range. Such measurements are now under way.

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EFFECT OF STRONG INCREASE OF ABSORPTIVITY OF A PARTLY IONIZED GAS AT HIGH LIGHT INTENSITIES

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We studied the absorption of light in a plasma. We observed for the first time, in so far as we know, a nonlinear effect of strong increase of absorption with increasing light intensity. A homogeneous plasma with stable parameters was produced in a shock tube similar to that described in [1]. We used a Q-switched ruby laser producing stable pulses of 20 MW power and 50 nsec duration. A lens with $f = 3$ cm was used to focus the beam in stationary ionized gas behind the reflected shock wave at a distance 1 cm from the end, near the tube axis. The diameter of the focused spot, determined by measuring the intensity distribution over the cross section of the focus, was 1.35×10^{-2} cm.

The radiation passing through the tube (8 cm path) was registered with an FEU-52 photomultiplier, the voltage pulse from which was fed to an I2-7 oscilloscope. A filter with a pass band 6938 - 6948 Å was placed in front of the photomultiplier. To attenuate the incident radiation, neutral filters were used.

A specially developed circuit synchronized the instant of formation of the laser pulse with the instant of passage of the reflected shock wave past the viewing windows of the tube. The synchronization was effected in such a way that the light entered into a plasma region known to be homogeneous, stable, and in thermodynamic equilibrium.

The experiments were performed in xenon under strictly constant conditions, namely initial pressure 10 mm Hg and Mach number of the incident shock wave 10.3. The density of the neutral atoms behind the reflected shock wave was $N_a = 5.5 \times 10^{18}$ cm^{-3}, the electron and ion density was $N_e = 0.97 \times 10^{18}$ cm^{-3}, and the temperature was $T = 11000^\circ$K (in calculating these quantities, account was taken of the drop of the ionization potential in the plasma; the cooling by radiation was not taken into account).

The same setup was used to perform experiments on the breakdown of cold xenon at the focus of a lens, at an approximate pressure 200 mm Hg, corresponding to the density behind the reflected shock wave. The obtained threshold power $P_t \approx 20$ MW and intensity $I_t \approx 1.4 \times 10^5$ MW/cm^2 agree with the known data.

