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Academician of the Academy of Sciences of the Ukrainian SSR A.  
P. KOMAR and E. D. MAKHNOVSKII

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**Abstract**

**Full Text**

## **Reports of the Academy of Sciences of the USSR**

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### **PHYSICS**

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## **FINE STRUCTURE OF THE ENERGY SPECTRUM OF PHOTOPROTONS AND LEVELS OF THE NUCLEUS $\text{Li}^6$**

The energy distribution of protons produced as a result of the reactions  $(\gamma, p)$  and  $(\gamma, n)$  under irradiation of  $\text{Li}^6$  by bremsstrahlung  $\gamma$  rays with  $E_{\gamma\text{max}} = 28$  MeV was studied. Irradiation of lithium foil  $8.6 \text{ mg/cm}^2$  thick, containing 90% of the isotope  $\text{Li}^6$ , was carried out in the vacuum chamber described in (1). The protons were recorded by NIKFI Ya2 nuclear emulsions  $400 \mu$  thick, placed at an angle of  $60^\circ$  to the direction of the photon beam.

All tracks of length  $\geq 4 \mu$  were measured, beginning at the surface of the emulsion and satisfying the geometrical criteria of the experiment. Measurements with a microscope were made at a magnification of  $1350\times$ . All measured tracks were regarded as proton tracks. In this case the background due to the reaction  $\text{Li}^6(\gamma, d)\text{He}^4$  amounted to  $\sim 1\%$ . Photodisintegration of impurity  $\text{Li}^7$  nuclei accounted for  $< 10\%$  of the measured tracks.  $\alpha$  particles arising from the decay of unstable  $\text{He}^5$  and  $\text{Li}^5$  nuclei from the "ground" state distorted the proton spectrum up to  $E_p \approx 0.6$  MeV.  $\alpha$  particles due to the decay of  $\text{He}^5$  and  $\text{Li}^5$  from excited states could distort the proton spectrum up to  $E_p \approx 1.4$  MeV. The "instrumental" background of protons produced by scattered radiation amounted to  $< 3\%$ .

The resulting proton energy spectrum, processed by the method of Ferreira and Waloschek, is presented in Fig. 1. Among the low-energy protons were included protons that did not leave the target. Their number was calculated on the assumption of an equal probability of emission of particles of a given energy from any layer of the target, from the front to the back in thickness. In accordance with this assumption, for protons with  $E_p = 0.4 \div 3$  MeV, corrections for energy losses in the target were introduced, and this part of the spectrum is shown by curve *I*. The part of the proton spectrum for which corrections were introduced for energy losses in half the target thickness is represented by curve

Fig. 1. Energy distribution of protons in the photodisintegration of  $\text{Li}^6$

Figure 1: Fig. 1. Energy distribution of protons in the photodisintegration of  $\text{Li}^6$

*II.* As is seen from the figure, the energy distribution consists of a number of discrete maxima. Some maxima stood out beyond the statistical error.

The results of previous investigations (2-4) lead one to suppose that the reactions  $(\gamma, n)$  and  $(\gamma, p)$  on  $\text{Li}^6$  proceed with the formation of unstable  $\text{Li}^5$  and  $\text{He}^5$  nuclei predominantly in the “ground” state. Decay of the  $\text{Li}^5$  nucleus into a proton and an  $\alpha$  particle from the “ground” state  $3/2^-$  causes the appearance of protons with an energy of about 1.44 MeV. If the influence of the photon momentum and of the recoil momentum acquired by the  $\text{Li}^5$  nucleus upon emission of a neutron from  $\text{Li}^6$  is taken into account, then the very intense peak near 1.9 MeV should be attributed to the  $(\gamma, n)$  reaction with transitions to the “ground” state of  $\text{Li}^5$ . Decay of  $\text{Li}^5$  from the “broad” first excited state  $1/2^-$  presupposes the presence in the proton spectrum of a broadened maximum at  $E_p$  about 4 MeV. Analysis of this part of the energy distribution suggests the existence, at 3.4 MeV, of a comparatively “sharp” peak, which most probably should be assigned to the  $(\gamma, p)$  reaction. The distinct maxima at 4.1 and 4.5 MeV apparently are also due to the  $(\gamma, p)$  reaction. As a result of the decay of  $\text{Li}^5$  from the second excited state  $3/2^+$  (at 16.8 MeV), in the proton spectrum one should—

one would expect a maximum near 15–15.8 MeV. However, no noticeable peak is observed in this part of the energy distribution. Thus, the proton spectrum obtained by us also confirms the assumption that the reaction  $\text{Li}^6(\gamma, p)\text{Li}^5 \rightarrow p + \alpha$  proceeds with the formation of  $\text{Li}^5$  predominantly in the “ground” state.

**Fig. 1.** Energy distribution of protons in the photodisintegration of  $\text{Li}^6$

In the case of the  $(\gamma, p)$  reaction with the formation of  $\text{He}^5$  in the excited state  $3/2^+$  at 16.7 MeV, from energy considerations ( $E_{\gamma \text{ max}} = 28$  MeV) one might expect maxima at  $E_p < 5.8$  MeV. However, it is difficult to suppose that such intense peaks as those at 5.5, 4.5, and 4.1 MeV are due to photons at the end of the bremsstrahlung spectrum. On the other hand, from consideration of the fine structure of the spectrum obtained it follows that, in the  $(\gamma, p)$  reaction, the formation of  $\text{He}^5$  in the “broad” excited state  $1/2^-$  is unlikely. Taking the foregoing into account, one may consider that all maxima in the spectrum at  $E_p > 4$  MeV are due to resonant absorption of  $\gamma$ -quanta by the  $\text{Li}^6$  nucleus, with subsequent emission of protons and formation of the  $\text{He}^5$  nucleus in the “ground” state.

**Table 1**

Position of maximum in the spectrum $E_p$ , MeV	Level energies, MeV: established levels	Level energies, MeV: proposed levels
4.1		9.5*
4.5		10.0**
5.5	11.2	
11.6	18.3	

\* According to (5), there is a level at  $9.3 \pm 0.2$  MeV.

\*\* In the work of E. A. Al'bitskaya et al. (4), a level at 10 MeV is indicated.

In the spectrum obtained, peaks at 5.5 and 11.6 MeV stood out above the statistics. A pair of mutually unresolved peaks at 4.1 and 4.5 MeV was clearly distinguished. The energies of the corresponding levels of the  $\text{Li}^6$  nucleus, calculated with allowance for the photon momentum and the recoil momentum of the nucleus, are given in Table 1. Other maxima did not stand out beyond the statistical error. However, there is reason to think that some of them also correspond to discrete levels or groups of levels of the  $\text{Li}^6$  nucleus.

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*Note: Figure translations are in progress. See original paper for figures.*

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