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ELECTRIC CHARACTERISTICS OF THE TOTAL IONIZED PLASMAS IN CONSTANT AND TIME-VARIABLE EXTERNAL FIELDS

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In this work we have treated the conductivity and some other electrical characteristics of fully ionized non-ideal plasmas in external electric and magnetic fields. The cases of time-independent electric and magnetic fields have been discussed, as well as the case of time-depending high-freqency (HF) electric field. Presented work is continuation of previous work (Mihajlov *et al.* 1993), treating static conductivity of the fully-ionized plasmas. In the work just mentioned a method of determining this conductivity was developed. This method is a semiclassical analog of previously developed version of the RPA method (Djurić *et al.* 1991; Adamyan *et al.* 1994). Employing this method, the expression for static electrical conductivity, σ_0, is obtained in the form

$$\sigma_0 = -\frac{4e^2}{3m}\int_0^\infty E\rho(E)\tau\frac{dw}{dE}dE, \qquad (1)$$

where $\rho(E)$ is the density of one-electron states in the energy space, $w(E)$ is the Fermi-Dirac distribution and τ is the relaxation time. In this theory the quantity τ is obtained by expresion

$$\tau = \frac{1}{\nu_e(E)}, \qquad (2)$$

where $\nu_e(E)$ is the semiclassical analog of the corresponding RPA effective frequency of electron scattering in plasma. Full expressions for $\nu_e(E)$ are given in the paper mentioned (Mihajlov *et al.* 1993).

This semiclasical method has been tested in the previous work (Adamyan *et al.* 1994) in the case of determination of static electrical conductivity of fully ionized plasmas in the presence of an external static magnetic field. In this case, the components of the tensor of static electrical conductivity $\sigma_{ij}(\omega_c)$ are being expressed through qantities $\sigma_l(\omega_c)$, defined by expression

$$\sigma_l = \frac{4e^2}{3m}\int_0^\infty \frac{(\omega_c\tau)^{l-1}}{1+(\omega_c\tau)^2} E\rho\tau\frac{dw}{dE}dE, \qquad (3)$$

where ω_c is the cyclotron frequency ($\omega_c = eB/mc$, where B is magnetic inductivity and $l = 1, 2, 3$. It is supposed here that the relaxation time τ is given by the same expression as when σ_0 was determined.

The developed formalism may be extended to fully ionized plasmas in an external, time-dependent electric field that varies with frequency ω. For this purpose, the real and imaginary parts of electrical conductivity, here denoted by $\sigma_r(\omega)$ and $\sigma_i(\omega)$ respectivelly, must be calculated. These quantities are determined in a way that is similar to the one described above for the electrical conductivity in the presence of a magnetic field, and are being expressed through the quantities σ_l with $l = 1, 2$. Thus, the following expressions are obtained for $\sigma_r(\omega)$ and $\sigma_i(\omega)$:

$$\sigma_r = -\frac{4e^2}{3m}\int_0^\infty \frac{1}{1+(\omega\tau)^2} E\rho\tau\frac{dw}{dE}dE, \qquad \sigma_i = -\frac{4e^2}{3m}\int_0^\infty \frac{\omega\tau}{1+(\omega\tau)^2} E\rho\tau\frac{dw}{dE}dE, \qquad (4)$$

where τ is again given by the expression (2).

Using the expressions presented above, we have calculated the values of $\sigma_{ij}(\omega_c)$, and $\sigma_r(\omega)$ and $\sigma_i(\omega)$ in the range of electron densities from 10^{18} to 10^{22} cm^{-3}, and in the temperature range $5 \cdot 10^3 - 5 \cdot 10^5 K$. Besides, we determined the values of the generalized Holl's constant (in the case of the static magnetic field), HF dielectric permitivity $\epsilon(\omega)$, reflexion coefficient $R(\omega)$ and some other characteristics of fully ionized plasmas as well. For each electron density and temperature, calculations have been performed for ω_c and ω between $0.1\omega_p - 1.5\omega_p$, where ω_p is the plasma frequency.

The obtained results make it possible to study the influence of the plasma's inner conditions over the relaxation time τ as well as the behaviour of the conductivity when the frequency of the external electric field ω approaches the plasma frequency ω_p. Besides, determining values of the reflexion coefficient $R(\omega)$ allowes comparison of the results obtained by this theory with the existing experimental results (Mintsev and Zaporogets, 1989).

References

Adamyan, V.M., Djurić, Z., Ermolaev, A.M., Mihajlov, A.A. and Tkachenko, I.M.: 1994, *J. Phys. D*, **27**, 111–118.

Djurić, Z., Mihajlov, A.A., Nastasyuk, V.A., Popović, M. and Tkachenko, I.M.: 1991, *Phys. Lett. A*, **155** (6,7), 415–418.

Mihajlov, A.A., Ermolaev, A.M., Djurić, Z. and Ignjatović, Lj.: 1993, *J. Phys. D*, **26**, 1041–1047.

Mintsev, V.B., Zaporogets, Yu.B.: 1989, *Contrib. Plasma Phys.*, **29**, 493–501.