THE DECAY OF 200 sec ^{157}Tm

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Abstract

The decay of 200 sec ^{157}Tm has been investigated owing to the ISOCELE facility. The low-lying part of the ^{157}Er scheme is discussed in Nilsson model terms. It appears that this configuration looks quite different than the neighbouring N = 89 nuclei.

INTRODUCTION

The shape coexistence observed in various nuclei, the transition between spherical and deformed nuclei, are evidences of special interest of the rare earth region around N = 89 neutrons. Up to now, the levels of deficient neutron erbium nuclei, which belong to this region, were only known from (HI, xn) reactions. 1,2)

The spectroscopic studies of light Thulium isotopes (A < 159), decaying to erbium levels is difficult due to their short half lives. We present here the experimental results obtained with the ISOCELE separator on line with the Orsay synchrocyclotron (157 MeV proton beam), after having resolved some peculiar problems of the thulium extraction. 3)

I - EXPERIMENTAL TECHNIQUES

I-1 - Separation of rare earth nuclei.

The ISOCELE facility was used for continuous production and electromagnetic mass separation of Tm isotopes issued from an Er target through the (p,xn) reactions. This target, situated in the ion source of the separator, was made of natural erbium alloyed with copper in order to decrease its melting temperature and obtain discrimination against Tm and Er volatilization - Nevertheless, owing to the weak difference between target and reaction products volatilities, some target volatilization could not be avoided. As a consequence, some stable erbium was extracted, but the current of the Er beam, estimated to be about 500 μA was easily supported by the separator able to handle a few mA beam intensity. Fig. 1 shows experimental production rates curve for various Tm isotopes measured at the collector side of the isotope separator.8) The sharp decrease of the yield with decreasing neutron number is a consequence of the rather large total diffusion time (about 3 minutes).

I-2 - Detection methods.

The activities were collected from the separator beam onto a transport tape system. The sequence of collection and counting periods was controlled by an automatic timing unit. By using different time intervals, one could enhance activities of selected elements and distinguish isobaric or daughter nuclides contaminations.

On line γ and γγ coincidence measurements (2048 x 2048 channels) were performed by means of Ge(Li) planar and coaxial detectors, and electron spectra were recorded using Si(Li) detectors in front of the samples.

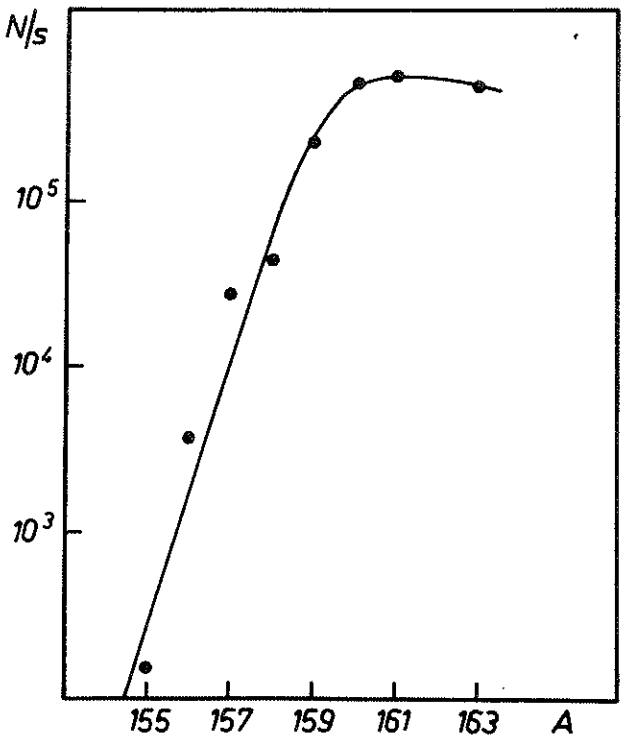

Fig. 1 - Experimental yields for Tm isotopes production obtained in ISOCELE with the 157 MeV (p,xn) reactions.

II - RESULTS ON THE DECAY OF ^{157}Tm ($T_{1/2}$= 200 sec) 3,4) TO THE ^{157}Er$_{89}$ LEVELS.

