THE DECAY OF SOME NUCLEI FAR FROM THE STABILITY LINE STUDIED WITH STANDARD SPECTROSCOPIC TECHNIQUES

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1. INTRODUCTION

Some nuclides in regions of deformation and far from the region of beta stability were studied with standard beta- and gamma-ray spectroscopic techniques for some cases with half-lives not shorter than a few minutes. The activities are produced by the (^{3}He,xn) reactions ($E(^3He) \leq 78$ MeV, x=2,3, ... 8) and the (p,xn) reactions ($E(p) \leq 55$ MeV, x=1,2, ... 5) on targets of natural and enriched isotopes. The activities produced this way are limited to a very small region of A and Z and can in most cases be assigned unambiguously even without carrying out a chemical separation.

In addition to gamma ray and electron spectra, coincidences were studied with Ge(Li)-Ge(Li) and Ge(Li)-Si(Li) detectors in combination with a 4k PDP-8, used as a two-dimensional 64000 channel analyzer[1]. Spectra of conversion electrons and positons were studied with Si(Li) detectors. Some features of the isotopes being studied are listed in the following section.

2. DECAY PROPERTIES

^{158}Tm: $T_{\frac{1}{2}} = 4.3 \pm 0.2$ min; mode of production: ^{162}Er(p,5n), measured γ-ray spectrum, γ-γ coincidences; γ-rays: 192.6 keV (100), 335.3 keV (28), 1150.5 keV (19). The existence of this isotope was reported independently by Neiman and Ward[2].

^{159}Tm: $T_{\frac{1}{2}} = 12 \pm 1$ min; mode of production: ^{162}Er(p,4n), measured γ-ray spectrum; γ-rays 84.8 keV (57), 144.1 keV (31), 220.2 keV (96), 272.0 keV (57), 289.6 keV (100), 348.3 keV (64). The existence of this isotope was found independently by Gromov et al.[3] who did not report γ-rays.

^{160}Tm: $T_{\frac{1}{2}} = 9.2 \pm 0.4$ min; mode of production: ^{162}Er(p,3n), ^{164}Er(p,5n), measured γ-ray spectrum, γ-γ coincidences; γ-rays: 126.1 keV (100), 264.2 keV (30), 727.9 keV (35), 853.5 keV (26), 860.3 keV (26). The existence of this isotope was reported independently by Neiman and Ward[2].

^{164m}Tm: $T_{\frac{1}{2}} = 5.1 \pm 0.1$ min; mode of production: ^{166}Er(p,3n), measured γ-ray spectrum, γ-γ coincidences, delayed γ-γ coincidences, conversion electrons; γ-rays: 91.4 keV E2 (43), 139.4 keV E2 (27), 208.1 keV E2 (152), 240.5 keV E1+M2 (78), 314.9 keV E2 (100), 410.2 keV E2 (15), 547.0 keV E1 (46), 820.7 keV (14), 897.9 keV (44),

1049.8 keV (16), 1231.2 keV (42), 1364.6 keV (43) and 17 transitions of lower intensities.

The decay scheme deduced from the present measurement for this thus far unreported isotope is shown in fig. 1.

