Topic number: 7

# SIMULATION OF DUST PARTICLES CHARGING AND INTERPARTICLE DISTANCE FORMATION IN LOW PRESSURE PLASMA

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Dusty plasma crystal is a self-organizing open non-equilibrium system formed by interaction of dusty particles with self-consistent electrical field of plasma. Under concrete conditions such as plasma parameters and particle sizes certain interparticle distance is observed. Dusty plasma crystal has 3D structure. Usually the elementary cell of the crystal has been considered, but not the whole dusty crystal. The elementary cell has a spherical form. Thus we have a symmetry. The unified parameter is radius of surrounding cell concerned with particles concentration $r_0 = (4\pi N/3)^{-1/3}$ (Seitz-Wigner cell).

Numerical simulation of particle charge and potential formation process with the use of molecular dynamics method has been carried out in accordance with interparticle distance. Production of ions due to ionization in the surrounding plasma cell, as well as their initial maxwellian velocity distribution and charge exchange resulted from collisions with neutrals were taken into account. The total number of model ions reached $10^6$, which is close to the number of ions in a typical undisturbed Seitz-Wigner cell. The initial state was specified as unperturbed (the charge and potential are equal to zero). Then the Poisson equation and equations of macroions motion were solved at every time step. The computations were stopped at constant values of charge and potential.

A body of data of potential, charge and potential energy of dusty particles has been obtained for different combination of dimensionless parameters ($a = \frac{r_p}{\lambda_D}$; $r_0^{/} = \frac{r_0}{\lambda_D}$; $l = \frac{\lambda_i}{\lambda_D}$; $\beta = \frac{T_i}{T_e}$, where $r_p$ - particle size, $\lambda_D$ - electronic Debye radius, $\lambda_i$ - free path of an ion, $T_i, T_e$ - ion and electron temperatures). Radial distributions of potential and concentration were studied as well.

Maxima of charge and potential were revealed to be depending on interparticle distance. The maxima are close to minima on the potential energy. This fact can be explained by respective behavior of the ionic current to particle. At small interparticle distances ions born by ionization move rapidly to the particle and produce large current. The ionic current drops with increasing of interparticle distance and, therefore, ions path. At larger distances the ionic current increases slightly again, because another effect of ionization weakens – lack of drift velocity corresponding to potential of a produced ion. Since charge of a particle governs electric field strength on its surface and stretching electrostatic force density, the location of maximum on the charge dependence determines steady interparticle distance.

The locations of charge maxima are close to minima of potential energy which correspond to the equilibrium state of a system in absence of interaction with external fields and constancy of the charge. These conditions do not hold strictly in dusty plasmas. Taking into account thermal energies at $\frac{T_i}{T_e} = 0.01$ the values of calculated Seitz-Wigner cell radius corresponding to 0.95 of the charge maximum location are presented in the figure 1. These data are in good agreement with experiment of various research groups [1 - 7].

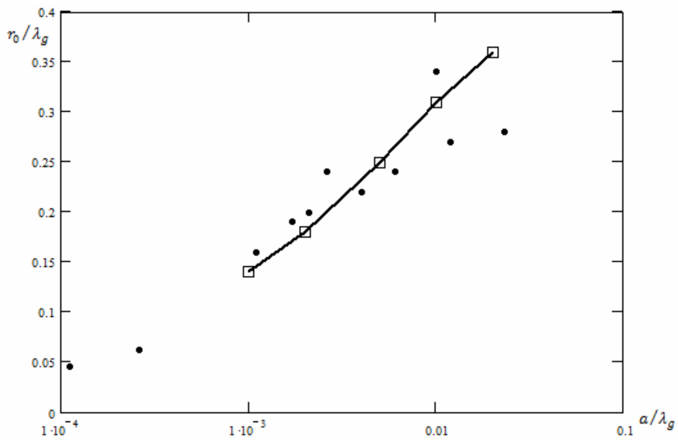


Fig. 1: Cell radius as a function of particle size (solid line – simulation; dots - experiments)

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