The electron concentrations were 1×10^{17} and 9×10^{17} cm^{-3}, the larger values corresponding to higher pressures and voltages. In figure the degrees of ionization ($\alpha = n_e/n_0$, where n_0 is the initial concentration of xenon atoms) are given by full lines. It can be seen that at 10 mm Hg and 840 volts the degree of ionization is about 70%, while at 400 mm Hg and 400 volts about 3%.

Assuming that the thermal equilibrium is reached during the quasistationary state of discharge, one can calculate the temperatures using measured α values and Saha equation⁵⁾:

$$\frac{\alpha}{\sqrt{1-\alpha}} = \frac{0.9}{\sqrt{p_0}}\, T^{3/4} \exp\left(-5850\, V_i/T\right)$$

where — p_0 (mm Hg) is the initial gas pressure, T (K) — temperature of plasma, V (eV) — ionization potential of xenon atom. The results obtained by iteration are given in the figure (dashed lines). The temperatures lie between 9700 and 13000 K, the highest value corresponds to 10 mm Hg and 840 volts.

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3.8 Electrical conductivity of Kr and Xe steady state plasmas in electrical discharges

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The aim of this paper is to analyse the plasma conductivity dependence on temperature and the degree of ionization, for high pressure electrical discharges in rare gases.

There is no exact expression for electrical conductivity of partially ionized gas, based on the solution of Boltzmann kinetic equation. Also, there is no criterion to limit the number of approximations in order to obtain required accuracy, in standard Enskog-Chapman method. This stresses the importance of choosing the satisfactory expression for numerical calculations of conductivity. As it was shown[1] the exact values of electrical conductivity, for certain temperature, electron and neutral density, must lie between the values which are given by the elementary expression:

$$\sigma = \frac{e^2 n_e}{m(\langle \nu_a \rangle + \langle \nu_i \rangle)}, \tag{1}$$

and the "top" expression[2]:

$$\sigma^{\mathrm{top}} = \frac{4 e^2 n_e}{3\sqrt{2\pi m}\, n_a (kT)^{5/2}} \int\limits_0^\infty \frac{E \cdot e^{-E/kT}\, dE}{q_a(E) + \frac{n_e}{n_a} q_i(E)}, \tag{2}$$

where, E is the electron energy, n_a and n_e are neutral and electron concentrations, q_a and q_i are momentum transfer cross-sections for e-a and e-i collisions, $\langle \nu_a \rangle$ and $\langle \nu_i \rangle$ are the avarage values of e-a and e-i collision frequencies, respectively. Electron distribution function is supposed to be near Maxwellian. The equation (2) gives exact results in the case of weakly ionized gas only.

For the purpose of this paper it seems to be most satisfactory to use the following expression[2]:

$$\sigma = \frac{4 e^2 n_e}{3\sqrt{2\pi m n_a}(kT)^{5/2}} \int\limits_0^\infty \frac{E \cdot e^{-E/kT}\, dE}{q_a(E) + \frac{n_e}{\gamma n_a} q_i(E)}, \tag{3}$$

where the coefficient $\gamma = 0.58$, due to e-e collisions, is introduced in order to obtain agreement with the Spitzer-Härm formula [3], for a fully ionized gas. Although this coefficient has no constant value in the whole range of the degree of ionization, the expression (3) gives the values between (1) and (2) as proposed [1], reaches the exact expressions in two limiting cases of a weakly and a completely ionized gas and is mathematicaly simpler than the higher approximations in Enskog-Chapman method.

The calculations using (3), for high pressure electrical discharges in Kr and Xe, were performed on an IBM 360/44 64K computer. The upper limit of integration for Xe was 8 eV, and 10.6 eV for Kr. The values for momentum transfer cross-sections q_a were taken from [4,5], while for q_i Debye-Hückel approximation was used. The degree of ionization, $\alpha = n_e/n_a$ was varied from 10^{-4} to 10, and temperature from 0.3 to 2 eV. The electrical conductivity as a function of temperature for different degrees of ionization and initial pressures of 10, 50 and 100 torrs is presented in Fig. 1,2 and 3, respectively. For higher degrees of ionization the curves have minimums, in vicinity of which lie the limits of validity of kinetic theory. Practically, on the left from the dotted-dashed lines the theory is not valid. As expected, the Kr curves are higher than the Xe ones. It can be seen that for low α's conductivity decreases with temperature, while for higher α's it increases. The curves for $\alpha = 10$ are very close to the curves obtained by Spitzer-Härm formula. The agreement is better for lower pressures. Different slopes at higher temperatures

