Search for highly excited state of the Li^6 nucleus

A. D. Duĭsebaev, G. N. Ivanov,[1)] É. I. Kébin, Yu. I. Nechaev, Yu. V. Solov'ev, V. G. Sukharevskiĭ, and V. A. Khaĭmin[2)]

Institute of Nuclear Physics, Kazakh Academy of Sciences
Institute of Nuclear Physics, Moscow State University
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We measured the differential cross section of the reaction $Be^9(p, \alpha)Li^6$ at $E_p = 30$ MeV at an angle of 30° in the *l.s.* At an excitation energy of the Li^6 nucleus 14.0 MeV we observed a relatively narrow state, the width of which does not exceed several dozen keV, and the differential cross section of the excitation is 200±60 μb/sr.

A number of theoretical and experimental papers, for example,[1–6] devoted to the excited states of nuclei with $A = 6$ have been published recently. It was also noted[7] that there are no reliably established highly-excited states in the Li^6 nucleus in the excitation-energy range 6–26 MeV, and in the Be^6 in the range 2–24 MeV.

We have carried out a search for such states of the Li^6 nucleus with the aid of the reaction $Be^9(p, \alpha)Li^6$, induced by a beam of neutrons of energy 30 MeV accelerated with the isochronous cyclotron of the Nuclear Physics Institute of the Kazakh Academy of Sciences. The dimensions of the proton beam on the target were 3×2 mm, and the free-standing beryllium target was 0.54 mg/cm² thick. The particles were registered with a telescope of 2 silicon counters ΔE (33 μ) and E (1000 μ) at an angle 30±0.1° in the *l.s.* The solid angle of the detectors was 10^{-4} sr.

The pulses from the semiconductor detectors were fed through charge-sensitive preamplifiers and amplifiers to an electronic system that identified the particles by their masses;[8] the operating principle of the system is based on the empirical energy dependence of the range of the charged-particles, $R = \alpha E^{1.73}$, where R is the range in cm and E is the energy in MeV, while α is a parameter that depends strongly on the particle mass and depends weakly on its energy. We obtained satisfactory separation of the identification pulses from He^3 and the α particles. The spectrometric $E + \Delta E$ pulses were fed to a multichannel analyzer controlled by an identification system tuned to register the α particles.

The obtained spectrum of the α particles from the reaction $Be^9(p, \alpha)Li^6$ is shown in the figure. An analysis of the spectrum did not show the presence of He^3 impurity from the reaction $Be^9(p, He^3)Li^7$, or of α particles from the reaction (p, α) on the possible impurities C^{12}, N^{13}, O^{16}, and the Cu and W isotopes.

The experimental resolution was estimated with allowance for the energy scatter in the beam, for the target thickness, for the uncertainty in the registration angle, and for the noise in the recording apparatus; it amounted to ~300 keV. However, a certain instability of the discrimination threshold and of the analyzer conversion coefficient has caused an additional broadening of the peaks, in proportion to the channel number. This has led to a poor separation of the α particles corresponding to the first excited states of Li^6.

As seen from the figure, no reliable information was obtained on the excited states in the Li^6 excitation-energy region from 6 to 14 MeV. At an α-particle energy 15.0 MeV one can see clearly a relatively narrow peak, which can be associated with the Li^6 state with excitation energy 14.0 MeV (this level is not noticed in the review.[7]) Comparing the experimental width of this state (~300 keV) with the energy resolution estimated above, we can state that the proper width of this state is small and does not exceed several dozen keV. The differential cross section at the angle 30° in the *l.s.* amounts to 200±60 μb/sr.

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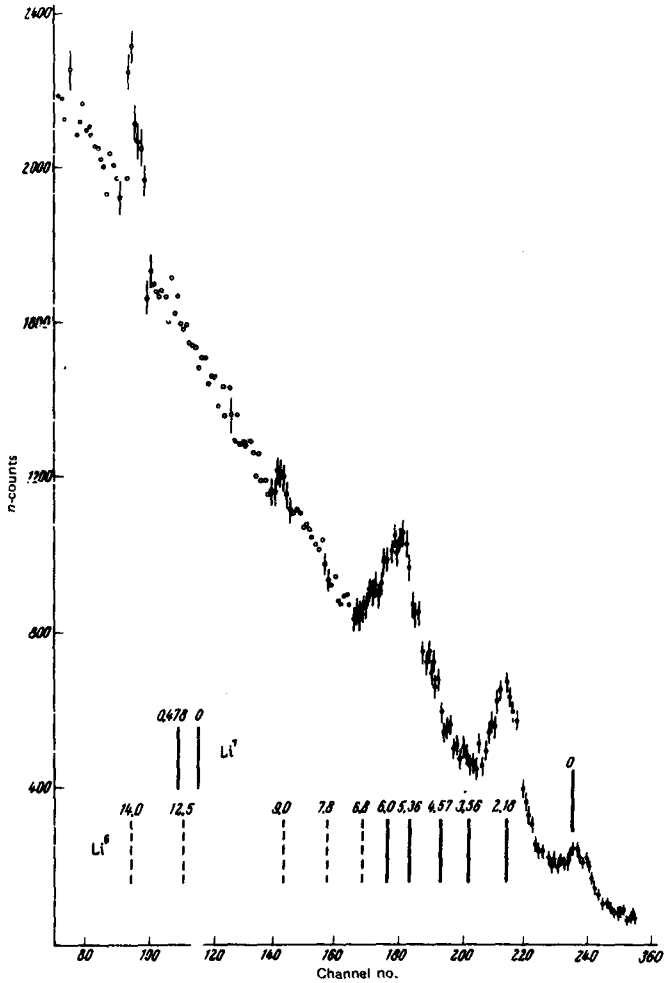

Spectrum of α particles from the reaction $Be^9(p,\alpha)Li^6$ at 30° *l. s.* at $E_p = 30$ MeV. The vertical solid lines show the positions of the excited state of Li^6 and Li^7 in accordance with the review,[7] while the dashed lines show the levels that have not been reliably established, in accordance with the review.[9]

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[1)]Institute of Nuclear Physics, Kazakh Academy of Sciences.
[2)]Nuclear Physics Institute of the Moscow State University.

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