in this state (its excitation energy after subtracting the electron-affinity energy of the I atom) can be carried away by the escaping electron.

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THERMAL CESIUM PLASMA IN A STRONG HIGH-FREQUENCY ELECTRIC FIELD

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We report in this letter the results of an experimental investigation of the behavior of a thermal cesium plasma in a strong high-frequency electric field. The experiments were made with a setup of the Q-machine type [1] with one incandescent plasma emitter. The thermal cesium plasma had the following initial parameters: length of plasma pinch 25 cm, pinch diameter 2.5 cm, plasma density $n_e = n_i = 1 \times 10^{10}$ cm^{-3}, temperature $T_e = T_i = 0.2$ eV, degree of ionization $\eta \sim 10 - 20\%$, longitudinal magnetic field 3500 Oe, and level of internal low-frequency plasma oscillations $e\varphi/T \sim 10^{-3}$.

An alternating voltage, variable in the frequency range 0.3 - 15 MHz, was applied to a flat collector electrode located on the free end of the Q-machine 25 cm from the emitter, so that a longitudinal hf current was excited in the plasma. When the hf potential on the collector of the Q-machine exceeded a critical value on the order of 5 - 10 V, intense hf oscillations of the plasma potential and density were excited. Their frequencies were in the range of the characteristic frequencies of ion sound, they were independent of the magnetic field intensity, and were inversely proportional to the length of the plasma pinch. Similar oscillations were observed by the authors of [2] in a thermal plasma through which a "supercritical" ($j \gg nec_s$) direct current flowed, and were identified as ion-sound oscillations. However, the spectrum of the oscillations excited by the hf current differed from the spectrum excited by passing direct current through the plasma, in that it had a much larger amplitude, and its fundamental sound frequency as well as its overtones were shifted towards higher frequencies (Fig. 1). The dependence of the amplitude A_1 and frequency f_1 of the first harmonic of the ion sound on the frequency Ω of the external high-frequency field, the amplitude of which was maintained constant at a level of 20 V ($V > V_{crit}$), is shown in Fig. 2. It offers evidence that the temperature of the electronic component of the plasma increases with increasing frequency of the external field. In fact, the increase in the frequency of the ion sound in our case may be connected with the heating of the electrons ($f \sim \sqrt{T_e/M_i}/L$). The increase in the amplitude of the plasma-potential oscillations can be explained in a similar manner if it is assumed, in accordance with the experimental

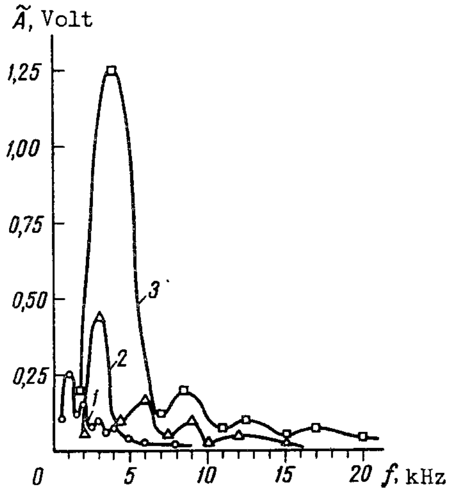

Fig. 1. Spectra of plasma potential oscillations in the center of the pinch; $n = 1 \times 10^{10}$ cm^{-3}, H = 3500 Oe, V_a = 20 V. 1) $\Omega = 0$, 2) Ω = 5 MHz, 3) Ω = 15 MHz.

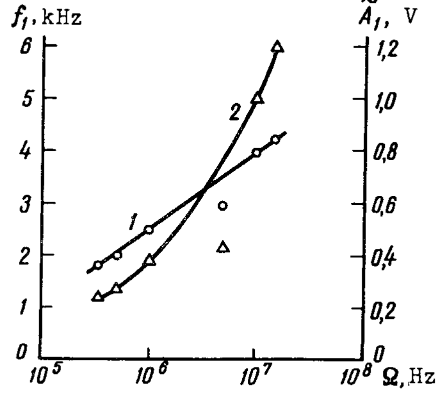

Fig. 2. Frequency (curve 1) and amplitude (curve 2) of the first harmonic of the ion-sound oscillations vs. frequency of the external alternating electric field. $n = 1 \times 10^{10}$ cm^{-3}, H = 3500 Oe, V_a = 20 V.

results [2], that the steady-state amplitude of the ion-sound oscillations A_1 is of the order of T_e/e.

Our earlier [3] probe measurements of the electron temperature under conditions that did not differ essentially from those described here are in satisfactory agreement with the results presented below. It was established that the current-voltage characteristics of a single Langmuir probe are greatly altered when the frequency of the external field is increased. The electron temperature determined from the slope of the characteristics reached several electron volts at frequencies 5 - 15 MHz.

It can be assumed that the observed electron heating is connected with collective processes that develop in the plasma upon passage of the current [4]. In fact, the plasma in our experiments is collisionless ($\lambda_{el} \sim L$), and the electric fields realized in the experiments are such (~1 V/cm) that during each half-cycle of the hf field the electrons acquire a directed velocity u exceeding the thermal velocity v_{Te} of the electrons, i.e., conditions are satisfied for the development of two-

Fig. 3. Oscillograms of hf voltage (upper beam) and hf current in the plasma (lower beam), $n = 1 \times 10^{10}$ cm^{-3}, H = 3500 Oe. 1) V_a = 5 V, 2) V_a = 10 V, 3) V_a = 15 V, 4) V_a = 20 V. Frequency of hf field 500 kHz. Multiple triggering of the oscilloscope sweep.

stream instability [5,6]. Turbulent heating of the plasma under conditions of two-stream instability is usually accompanied by an anomalously large resistance to current flow [7,8]. A similar effect is observed in our experiment. Figure 3 shows oscillograms of the hf voltage and current in the plasma. It follows from them that at low voltages (oscillograms 1-3) the current in the plasma has an inductive character, although a tendency is observed for the phase shift between the current and the voltage to decrease with increasing electric-field amplitude. When $V > V_{crit} \approx 20$ V, the current reaches a critical value, and is purely ohmic and limited in amplitude by the large plasma resistance (oscillogram 4). The plasma-density oscillations at the ion-sound frequency lead to low-frequency modulation of the current amplitude. Corresponding to this is the smearing of the current signal on Fig. 2, obtained by multiple triggering of the oscilloscope sweep. We note that the observed half-wave rectification of the hf current is due to the presence of an emitting surface on one end of the Q-machine only. The collector electrode on the other end was not heated.

Our experimental results can be summarized as follows:

1. A strong ($eEL \gg T$) high-frequency electric field superimposed on a "quiet" thermal plasma leads to an appreciable increase of the electron temperature.

2. The plasma heating efficiency increases with increasing frequency of the external laternating field, and this may be of interest from the point of view of turbulent plasma heating.

3. In a non-isothermal plasma situated in a strong high-frequency field, intense oscillations of the ion-sound type are excited, with a frequency much lower than that of the external alternating field.

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DEPENDENCE OF THE TRANSPARENCY OF ALUMINUM FILMS ON THE THICKNESS

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It was reported earlier [1] that the value of T_c of an aluminum film evaporated in a sealed ampoule under conditions that hinder the formation of an oxide layer increases with