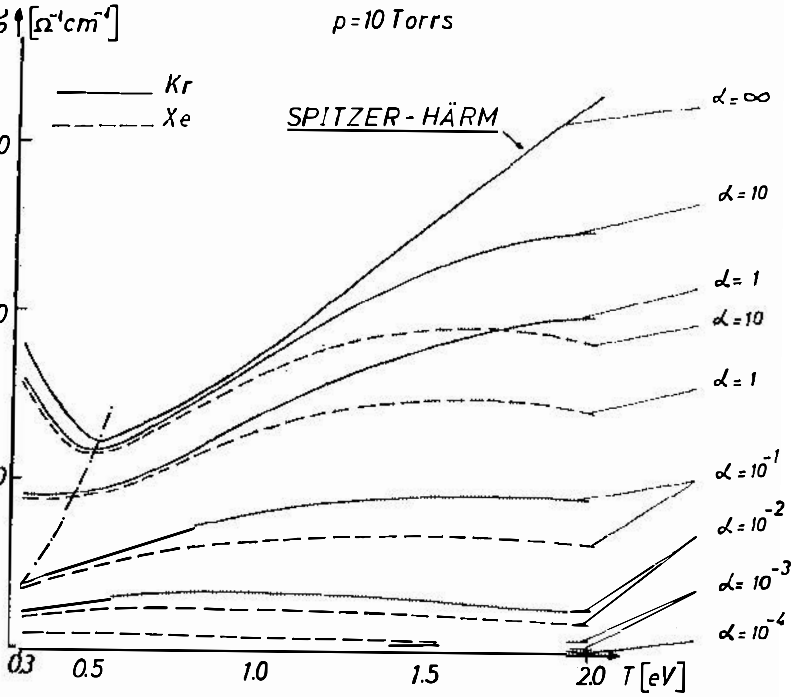
σ [Ω⁻¹cm⁻¹]
p = 10 Torrs
Kr
Xe
SPITZER - HÄRM
150
100
50
0.3
0.5
1.0
1.5
2.0
T [eV]
α = ∞
α = 10
α = 1
α = 10
α = 1
α = 10⁻¹
α = 10⁻²
α = 10⁻³
α = 10⁻⁴

Fig. 1

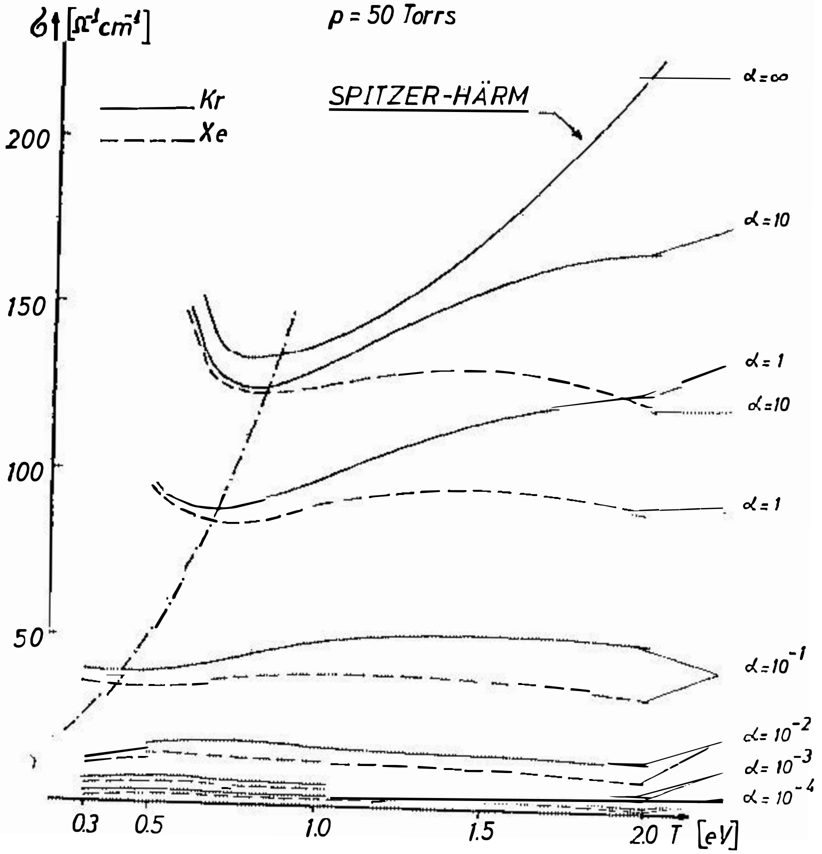
σ [Ω⁻¹cm⁻¹]
p = 50 Torrs
Kr
Xe
SPITZER-HÄRM
200
150
100
50
0.3
0.5
1.0
1.5
2.0
T [eV]
α = ∞
α = 10
α = 1
α = 10
α = 1
α = 10⁻¹
α = 10⁻²
α = 10⁻³
α = 10⁻⁴

Fig. 2

can be explained by the influence of the upper limit of integration. Also, in the high pressure conditions, even for such high degrees of ionization, there is still a great number of neutrals.

