TORCH STRUCTURE OF DRIFT INSTABILITY

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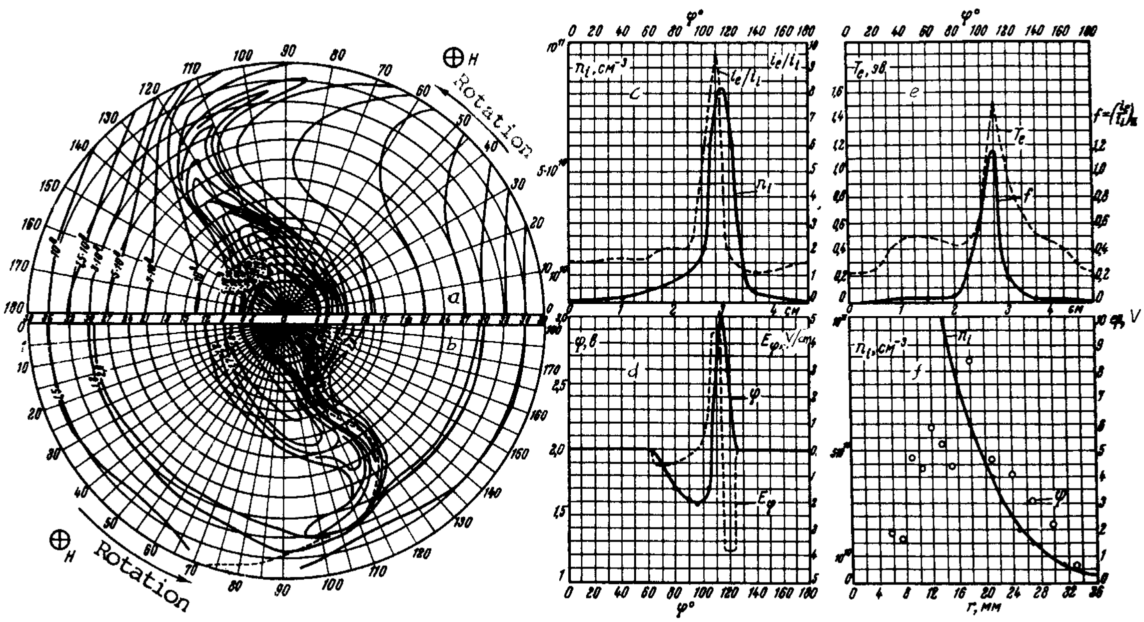
It was noted in [1] that drift instability occurs in an arc discharge of low pressure under certain conditions. This instability is manifest in the appearance of torches which erupt from the column of the arc. Such an instability increases the escape of the particle transversely to the magnetic field, with a diffusion coefficient close to that given by Bohm, $D_{\perp} = 10^7 T_e/H$. The character of the instability changes with the magnetic field, but a torch formation, which rotates in stationary fashion on the ion side at a frequency on the order of several kcs, is always observed near the critical field. The number of stable torches depends on the discharge conditions and ranges from 1 to 3 in the cited experiment. The stationary character of the torch rotation has made possible in some cases a detailed study of the density and the potential topographies in the unstable mode. The measurements were carried out with a probe procedure. The probe was a flat loop of tungsten wire (0.2 mm in diameter), elongated in the magnetic field direction. The density was measured by determining the saturation ion current in the cold cathode, and the potential was determined by measuring the floating potential of the incandescent probe. The probe was moved radially to analyze the distribution of the density n_i and of the potential φ over the entire discharge cross section. The probe signal was applied to the plates of an oscilloscope triggered by a signal from a stationary reference probe. In addition, oscillograms of the probe signals were obtained at fixed values of the radius for several values of the probe potential, making it possible to construct probe characteristics for different points of the discharge in azimuth.

The measurements were made in hydrogen at $p = 10^{-3}$ torr and $H = 730$ Oe. The anode voltage and the arc current were 200 V and 100 mA. Under these conditions, the existence of two torches was observed near the critical field.

It is natural to assume that the torch is the result of the development of an initial density disturbance on the boundary of the arc column. Owing to the difference in the drift velocities of the ions and electrons on the boundary of such a disturbance, the charges may become separated and this leads to an azimuthal electric field and to an outward drift of the plasma. The result is a torch, the behavior of which is determined by the character of the particle motion inside the torch and by their drift towards the ends of the chamber. Such a torch picture is well confirmed by the experimentally measured density and potential distributions in the torch (Figs. 1a and b), which demonstrate clearly the presence of polarization in the torch and its connection with the plasma inside the arc column. Figure 1c shows the



