IDENTIFICATION OF ^{158}Yb, $T_{1/2} = 1.1 \pm 0.2$ min.

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On the basis of the analysis of the gamma-spectrum of $A = 158$ isobars the ^{158}Yb isotope has been identified. Its half-life $T_{1/2} = 1.1 \pm 0.2$ min. has been measured. The ^{158}Yb decay is followed by emission of 74.2 ± 0.2 keV gamma-ray.

The existence of ^{158}Yb isotope was first reported by Neiman and Ward [1]. Studying the products of the ^{122}Te(^{40}Ar, xp yn) reaction they found gamma-transitions to occur in the ^{158}Tm decay. Observing some delay in the decrease of intensity of these transitions, the authors have attributed it to the presence of a new isotope ^{158}Yb. The half-life of this isotope has been estimated to be $T_{1/2} \approx 1.5$ min.

Studying the products of the ^{162}Er (^{3}He, xn) Yb reactions, de Boer et al. [2] detected the gamma-rays with energies of (intensities) 173.9 keV (100) and 215.9 keV (46) with the intensity decrease $T_{1/2} = 4.6 \pm 0.5$ min. These gamma-rays were attributed to the ^{158}Yb decay.

There is no evidence in the work by Neiman and Ward [1] that the half-life $T_{1/2} \approx 1.5$ min. belongs to the decay of ^{158}Yb isotope. In the work of de Boer et al. [2] all products of the reactions were measured simultaneously without separation. For these reasons we decided to reinvestigate the problem using mass-separated radioactive sources.

Our experiments were done with the experimental equipment made in the Laboratory of Nuclear Problems of the JINR [4] for investigations of the YASNAPP programme. Neutron deficient isotopes of the rare-earth elements (REE) were obtained by the spallation reaction from a tantalum target irradiated with $E_p = 660$ MeV protons of the JINR synchrocyclotron. Separation of the reaction products was achieved by a method described

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in Ref. [5]. The proton irradiated tantalum foil, 0.05 mm thick and weighting 0.3–0.4 g, was put in a vaporizer of an ion source of the mass-separator. The ion source was heated up to temperature $T = 2500$–$2800°K$; the REE isotopes were diffused from the target, ionized and then separated into isobars. The mass-separator parameters were chosen for maximum efficiency of ytterbium isotopes.

The results of the gamma-ray spectrum measurements of the samples with the mass of $A = 160$ were reported by us in an earlier paper [3]. The following gamma-rays with energies (intensities) of: 132.2 keV (12.8), 140.3 keV (22), 173.8 keV (100), 215.8 keV (41) and 373.2 keV (4.5) were identified as belonging to the decay of the new isotope of ^{160}Yb, $T_{1/2} = 4.8 \pm 0.2$ min. Thereby it is clear that in the work [2] a mistake in the mass identification was made.

In the present work the gamma-spectra of the sources with the mass of $A = 158$ were investigated.

The gamma-ray spectra were investigated using gamma-spectrometers with 1.0 and 50 cc Ge(Li) detectors. Their energy resolutions were 0.9 keV, at the energy of 120 keV, for the first detector, and 2.7 keV, at the energy 1333 keV, for the other one. The time interval between the end of the target irradiation and the beginning of the gamma-ray

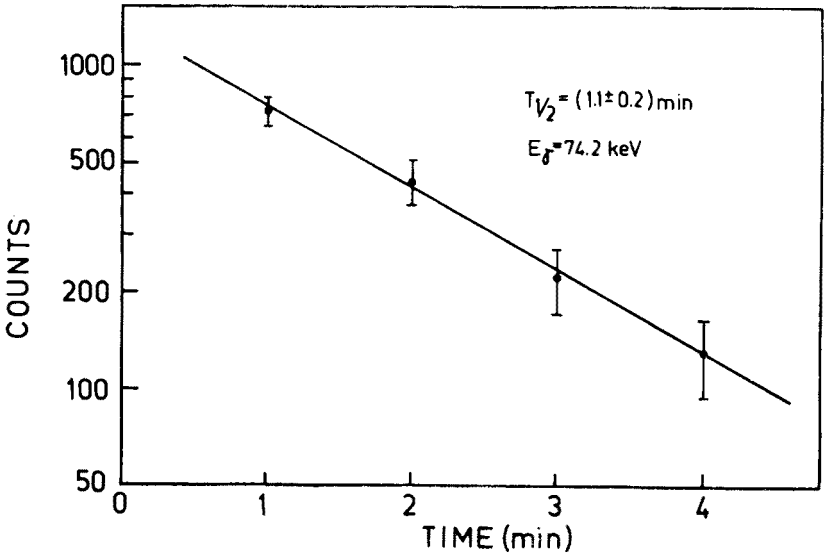

Fig. 1. Decay curve of the 74.2 keV γ-transition

spectra measurements did not exceed 3.5 min. In addition to the known gamma-transitions arising in the decay of ^{158}Tm, ^{158}Er and ^{158}Ho, we have discovered in the gamma-ray spectrum of $A = 158$ isobars, the gamma-transition with the energy of 74.2 keV with the intensity decrease $T_{1/2} = 1.1 \pm 0.2$ min. (Fig. 1). The half-life was determined from four runs of measurements. We have also observed K_α and K_β X-rays transitions of thulium. Their intensity decreased with $T_{1/2} \approx 1$ min. The spectra obtained in one of the measurements are plotted in Fig. 2. A delay was also observed in the decrease of the intensity of

the gamma-transitions occurring in the ^{158}Tm decay. This delay can be explained by accumulation of ^{158}Tm in the ^{158}Yb decay or by an isomer in ^{158}Tm or ^{158}Er with half-life $T_{1/2} \approx 1$ min. The ratio of intensity of KX to gamma-transition 74.2 keV is $I_{KX}/I_\gamma = 1.5 \pm 0.5$.

