EXPERIMENTAL INVESTIGATION OF RADIO-FREQUENCY DISCHARGE IN HELIUM

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In paper / 1 / it was noted that an increase in RF discharge voltage brought about a qualitative change in the discharge and in the discharge luminocity. In / 2,3 / it was shown that this change in regime (from α to γ) was accompanied by a sharp increase in the discharge current.

Given below are the results of the experimental investigation of plasma parameters and volt-ampere characteristics of RF discharge over a range of external conditions under which both regimes of discharge were realized. Measurements were carried out in a Helium filled cylindrical tube of radius R =3cm with two plane titanium electrodes placed inside it 7.7cm apart. The electron temperature V_e and the plasma density n were obtained from the electron branch of the volt-ampere curve of the Langmuir probe / 4 /. In calculating n the finiteness of the ratio of the probe radius (r_p =5 10^{-3}cm) to the electron mean free path was taken into account / 5 /. The discharge current was measured using a Rogovsky's coil. On increasing the discharge voltage to a critical point $V_\sim = V_{\alpha\gamma}$ which depends on the gas pressure P and the frequency f , a redistribution of discharge luminosity was observed. For voltages $V_\sim <$ $V_{\alpha\gamma}$ (α -regime) over the range of values of and investigated, the axial distribution of plasma density $n(x)$ is constant, except near the boundary where it sharply decreases (Fig.1). The electron temperature was close to the temperature of the plasma in the positive column of the direct-current discharge, taking values between 6-3V depending on the pressure. The fact that $n(x)$ here differs from the Shottky's distribution can be explained according to / 6 / by the fact that the electric field in plasma and thus the ionization frequency are functions of the x -co-ordinate. For $V_\sim > V_{\alpha\gamma}$ (γ -regime) the axial distribution of plasma density at pressures more than 1torr showed a maximum near the boundary (Fig.1). If the pressure increased the maximum was observed to move towards the boundary, while its value increased and at p =6torr the value of maximum was about 20.On going from α to the γ -regime, the electron temperature dropped to a fraction of its former value between 1.5 and 0.5V depending on the pressure (Fig.2).

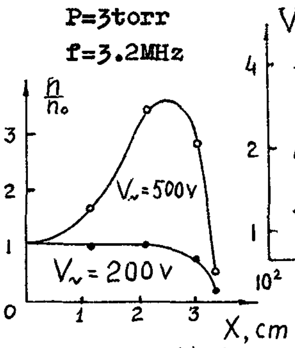

Fig.1

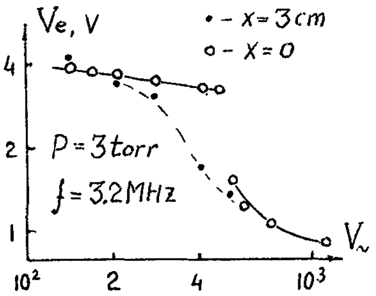

Fig.2

The observed changes are in accordance with the hypothesis put forward in / 1 /, according to which when $V_\sim$ is large enough ($V_\sim > V_{\alpha\gamma}$) physical processes on the electrode and in the sheath are similar to those in the cathode fall region of the glow discharge. In this case gas ionization is mainly brought about the beam of high energy electrons injected from the sheath / 7 /. The plasma density attains a maximum near the boundary (as result of damping of the beam) and the electron temperature is relatively low as in a non-autonomous discharge. The experimental values of the plasma density at the center n_c and the discharge current I/p , I/f are plotted in Fig.3,4 and 5. It can be seen here that these curves are different for α and γ -regimes. The perpendicular lines in Fig.3,4 show the voltage $V_{\alpha\gamma}$.

In the α -discharge, when $V_\sim$ is not too low: $n \sim V_\sim f^2$; $I/p \sim V_\sim$ and decreases with inincrease in pressure and $I/f \sim V_\sim f$.

