Reflectivity of the dense xenon plasma

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The investigation of optical properties of the dense xenon plasma is important for the realization of different technological applications [1-2].

In this work we consider the dense partially ionized xenon plasma consisting of the electrons, ions and atoms. Particle densities are in the range of $n = 10^{20} \div 10^{23}\, cm^{-3}$ and the temperature range is from $2.5\times10^4 K$ up to $5\times10^4 K$.

In work [3] the effective potential of electron–atom interaction, taking into account both quantum-mechanical effect of diffraction and screening effects, is presented. The way to take into account the dynamic screening was proposed in work [4], where the statical Debye radius was replaced by the dynamic one:

$$r_o = r_D (1+\frac{\upsilon^2}{\upsilon_{Th}^2})^{1/2}, \quad (1)$$

here υ is the relative velocity of the colliding particles, υ_{Th} is the thermal velocity of the particles in the system. Then the effective potential of electron-atom interaction with dynamic screening can be rewritten as [5]:

$$\Phi_{ea}^{dyn}(r) = -\frac{e^2\alpha}{2r^4(1-4\lambda_{ea}^2/r_o^2)}\left(e^{-Br}(1+Br)-e^{-Ar}(1+Ar)\right)^2, \quad (2)$$

where $A^2 = \frac{1}{2\lambda_{ea}^2}\left(1+\sqrt{1-4\lambda_{ea}^2/r_o^2}\right)$,

$$B^2 = \frac{1}{2\lambda_{ea}^2}\left(1-\sqrt{1-4\lambda_{ea}^2/r_o^2}\right).$$

In the framework of these pseudopotential models for the particle interactions, the scattering phase shifts were calculated on the basis of the Calogero equation [6].

Phase shifts enable us to calculate the transport scattering cross section $Q_{ea}^T(k)$. The collision frequency of electrons with atoms ν_{ea} can be obtained by the following expression:

$$\nu_{ea} = 4\sqrt{\frac{2}{\pi}}\, n_a \sqrt{\frac{k_B T}{\mu_{ea}}}\int_0^\infty Q_{ea}^T(g)g^3 Exp(-g^2)dg, \quad (3)$$

here $\mu_{ea} = m_e m_a/(m_e+m_a)$ is the reduced mass of the electron-atom pair, g is dimensionless reduced velocity. The results will be compared with earlier results which were based on experiments for the transport cross section [7].

After that the dielectric function due to the electron atom interactions was calculated using the generalized Drude-Lorentz [8] equation:

$$\varepsilon(\omega) = 1-\frac{\omega_p^2}{\omega^2 - i\nu_{ea}\omega}. \quad (4)$$

Howeer, for the total electronic dielectric functions contributions due to electron-ion and electron-electron interactions will also be considered [8,9]. From the dielectric function the reflectivity of the semiclassical electron plasma is calculated, using the Fresnel formula, and is compared with experimental results [10].

References

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