II-1 - Previous results

In ^{148}Sm (^{12}C, 3n)^{157}Er and ^{120}Sn (^{40}Ar, 3n)^{157}Er experiments, J.R. Leigh and coll, 1), have observed a positive parity band up to 29/2+. The 9/2+ member of this band decays via a 156 keV E_3 transition to the ground state assigned as 3/2-[521] 5), Leigh concludes that the lack of an M2 transition implies that the 5/2- member of the ground state band stays higher than 156 keV.

II-2 - Present results.

In fig. 2, is displayed part of the level scheme obtained in our investigations on ^{157}Tm decay and other details can be found in ref.6). We propose two low lying levels situated at 10.3 and 35.8 keV. The existence of the 10.3 keV level is supported by coincidences observations and on the basis of energy fit differences. The 35.8 keV level is fed by only one γ ray but observed in strong coincidences. A weak 155.4 keV transition, identified as E_3 by α_L & α_M determinations, is probably the same transition reported by Leigh and coll. as decaying from the 9/2+ level of the positive parity band. However, we cannot know which one of the three low lying states g.s, 10.3 keV and 35.8 keV is fed by this transition.

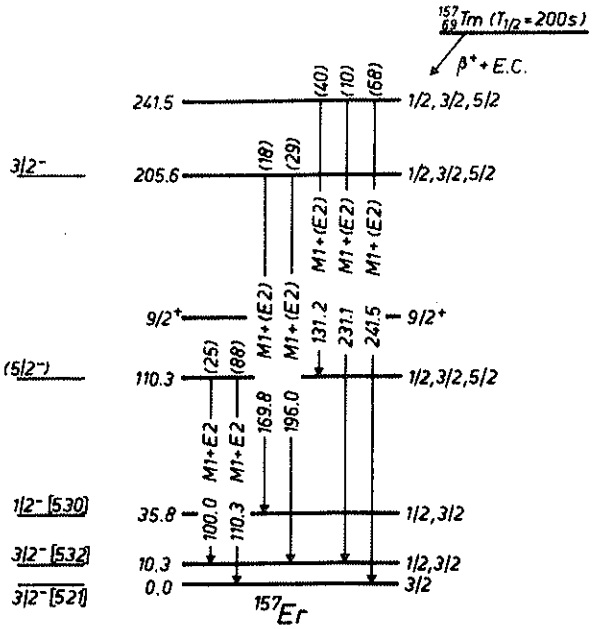

Fig. 2 - Experimental lower part of the ^{157}Er level scheme. On the left side are the proposed configurations.

II-3 - Discussion

According to Leigh and coll, a spin 5/2 or higher is forbidden for these levels and the ground state having been measured as 3/2, 5) the 10.3 and 35.8 levels can only be 3/2- or 1/2-.

It seems difficult to assume that three low lying levels, so close each other, have the same 3/2 spin, due to the Coriolis forces between the possible configurations.

Concerning two 1/2 states at 10.3 and 35.8 keV, these ones would belong to the 1/2-[530] and 1/2-[541] configurations. The 1/2-[530] configuration occurs at about 300 keV in the neighbouring rare earth nuclides and the 1/2-[541] one is considerably higher in energy. Then it seems unlikely to identify these configurations with these two levels and the most probable spin values for both levels are either 1/2, 3/2 or 3/2,1/2 respectively. A 1/2 assignement for the 10.3 levels would lead to a scheme where all the other five levels between the g.s. and 241.5 keV are 3/2-. This is rather peculiar and has never been observed in other isotones. So we suggest the following configurations : g.s. 3/2-[521]
10.3 keV 3/2-[531]
35.8 keV 1/2-[530].

As a consequence, the 205.6 keV level which decays through an $M_1 + E_2$ transition to the 35.8 keV level, is proposed 3/2- with a mixed configuration.

The attribution of spin to the 110.3 keV level presents some difficulty - With our assumption for the low lying levels spins, a 5/2- level is expected among the higher energy levels and the 110.3 level would be a good candidate. In that case, the absence of an M2 transition between the 9/2+ state and the 110.3 keV level would be a consequence of the small energy gap between these two levels.

CONCLUSION

The existence of an E3 transition decaying from the decoupled positive parity band is of a great importance. All the levels below this band head should have a spin lower than 5/2. If in all the other rare earth neighbouring isotones, several 5/2 states are noticed at very low energy, 7), and interpreted either in rotational band levels terms or as spherical configurations, in the preliminary state of our results, the level configuration of ^{157}Er looks quite different than the neighbouring N = 89 nuclides.

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