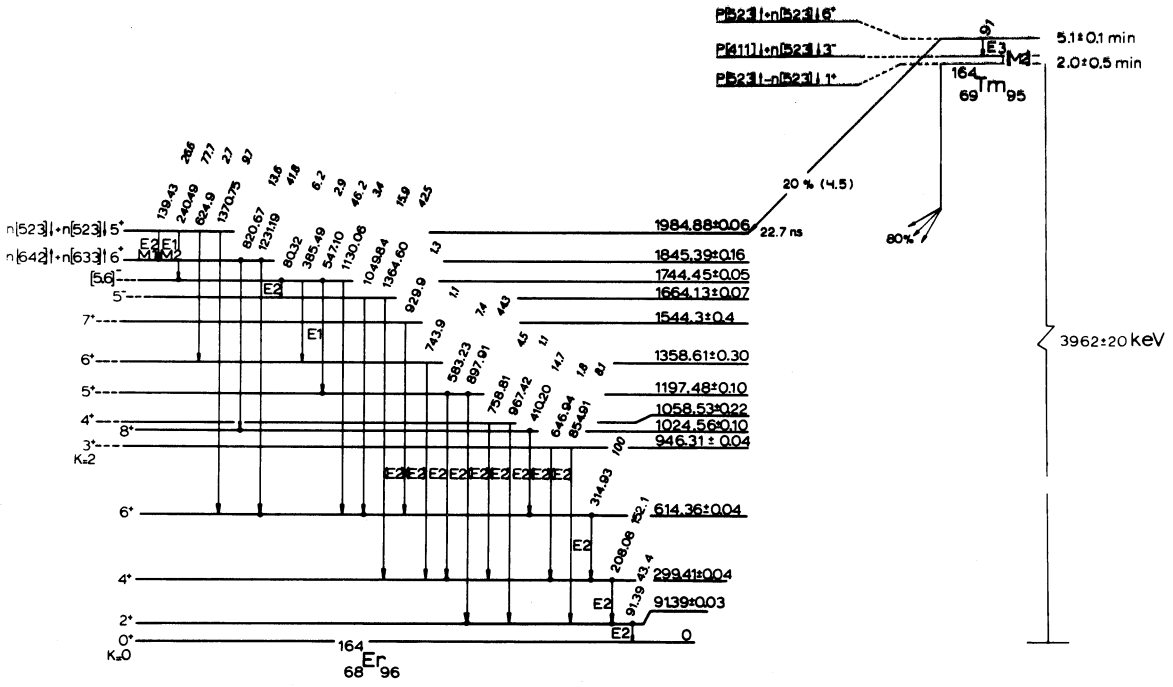

Fig. 1

Decay scheme of ^{164m}Tm

A delayed coincidence measurement with a Ge(Li)-NaI(Tl) setup was performed. The half-life of the 1985 keV level was determined as 22.7±2.0 ns. A spectrum of the γ-rays measured in delayed coincidence with the KX radiation is shown in fig. 2.

^{158}Yb: $T_{\frac{1}{2}}$ = 4.6±0.5 min; mode of production: $^{162}Er(^{3}He,7n)$, measured γ-ray spectrum; γ-rays: 173.9 keV (100), 215.7 keV (47). Our experiment does not completely

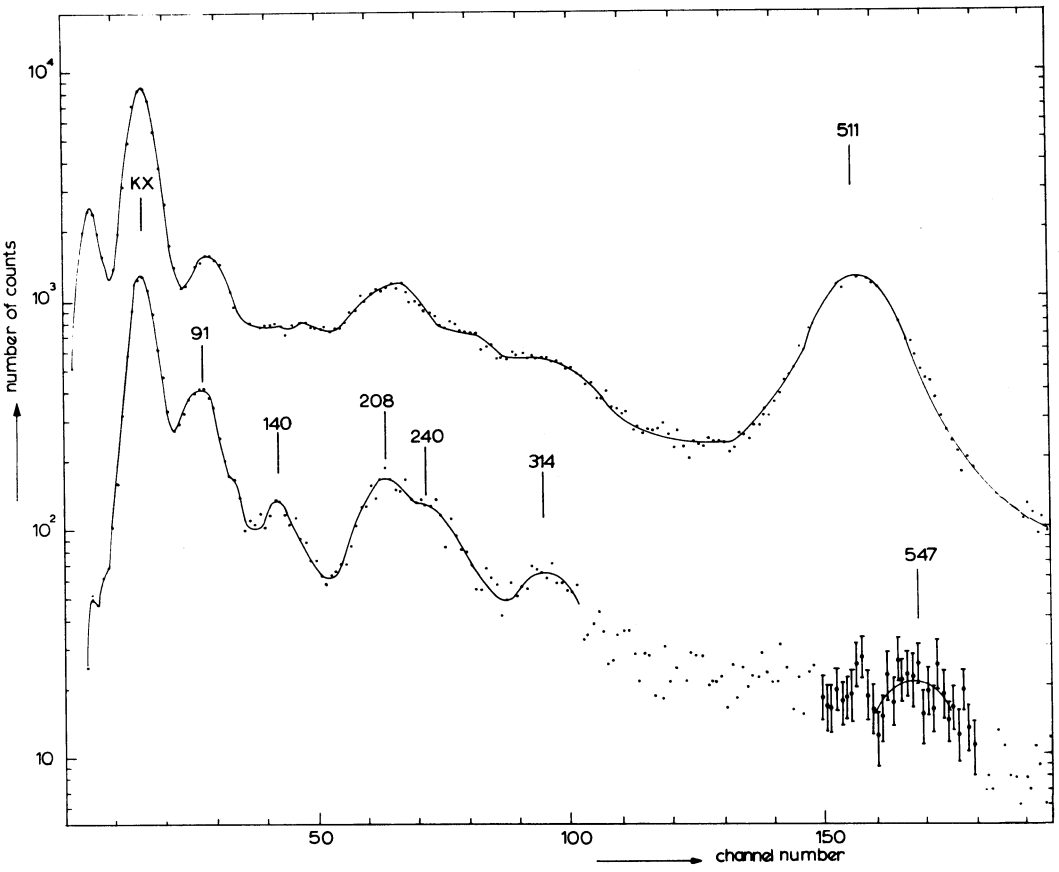

Fig. 2

γ-rays in the ^{164m}Tm decay measured in delayed coincidence with the KX radiation. A singles spectrum of this decay is shown in the upper part of the figure.

exclude a ^{159}Yb assignment. The existence of this isotope was reported independently by Neiman and Ward[2].