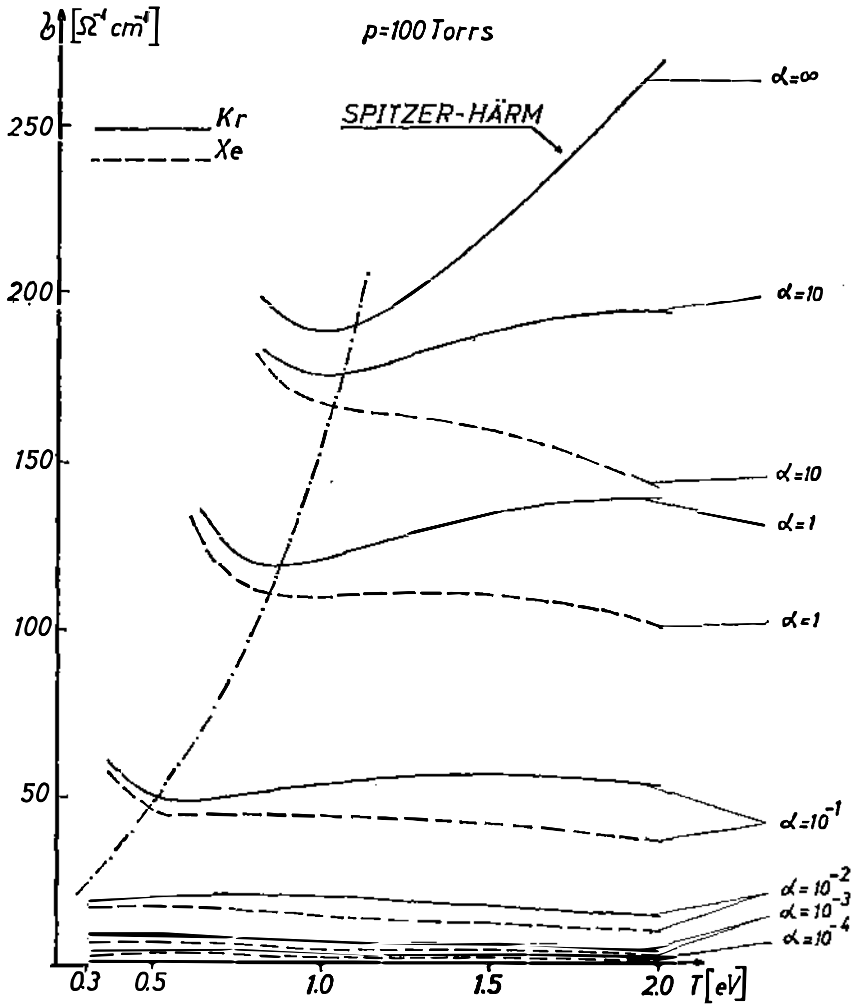

Fig. 3

The results for Xe plasma were compared with the experimental data in ref.[6].. Rather good agreement was obtained.

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3.9 Radiation and temperature of a dense plasma column

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3.10 A solution-jet method for mass transport study

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Abstract

A new technique has been developed for mass transport study in d. c. arc plasma. Pulsed injection of examined element's aqueous solution is used in order to reduce the evaporation time to the time of substance's passing through the arc. Chopping of the liquid jet into small bullets enables relatively undisturbed burning of the arc.

Excitation of the substance, which evaporated in the arc, enables observations of its motion either by photomultiplier technique or high-speed camera method. Time resolution is achieved by an osciloscope or time-base marker at the high-speed camera film, respectively. The advantages of the equipment lie in the determination of transport velocities, and residence time by different means.

3.11 Investigations of convection in d. c. arc

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Abstract

Time-resolved photomultiplier technique and high-speed camera method have been used for determination of convection velocities in the d. c. arc. The values of convection velocity are taken as equal to those of electrode particles' motion. A component of general transport velocity,