where n is the electron concentration and $c = d\bar{\epsilon}/dT$ the specific heat of the electron gas per electron.

To compare the obtained data with theory, we used the results of a calculation of the electron energy loss function P(T) for scattering by the piezoelectric and deformation potentials of the acoustic phonons and by the optical phonons, obtained in references [2] and [5] respectively. Comparison of the experimental and theoretical curves leads to the conclusion that the nonmonotonic dependence of τ_p on T is connected with the interchange of mechanisms for the transfer of energy to the lattice from the electron gas when the temperature of the latter increases. When $T < 8°K$, energy scattering by the piezoelectric potential of the acoustic phonons predominates, and the deformation potential makes a relatively small contribution to the scattering. In this temperature region, the experimental results are in good agreement with theory, so that it becomes possible to estimate the constants of the piezoelectric (e_{14}) and deformation (ϵ_c) potentials. According to our measurements, $e_{14} \approx 2.6 \times 10^4$ dyne$^{1/2}$ cm^{-1} and $\epsilon_c < 10$ eV.

At electron temperatures $T \geq 10°K$, the agreement between theory and experiment is only qualitative. It is obvious that the decisive contribution to the energy dissipation is made here by the optical phonons. A correct account of this scattering calls for a special calculation of the electron energy distribution in the electric field, with account taken of its non-Maxwellian character.

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INFLUENCE OF THE MIRROR RATIO ON PLASMA HEATING BY AN ELECTRON BEAM IN A "PROBKOTRON"

P. I. Blinov, L. P. Zakatov, A. G. Plakhov, R. V. Chikin, and V. V. Shapkin

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The use of electron beams to heat plasma has been stimulated by several theoretical investigations, which have pointed out the existence of a strong beam retardation mechanism, wherein part of the beam energy is transmitted to the plasma [1-3]. It has been shown experimentally that an appreciable part of the beam energy is transferred to the plasma [4,5].

High electron temperatures have been reported in [6,7]. In these experiments, the plasma was produced by an electron beam passing through a neutral gas.

We have investigated the interaction between an electron beam and a ready-made highly ionized plasma.

The apparatus (Fig. 1) comprises a trap with magnetic mirrors. The electron gun is located on the trap axis behind the mirrors on one end, and the plasma injector is located on the other end. The electron gun operates in a pulsed mode. The square-wave voltage pulse is of 450 μsec duration and 9 kV amplitude, the pulse current being 5 A. The plasma injector is made up of titanium buttons impregnated with hydrogen. The plasma and the electron beam are injected into the trap simultaneously. The residual pressure in the chamber is 10^{-6} mm Hg. The electron density was measured with a microwave interferometer (λ = 3 cm). The quantity nT (T = plasma temperature) was determined from the diamagnetic effect. The bremsstrahlung was registered by photomultiplier with NaI(Tl) crystal.

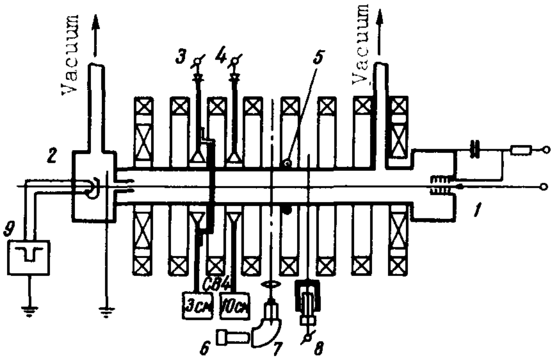

Fig. 1. Diagram of setup. 1 - Plasma injector, 2 - electron gun, 3, 4 - microwave source, 5 - diamagnetic probe, 6, 7 - electron-optical and spectral apparatus, 8 - bremsstrahlung recorder, 9 - low-voltage pulsed source.

Figure 2a shows an oscillogram of the signal from the diamagnetic probe following operation of the plasma injector only. The upper part of oscillogram 2a corresponds to plasma accumulation and the lower to decay. The estimated value of nT for the primary plasma is 10^{13} eV/cm^3. The maximum value of the concentration reaches $n = 10^{12}$ cm^{-3}, giving a temperature T = 10 eV for the primary plasma.

