§12. Grain Dynamics and Structure Formation of the Dust Plasma

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The dust particles (grains) in a plasma are found in planetary plasmas and play an important role in the formation of the structure, e.g., the rotating radial spokes of the Saturn's rings. Recently, they also become important and interesting in various plasma processing. In this study, we are investigating the dynamics of such dust particles as well as the charging processes and the structure formation in plasmas such as the crystallization. Our final goal is to clarify the physical mechanism of the ordered structure formation from the viewpoint of the "Self-organization".

The grains are usually charged negative because electrons of the dust plasma attach to the grains more frequently than ions. When the secondary electron emission effect from the grains is taken into account, Meyer-Vernet pointed out that the electric potential of dust grains can change from negative to positive or positive to negative in the way of "flip-flop" [1]. His theory, however, is a static one and its time scale under the Saturn's plasma parameters, for example, is of the order of the $10^{6\sim9}$ times of the inverse of the background plasma frequency. In order to clarify the physical mechanism of the structure formation, it is necessary to develop a dynamic model of the charging process of the grains and its self-consistent effect on the background plasma.

For the dynamic model of the charging process, we have made the following assumptions.
1) the attachment of electrons and ions occur in Poisson process.
2) the secondary electron emission can occur when the electron kinetic energy is larger than a certain critical value.
3) the production rate of the secondary electron is proportional to $E\exp(-\sqrt{E})$, where E is the kinetic energy of the colliding electron.

Shown in Figure 1 and 2 are the simulation results of the temporal charging process of the single grain when the secondary electron emission is neglected, and taken into account, respectively. It is clearly indicated in Fig. 1 that the grain is negatively and monotonously charged up to -18000e in the time-scale of 10^7 without the secondary emission effect. In contrast with above case, Fig. 2 shows that when the secondary emission effect is considered the charge of the grain changes suddenly ("flip-flp") from -180e to +93e at a few time-points.

Now, we are developing a new three-dimensional particle code including grains whose charging process is taken into account.

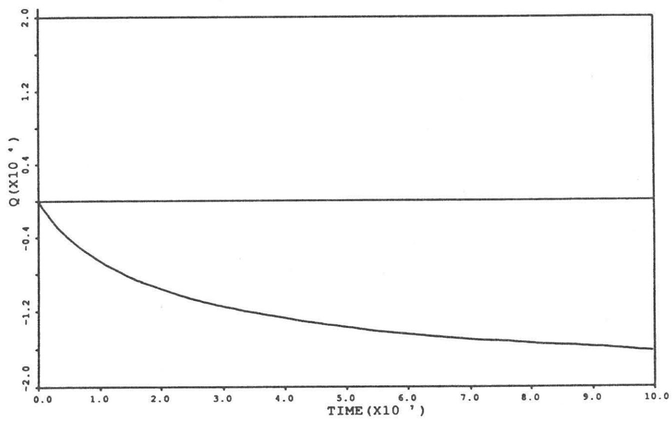

Fig.1. The temporal charging process of the grains when the secondary electron emission effect is neglected.

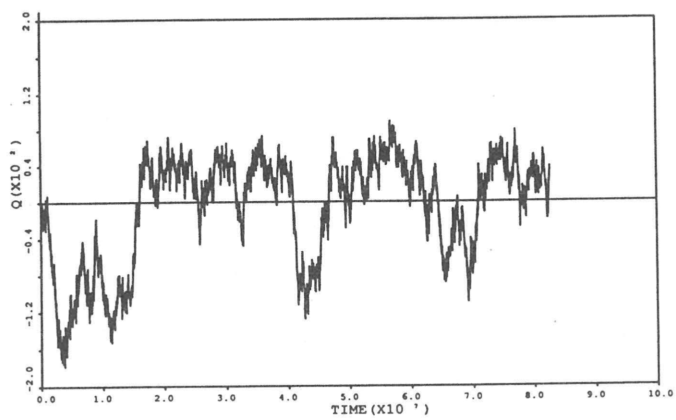

Fig.2. The temporal charging process of the grains when the secondary electron emis sion effect is taken into account.

References

1) N. Meyer-Vernet, Astron. Astrophys, 105, (1982) 98.