§23. Study on Control of Plasma Rotation and Associated Instabilities

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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 to enhance the magnetic confinement. Therefore, the investigation of the characteristics of the electric field and its effect on the plasma rotation and instabilities are very important.

Here, we report the control of plasma rotation in a supersonic regime [1,2], associated with low frequency oscillations, 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 [3,4]. Plasma parameters were measured by Langmuir probes, and the plasma flow by the Mach probe (directional probe). Typical plasma density and electron temperature were 4×10^{10} - 2×10^{11} cm^{-3}, 3 - 8 eV, respectively.

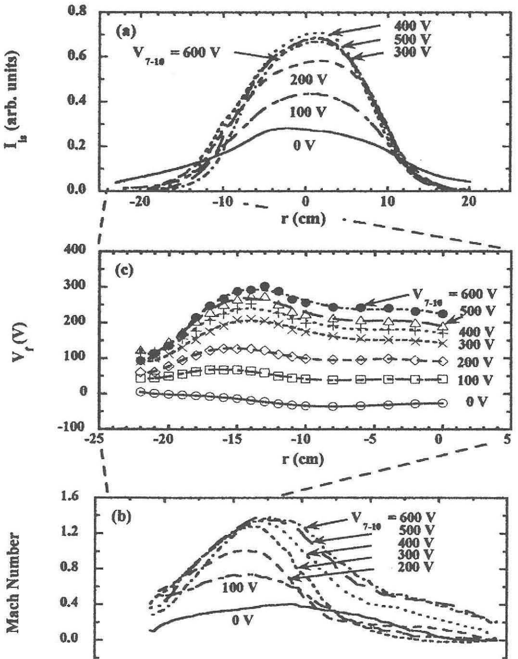

Fig. 1 Radial profiles of a) ion saturation current, b) floating potential and c) Mach number, changing biased voltage.

Changing biased voltage V_b, biased position and magnetic field configuration, various radial profiles of plasma density, floating potential V_f, and azimuthal and radial flow velocities were measured, in addition to the observation of associated instabilities. With a positive voltage biasing to the inner (outer) region of the electrodes, a hollow (peaked) density profile was obtained. Control of the enhanced plasma flow as well as localized strong shear flow could be demonstrated. Figure 1 shows radial profiles of the ion saturation current I_{is}, V_f and Mach number M (azimuthal rotation velocity normalized by the ion sound velocity). It is shown that a strong velocity shear near the edge region was observed in a supersonic regime ($M < 1.4$), and the saturation of these profiles was found with V_b above 300 V.

Furthermore, we have found a density transition between two stable states under certain conditions, with hysteresis characteristics, changing V_b. As shown in Fig. 2, with the increase in V_b, staying probability in the lower state increased in this bistable transition system. Time evolution of potential and density profiles, staying time and staying probability were also measured, changing P, V_b, and biased position.

In conclusion, we have demonstrated a strong velocity shear in a supersonic regime by voltage biasing, and found a density transition between two stable states.

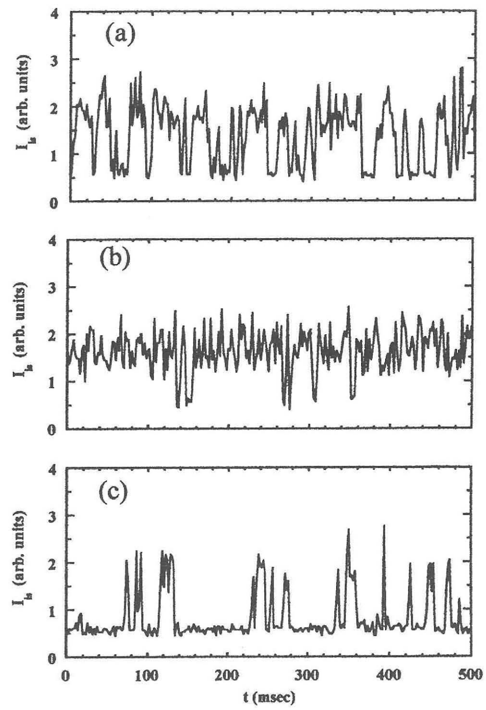

Fig. 2 Time evolution of ion saturation current with biased voltage = (a) 160 V, (b) 180 V and (c) 200 V.

Reference

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