§20. Characteristics of the Dust Plasma Near the Electric Thruster of the Spacecraft

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The presence of particulate contaminants in etching, sputtering and deposition processors remains a major problem in engineering and space plasmas. Particulates such as $BaTiO_3$ are used as the insulating material of the cathode or the insulator of the electrode in plasma engines[1-2]. Since $BaTiO_3$ is generally negatively-charged due to the adhesion of the faster moving electrons than the positive ions, we assume it as the dust grains. These phenomena can have the appearance of clouds associated with particulates suspended above or near the wall of the plasma engine of the spacecraft. We assume that the plasma components are electrons, positive ions, secondary electrons, photoelectrons and dust grains. A sheath with electron emission from the wall has been considered in a plasma with negatively-charged dust grains[3-5]. However not many theoretical works on the effects of the sheath structure and the time-dependent grain charge have been done in plasmas near the electric thrusters of the spacecraft. We investigate the effects of the negatively-charged dust grains to understand the behaviour of the sheath including dust grains emitted from the cathode or the insulator of the electrode in the electric thruster.

We perform numerical calculation based on the continuity, momentum transfer and Poisson's equations, and show the results as follows. We illustrate the space charge density ρ and the electric field E in the sheath in Fig.1 and 2, respectively. The parameters presented here are $\varphi_w=e\Phi_w/T_e=-20$, $Z=500$, $T_i/T_e=0.1$, $T_d/T_e=0.01$, $I_s/I_e=0.5$, $T_e=2eV$ and $n_{e0}=10^{16}m^{-3}$ for $n_{i0}/n_{e0}=10$(solid line), 100(dotted line) and 500(solid and dotted line), respectively.

If we don't consider the dust grains and secondary electrons, we cannot find the modification of the sheath structure. These effects give rise to the remarkable change of the profiles of the potential, the space charge density and the electric field. We understand that the time constant of the grain charge becomes long and the charge number increases due to the ion temperature. As a problem, the presence of the strong sheath bends the orbit of the exhaust gas composed of the plasma ions, and consequently decreases the velocity of the spacecraft. We show that the results may be applicable to the control of the sheath by modifying the potential of the wall and selecting the materials of the cathode or the insulator of the electrode of the electric thrusters. This is closely connected with the problems of the electric damage of the satellites or spacecrafts.

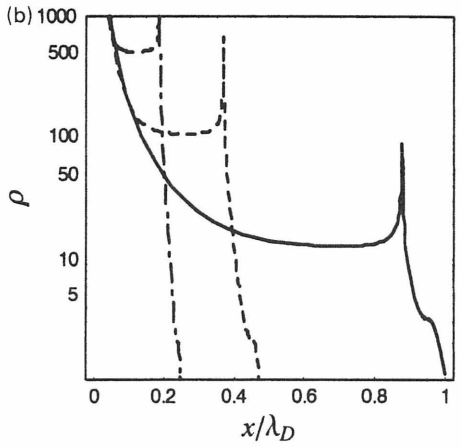

Fig.1 Space charge density in the sheath near the wall of the spacecraft.

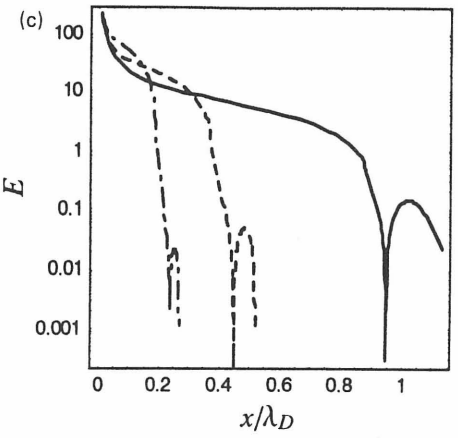

Fig.2 Electric field in the sheath near the wall of the spacecraft.

References

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