Staggering in γ-band energies and transition between isotopes of Mo nuclei

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Introduction

The staggering has long been considered as a key of 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]. The triaxial γ-rigid region between the vibrator and the triaxial rotor, characterized by fixed γ values between 0^o and 30^o, has no direct analog in the framework of IBM-1 [6].

Staggering as function of angular momentum

McCutchan et al. [7] studied the staggering in band energies and the transition between different structural symmetries in nuclei by using the expression

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

In the present work, we try to search whether the $J(J+1)$ rule obeys the three energy sequences of yrast and quasi γ band in Mo nuclei. Zamfir and Casten [1] examined the values of the staggering indices $S(4,3,2)$ and $S(6,5,4)$ obtained from the experimental data of even-even nuclei to check that whether the nuclei are γ-soft or γ-rigid. Liao [8] had commented that one cannot clearly distinguished between γ-soft and γ-rigid rotor according to the value of $S(4)$. Liao recommended that $S(6)$, $S(8)$ and $S(10)$ should be studied for testing the shapes of nuclei(γ-soft or γ-rigid). Here, we will search whether the $J(J+1)$ rule is obeyed in the three energy sequences of yrast and quasi γ-band. If the rule is obeyed, the nucleus is axially asymmetric rotor else it happens to be triaxial or γ-soft. It should be kept in mind that the indices $\Delta E_1 = E(3^+_1) - (E(2^+_1) + E(2^+_2)) = 0$. This condition is not only valid for the γ-rigid rotor but also for the axial rotor. Both axially symmetric and γ-rigid asymmetric nuclei follow these conditions. Also, ΔE_1 is very small as compared to ΔE_2 for both the cases.

Geometrical models

The predictions of the geometrical models to determine that whether the observed staggering patterns can indeed be associated with different form of the potential in the γ degree of the freedom. Fig. 1 and 2 give the staggering for those models that utilize a γ potential. In Fig.1 and 2 the Exp., Th., γ-vibrator, γ-soft and E(5) model calculation shows negative staggering at even angular momentum and odd staggering at odd angular momentum (J). But Davydov, Z(5) and Z(4) model calculation show opposite behavior with angular momentum. We took another test of tri-

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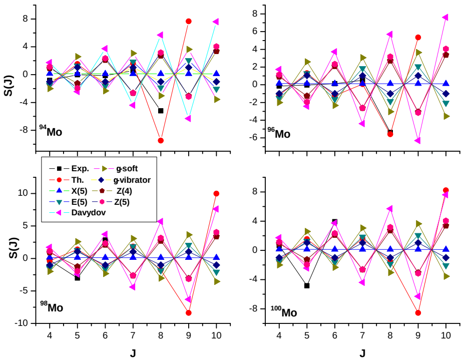

FIG. 1: Staggering S(J) for the IBM-1,X(5), E(5), Davydov, γ-soft, γ-vibrator, Z(4) and Z(5) for $^{94-100}$Mo.

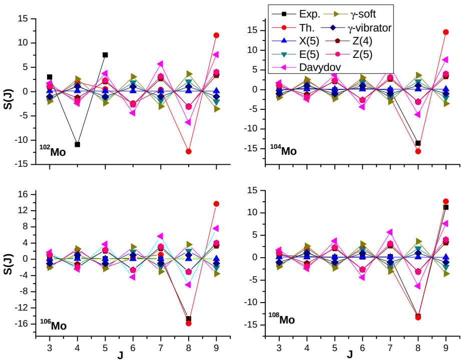

FIG. 2: Staggering S(J) for the IBM-1,X(5), E(5), Davydov, γ-soft, γ-vibrator, Z(4) and Z(5) for $^{102-108}$Mo.

axiality on the basis of energy relation $\Delta E_1 = E(3_1^+) - \left[E(2_1^+) + E(2_2^+)\right]$ for triaxial nucleus and $\Delta E_2 = E(3_1^+) - \left[2E(2_1^+) + E(4_1^+)\right]$ for γ-soft nucleus given by Wilets and Jean[9]. A large value of ΔE_1 and small value of ΔE_2 reflects a γ-soft character. The difference ΔE_1 is low while ΔE_2 is large for $^{96-104}$Mo which reflects the triaxial nature. The value of ΔE_1 and ΔE_2 are presented in Table I.

Conclusion

In the present work, the experimental energy staggering in γ-bands of Mo isotopes is investigated as a signature for the γ dependence of the geometrical potential. Comparison with both geometrical model predictions and IBM calculations shows that the observed staggering patterns can be linked back to the underlying form of the potential in the γ degree of freedom

TABLE I: The experimental and calculated difference $\triangle E_1$ and $\triangle E_2$.

Nuclei	^{96}Mo	^{100}Mo	^{104}Mo
Exp.$\triangle E_1$	425.8	392.0	23.9
Exp.$\triangle E_2$	1206.3	599.6	33.1
Th.$\triangle E_1$	420.6	331.2	83.5
Th.$\triangle E_2$	1273.0	448.5	109.2

Acknowledgments

We are 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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