One of the possible causes of the observed phenomena may be overheating of the electron gas in crossed electric and magnetic fields [3]. However, no suitable estimates can be made at present, in view of the lack of a theory of nonlinear effects in semimetals in crossed fields and in view of the insufficient amount of experimental data.

On the other hand, the results of the present investigation are similar to some degree to the results of the experiment aimed at observing helicons in sodium [4]. In both experiments, the frequency of the oscillations increases with increasing magnetic field and the attenuation decreases with increasing relaxation time. (These effects were not observed in the non-annealed samples described in this paper.) As is well known, the helicons do not propagate in a metal having an equal number of electrons and holes (see, e.g., [5]). Nonetheless, plasma waves of other types can be excited in these metals [6].

On the basis of the results of experiments in stationary fields, we are inclined to assume that the overheating of the electron gas can hardly be the cause of the anomalies.

For a final clarification of the nature of the observed effects we shall set up in the nearest future experiments which exclude the possibility of overheating of the electron gas.

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MEASUREMENT OF THE THRESHOLD PARAMETERS FOR THE BREAKDOWN OF LIQUID AND GASEOUS HELIUM BY A LASER BEAM

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The phenomenon of "laser spark" in media that are normally transparent at optical frequencies has been described in many papers (see the review [1]). The gas becomes ionized under these conditions if the radiation intensity reaches a certain threshold value. Many authors describe the results of measurements of the threshold parameters for the breakdown of gases at different pressures [2,3].

For a given gas, the threshold radiation intensity is determined by its density and should apparently not depend on the temperature (at least from helium to room temperature). This makes it possible, when investigating the breakdown, to work with a dense gas at low temperatures, instead of making the medium denser by increasing its pressure at room temperature.

We have measured the threshold radiation power for the breakdown of helium at low temperatures.

It follows from all that is presently known of the optical breakdown phenomenon that in the measurement of the threshold parameters it is immaterial whether the helium is in the liquid or in the gas phase. We have therefore measured also the threshold for the breakdown of liquid helium and plotted the threshold fields against the density, without distinguishing between the liquid and the gas state. This method makes it possible to study the breakdown of helium at large densities, without resorting to high-pressure chambers. It is possible to cover a broad range of densities (up to densities corresponding to helium pressure at room temperature $\sim 10^3$ atm), working with ordinary glass dewars at a helium pressure 1 - 2 atm.

The breakdown was revealed by the appearance of a spark at the focus of a lens; the focus was in liquid helium or over liquid helium, where the gas density depended on the height over the liquid level. The spark was observed visually or photographed through a window in the cover of the dewar. The threshold power corresponded to the appearance of a bright white spot at the focus of the lens, and not an elongated spot as is the case when the power exeeds the threshold.

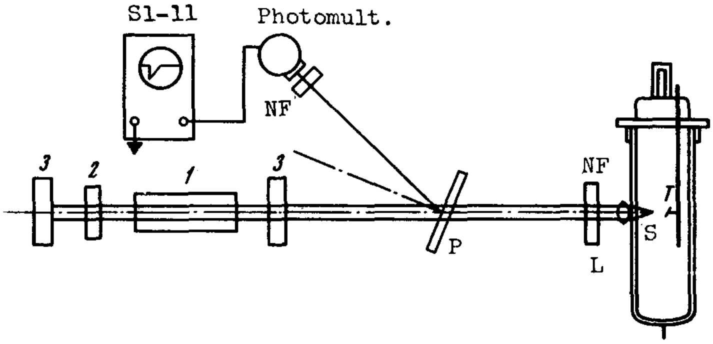

Fig. 1. Diagram of setup: 1 - ruby crystal, 2 - saturating filter, 3 - movable mirrors, NF - neutral filters, S - spark, T - carbon thermometer, P - deflecting plate, L - lens.

The experimental setup is shown in Fig. 1. A ruby rod and an IFP-1200 lamp were placed at the foci of an elliptical reflector. The Q was switched with the aid of a vanadium phthalocyanine solution in nitrobenzene. A typical pulse energy, measured with a vacuum calorimeter, was 0.2 J at a duration 20 nsec and a peak power 10 MW. The radius of the focal spot was estimated from the measured divergence of the beam and the focal distance of the lens (4.5 cm) and amounted to 1.6×10^{-2} cm. The laser beam was attenuated with the aid of a set of calibrated neutral absorption filters.

Initially the laser beam was focused in a dewar with liquid helium at 4.2°K. This was the procedure used to measure the threshold power at helium density 0.125 g/cm^3. During the experiment, the helium evaporated, and the focus of the lens shifted to the gaseous helium, whose density decreased with the height above the liquid level, so that the temperature along the dewar varied smoothly from 4.2°K (near the liquid surface) to 300°K (near the cover of the dewar). The pressure in the dewar always remained equal to atmospheric.

A miniature carbon thermometer was mounted in the dewar near the focus of the lens. The temperature was measured by a null method. The helium density was calculated from the

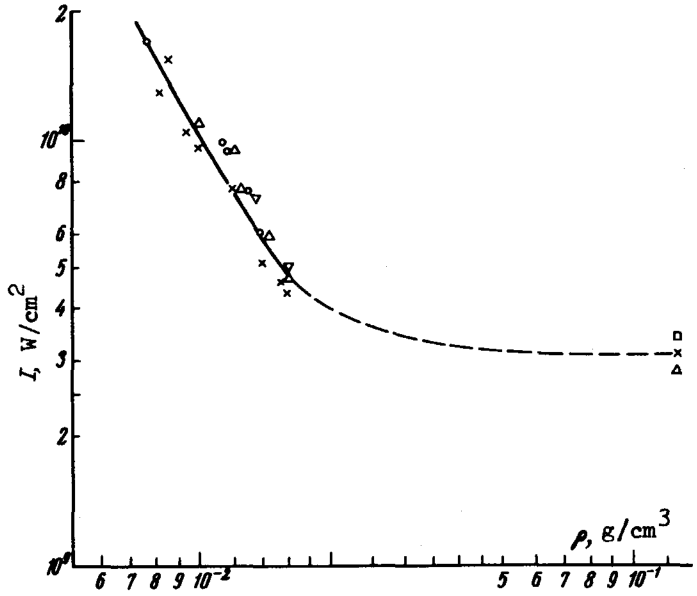

Fig. 2

equation with virial coefficients [4].

The dependence of the threshold flux of light energy J on the helium density ρ is shown in Fig. 2 (the different symbols on the plot denote results of several experiments).

The breakdown of the gaseous helium at low temperatures occurred at approximately the same electric-field intensity in the light wave as at room temperature in [2].

The breakdown thresholds cited in [5] are lower by an approximate factor of 2 than the values obtained by us for gaseous helium and for liquid helium when compared with the threshold fields at 10^3 atm. This discrepancy is probably due to the inaccuracy with which the area of the focal spot was measured.

The dashed line in Fig. 2 corresponds to the uninvestigated density region. By increasing the helium pressure in the dewar (to 2 - 2.5 atm) it will be possible to obtain data on the breakdown and to understand why the point on the right side of the figure does not fall on the $J(\rho)$ plot shown on the left.

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