^{160}Yb: $T_{\frac{1}{2}}$ = 4.1±0.2 min; mode of production: ^{164}Er(^{3}He,7n), measured γ-ray spectrum; γ-rays: 78.3 keV (100), 600.0 keV (91), 631.7 keV (37). Our experiment does not completely exclude a ^{161}Yb assignment. The existence of this isotope was reported independently by Neiman and Ward[2].

^{163}Yb: $T_{\frac{1}{2}}$ = 11.4±0.5 min; mode of production: ^{164}Er(^{3}He,4n), ^{166}Er(^{3}He,6n), measured γ-ray spectrum; γ-rays: 64.0 keV (70), 123.5 keV (21), 130.9 keV (18), 161.6 keV (12), 326.0 keV (18), 687.4 keV (14), 860.3 keV (100), 1746.6 keV (15), 1907.6 keV (15) and 32 transitions of lower intensities. The existence of this isotope was found independently by Gromov et al.[3] who did not report γ-rays.

^{170}Ta: $T_{\frac{1}{2}}$ = 6.3±0.4 min; mode of production: ^{175}Lu(^{3}He,8n), measured γ-ray spectrum; γ-rays: 100.8 keV (100), 221.2 keV (156). Not reported previously.

^{171}Ta and ^{171m}Ta: mode of production: ^{175}Lu(^{3}He,7n), measured γ-ray spectra. $T_{\frac{1}{2}}$ = 6.3±0.4 min; γ-rays: 59.3 keV (57), 87.9 keV (57), 111.9 keV (51), 198.8 keV (100) and $T_{\frac{1}{2}}$ = 2.0±0.5 min; γ-rays: 365.4 keV (100). The existence of both activities was not reported previously. The γ-ray spectrum of these Ta isotopes is shown in fig. 3.

^{172}W: $T_{\frac{1}{2}}$ = 6.7±0.5 min; mode of production: ^{176}Hf(^{3}He,7n), measured γ-ray spectrum, γ-γ coincidences, γ-γ delayed coincidences, conversion electrons; γ-rays: 35.9 keV (53), 39.7 keV (11), 130.4 keV (25), 175.0 keV (18), 457.6 keV (100), 623.6 keV (25) and 25 transitions of lower intensities. The existence is deduced from these

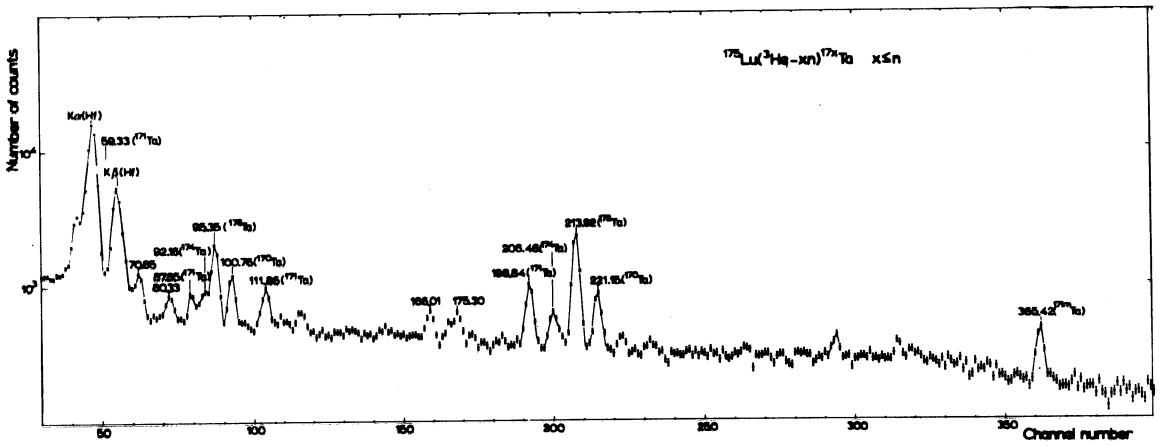

Fig. 3

γ-rays in the decay of ^{170}Ta, ^{171}Ta and ^{171m}Ta observed in a source produced by the ^{175}Lu(^{3}He,7n) reaction.

measurements of levels at 130.4 keV, 166.3 keV and 623.8 keV. A half-life of 180±10 ns was found for the 166.3 keV level. The existence of this isotope was found earlier by Arlt et al.[4] who did not report γ-rays.

