At sufficiently large n_e, the first term in (3) shows a rapid decrease at the start of the afterglow, and the second a slow decrease, which is indeed due to double ionization of the magnesium by collisions with the helium ions. The duration τ of the slow decrease depends on the magnesium vapor pressure:

$$\frac{1}{\tau} = \gamma + N_b v_T Q \qquad (4)$$

and from the experimental relation $(1/\tau) = f(N_b)$ we can find the cross section of the process (II). The cross section of the double ionization of magnesium by thermal collisions with helium ions, measured in this manner, turned out to be $(1.6 \pm 0.5) \times 10^{-15}$ cm^2.

It should be added that we have observed coherent lasing in the Mg + He mixture at the Mg II 9244 and 9218 Å lines $4P_{3/2,1/2} - 4S_{1/2}$. The lasing pulse lagged the current pulse by 30 - 50 μsec, i.e., occurred in that afterglow region where it is precisely the processes (II) and (III) which determine the level population of the magnesium ion.

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FORMATION OF INTENSE CHARGED PARTICLE BEAMS IN A CURRENT-CARRYING PLASMA

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This paper reports an investigation of intense charged-particle beams occurring in a current-carrying plasma as a result of formation of a "break" on which the entire potential difference is concentrated. A strong electric field inside a plasma [1] accelerates the charged particles and the entire discharge current is carried by the beams of electrons [2] and ions. The limiting accelerated-particle current J = env is determined by the plasma concentration and can reach large values.

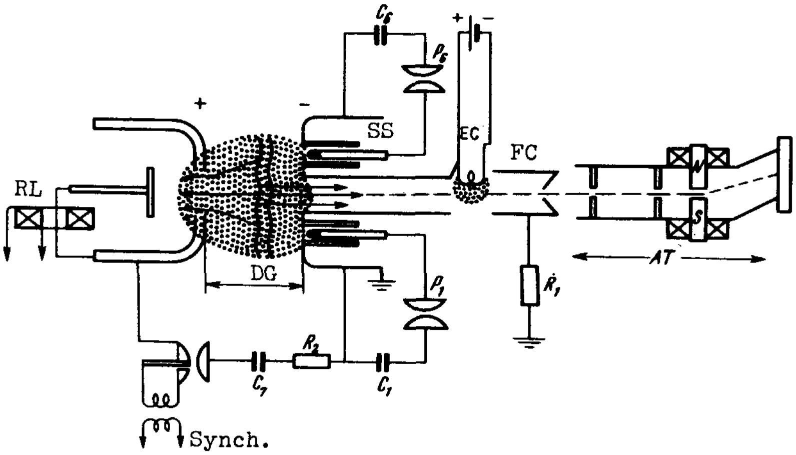

Fig. 1. Schematic diagram of experiments.

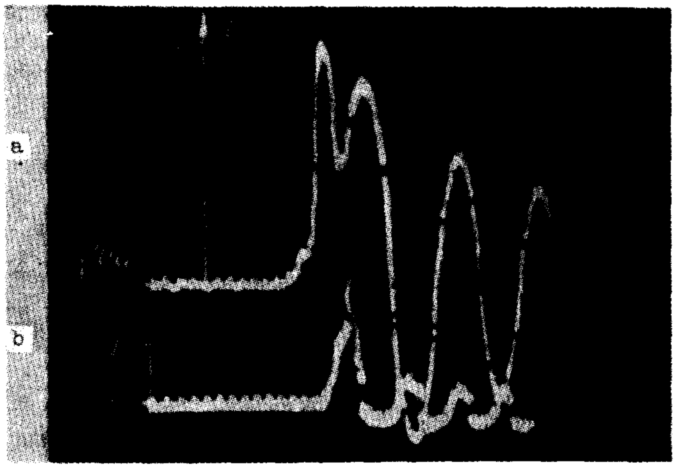

Fig. 2

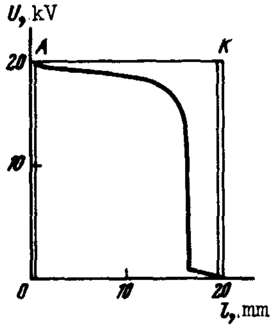

Fig. 3

Fig. 2. Current oscillograms: a) total current, b) current in Faraday cylinder.

