§17. Role of Generated Pulses in Particle Ejection Associated with Local Production of Negative Ions

Ishiguro, S., Oohara, W., Hatakeyama, R., Sato, N.
(Grad. School Eng., Tohoku Univ.)

We have investigated plasma dynamics associated with local production of negative ions by a Q-machine experiment and a numerical simulation[1].

A computer simulation has been performed by means of a one-dimensional electrostatic particle code based on a Q-machine configuration. Electrons and positive ions are emitted from a grounded plasma emitter placed at one end of the system, and a floated electrode as a plasma terminator is placed at the other end. After the plasma becomes a stationary state, negative ions start to be produced in a localized region of the plasma in such a way that some of electrons attached to huge neutral particles are replaced by negative ions as conserving a total momentum.

Figure 1 shows typical plasma distribution stationary (a) or quasistationary (b) state, which are on the potential profile ϕ (top) and the phase spaces of negative (middle) and positive (bottom) ions. Here, v_{the} is the electron thermal velocity at the plasma source and the ϕ profile is averaged over twice of the electron plasma period defined at the plasma source. For a small rate of negative ion production ($\eta = \eta_1$), a small negative potential dip is formed at $z/\lambda_{Ds} \sim 130$ since the produced negative ions are not completely shielded by the positive ions. The potential dip is almost stationary in time and its depth is about $e\Delta\phi/T_{es} \sim 0.1$. Negative ions with low kinetic energy are trapped between the dip and a sheath formed in front of the plasma terminator, and stay for a long time in the region. For a large rate of negative ion production ($\eta = \eta_2$), solitary pulses with negative potential are found in the region. The solitary pulses are intermittently generated as long as negative ions are produced. The generation period of the solitary pulse depends on the negative ion production rate.

Here, let us investigate a staying time of negative ions in the system and the role of the solitary pulse[2]. Two different states on macroscopic plasma structure are realized in the open system that negative ions are produced in a localized region of a plasma and are ejected from the plasma. One is that the produced negative ions stay for a long time in the system and are calmly ejected. The other is that the solitary pulses are generated and negative ions are rapidly ejected. Figure 2 shows the staying time τ_{st} distributions of negative ions $f_{-}(\tau_{st})$ in the stable state ($\eta = \eta_1$, top) and in the unstable state ($\eta = \eta_2$, bottom). The ordinate is normalized by the number of negative ions in the system, and τ_{st} is defined to be zero at the moment when negative ions are produced. Negative ions stay for a long time and are calmly ejected from the system in the stable state. It is to be noted that the averaged staying time of negative ions in the unstable state is much shorter than in the stable state. This is consistent with the rapid ejection of negative ions from the system due to the solitary pulses. The solitary pulses play a role in making negative ions ejected rapidly from the system.

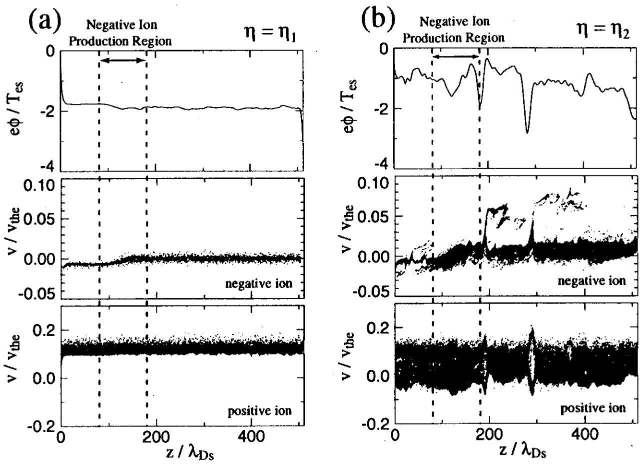

Fig. 1. Potential profile (top) and phase space distributions of negative (middle) and positive (bottom) ions with $\eta = \eta_1$ (a) and η_2 (b).

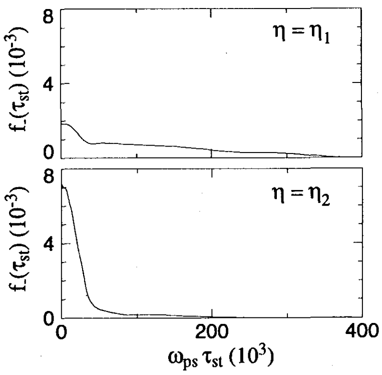

Fig. 2. Staying time distributions of negative ions in a stable state with $\eta = \eta_1$ (top) and in an unstable state with $\eta = \eta_2$ (bottom).

References

1) Oohara, W. *et al.*, in *Double Layers - Potential Formation and Related Nonlinear Phenomena in Plasmas* edited by Sendai "Plasma Forum" (World Scientific, Singapore, 1997) p. 149.

2) Oohara, W. *et al.*, in *Proceedings of 1998 International Congress on Plasma Physics & 25th EPS Conference on Controlled Fusion and Plasma Physics, Praha, 1998*, Vol. 22C, p.127.