^{176}Os: $T_{\frac{1}{2}}$ = 3.6±0.5 min; mode of production: ^{180}W(^{3}He,7n), measured γ-ray spectrum; γ-rays 81.5 keV (36), 775.8 keV (98), 857.2 keV (69), 1209.2 keV (71), 1290.9 keV (100). The existence of this isotope was reported recently also by Arlt et al.[5].

3. CONCLUDING REMARKS

It is possible to deduce the main decay properties of nuclei far from the stability line with half-lives in the minutes region with standard spectroscopic techniques. A

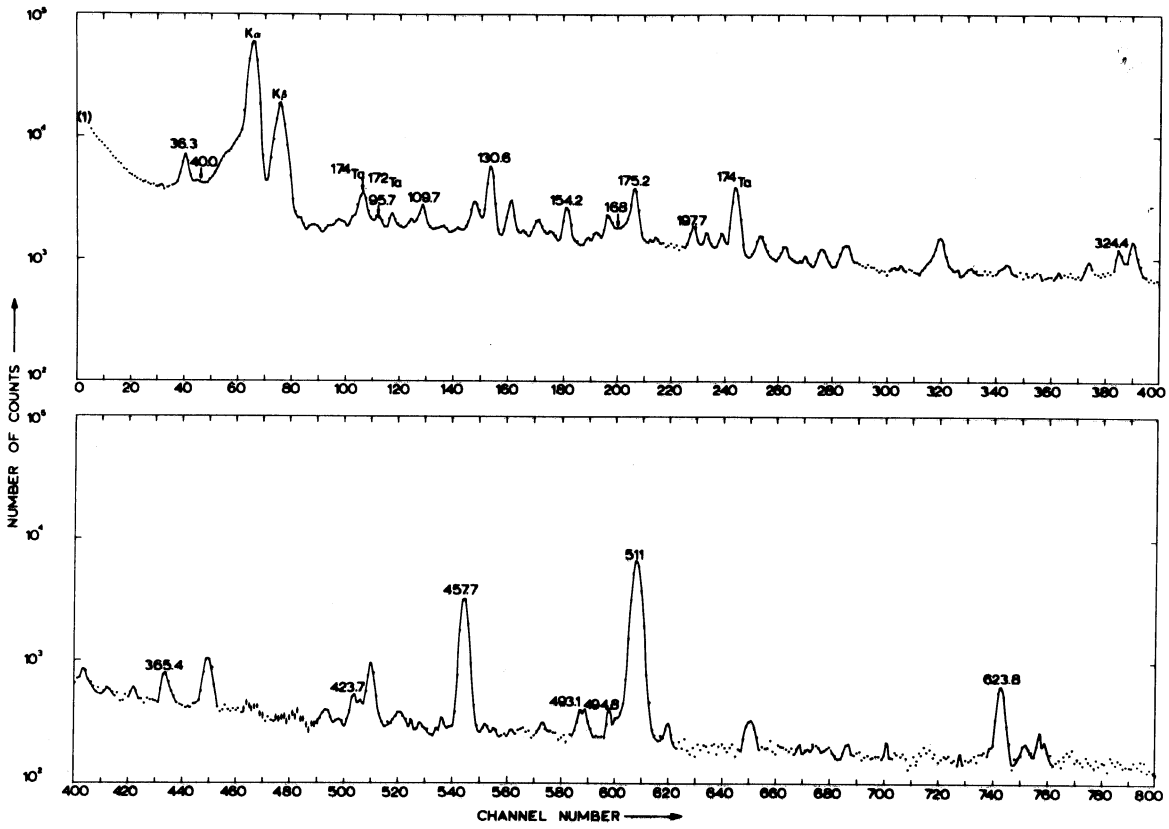

Fig. 4

γ-ray spectrum of the decay of ^{172}W

serious difficulty is, however, encountered in measurements of isotopes with high decay energies. Here a substantial part of the decay intensity can be contained in a large number of very weak transitions hidden in the Compton background of the stronger lines. In a recent study of the ^{178}Re decay[6] (Q=4.7 MeV) a serious discrepancy from the theoretical values was found for the K/β^+ ratio for the beta decay to the lower states in ^{178}W; this deviation is most likely caused by the above effect.

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Note: At the Conference our attention was drawn to the extensive measurements of Rezanka et al. (these proceedings) of the decay of 25 min. ^{171}Ta.

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