Brief Communications

PHOTOPROTONS FROM Li^6

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By means of nuclear emulsions exposed in a vacuum chamber at angles of 20, 50, 70, 90, 110, 130, and 160° to a γ-ray beam, we have studied the energy and angular distributions of protons produced by irradiation of Li^6 with bremsstrahlung of maximum energy $E_{\gamma\,max} = 20$ MeV. The target, containing 90% Li^6 and 10% Li^7, had a thickness of 6.8 mg/cm^2. All particle tracks measured were considered to be proton tracks. We estimate that the contribution of deuterons, tritons, and He^3 and He^4 nuclei to the proton spectrum was 11—13%. The background due to the reaction $Li^7(\gamma, p)He^6$ was 1.5%. The instrumental background of protons arising from scattered neutrons and γ radiation was evaluated by special measurements and was subtracted from the experimental results.

Figure 1 shows the total energy distribution of the photoprotons. In agreement with Titterton[1] and Proctor and Voelker[2], we find that protons with $E_p > 5.7$ MeV are most probably due to the (γ, p) reaction, when He^5 is formed only in the ground state. Their angular distribution has the form

$$N(\theta)=41.0+43.6\sin^2\theta\,(1+0.66\cos\theta)^2$$

which is quite characteristic of (γ, p) processes. The solid curve in Fig. 2 shows the excitation function for the reaction $Li^6(\gamma, p)He^5$, plotted from the total energy spectrum of protons with $E_p \geq 5.7$ MeV. The corresponding integrated cross section is

$$\int_{11.6}^{20}\sigma_{\gamma p}(E_\gamma)\,dE_\gamma=(3.2\pm0.3)\ \text{MeV-mb}.$$

We have approximately evaluated the integrated cross sections for the (γ, np) reaction and the (γ, p) and (γ, n) reactions accompanied by formation of He^5 and Li^6 in their ground states. For the evaluation the plotted excitation function of the (γ, p) reaction was extended to low energies in such a way that its shape was similar to that of the total photoneutron cross section[3]. By this means we obtain

$$\int_{4.7}^{19}\sigma_{\gamma p}(E_\gamma)\,dE_\gamma\approx(4.9\pm0.6)\ \text{MeV-mb}.$$

Assuming the (γ, n) excitation function to be similar in shape to the (γ, p) excitation function,

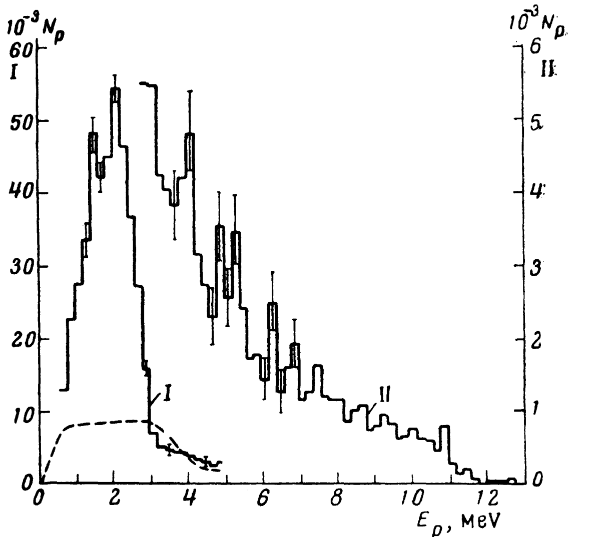

FIG. 1. Total energy distribution of photoprotons from Li^6. The dashed curve is the calculated total energy distribution of protons from the reactions $Li^6(\gamma,n)Li^5 \to p + He^4$ and $Li^6(\gamma,p)He^5 \to n + He^4$.

