

Fig. 2. Time dependence of resistance of Na-NH₃ with concentration 3.2 at.% Na. The two curves correspond to two different experiments.

The time dependence can be explained on the basis of the imbalance of the investigated system. The superconductivity produced at the initial period of time is destroyed as the system relaxes. Such a situation was considered in [6]. Estimates [6] yield a relaxation time $\tau \sim 10^{-5}$ sec, whereas in our experiments $t_0 \sim 20$ min.

The exponential growth of the resistance with time explains why the data obtained by others are contradictory, namely, the experimenters obtained different values of the physical quantities, depending on the instant of time when the measurements were started. Therefore, low values of the resistance were obtained at best in one or two out of a hundred experiments, for example, and only in two studies [3, 4] were "undamped" currents with lifetimes 1 - 2 min observed. The relatively short lifetimes of the persisting currents follow also from (2). If we use the estimated resistivities obtained in these experiments, $\rho \sim 10^{-12} - 10^{-13}$ ohm-cm, and our values of B, b, and t_0 , then the lifetime of the persisting currents is about 1 minute. We see thus how easy it is to miss the effect by delaying the start of the measurement. This explains in turn why there is no unequivocal answer to the question of superconductivity in sodium-ammonia solutions.

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1) The present paper deals mainly with the Na concentration interval 2.5 - 3.2 at.%. Details of the experiments and descriptions of the other compositions will be reported elsewhere.

2) The transformation at 165°K is accompanied by release of the latent heat of transition.

- [1] V. L. Ginzburg, *Usp. Fiz. Nauk* 101, 185 (1970) [*Sov. Phys.-Usp.* 13, 335 (1970)].
- [2] V. A. Slyusarev and I. A. Burakovich, Preprint FTINT, 1972.
- [3] R. A. Ogg, *Phys. Rev.* 69, 243, 544, 559 (1946).
- [4] J. W. Hodgins, *Phys. Rev.* 69, 568 (1946).
- [5] B. I. Verkin, B. G. Lazarev, V. I. Khotkevich, *Trudy, Physics Dept., Kharkov State Univ.*, Vol. 3, 1952.
- [6] D. A. Kirzhnits and Yu. V. Kopaev, *ZhETF Pis. Red.* 17, 379 (1973) [*JETP Lett.* 17, 270 (1973)].

THE REACTION $\text{Li}^7(e, e'p)$ AT 1200 MeV

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The cross section of the reaction $\text{Li}^7(e, e'p)\text{He}^6$ as a function of the detachment energy was measured at seven proton-emission angles at 4-momentum squared $0.16 (\text{GeV}/c)^2$. The angular distributions were plotted for the protons knocked out of the 1p and 1s shells of Li^7 . The results are compared with shell-model calculations with an oscillator potential. A χ^2 fit yields a wavefunction parameter $100 \pm 9 \text{ MeV}/c$ for the 1s shell of Li^7 and $70 \pm 5 \text{ MeV}/c$ for the 1p shell; the suppression coefficients are 0.30 and 0.47, respectively.

In the plane-wave impulse approximation, the cross section of the $(e, e'p)$ reaction is proportional to the cross section for elastic scattering of an electron by a proton moving with momentum q , and to the square of the wave function of this proton in the target nucleus. Since

the momentum is determined uniquely from the kinematics of the reaction, measurement of the reaction cross section makes it possible to determine the proton momentum distribution inside the nucleus [1].

The experiment was performed with the electron beam of the linear accelerator of our Institute, at a primary-electron energy $k_0 = 1180 \pm 3$ MeV. The electron current was measured with a secondary-emission monitor calibrated with a Faraday cup with accuracy $\pm 2.0\%$.

The target was made of lithium of natural isotopic composition. The target thickness was 0.237 g/cm^2 . The secondary electrons and protons were momentum-analyzed with two double-focusing magnetic spectrometers of the sector type [2], with solid angles 1.5 and 8.2 msr respectively. Telescopes of multichannel scintillation counters served as detectors. The three-channel telescope for electron registration had a momentum range 0.4% per channel, with a distance 0.6% between channels; the momentum range of each of the three proton counters was 2.5%. Coincidence between the signals of each electron counter and the signals of each proton counter were registered by nine time-amplitude converters.

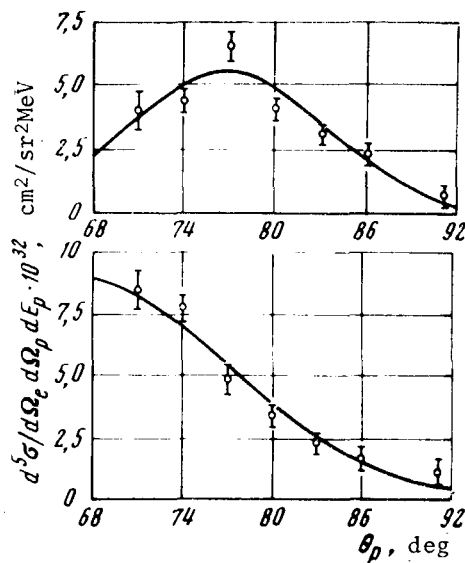
The missing energy is given by the expression $B = K_0 - K_1 - T_p - T$, where K_0 , K_1 , T_p , and T_R are the energies of the initial and final electrons and the kinetic energies of the proton and of the residual nucleus, respectively. The given value of B was set by suitably choosing the energy K_1 of the secondary electrons. The spectra of the missing energy B were measured at proton emission angles 71, 74, 77, 80, 83, 86, and 91° ; the electron registration angle was 20° and the momentum of the registered proton was 404 MeV/c. The total energy resolution of the apparatus was 9 MeV.

