We see that some uncertainty in the obtained results does not prevent their use for more detailed analyses, which are, however, beyond the scope of this brief communications.

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POLARIZATION OF THE IONIZATION AUREOLE OF A LIGHT SPARK IN A CONSTANT ELECTRIC FIELD

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We have investigated tne polarization of the ionization aureole of a light spark which is produced rapidly by an external electric field in the focus of a laser. In the case of ordinary discharge sparks such measurements are practically impossible, in view of the presence of rapidly varying breakdown fields that produce the discharge, the closeness of the electrodes, and the weak ionizing radiation from ordinary sparks. In this respect, the light spark is an ideal object, since it combines the absence of electrodes with a rapid development time and strongly-ionizing radiation generated by high initial temperatures.

The light spark was produced in air in a laser which was Q-switched by a rotating prism. Remote plane electrodes, with holes for the passage of the laser light, produced in the focus of the lens a constant electric field of intensity E_0 = 10 V/cm - 1 kV/cm.

In the first series of experiments, the rapid alternating perturbations of this field of the ionization aureole were registered with a thin probe, on which a dielectric sleeve was placed to reduce the photoeffect from the surface. The probe was placed perpendicular to the electric field at a distance $\simeq$1 cm above the spark. The probe signals ahead and behind the spark differed in sign, thus confirming that the registered field was due to charges produced by polarization of the ionization aureole, and not to the photoeffect from the spark, the signals from which should be of the same sign.

A typical probe signal in the presence of the field is shown in Fig. 1, obtained with a 300-nsec sweep. The pulse duration was close to the duration of the laser flash, 30 - 50 nsec. The intensity of the pulse $\mathcal{E}_m$ increased linearly with the field E_0, with $\mathcal{E}_m/E_0 \simeq$ 0.5×10^{-3} cm.

Let us compare the signal with the characteristics of the ionization aureole. The perturbation of the external field is determined by the dipole moment of the aureole $\vec{P} = \alpha(t)\vec{E}_0$, where $\alpha(t)$ is the aureole polarizability coefficient. We are interested in the region of

Fig. 1

Fig. 2

strong and rapid field perturbations, when $\alpha(t) \simeq a^3_{eff}(t)$, where a_{eff} is the dimension of the field region crowded out by the aureole.

The registered signal is a measure of the change of probe potential, determined by the current flowing through a resistor in the probe circuit. The charge induced on the probe is $q \simeq E_p s_{eff}/4\pi$, where E_p is the aureole dipole field ($E_p \simeq \alpha E_0/r^3$) and s_{eff} is the effective probe area crossed by the force lines. The probe current $I \simeq \dot{q} \simeq s_{eff}(d\alpha/dt)E_0/4\pi r^3$ produces across the wave resistance R a registered signal $\delta(t) = IR = s_{eff}R(da^3_{eff}/dt)E_0/4\pi r^3$. For the experimentally obtained $\delta_m/E_0 \simeq 0.5 \times 10^{-3}$ cm, a rise time $\tau \simeq 30$ nsec at $r \simeq 1$ cm, $R \simeq 75$ ohm $= 8 \times 10^{-11}$ cgs esu, and $s_{eff} \simeq 0.3$ cm^2 we obtain $a_{eff} \simeq 1$ cm.

In a second series of experiments, we investigated the polarization of the ionization aureole by a simpler system, without an auxiliary probe. The spark from the laser was produced between two remote plane electrodes, to which a potential difference V was applied. We measured the current flowing in an electrode connected to ground through a small resistor $R \simeq 75$ ohms. To exclude photoelectric effects, the electrodes were placed far enough from the spark. In addition, the contribution of the photoelectric effects from the electrodes was checked several times by comparing the pulses in the presence of dielectric covers on the electrodes, with the polarity of the electrode potential varied and the spark produced close to one electrode (the photoelectric field should be much larger from the nearer electrode if its potential is negative). The absence of a noticeable difference in the signals obtained in all the control experiments allows us to conclude that photoelectric effects from the electrode surface can be neglected and that the signal is directly connected with the polarized ionization of the air by the spark.

The current I produced in the electrode when a dipole moment P(t) is produced between the electrodes can be estimated from a generalization of the Ramo theorem

$$I \simeq (\dot{\vec{P}}\cdot\vec{E})/V = \dot{P}/d ,$$

where d is the distance between the electrodes. The signal $\delta = R\dot{P}/d = (RE_0/d)d\alpha/dt$ also enables us to estimate the time variation of the polarizability. Figure 2 shows an oscillogram with a 300 nsec sweep. Experiment yields also a ratio $\delta_m/E_0 \simeq 1.3 \times 10^{-3}$ cm For $d \simeq 6.7$ cm, $R = 75$ ohm, and a rise time $\tau \simeq 30$ nsec, we obtain $a_{eff} \simeq 1$ cm, in agreement with the previous result.

The rapid change in the ionization aureole was registered also with special inductive pickups, screened against capacitive induction with grounded slotted shields.

We have thus confirmed the presence of a rapidly produced ionization aureole that anticipates the ionization front, behind the shock wave which covers a very short path during the short time of the aureole. (A microwave investigation of the ionization aureole was reported earlier [1].)

We can estimate the lower limit of the effective conductivity of the ionization in the aureole, using only the time τ of dipole-moment variation. It is known that the time of expulsion of the external electric field from a volume with conductivity σ is equal to $t \sim 1/\sigma$. Since $t < \tau$, we have $\sigma > 1/\tau$, but $\sigma = n_e e^2/m\nu_{so}$, where ν_{so} is the frequency of electron collision with the neutral particles (in gas $\nu_{so} \simeq 3 \times 10^{10}$ sec^{-1} at normal pressure). We obtain from this $n_e > 10^{10}$ el/cm^3 at $\tau \approx 10^{-8}$ sec. The ionization of the gas can be due either to cascaded absorption of ultraviolet quanta or to absorption of kilovolt x-ray quanta emitted by the hot plasma of the spark. (For example, the number of kilovolt x-ray quanta whose free path in air is commensurate with the aureole dimensions is $N_{kV} \simeq N_e \epsilon e^{-\epsilon/kT} \nu_s \tau r_0/\hbar c \sim n_e a^3 I_i/\epsilon$ at a total number $N_e \sim 10^{17}$ electrons in the central plasma of the spark, a collision frequency $\nu_s(kT_e) \simeq 10^{15}$ sec^{-1}, and a quantum-energy to thermal-energy ratio $\epsilon/kT_e \simeq 20$.)

An interesting result of the experiment is also the observation of a rapidly produced intrinsic dipole moment of the spark, directed opposite to the light flux (positive charge on the side of the spark front), and apparently connected with the light pressure or with thermoelectric effects.

The polarization of the fast ionization aureole in external fields and the rapid changes in the intrinsic dipole moment of the light spark may serve as sources of bursts of radio emission in the meter band, whose intensity may be quite high because of the abrupt variation and magnitude of the dipole moment.

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PHOSPHORESCENCE AND BAND STRUCTURE OF RUBY

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Prolonged phosphorescence, reliably recordable 2 - 3 days after the instant of excitation, was observed in ruby crystals following high-power optical excitation (with several laser flashes of 450 Joules). This phosphorescence attenuates hyperbolically with exponent $\simeq 1$, and its spectrum is located near the R line.

To clarify the nature and mechansim of the observed phenomenon, we investigated the initial stages of the attenuation of phosphorescence excited with light of varying intensity and wavelength. We observed that 2 - 3 seconds after cessation of the excitation, the phos-