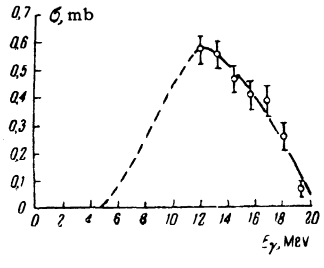

FIG. 2. Excitation function of the (γ,p) reaction for the case when the final He^5 nucleus is formed in the ground state. The dashed curve shows the extension of the excitation function to the low energy region with a form similar to the total cross section for reactions accompanied by neutron emission.

and taking into account that the (γ, n) reaction is roughly 1.9 times more probable than the (γ, p) reaction[2], we obtain

$$\int_{5.7}^{19} \sigma_{\gamma n}(E_\gamma)\, dE_\gamma \approx (9.2 \pm 4.3) \text{ MeV-mb}.$$

Since the integrated cross section of all reactions with neutron emission is 21 MeV-mb, then

$$\int_{3.7}^{19} \sigma_{\gamma np}(E_\gamma)\, dE_\gamma \approx (6.9 \pm 4.9) \text{ MeV-mb}.$$

In the region $E_p < 6$ MeV in Fig. 1, the dashed curve shows the total calculated energy distribution of protons produced in the reactions $Li^6(\gamma, p)He^5 \rightarrow He^4 + n$ and $Li^6(\gamma, n)Li^5 \rightarrow He^4 + p$. The calculation was carried out using the approximate excitation functions cited above and taking into account kinematic processes. For $E_p = 3-5$ MeV the calculated spectrum approximately exhausts the observed number of protons. The number of protons in the calculated spectrum with energies 0—3 MeV, as it turns out, amounts in all only to 25—30% of the number of protons of the same energy in the experimental spectrum. The contribution of tritons, α particles, He^3 nuclei, and protons from the $Li^7(\gamma, p)He^6$ reaction amount to roughly 15% in this region of the spectrum. Consequently 55—60% of the protons with energies ≤ 3 MeV most probably arise from the (γ, np) reaction. This number of protons agrees with the approximate evaluation given above of the integrated cross section for the $Li^6(\gamma, np)He^4$ reaction. The peak in the excitation function for the (γ, np) reaction, in agreement with the observed position of the large proton peak at $E_p \approx 1.9$ MeV, should occur at $E_\gamma = 7-9$ MeV.

[1] E. W. Titterton, Prog. Nucl. Phys. **4**, 31 (1955).

[2] D. G. Proctor and W. H. Voelker, Phys. Rev. **118**, 217 (1960).

[3] T. A. Romanowski and W. H. Voelker, Phys. Rev. **113**, 886 (1959).

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HALF LIFE OF Tb^{157}

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RADIOACTIVE Tb^{157} results from the decay of its parent Dy^{157}. Available estimates indicate that its half-life is $T_{1/2} > 100$ years[1].

In the present investigation we determined the half-life of Tb^{157} from the number N_0 of radioactive nuclei contained in the source and from the decay rate $dN/dt = -N_0 \log(2/T)$. The radioactive Tb^{157} was obtained as the decay product of Dy^{157} produced by irradiating tantalum with 660-MeV protons on the synchrocyclotron of the Joint Institute for Nuclear Research. N_0 was determined from the decay rate of the parent isotope Dy^{157}. A double-focusing β spectrometer with $\pi\sqrt{2}$ angle was used to measure the internal-conversion K line having the strongest period in the decay of Dy^{157}, with energy 327 keV. This transition occurs in 98% of decays with multipolarity E1 and with conversion coefficients $\alpha_C = 0.0113$ and $\alpha = 0.0136$. The transmission of the apparatus was estimated by measuring the 662-keV K-conversion line of the transition in Ba^{137} under the same condition, using a Cs^{137} standard compound. The number of accumulated Tb^{157} nuclei, equal to the number of the decaying Dy^{157} nuclei, was $N_0' = (1.18 \pm 0.26) \times 10^{13}$. Fourfold chromatographic purification yielded a sufficiently pure Tb^{157} compound. The losses during the chemical operations amount to $(66 \pm 7)\%$, and the number of nuclei in