Investigation of the Interaction Potential and Thermodynamic Functions of Dusty Plasma by Measured Correlation Functions

V. E. Fortov, A. V. Gavrikov, O. F. Petrov, I. A. Shakhova, V. S. Vorob'ev

Institute of High Energy Densities, Russian Academy of Sciences, Moscow, Russia

Dusty plasma is a quasi-neutral assembly of ions, electrons, and charged micro-particles. A great deal of effort has been devoted in recent years to study dusty gas-discharge plasma. This fact is primarily associated with the fact that dust particles interacting with one another may form ordered structures similar to liquid or solid. Studying the physical properties of such strongly interacting systems is of interest, on the one hand, from the standpoint of fundamental physics and, on the other hand, for various applications.

Here we report the first results of investigation of the compressibility factor, compressibility, the internal energy of dusty plasma and the interaction potential of dust particles that based on the integral equations approach and experimentally obtained pair correlation functions of ordered dust particles' structures. Also we calculated charge and screening radius of dust particle. It is demonstrated that states of dusty plasma structure cover the range on phase diagram between ideal gas and supercritical fluid. These parameters are presented in Table 1.

Table 1. Main parameters were obtained in this work. $\mathbf{n_d}$ – concentration of dust particles, $\mathbf{P_g}$ - argon pressure in vacuum chamber, $\mathbf{R_d}$ – radius of dust particle, $\mathbf{T_d}$ – temperature of dust component, $\boldsymbol{\lambda_d}$ – screening radius, $\mathbf{Z_d}$ – charge of dust particle, $\boldsymbol{\Gamma}$ – coupling parameter of dusty plasma system $\Gamma = (Ze)^2 n_d^{1/3}/T_d$, $\boldsymbol{\Gamma_1}$ – coupling parameter of dusty plasma system calculated in terms of correlation function $\Gamma_1 = \frac{4\pi n_d}{3T_d}\int_0^\infty W(r)\,g(r)\,r^2\,dr$, $\mathbf{P_d/(n_dT_d)}$ – compressibility factor, $\boldsymbol{\chi_d}$ – isothermal compressibility.

№ п/п	n_d, cm^{-3}	P_g, Pa	R_d, μm	T_d, eV	λ_d, μm	Z_d	Γ	$P_d/(n_dT_d)$	Γ_1	χ_d
1	200	~ 25- 30	1,5 - 5	~ 0.1	87	490	2	1	0.03	1
2	$3\cdot10^4$	20	~ 4	~ 5	500	1320	2.5	8.5	4.6	0.2