If we assume that the appearance of thulium KX-rays resulted from filling the holes produced in the 74.2 keV gamma-ray internal conversion process in the K-shell, we can

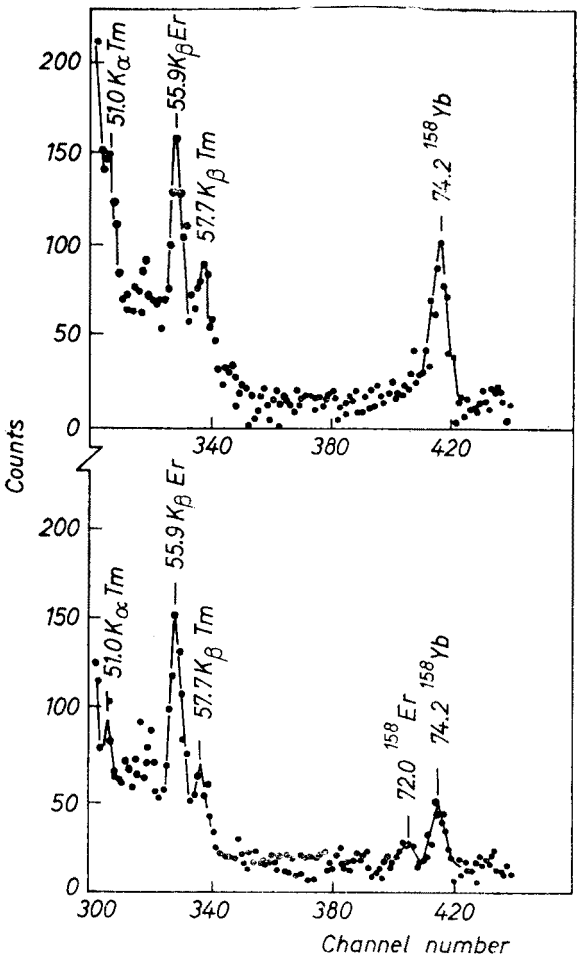

Fig. 2. Low-energy region of the γ-ray spectrum of the mass-separated isobar of $A = 158$. The time interval between 2A and 2B measurements is $\Delta t = 2$ min.

calculate the value of I_{KX}/I_γ: they equal 0.65, 1.67 and 3.1 for the assumed multipolarities of the 74.2 keV transition E1, E2 and E3, respectively. This result excludes the possibility of the 74.2 transition being a high multipolarity isomeric transition, but we cannot exclude the possibility that it is one of the members of a cascade, whose low energy isomeric transition is unobservable in our gamma-spectrum. Another argument comes from

the paper [6]. The authors declare that there are no half-lives longer than $T_{1/2} = 25$ sec, except for $T_{1/2} = 4.01$ min in the decay of ^{158}Tm.

If we assume that the 74.2 keV transition followed the decay of ^{158}Yb, we can calculate the value of I_{KX}/I_γ from tabulated quantities of the beta-decay energy Q_β, ε/β^+ ratio and the fluorescence yield. This quantity is $\geqslant 0.84$, $\geqslant 2.95$ and $\geqslant 7.3$ for the assumed multipolarities E1, E2 and M1, respectively.

Thus, the results obtained indicate that ^{158}Yb isotope has the half-life $T_{1/2} = 1.1 \pm 0.2$ min. The ^{158}Yb decay is accompanied by the gamma-ray emission with energy of 74.2 ± 0.2 keV multipolarity E1. The effect of the delay reported in paper [1] resulted from the ^{158}Yb decay. The preliminary results of this work have been reported in Ref. [7].

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REFERENCES

[1] M. Neiman, D. Ward, report UCRL-18667, 1968, p. 59.

[2] W. F. N. de Boer, M. H. Cardoso, P. F. Goudsmit, P. Koldwijn, B. J. Meijer, report CERN-70-30 Geneva 1970, p. 939.

[3] G. Beyer, M. Honusek, H. U. Siebert, K. Zuber, J. Zuber, A. Latuszyński, I. Penev, A. W. Potempa, H. Strusny, M. Jachim, report JINR-P6-8229, Dubna 1974; *Acta Phys. Pol.* **B6**, 427 (1975).

[4] K. Anders, R. Arlt, M. Honusek, H. U. Siebert, A. I. Kalinin, S. V. Medeved, G. Musiol, H.-G. Ortlepp, A. N. Sinaev, W. Habenicht, H. Strusny, report JINR-P6-8564, Dubna 1975.

[5] A. Latuszyński, K. Zuber, J. Zuber, A. W. Potempa, W. Żuk, *Nucl. Instrum. and Methods* **120**, 321 (1974).

[6] P. Auger, C. F. Liang, J. Libert, P. Paris, P. Peghaire, A. Charvet, R. Duffait, G. Marguier, *Nucl. Phys.* **A249**, 239 (1975).

[7] V. I. Gilev, M. Honusek, K. Ya. Gromov, H. U. Siebert, K. Zuber, J. Zuber, A. Latuszyński, I. Penev, A. W. Potempa, report JINR-P6-8419, Dubna 1974.