Correlation Functions of One-Component Plasmas

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The one-component plasma (OCP) is a model of plasma, in which it is considered as a system of point-like charges, immersed in a uniformly distributed neutralizing background of opposite sign charge. OCP is an object of constant interest in physics of non-ideal plasmas [1, 2].

At investigation of non-ideal plasmas it is necessary to take into account collective effects, especially the screening effect: the Coulomb interaction of chosen two particles is reduced by impact of neighbor charged particles, i.e. plasma medium. The screening radius is the Debye radius, which defined by $r_D = \sqrt{\frac{k_B T}{4\pi e^2 n}}$. Here T is the plasma temperature; k_B is the Boltzmann constant, e is a charge of electron, n stands for particles concentration. So the interaction potential as a function of distance r may be written as follows

$$\varphi_{ee}(r) = \frac{e^2}{r}\ell^{-r/r_D}.$$

This expression represents a pseudopotential. The pseudopotentials (i.e. macropotentials) or effective potentials are particles interaction potentials, depending on medium characteristics (temperature, concentration), i. e. $\Phi = \Phi(\vec{r}, T, n)$. For multicomponent plasmas pseudopotentials could be obtained by solving the Boltzmann-Poisson equations system [3].

The correlation function g(r) determines particle distribution in the system. The correlation functions, i.e. radial distribution functions, are applied for evaluation of plasmas thermodynamic characteristics such as pressure, free energy etc [3]. To estimate them a method of pseudopotentials, hypernetted chain approximation, the Monte-Carlo method etc. are used. By the pseudopotential method two-component plasma (TCP) and partially ionized plasmas (PIP) are explored [3]. By hypernetted chain approach one-component plasma (OCP), TCP and PIP have been examined. The advantage of this approach is concluded in its applicability both to non-degenerate and degenerate systems [4].

In the pseudopotential theory the binary correlation function can be defined by psedopotential [3]

$$g_{ab}(r) = 1 - \frac{\Phi_{ab}(r)}{k_B T}$$

Indexes 'a' and 'b' correspond to interacting particles. Pseudopotentials $\Phi_{ee}(r)$ can be found by direct Furje transform of the Boltzmann-Poisson equation for OCP and then by reverse Furje transform of the equation's solution:

$$\Phi_{ab}(r) = \int \tilde{\Phi}_{ab}(k)\exp(i\mathrm{kr})d\mathrm{k}.$$

Here $\tilde{\Phi}_{ab}(k)$ is the solution of the Boltzmann-Poisson equation for OCP in Furje-space.

In hypernetted chain approach correlation function g(r) is found by a procedure, which in detail is considered in [2].

A purpose of the article is to get the correlation functions of OCP by method of pseudopotentials and by hyper-netted chain approach and to compare results.

References

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