Regular structure in the region of the stream compression of a magnetoplasma compressor

P. E. Kovrov and A. I. Morozov

I. V. Kurchatov Institute of Atomic Energy
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Small-scale energy structures are observed in a magnetoplasma compressor in the region of maximum density. A possible explanation is offered in this article for the nature of these structures on the basis of the superheat instability.

At the exit from a magnetoplasma compressor (MPC), as is well known,[1] there exists a compression region (CR) where the stream is very strongly compressed under the influence of inertia and of the stream's own magnetic field. Measurements of the stream parameters in the CR have shown that the averaged density is $n \sim (2 \text{ to } 5) \times 10^{17}$ cm^{-3} and the averaged temperature is $T_e \sim 10$ eV.[2]

At the same time, we have registered rather hard x rays and neutron radiation from the CR.[3,4] It was assumed as a result that in the CR, against the background of a stream with the indicated parameters, there are produced much more energetic small-scale structures, arbitrarily called "pinchlets." It was natural to assume that the "pinchlet" proper should be surrounded by a jacket having lower parameters and radiating in the visible band.

To investigate the structure in the CR, we used an LV-03 electron-optical lens operating in the intermittent-frame regime (frame exposure 0.1 μsec, interval between frames 0.3 μsec). The compressor operated with helium in the preliminary-filling regime, the discharge current was 250 to 500 kA at ~200 μsec duration. The experiments were performed with a standard instrument using a rod anode.[2]

The obtained photographs are shown in Fig. 1. It is seen that in the volume of the jet there exist long-lived filamentary formations, whose number can range from one to three. By using a time scan it was possible to show that the lifetime of the "pinchlets" can reach several microseconds. An analysis of the photographs has shown that the "pinchlets" are observed only in the CR.

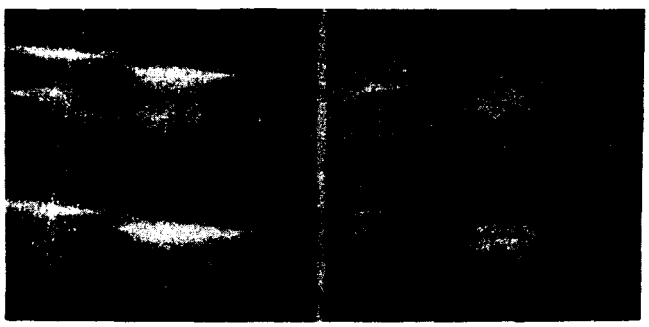

FIG. 1

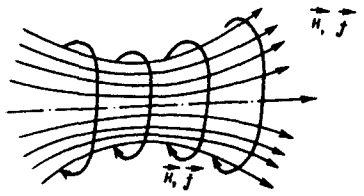

FIG. 2

At present there are no experimental data on the nature of the "pinchlets" or on their relation with the previously observed structures.[5,6] Nevertheless, the following working hypothesis can be advanced: The onset of the "pinchlet" is due to superheat instability, which becomes transformed and leads, under the conditions of the CR, to formation of a structure with a three-component magnetic field, as shown in Fig. 2. It recalls the waterspout structure[7] (with **H** replaced by **V**) and should be very stable under certain conditions. Numerical investigations of a system with a plasma focus[8] have shown that the pinch, in spite of the constriction, remains stable if the so-called "running number of ions" Π_i is of the order of unity,[1)] i. e.,

$$\Pi_i = n\pi a^2 \frac{e^2}{M_i c^2} \sim 1.$$

Here a is the radius of the pinch and the remaining symbols are standard. It can be assumed that the number of observed "pinchlets" is determined by the "running number of ions" in the stream. Favoring the proposed "pinchlet" model are the results of [8], where it was demonstrated that equilibrium configurations can be produced in the electronic component in the presence of the Hall effect.

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[1)] This result was proved only for a system with a one-component azimuthal magnetic field. It is more likely, however, that it is more general in character.

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