# TRANSITIONAL EVEN ERBIUM ISOTOPES

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Abstract

The decays of 4 min $^{158}$Tm and 80 sec $^{156}$Tm have been investigated with the on-line ISOCELE separator, in ORSAY. The level structure of $^{156}$, $^{158}$Er nuclei (N=88, 90) is compared to other nuclides in the same region.

## I - EXPERIMENTAL RESULTS

From the ($\beta^+$ + EC) decay of $^{158}$Tm ($T_{1/2}$= 4 min) and $^{156}$Tm ($T_{1/2}$= 80 sec) we have studied at ISOCELE two even erbium isotopes $^{158}$Er and $^{156}$Er with 90 and 88 neutrons respectively. Partial level schemes are displayed in fig.1 and further details can be found in ref. 1) and 2).

In both nuclei, several quasi-rotational bands have been identified, and their energy level sequence values can be expanded according to the expression

$$E_I = E_o + AI\,(I+1) + BI^2\,(I+1)^2$$

In table 1 are displayed the A and B parameter values for the β, the γ and the ground state band of the erbium isotopes. Since neighbouring isotones are known to have a similar level structure, the same parameters for the analogous bands in Sm and Gd are included for comparison. One can observe the increasing of the B value with the decreasing of the neutron number for every isotope, which is significant of an increase in the rotation vibration interaction.

| | g. s. band | | β band | | γ band | |
|---|---|---|---|---|---|---|
| N=90 | $A_{keV}$ | $B_{keV}$ | $A_{keV}$ | $B_{keV}$ | $A_{keV}$ | $B_{keV}$ |
| $^{152}$Sm | 21.15 | -0.14 | 22.66 | -0.29 | 21.15 | 0.24 |
| $^{154}$Gd | 21.4 | -0.14 | 24.23 | -0.29 | 31.18 | -0.74 |
| $^{158}$Er | 34.4 | -0.4 | 33.8 | -0.56 | 30.9 | -0.05 |
| N=88 | | | | | | |
| $^{156}$Er | 65.0 | -1.25 | 55.96 | -1.26 | 56.6 | -1.41 |
| $^{152}$Gd | 65.8 | -1.40 | 60.8 | -1.37 | 44.3 | -0.63 |
| $^{150}$Sm | 62.9 | -1.21 | 57.6 | -1.11 | 42.6 | -0.43 |

Table 1 - Inertia parameters in even 88 and 90 neutron nuclei.

In tables 2 and 3 are presented the relative B(E2) ratios. In the same way, they are compared to the Sm and Gd values, and to theoretical predictions of Kumar for $^{150}$Sm and $^{152}$Sm 4).

| Level $^{156}$Er keV | $I_i^\pi$ | $I_f^\pi/I_{f'}^\pi$ | $^{156}$Er | $^{152}$Gd | $^{150}$Sm | $^{150}$Sm Théor. Kumar |
|---|---|---|---|---|---|---|
| 1221.0 | $2^+_\beta$ | $0^+_g/2^+_g$ | 0.23(8) | 0.02 | 0.08(1) | 1.47 |
| | | $4^+_g/2^+_g$ | 7.3(23) | 2.0(3) | 3.9 (5) | 43.7 |
| | | $0^+_\beta/0^+_g$ | <175 | 107(11) | 28 (4) | 45.7 |
| 1546.8 | $4^+_\beta$ | $2^+_g/4^+_g$ | 0.15(7) | - | 0.002 | 0.3 |
| | | $2^+_\beta/4^+_g$ | 31(13) | 6.8(11) | 5.9(8) | 72.7 |
| 930.5 | $2^+_\gamma$ | $0^+_g/2^+_g$ | >0.04 | 0.14(1) | 0.23(3) | 0.08 |
| 1351.4 | $3^+_\gamma$ | $2^+_g/4^+_g$ | 0.18(5) | 0.45(5) | 0.29(6) | 0.52 |
| | | $2^+_\gamma/2^+_g$ | 34(10) | <28 | 24(5) | 10.2 |

Table 2 - Reduced transition probabilities in $^{156}$Er Data for Sm and Gd isotones are taken from ref. 3.

