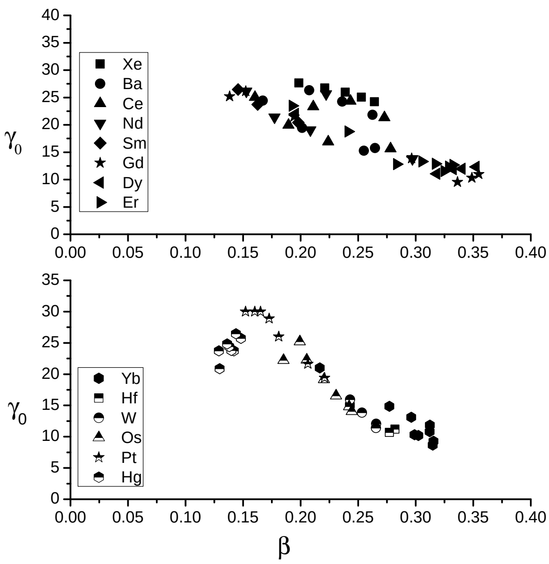

FIG. 1: Correlation of γ_0 with β for N=68-126 region nuclei.

By counting of particle (p) and hole (h) boson partitions the major shell space of Z=50-82, N=66-82, N = 82-126 are divided in four quadrants (Q) viz. quadrant I and III for p-p and h-h bosons, and II, IV for p-h and h-p bosons respectively [8]. In Fig. 1 we see the variation of asymmetric parameter γ_0 with deformation parameter β and these two parameter shows excellent agreement with each other. From this we observe that β is constant with γ_0 for soft nuclei as compared to the well deformed nuclei.

Conclusion

Above study reveals some important description for A=120-200 mass region nuclei with the help of Davydov Filippov model. The present work provides new insight into the triaxial rotor model, which is widely used as a basic description of nuclear collectivity. The correlation of asymmetric parameter γ_0 and deformation parameter β gives extremely well agreement with each other.

References

[1] A. S. Davydov and G. F. Filippov, Nucl. Phys **8** 237 (1958).
[2] T. K. Das, R. M. Dreizler and A. Klein, Phys. Rev. **C 2**, 632 (1970).
[3] H. M. Mittal and Vidya Devi, Proc. Symp. on Nucl. Phys. **52B**, 260 (2007).
[4] J. L. Wood, A-M. Oros-Peusquens, R. Zaballa, J. M. Allmond and W. D. Kulp, Phys. Rev. **C 70**, 024308 (2004).
[5] J. B. Gupta and S. Sharma, Physica Scripta **39** 50 (1989).
[6] L. Esser, U. Neumeyer, R. F. Casten and P. von. Brentano, Phys. Rev. C **55** 206 (1997).
[7] http: // www.bnl.nndc.gov / nsdf.
[8] J. B. Gupta, J. H. Hamilton and A. V. Ramayya, International Journal of Modern Physics A **5** 1155 (1990).