Study of correlation of γ-g transitions with $E(2_\beta)/E(2_\gamma)$ energy ratio

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The low energy collective spectra of even-even nuclei exhibit the $K=0_1$ ground state band, $K=0_2$ β-band and the K=2 γ-band. In the algebraic approach of Interacting Boson model (IBM-1) [1] conservation of correlated nucleon pair bosons in the boson-boson interaction, leads to the U(6) group algebra. In the SU(3) dynamic symmetry of U(6), the I=2 states in $K= 0_2$, 2 bands are predicted to be degenerate. This is true in experiment for a few nuclei. For most nuclei, the two bands lie apart. Casten et al. [2], while studying the robust predictions of IBM-1, used the IBM Hamiltonian:

$$H_{IBM}=kQ.Q+k'L.L+k''P.P \qquad (1)$$

$$\text{With } Q= e\,[d^+s + s^+d)+\chi d^+d] \qquad (2)$$

Here Q.Q, P.P and L.L are the quadrupole, pairing and angular momentum terms respectively, the strength determined by coefficients [1]. The variation of χ parameter in Q may be used to get perturbed SU(3) and to split the degeneracy of the excited K=0, 2 bands. Charge parameter in Q operator is e.

The larger excitation strength of $B(E2, 0_1\text{-}2_\gamma)$ than the $B(E2, 0_1\text{–}2_\beta)$ by an order of magnitude. (~ 2 to 10) is predicted well by IBM-1. Casten et al. [2] also noted that in IBM. one gets the ratio $B(E2, 0_2\text{-}2_\gamma)/B(E2, 0_2\text{-}2_g)$ large, contrary to the view held in collective BM model and the band mixing explaining the deviations from Alaga rules. This of course is not wholly true, since in the microscopic treatment of H_{coll}, such large ratios have been obtained earlier [3].

Casten et al. [2] proposed that the two excited bands are coupled and that R= $B(E2, 2_\gamma\text{-}0_g/2_g)$ ratio is correlated to the energy ratio $r=E(2_\beta)/E(2_\gamma)$. Following Gupta et al. [4], we have studied this correlation for the nuclei, quadrant wise for the Z=50-66, N=82-104 region. In quadrant-1 (Z=56-64, N<104) (Fig.1) and quadrant-2 (Z=66-74, N<104) (Fig. 2), n*o smooth correlation is exhibited*. Only in quadrant-3 (Z=70-78, N>104), the B(E2) ratio R decreases smoothly with the energy ratio r (Fig. 3), in agreement with the observation of Ref. [2].

The correlation observed in Fig. 3, led Casten and Brentano [5] to suggest that the *$K=0_2$ band may be the two phonon K=0 $\gamma\gamma$ excitation built on 2_γ* .However, this conclusion was contested by Burke and Sood [6]. Since this controversy of the nature of $K=0_2$ band persists [7], the present work will further help in settling this problem.

The answer to the question raised here is a partial yes, with a further reservation that the relation of R to r in Quad.-3 is only incidental. The latter is not the cause of the former. For example, in rigid triaxial model (RTR) [8], R is related to the energy ratio $R_\gamma=E(2_\gamma)/E(2_g)$ which is related to asymmetry parameter γ in all the three quadrants [9]. Also with increasing deformation and increasing $R_{4/2}$ the nucleus is expected to be β-rigid and beta band would rise, yielding increasing 'r' ratio. The B(E2) ratio is also correlated with the nucleon pair products N_pN_n [10].

Conclusion:

The variation of the $B(E2, 2_\gamma\text{-}0_g/2_g)$ ratio is a function of the energy ratio $r=E(2_\beta)/E(2_\gamma)$.in the third quadrant only. But it is a smooth function of N_pN_n, as well as the energy ratio $R_\gamma= E(2_\gamma)/ E(2_g)$ in general.

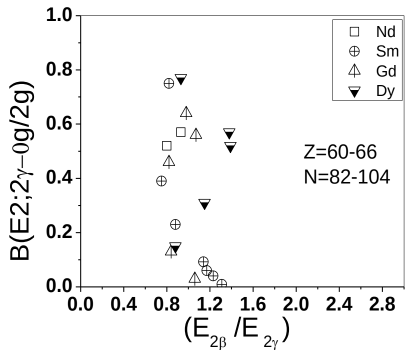

Fig: 1. Variation of B(E2; 2γ-0g/2g) with $E_{2\beta}/E_{2\gamma}$ in quadrant I.

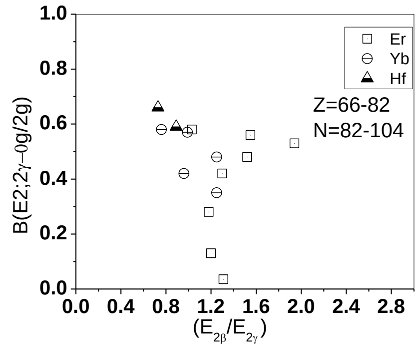

Fig: 2. Variation of B(E2; 2γ-0g/2g) with $E_{2\beta}/E_{2\gamma}$ in quadrant II.

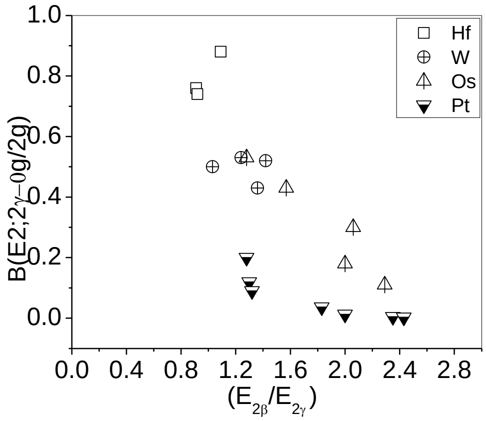

Fig: 3 Variation of B(E2; 2γ-0g/2g) with $E_{2\beta}/E_{2\gamma}$ in quadrant III .

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