| Level $^{158}$Er keV | $I_i^\pi$ | $I_f^\pi/I_{f'}^\pi$ | $^{158}$Er | $^{154}$Gd | $^{152}$Sm | $^{152}$Sm théor. Kumar |
|---|---|---|---|---|---|---|
| 989.0 | $2^+_\beta$ | $0^+_g/2^+_g$ | 1.1(2) | 0.121 | 0.16(2) | 0.11 |
| | | $4^+_g/2^+_g$ | 11(2) | 2.7(1) | 2.7(9) | 4.9 |
| | | $0^+_\beta/0^+_g$ | 128(68) | 125(6) | - | 236 |
| 1257.2 | $4^+_\beta$ | $2^+_g/4^+_g$ | >3.8 | 0.085 | 0.10(3) | 0.008 |
| | | $6^+_g/4^+_g$ | > 42 | 5.9(2) | - | 5.2 |
| | | $2^+_\beta/4^+_g$ | >480 | - | 41(20) | 41.3 |
| 820.1 | $2^+_\gamma$ | $0^+_g/2^+_g$ | 0.12(2) | 0.12(1) | 0.41(2) | 0.43 |
| 1043.4 | $3^+_\gamma$ | $2^+_g/4^+_g$ | 0.55(2) | 1.03(3) | 0.95(7) | 1.42 |
| | | $2^+_\gamma/2^+_g$ | 21(4) | 16.5(8) | - | 22.7 |

Table 3 - Reduced transition probabilities in $^{158}$Er. Data for Sm and Gd isotopes are taken from ref.3.

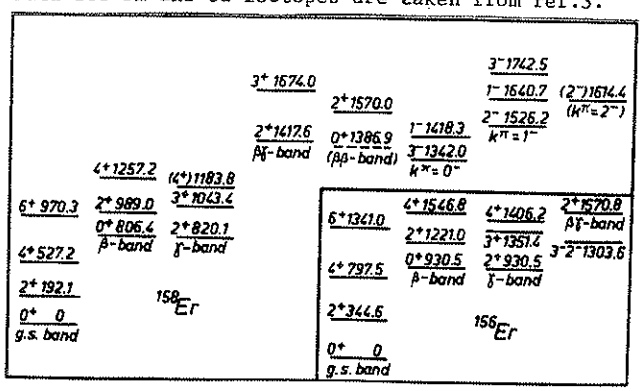


Fig.1 - Interpretation of partial level schemes.

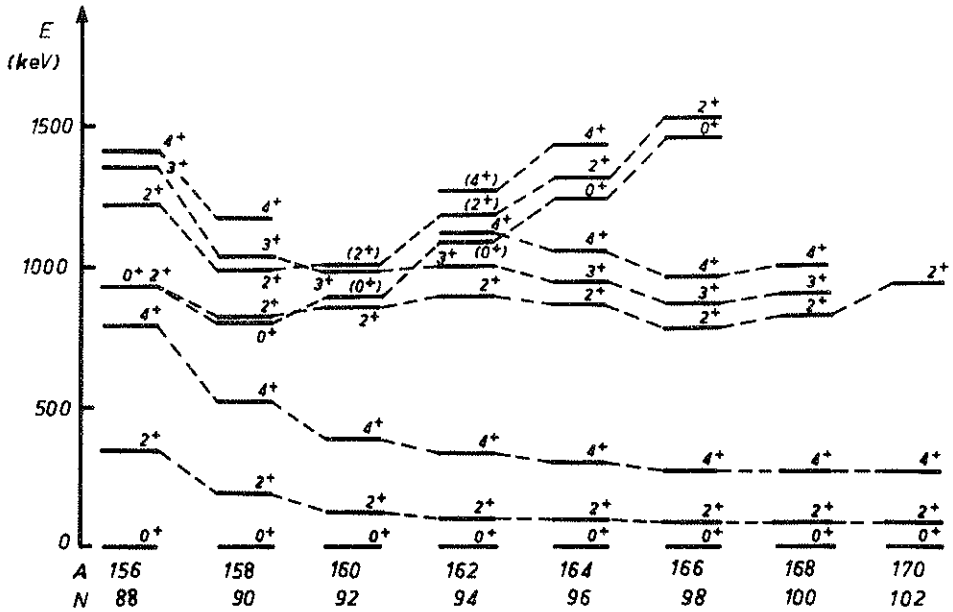


Fig. 2 - Level systematics of even erbium nuclei. Data for nuclei with A > 160 are taken from ref. 5.