In the γ -discharge $n(f)$, $I/p(p)$ and $I/f(f)$ practically cease to depend on their respective variables. The sharp increase of I noted in / 2,3 / is seen here when P is large enough and f is small. According to / 7 / this takes place when the crossing over to γ -regime leads to large decrease of the sheath thickness and thus to a decrease in the discharge impedance. $V_{\alpha\gamma}$ as a function of gas pressure is shown on Fig.6. It is seen here that this pressure dependence is similar to that of the cathode fall in the glow discharge; the minimum value of $V_{\alpha\gamma}$ is close to the normal cathode fall.

The behavior of the discharge parameters V_e , n , I and $V_{\alpha\gamma}$ agrees qualitatively with the theoretical analysis of γ-discharge carried out in / 7 /.

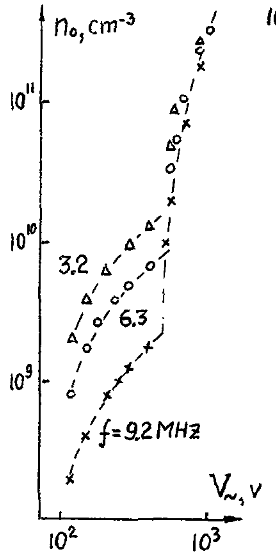

Fig.3(P=3torr)

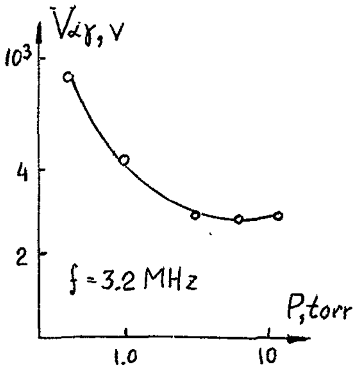

Fig.6

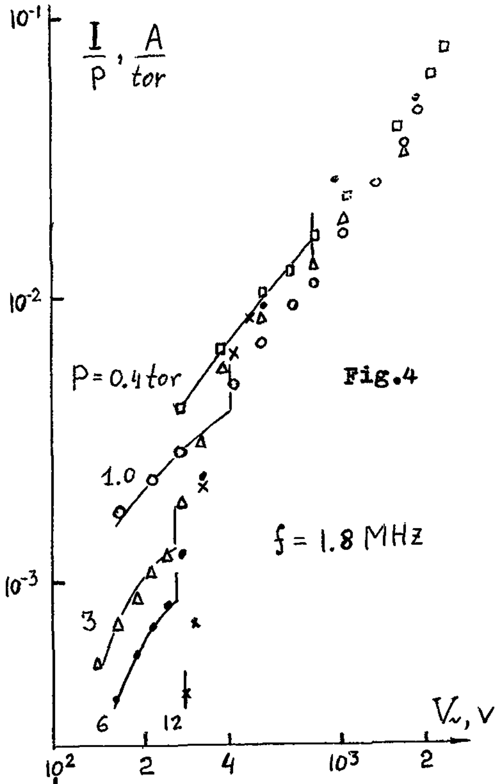

Fig.4

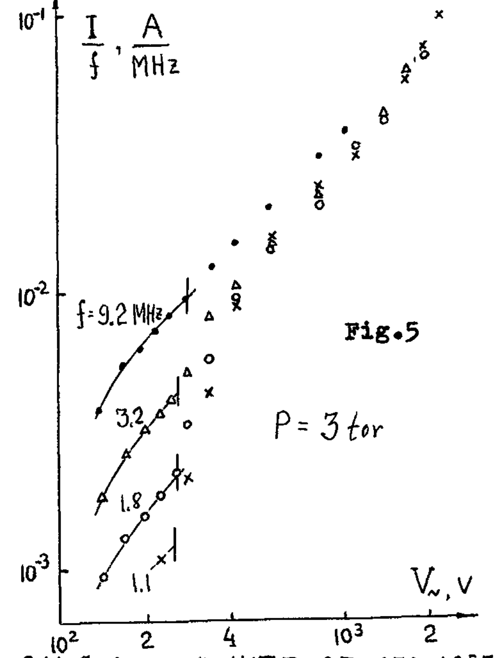

Fig.5

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