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3D Molecular Dynamics Simulation of Dust Charge Dynamics in a Coulomb Screened Plasmas

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When dust particles are added to an equilibrium plasma system, the electron flux and ion flux reaches the surface of the dust particles. At steady state, electron and ion fluxes balance each other and net charge on the dust particles is typically negative. Such Plasmas are known as Complex Plasmas. However, depending upon the density of the dust particles in a plasma medium, the average charge on the dust grains can vary.

The two parameters, which characterize the dynamics of dust grains are "Coulomb screening length", λ_c and "Debye screening length", λ_d [1]. In the low grain density limit, in which, $\lambda_c > \lambda_d$, the "Debye spheres'' of the individual dust grains remain isolated from the "Debye spheres'' of the nearby dust grains. In such case, the system is in usual Debye regime and all the grains have nearly the same mean charge. For example, in this regime, it is well known from fluid theory [2] that the mean charge of a dust grain is of the order 2.51 KT_e/e (K is the Boltzman Constant) for a Hydrogen plasma. In the high grain density limit, in which, $\lambda_d > \lambda c$, the "Debye spheres'' of the dust grains tend to overlap with each other. In such case, the system is found to be in Coulomb regime wherein a "charge reduction" and "charge distribution'' of the dust grains can take place depending on the grain location. We can further combine λ_c and λ_d to a single variable and the variable combining λ_c and λ_d is called Havnes parameter. The Havnes parameter is define as, $H = (\lambda_d / \lambda_c)^2$. When, H<1, the system is in "Debye regime" and when H>1, the system is in "Coulomb regime".

In our present work, with the help of 3D Molecular Dynamics (MD) simulation, we have investigated the system in both Debye and Coulomb regimes [3]. The average charge value that is obtained from the simulation for particular values of λ_d and λ_c , is in good agreement with the fluid theory [2]. Various novel results have been generated for various values of parameter H, including charge distribution and charge reduction across grains, details of such results will be presented, along with discussion of possible application to nano-dusty plasmas [3].

When the system is in extreme "Debye regime" or in other words, H << 1, then the average charge should be 2.51 KT_e/e. Considering $\lambda_d = 1$ and $\lambda_c = 10$, the average charge variation with time obtained from our 3D MD simulation code MPMD-3D [4] (an extension of MPMD-2D code [5]) is shown in Fig.1.

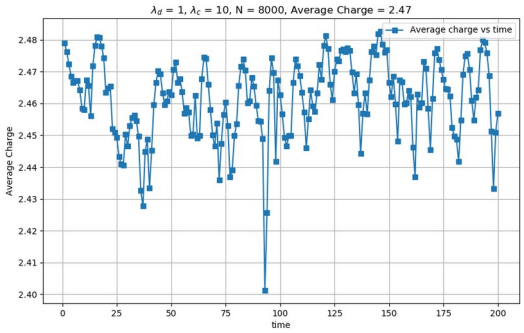

Figure 1: Variation of average charge with time is shown. The mean value is around 2.47. The charge, according to fluid theory is 2.50. The deviation in the charge value calculated by MD simulation is 1.2 %.

References

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