Transport properties of hot dense plasmas

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In this work the transport properties of non-isothermal dense plasmas were studied. Transport processes in dense plasmas were studied on the basis of the effective potentials using the Coulomb logarithm. These potentials take into consideration long-range multi-particle screening effects and short-range quantum-mechanical effects in two-temperature plasmas. The obtained results were compared with the theoretical works of other authors and with the results of MD simulations.

Investigation of transport properties of the dense plasma is a great importance for plasma physics, as well as for the problems of inertial confinement fusion (ICF), warm dense matter driven by heavy ion beams [1]. Experimental investigation of dense nonideal plasmas based on using of a shock wave compression, a high-power laser and an ion accelerator devices [1-2].

In presented work transport properties of hot dense, non-isothermal plasma are considered. One of the important values describing the transport coefficients of deuterium-tritium plasma is the Coulomb logarithm. The Coulomb logarithm is obtained on the basis of effective potentials. These interaction potentials take into consideration long-range many particle screening effects as well as short-range quantum-mechanical effects [3].

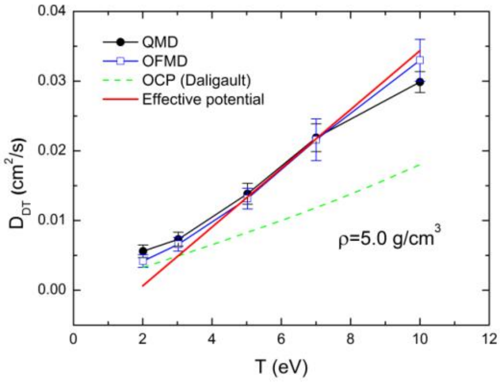
The Coulomb logarithm is determined by the center of mass scattering angle θ_c [4-5]:

$$\lambda_{\alpha\beta} = \frac{1}{b_\perp^2}\int_0^{b_{\max}} \sin^2\left(\frac{\theta_c}{2}\right) b db, \qquad (1)$$

$$\theta_c = \pi - 2b\int_{r^0}^{\infty} \frac{dr}{r^2}\left(1 - \frac{\Phi_{\alpha\beta}(r)}{E_c} - \frac{b^2}{r^2}\right)^{1/2}, \qquad (2)$$

where $E_c = \frac{1}{2} m_{\alpha\beta}\upsilon^2$ is the energy of the center of mass, $m_{\alpha\beta} = m_\alpha m_\beta / (m_\alpha + m_\beta)$ is the reduced mass of the particles of kinds α and β (electron and ion); $b_\perp = Z_\alpha Z_\beta e^2 / (m_{\alpha\beta}\upsilon^2)$, $b_{\min} = \max\{b_\perp, ƛ_{\alpha\beta}\}$ describes the minimum impact parameter, where is $ƛ_{\alpha\beta} = \hbar / \sqrt{2\pi m_{\alpha\beta} k_B T}$ is the thermal de Broglie wavelength.

For inertial confinement fusion applications, we have calculated diffusion and viscosity of deuterium-tritium plasma for density $\rho = 5\, g/cm^3$ and temperatures ranging from 2 to $10\, eV$ using the Coulomb Logarithm based on effective potentials. Fig.1 show a comparison of the calculated data on diffusion and viscosity in a DT plasma with the theoretical results of other authors [6] such as finite-temperature Kohn-Sham density-functional theory molecular dynamics (QMD) and orbital-free molecular dynamics (OFMD).



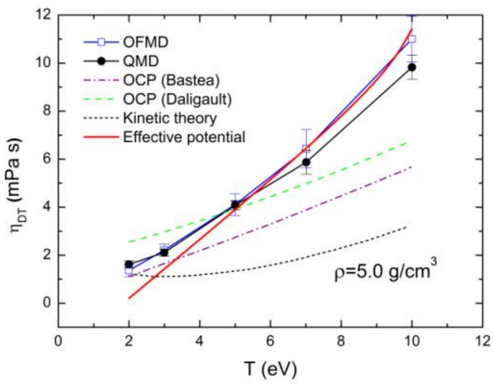


Fig. 1. The diffusion (a) and viscosity (b) coefficients for the DT plasma as function of temperature.

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