Polarization of "Dust Quasi-Atoms" in an External Electric Field

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Micron-sized dust particles immersed into low-temperature low-density plasma acquire a large negative charge, $eZ_d \sim 10^3$-$10^5 e$. Around the dust particles an ion cloud is formed [1-3], which consists of trapped and free ions. The system of the dust particles and the ion cloud can be regarded as "a dust quasi-atom".

In the paper, the ions movement in the field of dust particles and in an external electric field and their charge exchange collisions with neutral atoms are simulated by Monte Carlo method that permits us to obtain ion density distribution in the cloud. It is shown that in the external electric field the ion cloud around the dust particle becomes asymmetric, i.e. it is polarized and acquires a very large dipole moment; see [3-4]. It is found that for small reduced electric fields ($\hat{E}=eE_z\lambda_i/kT_i<<1$) the coefficient of polarizability $\alpha(\hat{E})$ is independent of the reduced electric charge of the dust particle $Q = eZ_d/\lambda_i kT_i$, and proportional to the cube of ion Debye length, $\lambda_i=(kT_i/4\pi e^2 n_0)^{1/2}$, i.e. $\alpha(\hat{E}\rightarrow 0) \approx A(l_i)\lambda_i^3$. The coefficient of proportionality $A(l_i)$ is almost independent of the mean free path length of ions l_i for $l_i>\lambda_i$. In this case $A(l_i) \approx 3$. However, the coefficient of polarizability decreases with the decrease of the ion mean free path length for $l_i<\lambda_i$. For $\hat{E} > 0.1$, the coefficient $\alpha(\hat{E})$ also begins to decrease with the increase of a reduced electric field, $\alpha(\hat{E}) \sim \hat{E}^{-\beta}$ with $\beta \approx 0.5$-0.66. The decrease of the coefficient of polarizability $\alpha(\hat{E})$ is connected with the field ionization of "dust quasi-atoms" [3].

The induced dipole moment of "dust quasi-atoms" influences inter-particles interaction and can be responsible for the formation of dust structures in complex plasmas.

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