Investigation of the reaction $Be^9(e, e'p)Li^8$ with registration of (e, p) coincidences

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A beam of 801-MeV electrons from the LUÉ-2000 accelerator was used to measure the cross section of the reaction $Be^9(e, e'p)Li^8$ as a function of the proton detachment energy. The values obtained for the detachment energies of the $1S$- and $1P$-protons are 28.7 and 16.9 MeV, respectively.

The LUÉ-2000 linear electron accelerator of our institute was used to investigate the reaction $Pe^9(e,e'p)Li^8$ with registration of the coincidences of the scattered electron and of the proton emitted from the nucleus. The obtained experimental energy resolution, 7.1 MeV, has made it possible to separate sufficiently well the effects due to the $1S$ and $1P$ shells of the Be^9 nucleus.

The measurements were made at the following values of the kinematic parameters: primary beam energy $K_0 = 801$ MeV, electron scattering angle $\theta_e = 30°$, proton emission angle $\theta_p = 63°$, and proton kinetic energy $T_p = 81.8$ MeV. The electrons and protons emitted by the nucleus were momentum-analyzed by two magnetic spectrometers[1] with solid angles 1.45 and 8.20 msr, respectively. These particles were registered with five- and one-channel scintillation-counter telescopes located at the focal planes of the magnetic spectrometers, with a momentum range (per channel) 0.5 and 1.38%, respectively. The coincidence of each of the electron channels with the proton channel were registered with time-amplitude converters.[2] The target used in the experiment was 0.562 g/cm² thick, was made of pressed beryllium powder, and was mounted at an angle 30° to the beam axis.

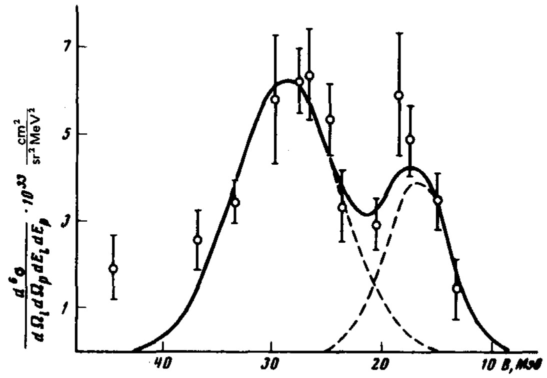
The (e,p) coincidence spectrum was measured as a function of the energy K_1 of the scattered electron, or equivalently of the energy of detachment of a proton from the Be nucleus, with the protons emitted from the nucleus registered at an angle of 63°. The detachment energy, according to the energy conservation law, is given by

$$B = K_0 - K_1 - T_p - T_{nuc},$$

where T_{nuc} is the kinetic energy of the recoil nucleus.

The detachment-energy scale and the efficiency of the registration systems were determined from the position of the peak and from the cross section for the elastic scattering of the electrons by hydrogen.

The figure shows the measured cross section of the reaction $Be^9(e,e'p)Li^8$ (without allowance for the radiative effect) as a function of the detachment energy. The solid line was obtained by fitting the sum of two Gaussian curves (dashed lines) to the experimental points. The maxima of the Gaussians are located at detachment energies 16.9 ± 1 and 28.7 ± 1 MeV. Taking into account the difference between the masses of Be^9 and Li^8, we can conclude that the position of the maxima corresponds to the residual nucleus Li^8 in the ground state and with excitation energy ~12 MeV. Based on the investigations the angular correlations of the reactions $Be^9(p,2p)Li^8$[3,4] and $Be^9(e,e'p)Li^8$,[6] the obtained peaks can be inter-



Dependence of the cross section of the reaction $Be^9(e,e'p)Li^8$ on the proton detachment energy.

preted as the results of proton knock-out from the 1*S* and 1*P* shells of the Be^9 nucleus. Within the limits of experimental accuracy, the obtained detachment energies of the 1*S* and 1*P* protons agree with the results of $(p,2p)$ experiments. In the investigations of the reaction $(e,e'p)$ on Be^9,[6,7] the insufficient energy resolution did not make it possible to separate the contributions of the 1*S* and 1*P* shells.

The total width at half-height of the peak corresponding to the 1*P* shell is equal to the experimental energy resolution of the setup and amounts to 7.1 ± 0.8 MeV. The width of the peak corresponding to the 1*S* shell is 11.5 ± 0.9 MeV. This increase in width can be attributed[8] to the finite lifetime of the hole state of the residual nucleus.

The experimental cross sections $d^5\sigma/d\Omega_e d\Omega_p dE_p$, with allowance for the radiative corrections,[9] turned out to be $(0.35\pm0.06)\times10^{-31}$ and $(0.84\pm0.20)\times10^{-31}$ cm^2/sr^2-MeV for the 1*P* and 1*S* shells, respectively. In order for the ratio of the experimental cross section to the theoretical ones, calculated in the plane-wave-momentum approximation with oscillator wave functions, to be equal to the suppression coefficients obtained from[10] for this reaction (0.62 and 0.77 for the 1*S* and 1*P* shell, respectively), it is necessary to use the values 99 and 69 MeV/*c* for the oscillator parameters of the 1*S* and 1*P* shells. These values are close

1) *B*, MeV 2) Width at half height, MeV 3) cm^2/sr^2-MeV

B, MeV	Width at half height, MeV	$\frac{d^5\sigma_{expt}}{d\Omega_e d\Omega_p dE_p}\cdot10^{31}$, cm^2/sr^2-MeV
17.4 ± 1	7.1 ± 0.8	0.41 ± 0.14
26.4 ± 1	7.1 ± 0.8	0.41 ± 0.16
33.3 ± 1	11.2 ± 3.4	0.44 ± 0.30

to those obtained in the investigation of reaction of $Be^9(p, 2p)Li^8$,[4,11] namely 105–110 and 65 MeV for the 1*S* and 1*P* shell, respectively. The small decrease of the oscillator parameter of the 1*S* shell in our case may be the consequence of the background for multiple collisions[6] in the region of the 1*S* peak. It is possible that this, and also the presence of the radiative tail, causes the observed rise of the spectrum at large *B*.

In a number of studies[5,7] of the quasielastic knock-out of protons from Be^9, it was proposed that the peak corresponding to the 1*S* shell consists of two peaks connected with different excitations of the residual nucleus. Starting with these assumptions, the sum of three Gaussians was fitted to the experimental points, keeping the distance between maxima of the peaks constant at the value given in[5].

The results of this fitting are listed in the table.

It should be noted that our results do not allow us to conclude unequivocally that a third peak exists.

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