INVESTIGATION OF THE ELECTRON ENERGY DISTRIBUTION FUNCTION IN KRYPTON AFTERGLOW PLASMA

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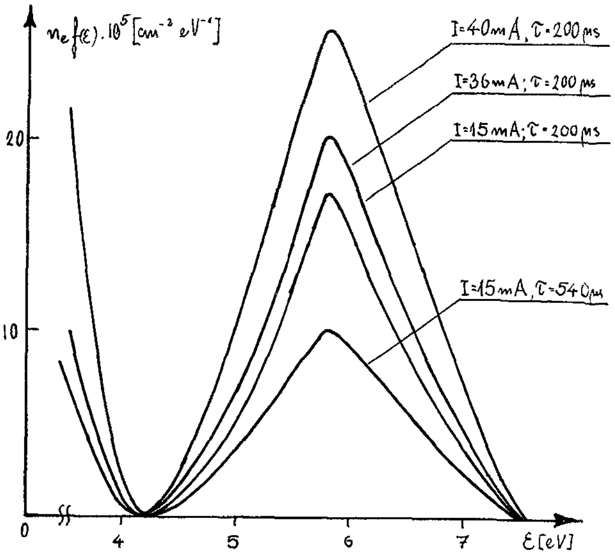
Several previous works /1-3/ made in the afterglow of helium, neon and argon positive column show out that in the initial period of the plasma decay, when the quantity of the excited atoms and charged particles has not yet been substantially decreased, the electron energy distribution function (EEDF) may substantially deviate from the Maxwellian distribution function in the high energy region: 1.The fast electrons number could be many orders higher than in a Maxwellian distribution with the temperature of the main group of electrons T_e. 2.This number decreases in time much more slowly than usually presumed.

This work gives the results of similar investigations in the krypton afterglow for which no previous data exists as far as we know.

The measurements were carried out on the same experimental device, used and described in details earlier /1/. Short, rectangular voltage pulses at repetition frequency 1,5 kHz were applied on the electrodes of the discharge tube. The experimental conditions were: discharge pulse current I = 6 ÷ 60 mA, gas pressure about 0,7 torr, tube diameter r = 2,6 cm, radius of cylinarical probe 4.10^{-3} cm.

In a selected moment after the cesation of the aischarge current were made both electrical probe and optical absorbtion measurements. As it is well known EEDF is connected with the second derivative of the probe current $i''_e(v)$ by Druvestain relation. We used the time-resolving method for obtaining $i''_e(v)$ in a plasma with periodically changing parameters/1/. On fig.1 are shown experimental EEDF in absolute units measured at delay time τ=200 and 540 mks after the aischarge pulse end.



The maximum at 5,8 volts is due to the electrons, created in the chemoionization reactions:

$$Kr\,^3P_2 + Kr\,^3P_0 \rightarrow Kr\,^1S_0 + Kr^+ + e(6,47eV) \quad (1)$$

$$Kr\,^3P_2 + Kr\,^3P_1 \rightarrow Kr\,^1S_0 + Kr^+ + e(5,94eV) \quad (2)$$

$$Kr\,^3P_2 + Kr\,^3P_2 \rightarrow Kr\,^1S_0 + Kr^+ + e(5,82eV) \quad (3)$$

These reactions may also produce $Kr_2^+ + e$. In the processes (1)-(3) the electrons are created with definite energies, but experimental maximums are broadened and fused by the influence of the finite amplitude of the imposed modulating voltage.

The density n_2 of the excited krypton atoms Kr^3P_2, n_1 of the Kr^3P_1 atoms and n_o of the Kr^3P_o atoms, which are vital for the fast electrons creation, was determined by measuring the fractional absorbtion of the spectral lines Kr7694A, Kr5870 A and Kr7854 A connected with these levels. The line strength values were taken from the works /4,5/.

At our experimental conditions of low gas pressure and discharge currents, the behaviour of fast electrons is governed by free diffusion towards the tube walls. In this case theoretical calculations /1/ for the EEDF give the following expression for the total density of electrons in the energy range about $\mathcal{E}_m$=5,8 eV at the tube axis

$$S_m = \int_{(\Delta \mathcal{E}_m)} \frac{2\pi \sqrt{2\mathcal{E}}}{m^{3/2}} f(\mathcal{E},0)\, d\mathcal{E} \simeq \simeq \sum_{k=0}^{2} \beta_{2k} \overline{n_2 n_k} \frac{\Lambda^2}{D(\mathcal{E})} \qquad (4)$$

where β_{20}, β_{21} and β_{22} are the rate constants for the reactions (1), (2) and (3) respectively,

$$\overline{n_2 n_k} = \frac{\int_0^r n_2(\rho) n_k(\rho) J_o(\mu_1 \frac{\rho}{r}) \rho\, d\rho}{\int_0^r J_o^2(\mu_1 \frac{\rho}{r}) \rho\, d\rho}$$

Λ is the difusion length, $D(\mathcal{E})$ is the free diffusion coefficient of an electron with energy $\mathcal{E}$, $J_o(\mu_1 \frac{\rho}{r})$ is the Bessel function.

Because of the small density of the ^3P_o and $^3P_1$ levels significant contribution in the S_m have exclusivelly reactions including $^3P_2$ level, namely (1) - (3).

For the determination of the rate constants of Penning ionizations were made complex measurements at 40 different discharge conditions and delay times. A system of independant equations in the form of relation (4) was set up from the results of these measurements. It was solved by the smallest square method.

In this way it was found out that the rate constant for the reaction $(^3P_2, {}^3P_2)$ is $\beta_{22} = (9,3 + 0,4).10^{-9}\ cm^3s^{-1}$, for the reaction $(^3P_2, {}^3P_1)$ is $\beta_{21} = (1 + 0,5).10^{-8}\ cm^3s^{-1}$ and for the reaction $(^3P_2, {}^3P_o)$ is $\beta_{20} = (3,2 + 1,0).10^{-8}\ cm^3s^{-1}$.

The gas temperature at these small discharge currents is about 300^oK, so the corresponding cross-sections for these processes at the energy 0,026 eV are: $\sigma_{22} = (2,4 + 0,1).10^{-13}cm^2$,

$\sigma_{21} = (2,6 + 1,2).10^{-13}cm^2$,

$\sigma_{20} = (8,3 + 2,6).10^{-13}cm^2$

The results strongly depend on the line strength values.

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