Test for the global validity of Grodzins product rule

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Introduction

The study of energy levels of the ground state bands yield important information on the collective nuclear structure. The energy of first excited state $E(2_1^+)$ and reduced electric quadrupole transition probabilities $B(\text{E2})\uparrow$ for transition from ground (0_1^+) to first excited state (2_1^+) tell us about the deformation of the nuclear core. A systematic study of the energy of the 2_γ^+ excitation was performed to examine the role of higher excitations in the determination of nuclear structure [1]. Grodzins [2] identified a relation between the energy $E(2_1^+)$ of the ground state and the γ-ray transition probabilities. An approximate inverse proportionality between the γ-ray transition probabilities and energy $E(2_1^+)$ of even-even nuclei is indicated by this relation. Gupta [3] studied the breakdown of Grodzins product rule in $N = 88$ isotones occurring due to the effect of $Z = 64$ subshell and shape phase transition at $N = 88 - 90$, which led to a series of systematic analysis performed on the constancy of Grodzins product by various workers. In the present work, we explore the constancy of Grodzins product for higher spins of the ground band.

The Grodzins Product Rule

Grodzins [2] studied the uniform behavior of gamma-ray transition probabilities T_γ from $A \sim 12$ to $A \sim 240$ and examined their dependence on the energy of transition. 80% of the 126 transition probabilities known at that time were found to fall within

$$T_\gamma = \tau_\gamma^{-1} = (3 \pm 1) \times 10^{10} E^4 Z^2 A^{-1} \quad (1)$$

where T_γ is in ps^{-1}, τ_γ is the radiative mean life (in ps) and E is in keV.

The Grodzins product was modified by Raman *et al.* [4] by including the reduced transition probabilities $B(E2)$'s as

$$E(2_1^+) \times B(E2) \uparrow = (2.57 \pm 0.45) Z^2 A^{-2/3} \quad (2)$$

Pritychenko *et al.* [5] used the nuclear systematic approach by examining the $B(E2)$ data and concluded that there is a strong preference for an elemental analysis instead of global analysis. Following which, Gupta and Katoch [6] presented a new perspective to study the intimate relation of $B(E2)$ and $E(2_1^+)$ by plotting $B(E2)$ versus the inverse of $E(2_1^+)$. We used the approach adopted by Gupta and Katoch [6] to study the constancy of Grodzins product in higher states of ground band. The data for present analysis has been obtained from the refs. [7] and [8].

Results and Discussion

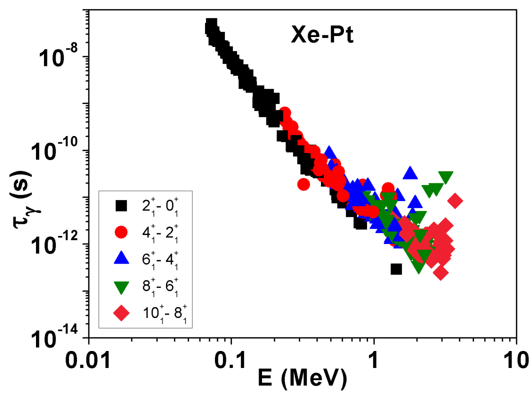

FIG. 1: The plot of lifetime versus E.

The systematics of gamma-ray transition probabilities suggest the uniform behavior of transition probabilities without any visible

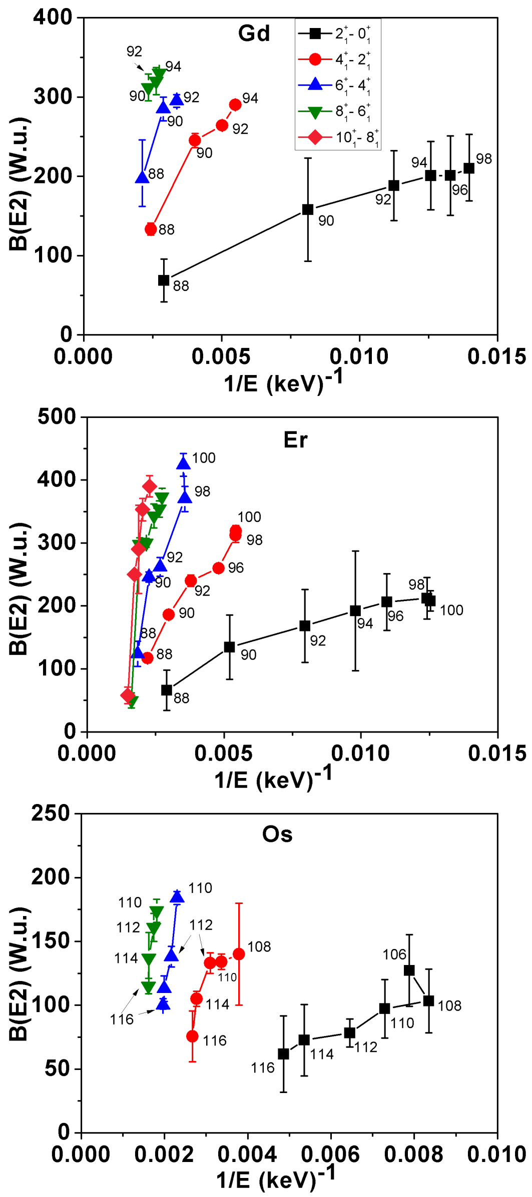

FIG. 2: The plots of $B(E2)$ versus $1/E$ for Gd, Er and Os nuclei.

discontinuity at transition regions [2]. However, it was observed for the first 2^+ excited states of the ground band. Fig. 1 shows the combined plot of lifetimes τ_γ vs. E for $Xe-Pt$ nuclei for spins upto 10^+. The data for all spins coincide, with a very few deviations, thus indicating the transition probabilities possess a uniform behavior for higher spins as well, for all nuclei studied in the present work.

The $B(E2)$ versus $1/E$ data has been plotted for $Xe-Pt$ nuclei for spins upto 10^+. Out of which, the plots of $B(E2)$ versus $1/E$ for Gd, Er and Os nuclei belonging to quadrant-I, II and III [9] respectively are displayed in Fig. 2. As evident from Fig. 2, the data for each spin lie separately. For a particular spin, the $B(E2)$ versus $1/E$ exhibits a linear variation with a few deviations. Thus, the approximate constancy of Grodzins product is visible in all quadrants for all spins.

Conclusion

The uniform behavior of transition probabilities observed in the lifetime versus E and the $B(E2)$ versus $1/E$ plots points towards a global validity of Grodzins product rule to all the spins of the ground band.

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