Thus, generation is obtained during the time of the working pulses by using the energy stored in the free radicals stabilized on the tube walls, including the metastable states of nitrogen and oxygen.

In conclusion, the authors are grateful to Ya.B. Fainberg, L.I. Bolotin, and V.P. Tuchinskii for interest in the work and for useful discussions.

[1] Obrazovanie i stabilizatsiya svobodnykh radikalov (Formation and Stabilization of Free Radicals), in: Collection of translated articles edited by V.N. Kondrat'eva and V.L. Tal'roze, IIL, 1962.
[2] W. Bridges and A.N. Chester, Appl. Opt. 4, 573 (1965).
[3] P.K. Cheo and H.G. Cooper, J. Appl. Phys. 36, 1862 (1965).
[4] W.R. Bennet, W.L. Faust, R.A. McFarlane, and C.K.N. Patel, Phys. Rev. Lett. 8, 470 (1962).
[5] C.K.N Patel, R.A. McFarlane, and W.L. Faust, Phys. Rev. 133, A1244 (1964).
[6] S.K. Mitra, Active Nitrogen - A New Theory, Calcutta, 1945.
[7] J. Kaplan, Phys. Rev. 57, 662 (1940).
[8] D.R. Bates, Phys. Rev. 78, 492 (1950).

FINE STRUCTURE OF THE DISTRIBUTION FUNCTION OF IONS IN THE PLASMA OF A STRONG-CURRENT z DISCHARGE

T.S. Gosteva and V.P. Fedyakov

Submitted 21 June 1971
ZhETF Pis. Red. 14, No. 3, 158 - 160 (5 August 1971)

We investigated the spectra of ions leaving the plasma of a strong-current z discharge along the field through the mirrors, and also of the neutrals leaving in a direction transverse to the field.

The experimental conditions were: discharge current 20 - 40 kA, plasma diameter $\sim$7 cm, longitudinal field $H_0 \sim 2$ kOe, initial hydrogen pressure in the chamber $p \sim 10^{-4} - 6 \times 10^{-3}$ mm Hg.

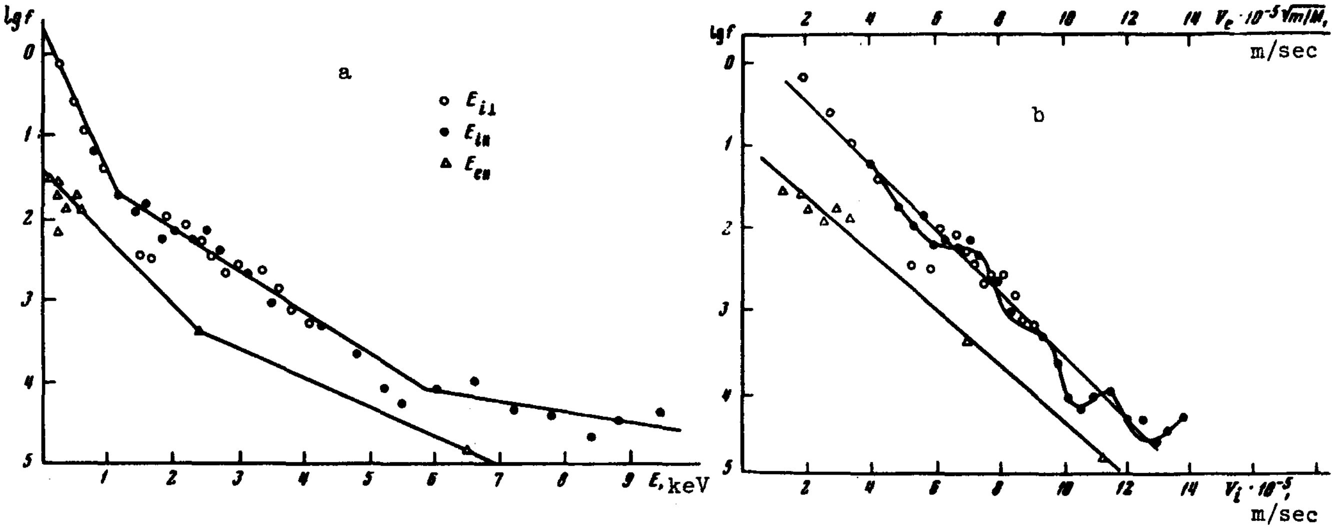
The ion spectra differ from Maxwellian ones and can be approximated by several Maxwellian spectra with different temperatures. A plateau appears at pressures $p > 10^{-3}$ mm Hg.

In a collisionless plasma of a strong-current z discharge there were observed, for the first time, deviations of the distribution function f_1 from the mean value f_0 (background), analogous to those of [2], following each other approximately at equal intervals Δz (Fig. 1); they can be represented by a set of opposing beams with slightly differing velocities. These singularities are probably connected with the buildup of oscillations at the cyclotron harmonics, which can be strong because $H_{\phi\ \max} \sim H_{z\ \max}$ and the radius is of the order of the skin-layer thickness. These oscillations are absorbed by a group of resonant ions in accordance with the generalized phase resonance [3]:

$$v = \frac{\omega - l\omega_c}{k}; \quad l = 0;\ \pm 1;\ \pm 2 \ldots$$

Here ω and k are determined by the instability that leads to the buildup of the oscillations.