Fig. 3. Distribution of plasma potential.

The experimental setup is shown schematically in Fig. 1. The plasma was fed from a six-channel spark source (SS) into a discharge gap (DG = 2 cm). The electric field ($\tau \sim 1 - 2$ μsec) was applied to a gap [2, 3] filled with plasma ($n \sim 10^{13}$ cm^{-3}) and maintained by the charge of the capacitor $C_7 = 0.4$ μF, connected to the discharge circuit. The total current in the circuit was measured with the aid of the resistor R_2. The ion-beam current was measured with a Faraday cylinder (FC) and resistor R_1, while the electron-beam current was measured with a Rogowski loop (RL). The distribution of the plasma potential in the gap was determined by a single electric probe loaded with a voltage divider of 8 kΩ resistance. The compositions and energy spectra of the beams were investigated with a Thomson analyzer.

The necessary conditions for the excitation of the current instability [4 - 6] and for the occurrence of a "break" in the current-carrying plasma are the following: a) The discharge gap must first be filled with a plasma having parameters such that when the current is increased the plasma resistance becomes larger than the wave resistance of the circuit. b) The critical current, reached at a certain initial voltage V_0 for a given plasma concentration, must flow through the plasma. Under these conditions, an anomalous increase of the plasma resistance is observed, and this breaks the common current in the gap (Fig. 2a) and increases rapidly the potential difference across the gap, to a value frequently exceeding the initial voltage on the capacitor bank. As shown by probe measurements, the potential difference is concentrated in a turbulent layer inside the plasma. Figure 3 shows the distribution of the potential in the plasma. Such a potential distribution is established at the instant when the current reaches the critical value and is retained during the stage when the current is interrupted. The electrons and ions are accelerated in the layer towards each other to an energy close to the applied voltage, and intense beams are formed.

It should be noted that there is a certain similarity between the beams investigated in this study and the anode and cathode rays observed in an amonalous glow discharge [7]. In essence, however, a new method of beam formation in a plasma has been observed.

The beams were energy and mass analyzed. The electrons and H^+ ions have a considerable energy scatter. The average energies of the charged particles are of the order of the applied voltage. If the number of pulses is large, one can see on the photographic plate the carbon ions C^{+1}, C^{+2}, and C^{+3}. The maximum energy of the carbon ions is proportional to the multiplicity of the charge, thus indicating that the particle acceleration in the layer has a potential character. Since the plasma had not time to flow into the tube (1 cm dia, ℓ = 15 cm) through which the ion beam is drawn, there was no compensating medium, so that the beam current is limited by its own space charge. To increase the ion current, the space charge of the beam was compensated for by electrons produced by an incandescent tungsten coil (EC). Figure 2b shows the ion current to the Faraday cylinder, superimposed on the total electron current in the gap (Fig. 2a). The ion-current signal is shifted by an amount equal to the time of flight $\tau = 10^{-7}$ sec (the time-marker frequency is 10 MHz). At a voltage V_0 = 20 kV and at a 1-cm diameter of the hole in the cathode electrode, the ion-beam current reached I = 20 A. The critical value of the electron current was 9 kA. It should be noted that the source geometry did not make it possible to extract the entire beam current.

A space-charge sheath is produced in the region of the plasma "break," bipolar current flows, and the beam space charges are compensated for. The relation $j_e/j_i \approx (M_i/m_e)^{1/2}$ should therefore be satisfied (in the quasistationary case). In our case it is valid for qualitative estimates, since the time of depletion of the layer is $t \gg \tau$ (where τ is the time of flight of the particles through the layer). Starting from this relation, ion beams of 1.2×10^3 A can be obtained at an electron-beam current 5×10^4 A.

It is impossible at present to estimate the thickness of the layer and to present a complete picture of the mechanism whereby the layer is produced in the plasma. It should be noted, however, that the point of localization and the thickness of the layer vary with time and depend on a number of parameters (plasma concentration, concentration gradient, current density, the magnetic field of the current itself) and on the length of the discharge gap. There is no doubt that the formation of the layer is preceded by a directional supersonic electron flux in the plasma and by development of a current instability [1, 4 - 6]. The observed phenomenon is not connected with purely near-electrode processes or with a reduced cathode emission.

