UNEQUILIBRIUM KINETIC OF COLLISIONLESS BOUNDARY LAYERS IN BINARY PLASMAS

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As well it is known difficulties connected with solutions of kinetic problems about relaxation processes in boundary layers of plasmas. This kind of problems are usually nonlinear and practically do not give possibilities of small parameters introduction, that expel analytic solutions in the general view [1]. Some effects such as multydimension of problems, presence components of plasmas, which have strong difference of own times, drift of distribution function region is not equal zero in the boundary layers relaxation [2] , give big difficulties in numerical simulation also. In connection of this, physical and mathematical models of processes are usually greatly simplified, using apriori assumptions about lighter components distribution in the boundary layer [3]. In this situation many nonlinear effects counected with the boundary layer relaxation are neglected, and the results of the numerical treatment can be used only under very rigid constraints.

In this paper we discusse some results of numerical treatment for selfconsistent problem about relaxation process of kinetic nonequilibrium collisionless boundary layers near spherical charged full absorbing surfaces in a binary lowtemperature plasmas. We have analysed the relaxation in the boundary layer after pulse $\varphi_{01} \to \varphi_1$ for surface potential concerning plasma. An action of magnetic field on relaxation process was neglected [4] . The dynamics of components of ionized gas unequilibrium layer was investigated in a general view.
In relative units an equilibriums are:

$$\frac{\partial f_\nu}{\partial t} + \sqrt{\frac{m_-}{m_\nu}}\left\{V_\nu \cdot \frac{\partial f_\nu}{\partial r} + \frac{z_\nu E_r \gamma}{2} \cdot \frac{\partial f_\nu}{\partial V_\nu} + (1-\gamma^2)\left(\frac{V_\nu}{r} + \frac{z_\nu E_r}{2V_\nu}\right)\frac{\partial f_\nu}{\partial \gamma}\right\} = 0 ;\ \nu = +,- ;$$

$$\frac{\partial^2 \varphi}{\partial r^2} + \frac{2}{r}\frac{\partial \varphi}{\partial r} = -2\pi \sum_\nu z_\nu \int f_\nu V^2 dV d\gamma ;$$

$$E_r = -\frac{\partial \varphi}{\partial r} ;\ f_\nu(r_1, V_\nu, \gamma, t) = 0,\ \gamma > 0 ;$$

$$f_\nu(r, V_\nu, \gamma, 0) = f_{0\nu}(r, V_\nu, \gamma) ;\ \varphi(r_\infty, t) = 0 ;$$

$$\varphi(r, 0) = \varphi_0(r) ;\ \varphi(r_1, t) = \varphi_1 ;$$

$$f_\nu(r_\infty, \vec{V}_\nu, \gamma, t) = \pi^{-3/2} \frac{n_{\nu\infty}}{n_{-\infty}} e^{-(\vec{V}_\nu - \vec{V}_{\nu\infty}(t))^2 T_{\nu\infty}/T_{-\infty}} .$$

We have used the scale system in which the difficulties connected with keeping of numerical form of distribution are dissipated:

$$M_n = n_{-\infty} ;\ M_T = T_{-\infty} ;\ M_r = \left(\frac{\kappa T_{-\infty}}{4\pi e^2 n_{-\infty}}\right)^{1/2} ;$$

$$M_\varphi = \frac{\kappa T_{-\infty}}{e} ;\ M_E = \frac{M_\varphi}{M_r} ;\ M_t = \left(\frac{m_-}{8\pi e^2 n_{-\infty}}\right)^{1/2} ;$$

$$M_{V_\nu} = \left(\frac{2\kappa T_{\nu\infty}}{m_\nu}\right)^{1/2} ;\ M_{f_\nu} = \frac{M_n}{M_{V_\nu}^3} ;\ \nu = +,- .$$

"+" and "-" indexes corresponds positive and negative ions, "∞" corresponds undisturbed plasma. We have used (r, v, γ) coordinate system, where $\vec{v}, \vec{r}$ are velocity and radius-vector of particls;
$\gamma = (\vec{r} \cdot \vec{v})/rv$; r_1, r_∞ are the surface radius and radius of undisturbed boundary zone [2, 3];
φ, E_r are the potential and radial part of electric field intensity;
Z, m are particle charge number and mass; f is a distribution function;
n, T are consentration and temperature; k, e are Bolcman's constant and elementary charge. Functions f_{0y} and φ_0 discribes a stationary structure of boundary layer, when spherical surface has potential φ_{01}. The numerical solution have been done by "big particles" methode [5] after its modification [2, 3] with help of BASM-6. This problem was solved with wide range of relation for particle masses m_+/m_- from 1 to 2000. Boundary values in puls of surface potential were variated in wide region also. In particular, we have used surface potential quite close and much higher then float potential. Last situation very importent becose information about kinetic structure of collisionless boundary layer for such kind of surface potential is practically absent.

The influence of m_+/m_- and φ_1 on the relaxating time τ of the boundary layer, that defined as a time of stabilization for surface current with accuracy 2÷ 3%, and the thickness of volume charge layer D for $r_1 = 7, T_{+\infty} = T_{-\infty}$,
$\varphi_{01} = 0$, $\varphi_1 = -1$
was shown in Fig. 1,2. Also we defined corrections for Langmire's periods connected with unequilibrium distribution of components, received the voltage - current characteristics of spherical surface and distribution functions of components including free electrons. In particular, our results have shown the big kinetic unequilibrium of component's distribution in the boundary layer. The kinetic unequilibrium type of distribution functions in collisionless boundary layer can be used for kinetic coefficients and speed of chemical reactions variation range investigation for wide range of Knoodsen's number.

We have investigated a possibility for use of some approximate distributions [4] for ionized components in the selfconsistente electric field in multycomponent collisionless boundary layer numerical simulations. In particular, we have shown that this distributions leads to conduction ion current's definition mistakes to 45% and higher, if the surface potential φ_1 is close to float potential φ_f . Else, if $\varphi_1 \leq 3\varphi_f$ these mistakes are less than 7%.

A careful analysis of our results have shown that there would be used for interpretation of experimental materials successfully.

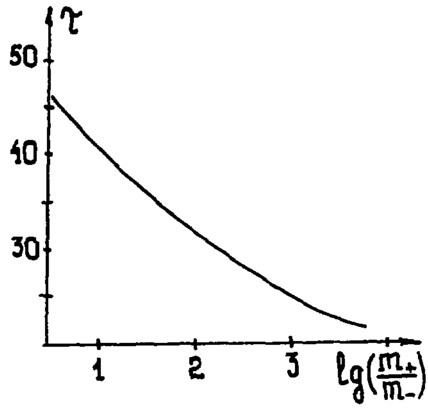

Fig. 1.

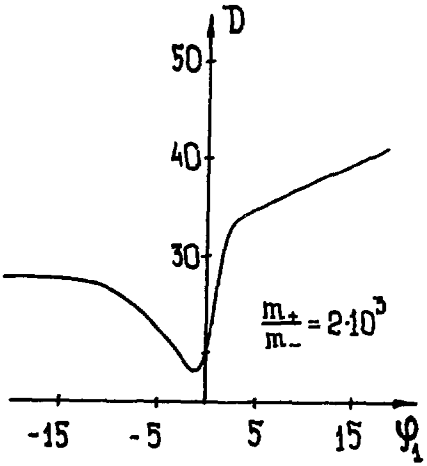

Fig. 2.

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