Evidence of triaxiality in ^{162}Er

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The collective excitations resulting both oscillations and rotations are well established in the form of γ – soft by Wilet and Jeans and γ – rigid by Davydov and Filippov. The rotation of rigid asymmetric nucleus not only yields yrast band but also 2^+, 3^+, 4^+, 5^+, 6^+…… levels (anomalous rotational band or γ – band). In another mechanism the generation of γ – band is from oscillations of γ – soft nucleus. Currently asymmetry in even – even nuclei is considered as established phenomena and as such researchers have been considering the structure of γ – band as rotational at low energies.

Zamfir and Casten used staggering indices S (J, J-1, J-2) defined as –

$$S(J, J-1, J-2) = \frac{[(E_J - E_{J-1}) - (E_{J-1} - E_{J-2})]}{E2_1^+}$$

as useful signature to distinguish γ – soft and γ – rigid nuclei. It is concluded that in the low energy region no nucleus is γ – rigid. However, using the rotation – vibration interaction, influence on the rigid rotor model, and the behavior of the staggering indices exhibit different results. Liao – Ji – Zhi found that the most of the nuclei with clear staggering are γ – soft but few may be slightly triaxial [1].

Minkov et al used the quantity Stg (L) to study the odd – even staggering (OES) in the γ – band of heavily deformed nuclei [2]. The quantity Stg (L) is defined as –

$$\mathrm{Stg(L)} = [10E(L+1) + 5E(L-1) + E(L+3)] - [10E(L) + 5E(L+2) + E(L-2)$$

The quantity Stg (L) is determined by six band level energy with $L-2, L-1, \ldots\ldots . L+3$. It is well known that towards the mid shell region (Z=68 in ^{162}Er) the properties are better revealed so that any kind of deviation from the regular rotational band structure is caught. The theoretical calculations of Vector Boson Model (VBM) that used similar seven input parameters have produced zigzag plot of staggering as that of experiment in case of ^{162}Er.

In the present work, we use soft rotor formula for evaluating the γ – band energies which has recently been modified [3]. We will show that the energies obtained by the formula by using three input parameters only, are very close to the experimental data (Table – I). This work not only hints at the rotational character of the nucleus but, assign nearly rigid shape to the nucleus. Our view point is further supported by the recently published data on some interband transition within γ – band and also from γ – band to yrast band [4]. The transitions are expected to be very weak of order 1 w. u. where accurate prediction with a collective model are difficult. Some model quantitative predictions are also listed for the sake of comparison. It is clearly seen that rigid rotor predictions reproduced the data remarkably well with the largest deviation in $B(E2; 6_2^+ \rightarrow 6_1^+)$. In $B(E2; 9_2^+ \rightarrow 8_2^+)$ all theoretical values are almost same and therefore this deviation does not matter (Table – II).

Table – I

Level energies (in KeV) of $K^{\pi} = 2^{+}$, γ – band for ^{162}Er

Energy/Spin	Exp.	SRF
2_2^+	900.7	900.7
3_1^+	1001.9	1002.0
4_2^+	1128.2	1128.7
5_1^+	1286.3	1278.0
6_2^+	1459.7	1445.0
7_1^+	1669.2	1633.0
8_2^+	1872.8	1835
9_1^+	2133.9	2057
10_2^+	2346.7	2280.0
11_1^+	2656.7	2438.0

Table – II

$B(E2; I_f \rightarrow I_i)$ Values of ^{162}Er

$(I_f \rightarrow I_i)$	Rigid rotor	Exp.	X(5)	CBS	IBM
$9_1^+ \rightarrow 7_1^+$	100	100	100	100	100
$9_1^+ \rightarrow 8_2^+$	0.97	<2.87	1.0	1.0	0.97
$8_2^+ \rightarrow 6_2^+$	100	100	100	100	100
$8_2^+ \rightarrow 6_1^+$	0.31	< 0.6	0.32	0.31	0.001
$7_1^+ \rightarrow 5_1^+$	100	100	100	100	100
$7_1^+ \rightarrow 6_1^+$	1.14	1.80	1.19	1.19	1.81
$6_2^+ \rightarrow 4_2^+$	100	100	100	100	100
$6_2^+ \rightarrow 6_1^+$	1.54	10	1.68	1.67	13.93
$5_1^+ \rightarrow 3_1^+$	100	100	100	100	100
$5_1^+ \rightarrow 4_1^+$	1.67	2.30	1.79	1.76	4.42
$4_2^+ \rightarrow 2_2^+$	100	100	100	100	100
$4_2^+ \rightarrow 4_1^+$	2.94	7.0	3.30	1.32	26.8

Concluding remark:

This is natural while a triaxial nucleus rotates as angular momentum increases some physical effects such as centrifugal stretching and rotation – vibration interaction come into play so the triaxial energies are perturbed and nucleus becomes slightly soft, whose energies are better reproduced by soft rotor formula. Thus, the energies of this nucleus have been evaluated from SRF. Interestingly, the perturbations of energies do not alter the B (E2) values and so the evaluation of B (E2) values from rigid model are justified. The present work supports the near rigid shape of ^{162}Er nucleus. As the level energies of rotational γ – band along with the B (E2) transition rates are reproduced in this work.

References:

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