It is possible to determine the interval Δv at which the perturbations follow each other. For ion-acoustic oscillations $k = 1/\lambda_a$ and



$$\Delta v \sim \frac{\omega_{ci}}{\omega_0} v_{Te} \sim \frac{(H_\phi H_\perp^3 \beta_e)^{1/2}}{4\pi\rho c} = \frac{v_0^{*2}}{c}\sqrt{\beta_e}$$

For ion-cyclotron instability $k \sim (a\rho_{ci})^{-1}$ and

$$\Delta v \sim a\omega_{ci}\rho_{ci} \sim a v_{Ti} \sim a\left(\frac{H_\phi H_\perp \beta_i}{4\pi\rho}\right)^{1/2} = v_n^* a\sqrt{\beta_i}$$

Here $H_\perp^2 = H_\phi^2 + H_z^2$ and we used $nT \sim \beta H_\phi H_\perp/8\pi$. The second case gives better agreement with experiment at $k = (0.2\rho_{ci})^{-1}$.

For $p = 6 \times 10^{-4}$ mm Hg we obtained the tentative spectrum of the electrons emerging along the field, making it possible to estimate $T_e/T_i \sim 2$.

We see from Fig. 1 that

$$b = f_1(v) / f_0(v) \sim 0{,}2 = \text{const}$$

and then for the stationary process

$$\frac{E^2}{8\pi} \sim \int \frac{Mv^2}{2} f_1 dv \sim \frac{1}{3} b n T_i$$

and therefore the value of the turbulent-pulsation fields is $\tilde{E} \sim 4 \times 10^4$ V/cm, which is close to the values obtained earlier from measurements of the Stark broadening [4].

The condition b = const and $T_i \sim T_e$ allows us to conclude that the electrons are strongly bound to the ions having nearly equal velocities, and therefore the thickness of the skin layer is $\delta \sim c/\omega_{0i}$ instead of $\varepsilon \sim c/\omega_0$. Allowance for the losses approximately doubles the skin layer.

The authors are grateful to all those who took part in a discussion of the results, particularly L.V. Dubovoi, and also to V.D. Dyatlov and Yu.A. Vasilveskaya, who placed the analyzer at their disposal.

[1] L.V. Dubovoi, V.T. Fedyakov, and V.P. Fedyakova, Zh. Eksp. Teor. Fiz. 59, 1475 (1970) [Sov. Phys.-JETP 32, 805 (1971)].
[2] S.M. Levitskii and K.Z. Nuriev, ZhETF Pis. Red. 12, 172 (1970) [JETP Lett. 12, 119 (1970)]; H. Ikesy and T.H. Tailor, Phys. Rev. Lett. 22, No. 18, 923 (1969).
[3] D.A. Frank-Kamenetskii, Lektsii po fizike plazmy (Lectures on Plasma Theory), Atomizdat, 1964, p. 229; V.L. Ginzburg and A.A. Rukhadze, Volny v magnitoaktivnoi plazme (Waves in a Magnetoactive Plasma), Nauka, 1970.
[4] A.B. Berezin, L.V. Dubovoi, and B.V. Lublin, Proceedings, Fourth Conference on Controlled Fusion and Plasma Physics, Rome, 27 August - 4 September 1970, p. 67 - bis. E.K. Zavoiskii et al. Dokl. Akad. Nauk SSSR 194, 55 (1970) [Sov. Phys.-Dokl. 15, 823 (1971)].

OPPOSING FERROELECTRIC DOMAINS IN SbSI SINGLE CRYSTALS

A.G. Zhdan, E.V. Chenskii, E.S. Artobolevskaya, R.S. Gvozdover, E.I. Rau, and V.I. Petrov
Institute of Radio Engineering and Electronics, USSR Academy of Sciences; Moscow State University
Submitted 21 June 1971
ZhETF Pis. Red. 14, No. 3, 161 - 164 (5 August 1971)

It was predicted in [1] that opposing ferroelectric domains can be produced in semiconducting ferroelectrics by an injecting contact field. The formation of these domains should lead to a number of singularities in the electric characteristics of the ferroelectric, such as nonmonotonic distribution of the potential, jumps of the electric conductivity, etc. According to [2], analogous phenomena can appear also in a ferroelectric under the field effect. Obviously, these phenomena are particularly easy to observe in the presence of barrier contacts (e.g., Schottky contacts [3]), which ensure, under definite conditions, both carrier injections (Schottky emission) and the field effect (the depleted layer can be regarded as a "dielectric" insulating the metallic contact - "field electrode").

One of the main consequences of the existence of opposing domains is the nonmonotonic distribution of the potential along the ferroelectric axis of the crystals [1]. It can be observed in principle by a probe method, but such measurements, performed on SbSI [3, 4] and $BaTiO_3$ [5], revealed no singularities of this type. We investigated qualitatively the distribution of the potential in SbSI single crystals by methods of raster electron microscopy [6]. We used the ISM-U3 raster electron microscope operating in the secondary electron emission regime. The investigations were carried out in the ferroelectric and in the para-phases at different voltages on the samples, on which Sb contacts were sputtered on the {110} face; the direction of the external field coincided with the direction of the C axis.

The measurements performed in the para-phase have shown that the external voltages concentrated mainly at the anode (Fig. 1a). This can be readily understood by recognizing that the electric conductivity of SbSI is of the p-type [3, 8, 9]. For the ferroelectric phase there appear in the potential distribution a number of singularities connected with the occurrence of spontaneous polarization and with the existence of a preferred direction, the presence of which causes, in the absence of an external field, the spontaneous polarization to have a definite direction (this polarization can be readily revealed by the pyroelectric current). In the absence of voltage, in the ferroelectric phase, as well as in the para-phase, one can see jumps of the contact potential near the electrodes (Figs. 1a and b; U = 0). When an external field opposing the spontaneous polarization is turned on, at relatively low voltages ($U \leq 20$ V), the entire applied field is concentrated at the anode (Fig. 1b). With increasing voltage, the external field begins to penetrate into the interior of the