Thus, the possibility of occurrence of a "break" in a current-carrying plasma (a turbulent layer) has been established. As a result, the entire current in the plasma is carried by electron and ion beams. This effect is of interest from the point of view of formation of powerful streams of charged particles, as well as from the point of view of understanding the dynamics of straight discharges [8, 9] and of vacuum breakdown [10].

In conclusion, I am grateful to I.F. Kvartskhava, A.A. Plyutto, and L.P. Skripal' for a discussion of the result and interest in the work, and also to B.A. Tskhadaya and A.T. Kapin for help with the experiments.

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EFFECT OF CHARGE PARITY IN X-RAY SPECTRA OF FISSION PRODUCTS

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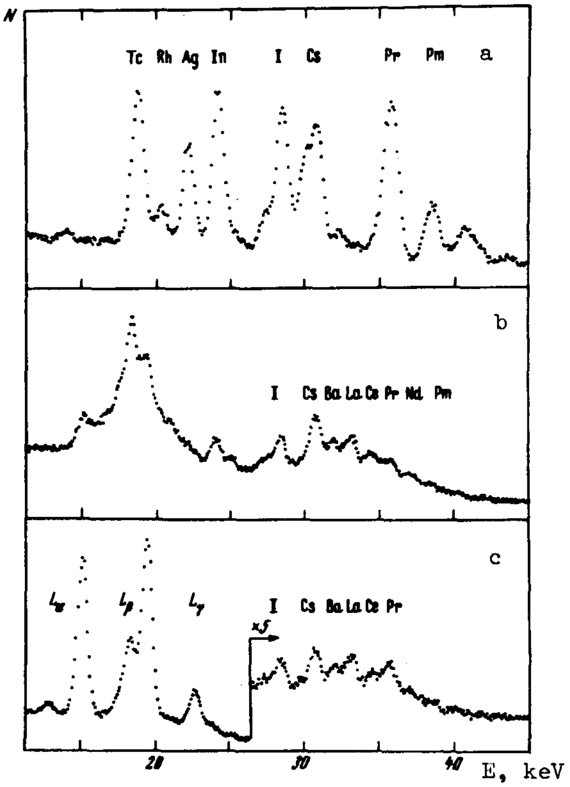
At the present time, in connection with the new possibilities uncovered by semiconductor high-resolution spectroscopy techniques, research on the x-rays accompanying the radioactive decay of atomic nuclei is being diligently pursued. We have investigated the x-ray spectrum of fission products, using the semiconductor soft-electromagnetic-radiation spectrometer developed by us earlier [1] and employed previously to determine the fluorescence yield of the L_2 subshell of curium [2]. We report here the first experimental results.



X-ray spectra: a) K series of secondary fission products, b) fission-fragment series, c) total spectrum of Cf^{252} target.

We investigated the x-rays from the products of the spontaneous fission of Cf^{252}. To this end, the fragments were accumulated on an aluminum foil placed over an open Cf^{252} source, after which the foil was placed near the window of a semiconductor spectrometer. The time of accumulation of the products, as well as the time between the end of the accumulation and the measurement of the x-ray spectra, ranged from one hour to one month. Figure a shows the energy distribution of the x-ray quanta of the fission products, obtained 12 hours after a 30-day accumulation. Although the absolute and relative intensities of the individual spectral lines, which can be seen in the figure, are significantly different for different accumulation durations and delays prior to measurement, this distribution reflects quite well the most interesting feature, namely that the spectrum contains only the characteristic radiation of products with odd charge. We see the lines of the Kα transitions of ${}_{43}Tc$, ${}_{45}Rh$, ${}_{47}Ag$, ${}_{49}In$, ${}_{53}I$, ${}_{55}Cs$, ${}_{50}Pr$, and ${}_{69}Pm$ (the Kβ lines appear as kinks on the Kα lines or between the Kα lines of the elements with large Z), and there are no lines of the neighboring even elements (in this case, with intensity $\gtrsim 0.1$).

The observed radiation is the result of internal conversion in β decay