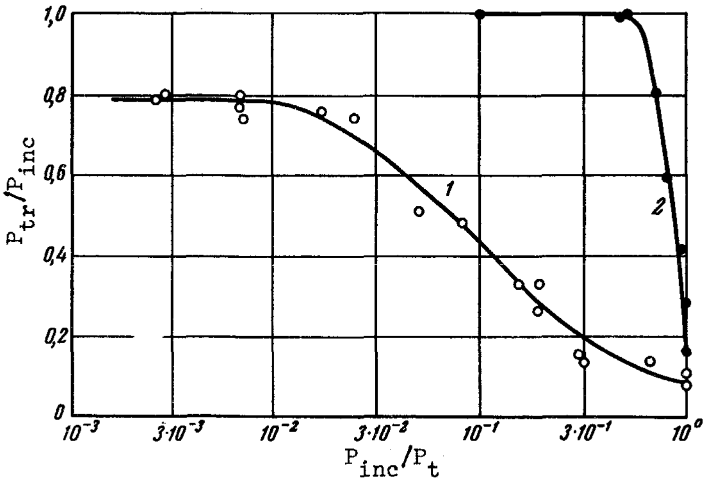

Fig. 1

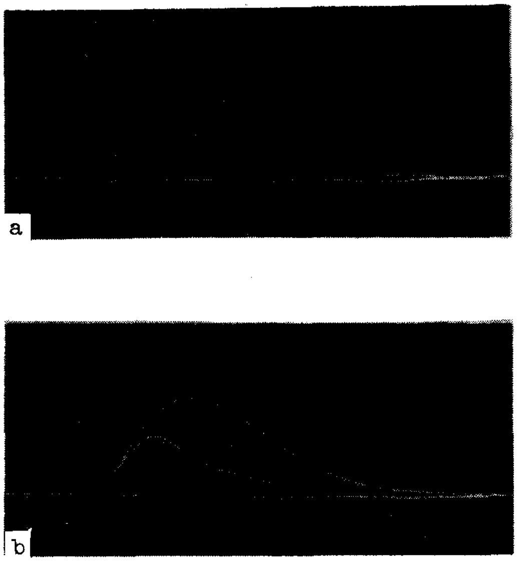

Fig. 2

The measurement results are shown in Fig. 1, where P_{tr}/P_{inc} is the ratio of the transmitted and incident power. Special experiments have shown that the reflection or scattering from the plasma is very small, and the small reflection from the viewing windows was taken into account, so that P_{tr}/P_{inc} characterizes absorption only. Curves 1 and 2 pertain to the plasma and to the cold gas, respectively. A striking feature of the figure is the abrupt breakdown threshold in the cold gas and the gradual increase of absorption in the plasma. A substantial change occurs also in the time dependence of the light absorption, as is readily seen from the pulse oscillograms in Fig. 2, where the upper curves pertain to the incident light, and the lower to the transmitted light (2a - plasma, 2b - cold gas).

The main cause of the increase in the absorption is ionization developed under the influence of the light. The electrons, absorbing quanta in free-free transitions, acquire energy, and excite the atoms, which become rapidly ionized by electron impact (unlike in the breakdown of cold gas [2], there are many electrons here from the very outset). The intensity I_1 at which noticeably additional ionization sets in and the absorption becomes nonlinear can be estimated by starting from the formula for the energy ϵ acquired by the electron in the light field E, with allowance for the elastic losses

$$\frac{d\epsilon}{dt} = \left[\frac{e^2E^2}{m\omega^2} - \frac{2m}{M}\left(\epsilon - \frac{3}{2}kT\right)\right]\nu_i .$$

Here $E^2 = 4\pi I/c$ and ν_i is the frequency of the Coulomb collisions between the electrons and the ions.

In order that the average electron energy in the field rise by several electron volts in the presence of elastic losses (as is required in order to accelerate noticeably the ionization acts), the required intensity is $I_1 \approx 10^3$ MW/cm^2, as gotten from the condition $d\varepsilon/dt = 0$. This value agrees with the experimental point where the strong nonlinearity begins, $(P_{inc}/P_t)_1 = I_1/I_t \approx 10^{-2}$. The subsequent course of the absorption curve is determined by the kinetics of the ionization development in the plasma and by the influence of the geometric factor - the taper of the beam. It is important, however, that at high intensities it is meaningless to speak of a local light absorption coefficient $\kappa(I)$, since hydrodynamic effects set in as a result of the large energy release [2].

We emphasize that at intensities larger than I_1 nonlinear absorption will take place not only in the focal region, but in the entire volume of the light cone where $I > I_1$, thus strongly influencing the optical thickness of the nonlinearly absorbing layer of the plasma.

The difference in the character of the curves 1 and 2 of Fig. 1 is partly connected with the fact that in breakdown of cold gas there can be born many ($n \approx 40$) generations of electrons [2]. If the multiplication time is, say, inversely proportional to I, halving I decreases the final ionization by a factor $2^{n/2} \approx 10^6$, which is tantamount to no absorption. In a plasma, on the other hand, only several generations are born, and halving I decreases the number of electrons and the absorption by only several times.

Another reason for the gradual growth of absorption with increasing I is the increase of the geometric thickness of the nonlinearly absorbing layer.

Bearing in mind the obtained results, great care should be exercised when using those laser plasma-diagnostics methods in which high-intensity light beams are employed.

Articles devoted to a detailed description of the experimental setup and results are being readied for publication.

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STIMULATED RAMAN SCATTERING AND GENERATION OF INFRARED RADIATION IN QUARTZ AT LOW TEMPERATURES

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In this investigation we observed infrared (IR) radiation when stimulated Raman scattering (SRS) is produced in single-crystal quartz at a temperature close to 10°K. If the laser beam is directed along the crystal axis z and the scattering is registered forward in the same direction, then the SRS spectrum contains Stokes and anti-Stokes lines due to the fundamental quartz lattice vibrations, with $\nu_1 = 130$ and $\nu_2 = 467$ cm^{-1}. Some of the lines of