Triaxiality in light mass Ni- Sn region from asymmetric rotor model

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Introduction

Asymmetric rotor model (ARM) of Davydov and Filippov [1] is widely used to study the nuclear structure of light mass (Te- Sm for N<82 [2]; (Mo- Cd for N<66 [3]), medium mass (Nd – Pt for A=150-200) [4] region to test the internal consistence of the model predictions. Bohr and Mottelson [5] earlier pointed that at $\gamma_0 \geq 24^0$, nuclei are no longer to be considered deformed in the original sense and the nucleus is expected to take any shape, including triaxial.

The rigid triaxiality for light mass Ni-Sn nuclei has not been studied so far. This is a very interesting region, which encompass two magic numbers at N= 28 and 50 and Z = 28 and 50. Also at N= 60 shape phase transition is evident see Fig. 1 of [6]. The rapid onset of deformation near A=100 was observed [7, 8]. Here the key orbits are $1g_{9/2\pi}$ and $1g_{7/2\nu}$; the filling of the latter near N = 60 rapidly induces deformation. It become recognized that this explanation is not an isolated ad hoc one for a particular mass region but is a paradigm for the development of collectivity and deformation throughout heavy nuclei [9, 10].

In the present work, we focus on rigid triaxiality in light Ni – Sn nuclei for N = 28 and 50 and Z = 28 and 50. A comprehensive review on interband B(E2; 2γ→0g/2g), B(E2; 2γ→2g/4g), B(E2; 3γ→2g/4g) and B(E2; 4γ→2g/4g) has been carried out to test (i) the internal consistence of the rigid triaxial ARM predictions and (ii) B(E2) ratios do have some relation with asymmetry parameter (γ_0).

Results and Discussions

The B(E2) branching ratios are determined from the energy (E_γ) and intensity (I_γ) of γ-rays experimental data using the following relation:

$$\frac{B(E2;I_{i\lambda}-I_{f0})}{B(E2;I_{i\lambda}-I_{f'0})}=\frac{I_\gamma(I_i\rightarrow I_f)}{I_\gamma(I_i\rightarrow I_{f'})}\frac{E'^5_\gamma}{E^5_\gamma} \qquad (1).$$

Most of the experimental data are taken from [11]. The experimental B(E2) branching ratios are calculated from Eq.(1) by using the energy (E_γ) and intensity (I_γ) of γ-rays for different interband transitions. The experimental B(E2) ratios are plotted versus γ_0. On each plot the rotor model (RM or SU(3)), vibrational model (VM or SU(5)) values and ARM predictions are shown for useful comparison. The error bars are not shown to keep the illustration readable. Different symbols are used for different series of isotopes and one can read the values of B(E2) ratio for a given value of γ_0. The γ_0 is calculated from experimental values of $E2_\gamma$ and E2g states as discussed in Ref. [4].

B(E2; 2γ→0g/2g) ratios

The variation of B(E2; 2γ→0g/2g) vs. γ_0 is shown in Fig. 1. The graph shows the experimental data points for various nuclei. The ARM values are shown by solid circles which has smooth dependence on γ_0 unlike experiment, where the experimental data point are scattered from VM to RM limit at $\gamma_0 \approx 22^0 - 30^0$. The Pd(N=62), Ru(N=56) and Ge(N=44) data points are above the RM limiting value.

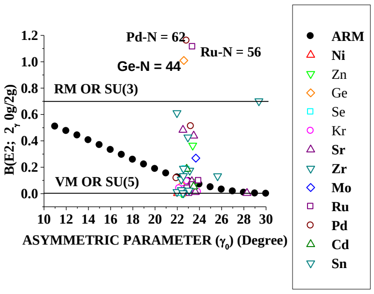

Fig. 1 The variation of B(E2; 2γ→0g/2g) vs. γ_0.

B(E2; 2γ→2g/4g) ratios

The variation of B(E2; 2γ→2g/4g) vs. γ_0 is shown in Fig. 2. Only few observed data points are available to find any conclusion and their values is close to zero at $\gamma_0 \approx 23^0$ unlike ARM.

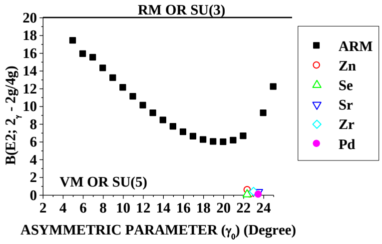

Fig. 2 The variation of B(E2; 2γ→2g/4g) vs. γ_0.

B(E2; 3γ→2g/4g) ratio

The variation of B(E2; 3γ→2g/4g) vs. γ_0 is shown in Fig. 3. ARM predicts smooth decreasing values with γ_0. The observed data points have the similar behavior as for B(E2; 2γ→0g/2g) ratio. The observed values for Mo(N=56 and 58) are more than RM may be due to the shape phase transition at N=60. The Pd attains the RM (=2.5) values at $\gamma_0 \approx 23^0$ while ARM values is only 0.25.

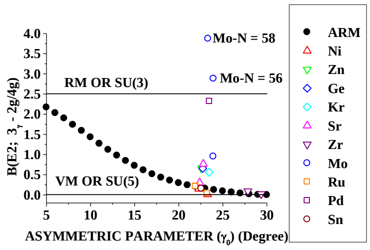

Fig. 3 The variation of B(E2; 3γ→2g/4g) vs. γ_0.

B(E2; 4γ→2g/4g) ratio

The variation of B(E2; 4γ→2g/4g) vs. γ_0 is shown in Fig. 4. ARM predicts smooth decreasing values with γ_0 for 8^0 to 20^0 and a peaking at 27^0. The observed data points are very close to ARM at 23^0. Six isotopes (one each of Sr and Sn; and two point of Ru and Pd) attains the higher value at $\gamma_0 \approx 24^0$ while ARM values is only 0.05. The observed values for Cd(N=58), Mo(N=60), Sr(N=38), Zn(N=32), Ge(N=42 and Kr(N=38) are more than RM values may be due to M1 or E1 admixture.

Conclusions

Since the available data points are limited therefore a definite conclusion cannot be drawn. But it clear that the ARM partially supports the observed ratios except for B(E2; 2γ→2g/4g). Detailed results will be presented, included the results from critical point symmetry (T5) [12] for spherical to triaxiality deformed shape phase transition.

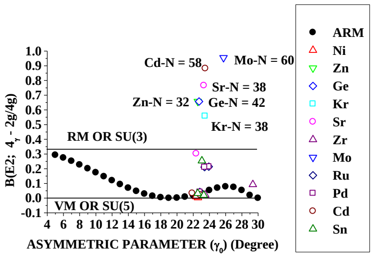

Fig. 4 The variation of B(E2; 4γ→2g/4g) vs. γ_0.

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