§ 20. Study on Electric Field and Density Transition Phenomena in Magnetized Plasma

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In NIFS, transport barrier and its formation mechanism have been actively investigated, and advancing these understandings is crucial in the future nuclear fusion studies. Plasma rotation driven by so-called $\boldsymbol{E} \times \boldsymbol{B}$ drift has been also studied in relation to improvement of the magnetic confinement. Therefore, investigations of the characteristics of the electric field and its effect on transition phenomena are very important.

Here, we studied the density transition phenomena[1,2] along with plasma rotation and density profile modification,[1,3-5] using ten concentric circular rings as biased electrodes. Argon plasma at a pressure P of 0.1 - 10 mTorr in the cylindrical chamber, 45 cm in diameter and 170 cm in axial length, was produced by a RF wave of 7 MHz using a spiral antenna. Plasma parameters were measured by a developed 24 ch. Langmuir probe and a 3D scanning probe,[6] and the plasma flow by the Mach probe (directional probe). Data were stored with a data logger. Using this system, detailed spatio-temporal behavior was investigated. Typical plasma density n_e and electron temperature were 4×10^9 - 4×10^{10} cm^{-3}, 3 - 6 eV, respectively.

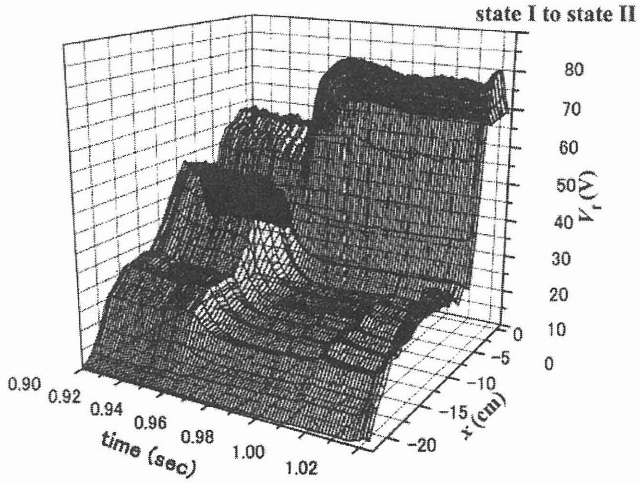

Fig. 1 Time evolution of radial profile of floating potential

Changing biased voltage, fill pressure and biased position, global structural changes of plasma parameters such as plasma density, floating potential and azimuthal plasma rotation were investigated. Applying a bias voltage, repeated transitions phenomena with abrupt reductions and jumps of the electron density were observed (flip-flop pattern in bistable system). With the increase in the bias voltage, possibilities to possess one state (state II, lower density) compared to the other state (state I, higher density) increased. These global, self-excited, density transitions and back ones between two states were accompanied by changes of the floating potential (see Fig. 1) and rotation profiles and the bias current under various parameters.

Transition time was measured as to ion saturation current and floating potential, which were dependent on the spatial position. As shown in Fig. 2 (Lissajous figure), bias current changed faster than ion saturation current, and ion saturation current changed faster than floating potential (not shown) in the bulk plasma region. On the other hand, ion saturation current near the electrode changed very fast (comparable to bias current change of ~ 15 μs), while floating potential near the electrode changed slowly with a time scale of several ms. Floating potential profile showed that near the electrode electron can be trapped easier in the state I compared to that in the state II.

Hysteresis characters such as average staying time and staying probability, changing bias voltage, were also found, and it suggests the fine structure from the analysis of probability distribution function of ion saturation current.

In conclusion, we have investigated the detailed characteristics of density transitions (bistable sytstem) in a wide range of operational parameters. These understandings will be expected to contribute to the plasma confinement and stability control.

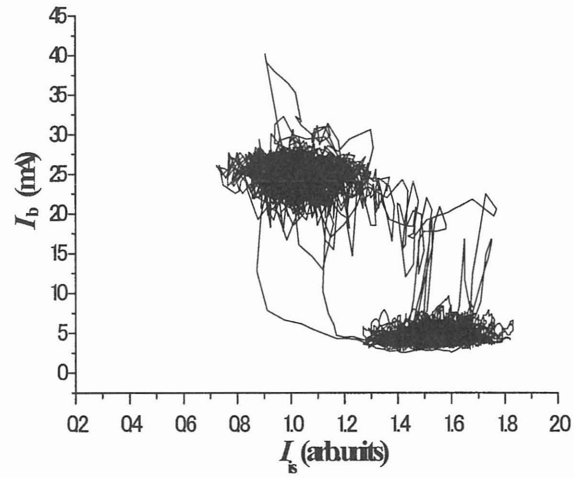

Fig. 2 Lissajous figure between bias voltage and ion saturation current (counter clockwise rotation)

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