Ground- γ band odd-even staggering in $^{188-192}$Os and $^{228-230}$Th nuclei

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Introduction

The staggering has long been considered as a key signature [1] for the γ dependence of the potential. Being the differential quantity, it is a very sensitive measure of the γ band in a γ-independent potential cluster (2^+_γ), (3^+_γ, 4^+_γ), ... opposite to the rigid triaxial rotor (2^+_γ, 3^+_γ), (4^+_γ, 5^+_γ), ... clustering pattern. The evolution of the γ-band staggering between the above two limits has been investigated in the $A \approx 100 - 130$ mass region [2]. The γ-soft region between the vibrator and a deformed γ-soft structure where the potential is γ independent corresponds to the SU(5) to O(6) transition region according to the interacting boson model [3]. The critical point symmetry E(5) [4] also occurs in between SU(5) and O(6). The axially γ-rigid region between the vibrator and the axially symmetric rotor is the SU(5) to SU(3) transition region. The X(5) critical point symmetry also lies in this region [5]. McCutchan et al. [6] studied the staggering in band energies and the transition between different structural symmetries in nuclei by using the expression

$$S(J) = \frac{\{E(J) - E(J-1)\} - \{E(J-1) - E(J-2)\}}{E(2^+_1)}. \quad (1)$$

which measures the displacement of the $(J-1)^+_\gamma$ level relative to the average of its neighbors, J^+_γ and $(J-2)^+_\gamma$, normalized to the energy of the first excited state of the ground band, 2^+_1. The idealized geometrical models discussed thus far provide a reasonable qualitative classification of the staggering patterns in the nuclei outline above.

Result and Discussion

Geometrical models we consider in this paper are based on the E(5) [7] and X(5) [8] critical point symmetries, describing shape phase transitions from vibration to γ-unstable and vibrational to prolate deformed nuclei respectively [9]. The E(5) model is obtained as an exact solution of the Bohr Hamiltonian [10] for γ-independent potentials [9] while the X(5) model is obtained as an approximate solution for $\gamma = 0^o$. Another approximate solution with $\gamma = 30^o$, called Z(5) has also been obtained [11]. The number of these new geometrical models are quite large and the list continue to grow. The infinite square well potential can be replaced by a potential involving power of $\beta u(\beta) = \beta^{2n}$, where n is integer giving $X(5) - \beta^{2n}$ model [12] and $E(5) - \beta^{2n}$ model [13].

Figure 1 represents the variation of $S(4)$ versus $R_{4/2}$ for geometrical model and IBM calculations. The smooth evolutions from $SU(5) \rightarrow O(6)$, $O(6) \rightarrow SU(3)$ and $SU(5) \rightarrow SU(3)$ are shown in this figure. These transitions are also compared with the $^{188-192}$Os, $^{228-230}$Th nuclei spectra. We observe that the calculated spectra shows excellent agreement with the $O(6) \rightarrow SU(3)$ transition, which is the hallmark of the triaxility.

Figure 2 shows the staggering effect of Os nuclei and the obtained staggering pattern is also compared with the triaxial rotor model, γ-soft and axial model limits.

Conclusion

The interacting boson model was applied to five nuclei ^{188,190,192}Os, ^{228}Th and ^{230}Th. The

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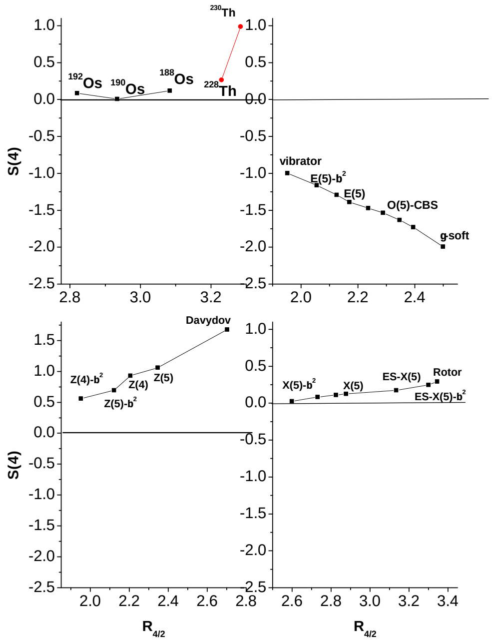

FIG. 1: Staggering S(4) for the IBM and compared with vibrator and γ-soft, Davydov and other geometrical models.

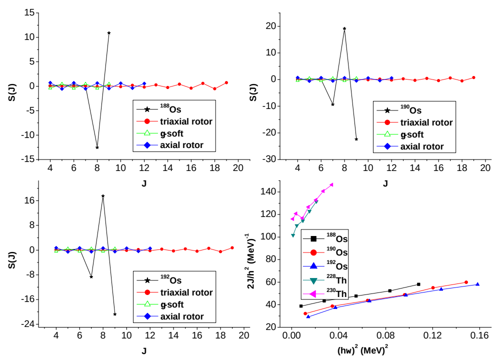

FIG. 2: Zig-Zag phase transition in S(J)-J plot and $2J/h^2$-$(h\omega)^2$ plot for $^{188-192}$Os and $^{228-230}$Th nuclei.

calculated B(E2) values agree with the experimental data fairly well and can be compared with result of IBM-2. At the same time, some E2 transitions which are forbidden in O(6) limit become allowed because of the broken symmetry of the three body potential.

Acknowledgments

The author is grateful to Dr. Kiyoshi Kato (Researcher, Professor Emeritus, Nuclear Reaction Data Centre (JCPRG), Faculty of Science, Hokkaido University, Sapporo-JAPAN) for constant encouragement.

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