ION SOURCE WITH uhf POWER SUPPLY

V. K. Molchanov and O. Ya. Savchenko UDC 621.3.078.612

Ion beams are traditionally obtained from a discharge plasma formed by a system of electrodes, to which an external, with respect to the plasma, voltage is applied. The energy of the beam of ions is determined by this voltage [1]. In this paper, we describe a source, in which the energy of the ions is regulated by power supply. The construction of the source is similar to that described in [2], but the proposed variant operates without external voltages. The source (Fig. 1) consists of a resonator 1, excited in the mode $E_{010}$, on whose axis a capillary 2 is placed, and the cavity of the resonator is evacuated. Gas is passed through the capillary in which a discharge is executed with uhf power input. Under the condition that the uhf field penetrates into the bulk of the plasma, the expression for the maximum energy of translational motion of electrons has the form $W_e = e^2E^2/(2m_e\omega^2)$, where $W_e$ is the energy of an electron, e is the electron charge, $m_e$ is the electron mass, $\omega$ is the frequency, and E is the amplitude of the uhf field intensity. The electrons leave the bulk of the plasma, and the plasma is charged positively and emits ions. The steady-state potential is determined by the fastest electrons, while the remaining electrons fall into an electrostatic trap. In addition, the ion current equals the electron current, and the energy is determined by the plasma potential

$$\varphi = W_e/e = eE^2/(2m_e\omega^2). \quad (1)$$

At a frequency 1818 MHz with a field intensity 20-50 kV/cm, it is possible to obtain ions with energies 3-18 keV. Thus, on order to obtain a beam of ions, it is not necessary to have a constant voltage source. It follows from (1) that the ion energy is proportional to the power introduced into the resonator.

Two variants of the source were tested: frequency 2750 MHz, $\tau$ = 3 μsec, capillary diameter 1.25 mm, continuous gas injection; frequency 1818 MHz, $\tau$ = 8 μsec, capillary diameter 3 mm, pulsed input; hydrogen is used for the gas. The scheme for the measurements is shown in Fig. 1 (3, 5 are diaphragms). The beam consists of $H^+$ and $H_2^+$ ions. The central part of the

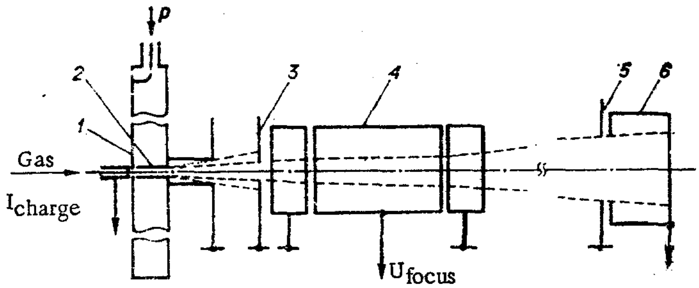


Fig. 1

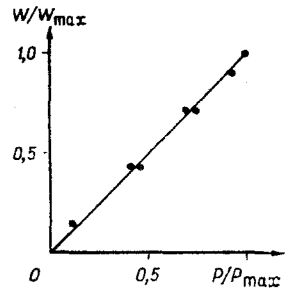


Fig. 2

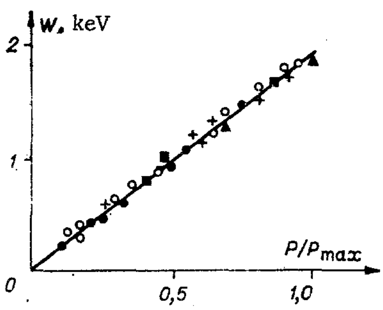


Fig. 3

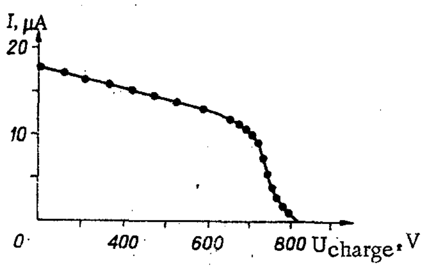


Fig. 4

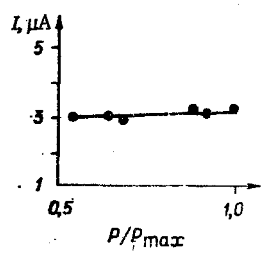


Fig. 5

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beam was formed by an electrostatic lens 4 on a Faraday cylinder 6. The energy was determined with the help of a magnetic analyzer and at energies less than 2 keV by the retarding potential method. The retarding potential was applied to a grid, positioned at the inlet to the Faraday cylinder. Figure 2 shows the dependence of the ion energy on the power introduced into the resonator at a frequency 1818 MHz ($W_{max}$ = 15 keV, $P_{max}$ = 52 kW). Figure 3 shows a similar dependence for the first variant of the source with gas injection in the range 0.01-0.68 $cm^3/h$, and the absolute value of the power was not determined. The energies of the $H^+$ and $H_2^+$ ions are identical. Figure 4 shows the dependence of the ion current on the retarding potential, measured for the first variant of the source. The nonmonochromaticity of the beam was less than 10%. The maximum ion energy, obtained in the second variant, was 30 keV and the maximum current, conducted at a distance of 85 cm, was 3 mA. The dependence of the current on the gas flow rate was studied in detail for the first variant of the source. For ions with 2-keV energies, the dependence of the current on the gas flow rate for flow rates less than 0.1 $cm^3/h$ is linear. In this case, the use factor of the gas is close to 70%. Probably, the degree of ionization in the second variant is close to 100%, since the ion current at the closed end of the capillary (Fig. 5) is practically independent of the power for a constant gas flow rate.

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# DYNAMICS OF A PLASMA SHELL WITH AN OUTSIDE CURRENT

V. S. Komel'kov, A. P. Kuznetsov, V. V. Perebeinos,
A. S. Pleshanov, and M. T. Solomonov

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The present article is an extension and development of the research of [1]. In this case the investigation was carried out on a more powerful experimental installation than in [1], while the numerical calculation method was considerably improved. Predicted variants of the plasma dispersion and acceleration beyond the accelerator electrodes on installations with still higher parameters, permitting a significant increase in the outside current, are theoretically analyzed.

## 1. Experiment

The plasma cluster was generated by a pulsed coaxial accelerator similar to that of [2]. The gas being accelerated and the atmosphere in which the acceleration and dispersion took place was hydrogen at a pressure of about $p_0 = 10^4$ Pa. Two capacitor batteries with a total capacitance of 72 μF and a working voltage of 30 and 40 kV served as the accumulators. The method of repeated application of current [3] was used, so that by the moment the cluster emerged from the end of the accelerator the total current in the discharge reached 1.2 MA.

A diagram of the current supply and the design of the system of shaped electrodes of the plasma accelerated are shown in Fig. 1. The central electrode 1 consists of a tantalum rod 10 mm in diameter placed along the accelerator axis while the outer electrode 2 is a stainless steel cylinder, the inner diameter of which is 40 mm. The geometrical dimensions and shape of the electrodes are chosen so that ignition of the discharge took place not over the

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