POTENTIAL AROUND A DUST GRAIN IN DUSTY PLASMAS

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ABSTRACT

Using the results of the kinetic theory of dusty plasmas developed by V.N. Tsytovich and U. de Angelis, we evaluate numerically the potential around a dust grain. The potential is evaluated using self-consistently the numerical solutions of the kinetic equations of dusty plasmas and it is compared with the analytical approximations obtained previously.

Dusty plasmas are often described using the theory of multicomponent plasmas, the dust particles with a fixed charge eZ_d (e<0) being a massive plasma component. In this case, the main differences with the results of other three-component plasmas arise from the large (sometimes infinite) dust to ion mass ratio and from the possible high values of Z_d, which can introduce nonlinearities and strong coupling.
A kinetic theory has been introduced [1-3], which takes into account another distinctive feature of these systems: the dust particles must absorb plasma particles (electrons and ions) at all times to maintain their charge and, therefore, a plasma source must be present to replace the absorbed particles. The collisions between plasma particles and dust are an essential feature of the kinetic model.
The charging collisions alter the dust charge, which is in principle different on each dust particles, depending on the local plasma conditions and fluctuations. The problem has been treated introducing the grain charge q as a phase space variable and the self-consistent kinetic equations for the dust distribution $f_d(\mathbf{r},\mathbf{p},q,t)$ and for the plasma particles distributions $f_\alpha(\mathbf{r},\mathbf{p},t)$ have been deduced [1].
Two consequences of the kinetic equations have been investigated.
First, the continuous absorption of plasma particles on the dust and the properties of the plasma source cause changes in the plasma distribution functions. In [4], the time evolution of the plasma distributions (electrons and ions) is found solving numerically the equations of the kinetic theory of dusty plasmas and the role and importance of the plasma source and particle diffusion are investigated.
Second, the dust charge fluctuations and plasma absorption modify the space charge around dust particles and one might expect deviations from the usual Debye screening. In [3], simplified analytical expressions were derived for the forces between two dust particles. In [4] the solutions of the kinetic equations were used to calculate the static screening of a dust particle in the Fourier space, and the difference with the usual result (Debye screening) of a three-component plasma was shown for different parameter regimes.
In the present work, the numerical potentials around a dust grain found in [4] are Fourier transformed numerically in the real space. The potentials are studied for different parameter regimes and the numerical potentials obtained are compared to the analytical expression found in [3].

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