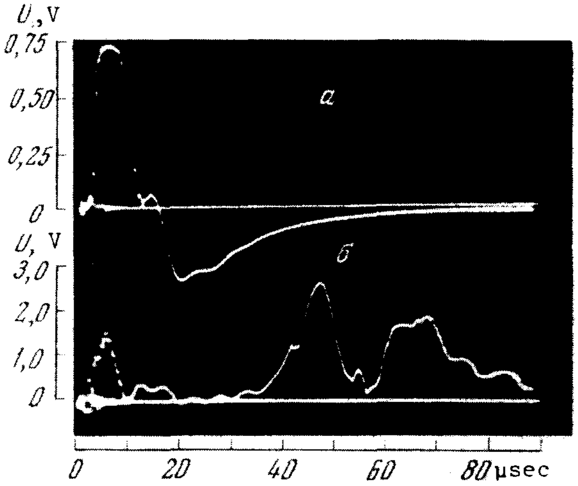

Fig. 2. Diamagnetic-probe signal. a - Operation of plasma injector only, b - simultaneous injection of the electron beam and the plasma.

When the plasma and the electron beam are simultaneously injected in the plasma, the concentration does not rise, but the energy released by the plasma increases strongly, as evidenced by the oscillogram of the diamagnetic signal in Fig. 2b. This oscillogram yields nT = 3×10^{14} eV/cm^3. The value of nT during the entire time of injection of the electron beam (450 μsec) reaches 5×10^{14} eV/cm^3. These values of nT were obtained for a mirror ratio R = 4 and a magnetic field 500 Oe. nT = 0.6×10^{14} eV/cm^3 in the field interval 500 - 2000 Oe and R = 1.8.

It is seen from Fig. 3 that when R = 1.8 the concentration decreases with a time constant τ = 300 μsec. When R = 2 the curve exhibits a kink near $n = 10^{11}$ cm^{-3}, and the plasma decay slows down. This can be attributed to the fact that the plasma has two components.

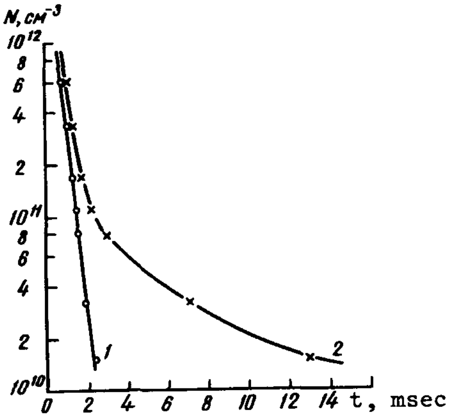

Fig. 3. Plasma decay at different mirror ratios: 1 - R = 1.8, 2 - R = 4.

The "cold" but denser component decays with a time constant on the order of 500 μsec. Below the $n = 10^{11}$ cm^{-3} level, τ increases sharply, owing to the presence of "hot" electrons with density on the order of 10^{10} cm^{-3}.

The presence of "hot" electrons in the trap is evidenced also by the prolonged, intense, and hard bremsstrahlung. Whereas for R = 1.8 the bremsstrahlung duration never exceeded 1 msec, in the case of R = 4 the duration was more than 100 msec. The radiation intensity increases sharply, and the quantum energy increases by several times. An estimate of the temperature from the spectral distribution of the bremsstrahlung yields T = 40 keV.

Thus, the efficiency with which the plasma electrons are heated by the beam depends substantially on the mirror ratio. As the mirror ratio is varied from 1.8 to 4, the plasma pressure increases tenfold. The plasma lifetime in the trap increases. A group of "hot" electrons, with a prolonged confinement time and with density close to 10^{10} cm^{-3} appears. Accordingly, the energy lost by the electron beam to plasma heating increases from fractions of one per cent to 3.5%, and during the initial stage of the heating (the first 90 μsec) the loss reaches 10%.

The influence of the mirror ratio on the heating of plasma with direct current was observed also in experiments of M. V. Babykin et al.

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