Mass coefficient systmatics in triaxially deformed Xe & Ba nuclei

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In past few decades, extremely rich experimental data have been accumulated in low–lying nuclear spectroscopy. The observed levels are interwoven in a rich and complicated manner and to understand them is a challenging problem [1]. In A ~ 120-140 region where transition occurs from vibrator like stretching around the neutron closed shell (N = 82) to a region with more rotational character (N = 66) energies and B(E2) values of the low lying states change slowly and smoothly with N and Z indicating the collective nature of the levels. The systematic investigation of such nuclei within an isotopic chain undergoing shape or phase transitions is of particular current interest in nuclear structure physics. Rotation is one of the specific collective motions in finite body systems. When the angular momentum increase, one can observe how the energies of the quantum state change due to the effect of the coriolis and centrifugal forces. Thus in the transition to excited states the axial symmetry of the nucleus is violated even if it existed in the ground state. Surface oscillations begin to appear and the rotational motions are connected with surface vibrations. The rotation vibration interaction rectifies the rotational energy. Toki and Faessler [2] suggested that there are three rotational bands when asymmetric nucleus rotates one is yrast and the other two are even and odd gamma bands. The mass coefficients of these three modes of rotations are different and are calculated from band head energies.

Liao [3] suggested a new relation for $E_{In}(b)$ (the energy of the In level) with rotation vibration coupling 'b' for nuclei having large asymmetric angle γ. According to which

$$E_{In}(b) = a\varepsilon_{In}(1-b\,\varepsilon_{In}) \qquad (1)$$

where $a = \frac{\hbar^2}{J_0}$; mass coefficient and b = rotation vibration coupling parameter. We have calculated the values of three mass coefficients as $a_r = \frac{E(2_1^+)}{\varepsilon(2_1^+)}$; $a_e = \frac{E(2_2^+)}{\varepsilon(2_2^+)}$ & $a_o = \frac{E(3_1^+)}{\varepsilon(3_1^+)}$

The values of'a_r', 'a_e' and 'a_o' and N_pN_n of Xe and Ba nuclei are listed in table 1.

On investigating the systematic behavior of the parameters 'a' and 'b', following conclusions emerge;

a_r, a_e and a_o have strong correlation with N_pN_n in both the isotopic chains of Xenon and Barium (fig. 1). These trends are expected one since the experimental $E(2_1^+), E(2_2^+)$ and $E(3_1^+)$ increase smoothly with decrease of N_pN_n in Barium nuclei and these experimental values first decrease with increase of N_pN_n (48 to 64) and then increase with decrease of N_pN_n (64 to 24) in Xenon nuclei. Rotation-vibration interactions do not perturb these band head energies. The even spin of gamma band are pushed up due to repulsive force for $I^+ \geq 4^+$ while the odd spins of gamma band remain unaffected. The smooth variation of moment of inertia observed in present work exhibits collectivity and as such this extends the work of Yan et al. [4] whose correlations of basic parameters β and γ versus N_pN_n are now being extended to another basic parameter of asymmetric rotor model i. e. moment of inertia.

The parameters a_r, a_e, and a_o vary smoothly with Z and N. In particular, these values decrease with increase of Z (for the same value of N) and increase with increase of N (for the same value of Z). This observation remains unaltered if some nuclei of even Ce and Nd are also included. So this is true in broader range also.

The values of ε_{In} depend on γ alone. And the values of E_{In} can be related with deformation parameters β and γ [2]. Thus, the value of $a = \frac{\hbar^2}{J_0}$ can be related with β and γ. If we make use of the semi-empirical relation of Grodzins on the assumption of axial symmetry, we have

$$E2_1^+ B(E2;2_1^+ \rightarrow 0_1^+) \approx 2.5\times10^{-3} Z^2 A^{-1}$$

[MeV e^2b^2]

This relation allows us to relate the parameter J_0 to an effective value of β (=βe)

$$\frac{\hbar^2}{J_0} = \frac{408}{\beta_e^2 A^{7/3}}$$

If the γ deformation is taken into account, the corrected β deformation parameter is given by

$$\beta = \beta e \frac{9-\sqrt{81-72\sin^2 3\gamma}}{4\sin^2 3\gamma}$$

The deformation parameter β has a maximum at midshell (N= 66), the values of $a = \frac{\hbar^2}{J_0}$ should be minimum for N = 66 since β^2 occurs in denominator in the expression of 'a'. On looking at the Xenon figures, a_r and a_e have minimum values at N_pN_n = 64 where N = 66. The value of a_o is minimum at N = 68, (N_pN_n = 56) and these values increase to both the sides of N_pN_n where the deformation parameter β decrease. The Barium nuclei also show increasing values for all of three parameters a_r, a_e and a_o with the decreasing values of N_pN_n (fig. 1).

N_pN_n vs β plot of Yan et al. [4] for even Xe and Ba nuclei are not so smooth as NpNn vs 'a' plot of the present work. This is significant; it relates 'a' moment mass coefficient instead of β with N_pN_n more smoothly may be due to inclusion of atomic mass (A).

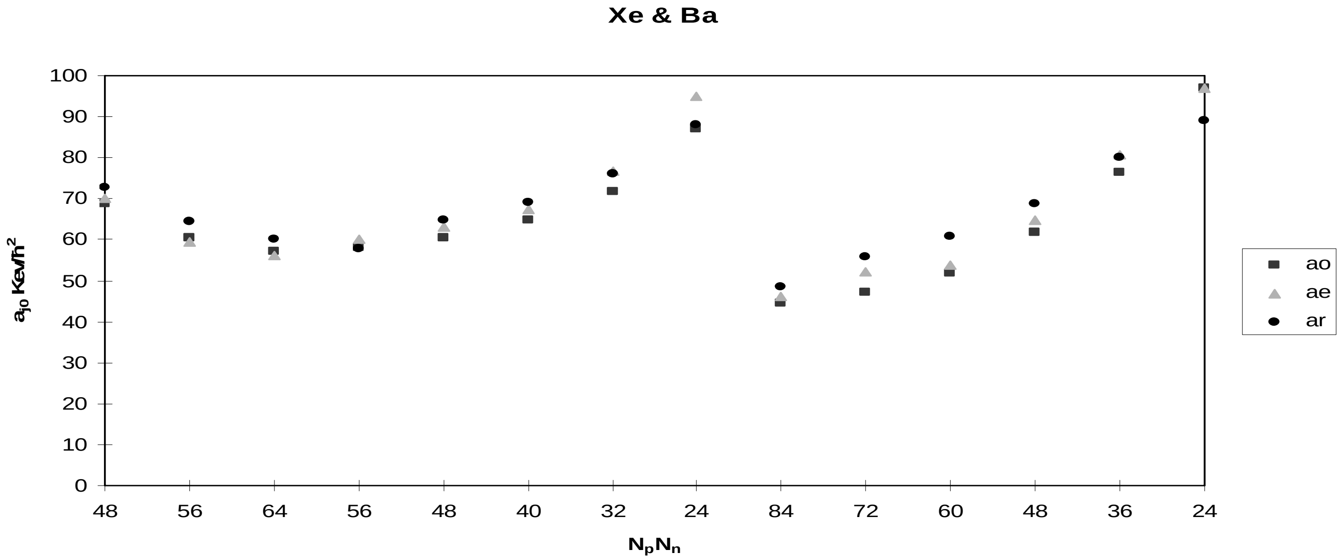

Fig.1

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