azimuthal plasma-density distribution at a radius r = 6 mm. It is seen that the charged-particle density increases in the torch by approximately two orders of magnitude, and the ratio of the electronic saturation current to the ionic saturation current in the probe (i_e/i_i) increases at the same time. Both facts point to an increased particle escape along the torch, which can naturally be related to the particle drift. The azimuthal electric field E_φ that leads to such a drift can be obtained from the azimuthal distribution of the potential at the given radius (Fig. 1b). We see that the polarization leads to the appearance of an electric field E_φ up to 4 V/cm. The distribution of n_i and φ along the torch (dashed line on Fig. 1b) is shown in Fig. 1f. The decrease in density with increasing radius is connected with the escape of the particles to the ends. From an analysis of the probe characteristics we can determine the variation of the boundary conditions in the torch. In our case, the ends of the system are at anode potential, and therefore the boundary conditions can be characterized by the ratio $f = (i_e/i_i)_a$ of the electronic and ionic currents in the probe at anode potential. As seen from Fig. 1e, the value of f increases sharply in the torch, thus indicating an increased escape of electrons from the torch to the ends. At the observed potential distribution, this points to a considerable increase in the electron temperature T_e in the torch. Knowing the dependence of φ, i_e/i_i, and f on the azimuth we can determine the azimuthal variation of the electron temperature from the expression $f = (i_e/i_i)\exp(-\varphi/T_e)$. The results of the calculation are shown in Fig. 1e.

An analysis of the experimental results indicates that the development of drift instability leads to the appearance of a relatively narrow torch, along which the plasma escapes transversely to the field. Outside the torch, the character of the diffusion remains classical, as indicated by the low values of the density and of i_e/i_i in these regions.

The difference between the charged-particle currents in the ends and in the side walls of the chamber leads to the appearance of a current along the torch. It follows from the azimuthal variation of f (Fig. 1e) that, on the average, an ion current I_i flows along the torch in an outward direction. The interaction between this current and the magnetic field leads to the appearance of a force $(1/c)\vec{I}_i \times \vec{H}$, which can be responsible for the torch rotation. It must also be noted that the obtained distributions of n_i and φ over the discharge cross section are well confirmed by the plasmograms observed under these conditions [1].

[1] M. A. Vlasov, JETP Letters 2, 274 (1965), translation p.174.

OBSERVATION OF PARAMETRIC AMPLIFICATION IN THE OPTICAL RANGE

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We report here the results of an experiment in which we observed directly parametric amplification of an optical signal with wavelength $\lambda_s = 1.06\ \mu$ in a KDP crystal excited by an intense pump wave with $\lambda_p = 0.53\ \mu$. The feasibility of such an effect in the optical band and its theory were detailed in [1-3]; results of experiments in which parametric amplification at wavelength $\lambda_s = 0.63\ \mu$ has been indirectly registered are described in [4].

In a nonlinear medium with a polarization that depends quadratically on the magnetic field intensity, the energy of an intense pump wave (frequency ω_p) can be transferred to waves with frequencies ω_1 and ω_2 satisfying the relation $\omega_p = \omega_1 + \omega_2$. The energy transfer is most effective if the following relation is satisfied between the wave vectors of the interacting waves (the so-called synchronism condition):

$$\vec{k}_1 + \vec{k}_2 = \vec{k}_p. \qquad (1)$$

The parametric amplification effect has a clearly pronounced threshold. An approximate relation (which is valid for sufficiently large crystal length ℓ) for the threshold-pump amplitude $A_{p.thr}$ is [2]:

$$\Gamma_0^2 = \left(\frac{2\pi}{c^2}\right)^2 \frac{\omega_1^2\, \omega_2^2\, A_{p.thr}^2}{k_1 k_2} \cdot \frac{(\vec{e}_1\, \chi^{\omega_p - \omega_2}\, \vec{e}_p\, \vec{e}_2)\, (\vec{e}_2\, \chi^{\omega_p - \omega_1}\, \vec{e}_p\, \vec{e}_1)}{-\cos \vec{k}_1 \hat{\ } \vec{s}_1 \cdot \cos \vec{s}_1 \hat{\ } \vec{z}_0 \cdot \cos \vec{k}_2 \hat{\ } \vec{s}_2 \cdot \cos \vec{s}_2 \hat{\ } \vec{z}_0} \simeq \delta_1 \delta_2. \qquad (2)$$

Here $\vec{e}_i$ are unit vectors characterizing the polarization of the interacting waves, $\vec{s}_i$ their ray vectors, $\vec{z}_0$ the normal to the boundary of the nonlinesr medium, $\chi^{\omega_p - \omega_i}$ the spectral components of the nonlinear polarizability tensor, and δ_i the damping decrements at the frequencies $\omega_{1,2}$. When $A_p < A_{p.thr}$ a wave of frequency ω_1 (signal wave) attenuates on entering the crystal, and the supplementary wave of frequency ω_2, which is produced in the crystal, first increases and then also attenuates. Therefore indirect measurements of parametric amplification, for example by recording the difference-frequency oscillations (the procedure used