§36. Dynamic Structure Formation Due to Local Production of Massive Negative Ions

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We have investigated plasma dynamics associated with local production of negative ions by a Q-machine experiment and a numerical simulation[1]. When fullerene C_{60} particles are introduced in a localized region of an alkali plasma flow, massive negative ions C_{60}^- are produced as a result of electron attachment[2]. Figure 1 shows a typical time-averaged density profile of negative ions, which is experimentally measured downstream from the production region and described on a two-dimensional $(r-z)$ plane. The density on the axis decreases in the downstream direction, while negative ions radially diffuse from a core region ($|r| < 2$ cm) to a periphery region ($|r| > 2$ cm), being localized in the periphery region. A drift-wave instability associated with negative ions is observed around the high density region in the periphery region, which has a mode number $m = 1$, a node number $n = 1/2$, frequency $f \simeq 500$ Hz and propagates in the diamagnetic direction of positive ions.

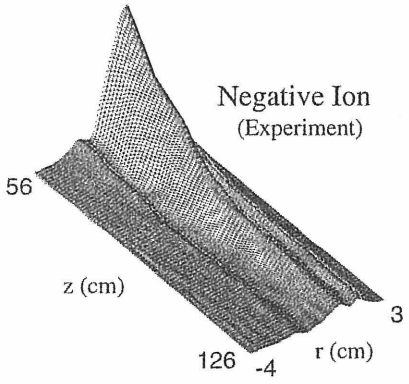

Fig. 1. Time-averaged density profile in Q-machine experiment.

To elucidate this mechanism of the localization in the periphery region, a computer simulation has been performed by means of a 3D electrostatic PIC code which is based on the Q-machine configuration. Massive negative ions are locally produced in $80 \leq z/\lambda_{Ds} \leq 130$, and the measurement region in the experiment corresponds to $z/\lambda_{Ds} > 130$. Typical averaged density profiles of negative and positive ions are shown in Fig. 2 (top and bottom), which is obtained in the simulation. A drift wave associated with negative ions is easily destabilized, which has $n = 1/2$ between the production region and the plasma terminator, and $m = 2$ (depending on magnetic field). An isosurface of the negative ion density has a helical structure, rotating in the diamagnetic direction of positive ions with a period of about $8000\omega_{pe}^{-1}$. The averaged density of negative ions is high in a region where the drift-wave amplitude is large. The localization of negative ions in the periphery region is connected with the drift wave propageation.

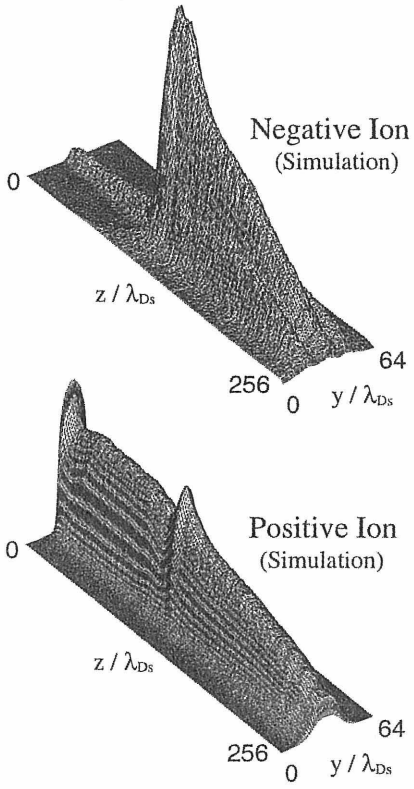

Fig. 2. Time-averaged density profiles in particle simulation.

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