Shell parameters q_p and q_s and suppression coefficients k_p and k_s

	Our data	Data of [5]	(p, 2p) data of [5]
q_s	100 ± 9	109	115
q_p	70 ± 5	88	65
k_s	0.30	0.38	-
k_p	0.47	0.35	-

When the cross section of the $\text{Li}^7(e, e'p)\text{He}^6$ reaction is measured with this resolution, it is impossible to separate to a sufficient degree the state of the He^6 nucleus, so as to measure the angular correlation function by the same procedure as for Li^6 [3]. We obtained the angular distribution by resolving the detachment-energy spectra measured at different proton emission angles, into two peaks of Gaussian shape with identical variances and with a distance 13 MeV between them.

Such a resolution is justified by the level structure of the He^6 nucleus [4] and by the results of the $\text{Li}^7(p, 2p)\text{He}^6$ experiment [5]. The area under each peak corresponds to the cross section $d^5\sigma/d\Omega_e d\Omega_p dE_p$. The results of the resolution performed with a computer at minimum χ^2 are shown in the figure. Only statistical errors are indicated. The total error in the cross section can reach 20%. Radiative corrections were introduced by the procedure proposed in [6]. The solid line in the figure is the result of a χ^2 fit of the angular distributions with different momentum-distribution parameters. The calculation was performed in accord with the shell model with an oscillator potential by the Monte Carlo method with allowance for the energy and angular ranges of the apparatus.



Angular distribution of the protons in the reaction $\text{Li}^7(e, e'p)\text{He}^6$. Top - p-shell of Li, bottom - s-shell.

The suppression coefficients, which are usually determined from the measured cross section to that calculated without allowance for the distortions, are $k_p = 0.47$ and $k_s = 0.30$. As seen from the table, our data for the Li^7 p-shell differ from those cited by the Japanese group [7], but are close to the data of the (p, 2p) experiment [5]. The difference in the s-shell parameters is much less.

- [1] G. Jacob and T. A. Maris, *Nucl. Phys.* 31, 139 (1962).
- [2] N. G. Afanas'ev, V. A. Gol'dshtein, S. V. Dementii, et al., *Prib. Tekh. Eksp.* No. 3, 30 (1968).
- [3] Yu. P. Antuf'ev, V. L. Agranovich, V. S. Kuz'menko, and P. V. Sorokin, *ZhETF Pis. Red.* 16, 77, 339 (1972) [*JETP Lett.* 16, 52, 240 (1972)].
- [4] T. Lauritsen, *Nucl. Phys.* 78, 1 (1966).
- [5] M. Riou, *Revs. Mod. Phys.* 37, 375 (1965).
- [6] C. de Calan and G. Fuchs, *Nuovo Cimento* 38, 1594 (1965).
- [7] S. Hiramatsu et al., *Phys. Lett.* 44B, 50 (1972).

INTERFERENCE STATES OF OPTICAL EXCITONS. OBSERVATION OF ADDITIONAL WAVES

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We consider size quantization of optical excitons in ultrathin crystals. It becomes manifest in a special structure of the optical spectrum of the exciton. We observed the interference between the additional waves, which was predicted by Brodin and Pekar [1].

In thin crystals of thickness $\ell \leq 0.5 \lambda$ (where λ is the wavelength of the light in the transparency region), size quantization of the optical-exciton states takes place in a direction perpendicular to the plane of the crystal, and these states should form a discrete set of two-dimensional subbands in the plane of the sample. The quantization is due to interference between the optical-exciton wave when it is multiply reflected between the front and rear faces of the crystal. Such interference states should become manifest in the optical spectrum of the exciton in the form of a definite interference pattern consisting of a finite number of lines passing through the entire resonance region of the spectrum. As a result, unlike ordinary interference of light observed in thicker crystals, it becomes possible to study the refractive-index singularities due to the optical-exciton interaction and spatial dispersion [2]. No such investigations can be performed in thick samples, owing to the crowding together of the interference pattern and to the strong-absorption of light in the resonance region.

We have investigated experimentally the interference states of optical excitons by determining the absorption, luminescence, and reflection spectra of CdS and CdSe crystals from 0.1 to 0.3 μ thick. The temperature of the crystal was 4.2°K, and the spectra were photographed with a spectrograph having a dispersion 1.9 Å/mm.

Figure a shows the reflection spectrum of a thin CdSe crystal ($\ell = 0.24 \pm 0.03 \mu$) in the region of the line A ($n = 1$) at 4.2°K and at a light polarization $E \perp C$. As seen from the figure, on the long-wave side of the longitudinal-exciton frequency $A_L = 14\,730.8 \text{ cm}^{-1}$ there is a distinct set of narrow interference minima in a frequency interval $\sim 15 \text{ cm}^{-1}$. They were set in unique correspondence with interference numbers N from 3 to 8. The numbers $N = 1$ and 2 correspond to interference minima located on the short-wave side of the resonance (see the figure).

To determine the order of the interference of the indicated minima, we used the formula for the refractive indices of two optical-exciton wavelengths [3]

$$n_{1,2}^2 = \frac{1}{2} \left\{ \left(\epsilon + \frac{2mc^2(\omega - \omega_T)}{\hbar\omega_T^2} \right) \pm \left[\left(\epsilon - \frac{2mc^2(\omega - \omega_T)}{\hbar\omega_T^2} \right)^2 + \frac{8mc^2\epsilon\omega_L\tau}{\hbar\omega_T^2} \right]^{1/2} \right\} \quad (1)$$