## II - COMMENTS ON SOME SYSTEMATIC TRENDS

### II-1 - Comparison with other even erbium isotopes.

In fig.2 our results are presented in a systematic form including heavier erbium isotopes 5). It should be noted :

- The increasing of the $2^+$g.s. and $4^+$g.s. energy when the neutron number is decreasing.
- The minimum energy of the $0^+_\beta$ level for $^{158}$Er, which is a characteristic feature of transitions between deformed and spherical nuclei 8).
- The stability of the $2^+_\gamma$ energy in the whole region.

### II-2 - Comparison with the neighbouring N=90 and N=88 isotones (fig.3 and 4)

These schemes give evidence for the similar behaviour of these isotones. In fig.3, $^{158}$Er with a larger moment of inertia, inferred from the increase of the $(4^+ \rightarrow 2^+)$ and $(2^+ \rightarrow 0^+)$ level spacings seems less deformed than the other N=90 nuclei. In fig.4, the small spacing between the three levels $0^+$, $2^+$, $4^+$ at about 930 keV and the proximity of the $2^+$, $3^+$, $4^+$ and $6^+$ level around 1300 keV provides an indication of vibrational character of $^{156}$Er. Moreover the small spacing between the $4^+_\gamma$ and $3^+_\gamma$ levels could be indicative of softness.

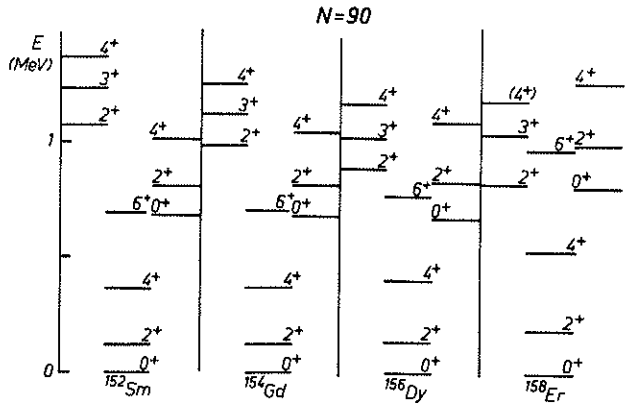


Fig. 3 - Ground state and quadrupolar vibrational bands in even N = 90 nuclei

Data for nuclei other than Er are taken from ref.3 (Sm and Gd), ref.6 ($^{154}$Dy) and ref.7 ($^{156}$Dy).

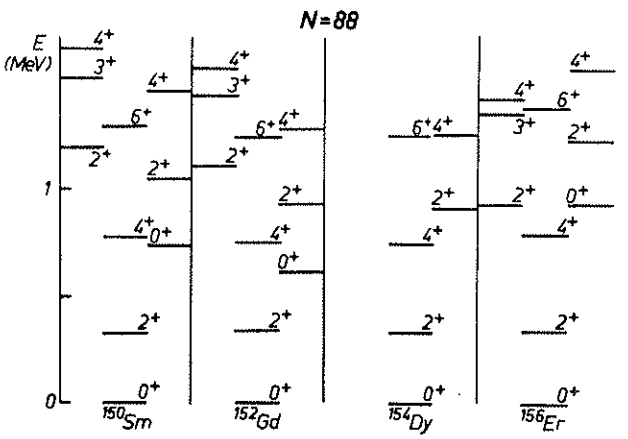


Fig. 4 - Ground state and quadrupolar vibrational bands in even N = 88 nuclei.


1) P. Aguer, C.F. Liang, J. Libert, P. Paris, A. Peghaire, A. Charvet, R. Duffait and G. Marguier. Nucl. Phys. A 249 (1975) 239.
2) P. Aguer, C.F. Liang, J. Libert, P. Paris, A. Peghaire, A. Charvet, R. Duffait and G. Marguier. Nucl. Phys. A 252 (1975) 293.
3) D.R. Zolnowski, E.G. Funk and J.W. Mihelich. Nucl. Phys. A 177 (1971) 513.
4) K. Kumar. Nucl. Phys. A 231 (1974) 189.

5) A.A. Abdurazatov, G. Beyer, K.Ya. Gromov, E. Herrmann, T.A. Islamov, M. Jachim, F. Molnar, G. Musiol, H.U. Siebert, H. Strusny, H. Tyroff and S. Usmanova. Report E6-8008, JINR, Dubna (1974).
6) D. Ward and M. Neiman. Nucl. Phys. A 115 (1968) 529.
7) Y. El Masri, R. Janssens, C. Michel, J. Steyaert, J. Vervier. Z. Phys. A 274 (1975) 113.
8) K. Kumar. Phys. Scripta 6 (1972) 270.