atoms, and consequently the longer the pulse.

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BREAKDOWN OF LIQUID AND GASEOUS HELIUM BY A LASER BEAM, AND OBSERVATION OF STIMULATED MANDEL'SHTAM-BRILLOUIN SCATTERING IN LIQUID HELIUM

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1. A low-temperature method of measuring the threshold parameters of the breakdown of liquid and gaseous helium was proposed in [1]. A diagram of the experimental setup is shown in Fig. 1. The laser power is 10 MW, the pulse duration 30 - 35 nsec, and the radius of the focused spot 10^{-2} cm. By increasing the helium pressure in the Dewar to 2.2 atm we were able to obtain information on the breakdown of the helium in the region between the liquid and gas desnities at an equilibrium pressure of 1 atm. The dependence of the threshold electric field intensity E in the light wave on the helium density ρ (Fig. 2, different symbols correspond to different experiments) indicates that the liquid helium can be regarded in this case as a dense gas. The magnitude of the threshold fields and the course of the curve are close to those obtained in [2, 3] at room temperature and at high helium pressures.

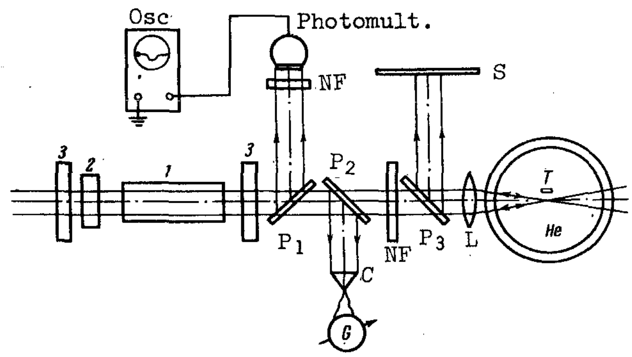


Fig. 1. 1 - ruby crystal, 2 - saturable filter, 3 - removable mirrors, NF - neutral filters, T - Allen-Bradley thermometer, C - vacuum calorimeter, P_1, P_2, P_3 - deflecting glass plates, S - screen, L - lens.

The low-temperature method makes it possible to obtain a very pure dense medium, since all the impurities are frozen out and precipitated. It was of very great interest, therefore, to use this method to investigate the question of the origin of the first "bare" electrons initiating the cascade ionization of the dense medium under the influence of the laser beam. The breakdown of the helium at low temperatures

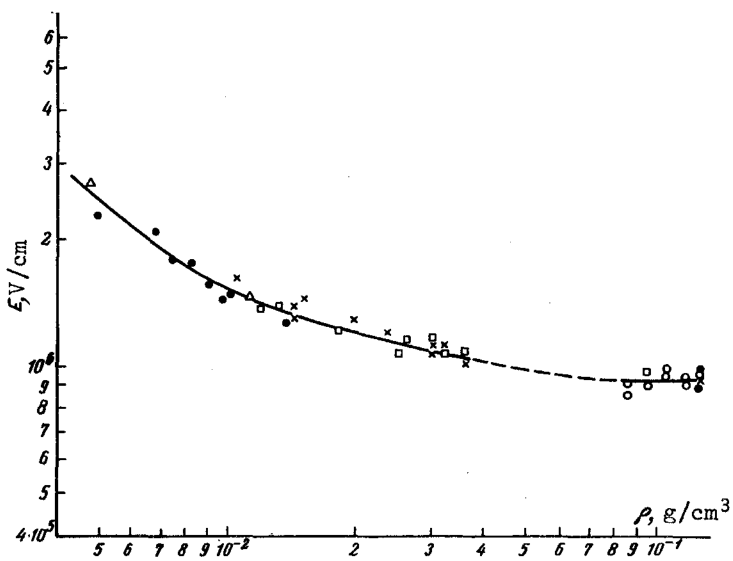


Fig. 2

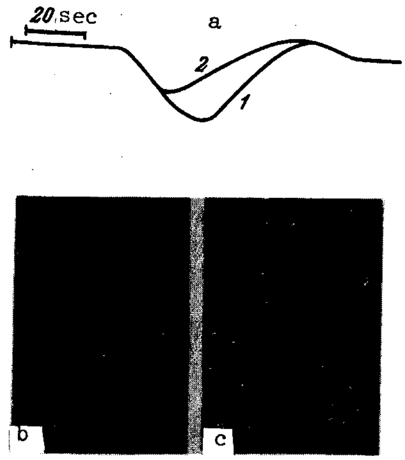
can be initiated only by multiquantum ionization of the helium atoms (14-quantum photoeffect!) or else as a result of thermionic or photoemission from solid submicroscopic impurity particles which may remain suspended, in small amounts, in the helium [4].

