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MEASUREMENTS OF ELECTRON ENERGY DISTRIBUTION IN THE THETA-PINCH NEUTRAL SHEET

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Dissipative processes in neutral current sheets may play an essential role in plasma heating and confinement in laboratory devices of the theta-pinch type. In addition, annihilation of the magnetic fields in the current sheet is now considered as one of the most real mechanisms of energy release in solar flares.

The experiment was performed on the "UN-Fenix" device /1/. The initial plasma (hydrogen, argon, \( n_0 = 10^{12} \text{ cm}^{-3}, T = 5 \text{ eV} \)) was frozen in a quasistationary magnetic field \( H_0 = 100-600 \text{ Oe} \), directed along the working volume axis (\( \varnothing = 16 \text{ cm}, l = 1.5 \text{ m} \)). The cylindrical neutral sheet with a thickness of about \( 10^{-3} \text{ cm} \), converging to the volume axis is formed at a rapid compression of plasma by the magnetic piston (\( H = 1300 \text{ Oe}, \tau = 1.5 \text{ sec} \)), whose magnetic field was antiparallel to \( H_0 \). The formation process and magnetic structure both are described in /1/.

In this paper, experimentally is investigated the dependence of the electron energy distribution on the plasma conductivity value in the sheet and the properties of its evolution in time and space.

The electron energy spectrum was measured by analysis of the X-ray radiation arising on the target placed into plasma /2/. Plasma conductivity and the electron temperature in the sheet were measured by probe methods. In a first series of experiments, we measured the dependence of plasma conductivity on the azimuthal (current-aligned) electric field strength in the sheet. This dependence \( \sigma (E_p) \) is given in Fig. 1a. The measurements were for the whole range of the initial plasma parameters and showed that the conductivity values are several orders less than the Coulomb ones and are inversely proportional to the value \( E_p \). Such a dependence indicates the realization in the sheet of the quasilinear stage of ion-acoustic instability.

![Fig. 1](http://dx.doi.org/10.1051/jphyscol:19797350)

Measurements of the low-energetic portion of the electron energy spectrum agree with this inference. In Fig. 2a, a solid line indicates the electron spectrum provided \( n_0 = 10^{13} \text{ cm}^{-3}, H_0 = 230 \text{ Oe} \) within the energy range 0.5-12 keV. It is seen that the thermal part of the spectrum differs from the maxwellian one (dash-dot line).
and is close to the distribution \(-\exp(-k_0^2)\) (dash line) which must be realized at the quasilinear stage of ion-acoustic instability /3/.

At the same time, one observes the presence of accelerated electrons \((\mathcal{E} > 4\text{ keV})\) whose number exceeds the thermal level. Isolated directions of motion of high-energetic electrons are lacking, i.e. the spectrum may be considered as isotropic. The measurement results of energy spectra \(\frac{dn}{d\mathcal{E}(\mathcal{E})}\) of electrons in the current sheet are given in Fig. 3 (a \(- n_0=6\cdot10^{12}\text{ cm}^{-3}\), b \(- n_0=10^{12}\text{ cm}^{-3}\), c \(- n_0=4\cdot10^{13}\text{ cm}^{-3}\), d \(- n_0=4\cdot10^{14}\text{ cm}^{-3}\)).

It is evident that with increasing plasma density, the acceleration efficiency drops. If the high-energetic part of the spectrum is approximated by a power function \(\mathcal{E}^{\gamma}\) within energy range 4–12 keV, one may obtain the dependence of the efficiency of the acceleration mechanism determined by the value \(\gamma\) on the azimuthal electric field strength \(E_\varphi\) which is shown in Fig. 1b.

High-energetic electrons are located in the vicinity of the neutral sheet. When moving away from the zero line, the index \(\gamma\) grows which indicates a special role of the neutral line in electron acceleration. With parallel orientation of magnetic fields of piston and initial field, the signal from X-ray detectors is absent. One may suggest the stochastic acceleration by Langmuir pulsations /4/ as an acceleration mechanism.

It is of interest to study plasma heating dynamics in the neutral sheet. Plasma heating with the sheet moving towards the device axis is found to have a relaxation character, i.e. the plasma temperature in the sheet increases periodically and then decreases. The typical time of this process is several tens of nanosec. The amplitude of temperature change is of the order of its value.

REFERENCES