The curve of Fig. 2 is the result of several experiments, in which a reproducible sharp threshold was observed for each density, and the minimal fields required for the breakdown were relatively low. It was noted that the threshold intensity could frequently vary from experiment to experiment at fixed laser-beam characteristics and at the same helium density; the threshold sometimes changed during the course of one experiment. In almost all experiments the first pulse in liquid helium produced no breakdown even at the maximum power of our laser, wheich was approximately nine times the threshold at the given helium density. In this case, very intense stimulated Mandel'shtam-Brillouin scattering (SMBS) took place in the liquid helium (see Sec.2). In gaseous helium, and particularly in He-II where, as is well known, the finely dispersed suspension coagulates and settles rapidly [5], there likewise was no breakdown at maximum beam intensity in many cases. It was impossible to plot the threshold curve in such experiments, since there was either no breakdown at all, or else a spark appeared, with different magnitudes at the same density of the medium. The explain the cause of the "primers" initiating the cascade, a mixture of hydrogen with helium was injected slowly into the Dewar with the liquid helium, in such a way that the H_2 concentration in the liquid helium was 10^{-7} - 10^{-9}. In this case, a lowering of the threshold to the very low limiting values corresponding to the curve of Fig. 2 was observed each time; in all the experiments, the instrument with the helium remained transparent.

An analysis of a large number of experiments has shown that the breakdown begins with the appearance of electrons in the focus of the lense; these are most likely the result of thermionic emission from heated minute dust particles suspended in the helium. The appreciably higher breakdown threshold in pure helium, compared with the customarily observed thresholds, indicates that the first electrons appear in such experiments not as the result of multiquantum ionization of the helium atoms themselves. It is possible that the solid particles produce the first electrons also in other experiments on the breakdown in dense gases, where it is apparently impossible to get rid of the dust completely.

2. When the laser radiation power exceeded 10^{10} W/cm^2, stimulated Mandel'shtam-Brillouin scattering (SMBS) was observed in the liquid helium. Stimulated emission in He^4 was observed earlier in [6]. The scattered light propagates in a direction opposite to that of the laser beam and is characterized by a high degree of directivity; its frequency is close to that of the incident light and its intensity is comparable with the intensity of the laser emission. The backward beam was particularly intense in the case of pure helium, when there was no breakdown (see the oscillogram of the backward beam in Fig. 3a, curve 1; when a spark was produced in the liquid helium, scattering was likewise produced, see curve 2 of Fig. 3a). The threshold for the SMBS was higher than the breakdown threshold. The photographs of the back-reflected light (Figs. 3b and c; the photographic plate was placed in front of screen S of Fig. 1) indicate apparently that the beam becomes self-focused in the liquid helium. The possibility of self-focusing of the back-reflected radiation due to the SMBS was suggested

in [7]; the trapping of the backward beam in filaments in the case of SMBS in CS_2 was reported in [8]. The photograph of Fig. 3c was obtained at a laser power close to the SMBS threshold. A similar spot, surrounded by a ring, can be seen on the photographs of the cross sections of the beam trapped in a filament in CS_2 [9].



Further investigations of SMBS will probably make it possible to obtain informa tion on the electro-optical and elastic properties of liquid helium.

Helium scatters light very weakly [10 - 12]. Owing to the large intensity of the SMBS, it becomes possible to investigate molecular scattering of light in liquid helium.

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SINGULARITY OF SPECIFIC HEAT C_p AT THE CRITICAL POINT OF LAMINATION OF A BINARY SOLUTION

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Whereas the singularity of C_v at the critical point of a pure liquid and the singularities of C_p at second-roder phase-transition points have been discussed extensively [1], there is very little material concerning the critical points of lamination of binary mixtures [2]. It can be assumed that a singularity of C_p should take place at these points, but only a single paper [3] is devoted to a reduction of old experimental data [4] confirming this possibility.

Yet binary liquid-liquid systems offer many advantages to the experimenter, both over a pure substance at the critical points and over solids. Indeed, we are able in this case to work with a liquid sample at low pressure at temperature, stirring it during the time of the measurement, and freely varying the concentration of the components at our discretion. Thus the problems of structure imperfections, inhomogeneities, and point defects are eliminated, and the experimental technique remains relatively elementary, owing to the low vapor pressure.