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

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Transport barrier and its formation mechanism have been actively investigated in NIFS, 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, which is related to the plasma profiles. Controlling the density profile is very important in magnetic confinement devices and plasma sources in the various plasma application field. However, there have been few experiments to demonstrate a large change of density profile as well as to change the plasma rotation from a basic viewpoint [1,2].

Here, we report the control of plasma rotation and density profile, associated with low frequency instabilities, using ten concentric circular rings as biased electrodes [2] under the three magnetic field configurations: straight field (case A, magnetic field was typically 500 G), good (case B) and bad (case C, mirror field) curvatures. Argon plasma at a pressure of 0.1 - 0.2 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 [1,2]. Plasma parameters were measured by Langmuir probes and the plasma flow by the Mach probe (directional probe). Typical plasma density and electron temperature were ~ 10^{10} cm^{-3}, 3 - 5 eV, respectively.

Plasma density profile could be controlled by a proper choice of biased electrodes; with a positive voltage biasing to the inner (outer) region of the electrodes, a hollow (peaked) profile was obtained. This was enhanced with an increase in the biased voltage up to 300 V. The azimuthal plasma rotation more than Mach number 1 could also be controlled under the various conditions: biased voltage, position of the electrode, magnetic field configuration (see Fig. 1). Here, the biased electrode was numbered from the center to the outwards, and a high velocity shear, in other words, a large change of vorticity including a polarity, was realized and the shear flow region could also be changed.

As for the instabilities, typical fundamental frequency of 3 - 4 kHz (electron diamagnetic direction), which was opposite to the edge plasma rotation, was observed and identified as a drift wave type from the following findings: azimuthal mode number was 1, parallel and perpendicular (radial) wavenumbers were very small, potential fluctuation lagged density one by 30 - 50 degrees, relative fluctuation of potential was smaller than that of density one, and a drift wave frequency estimated from the steepest density region (a small plasma rotation region), was nearly the same as the observed frequency.

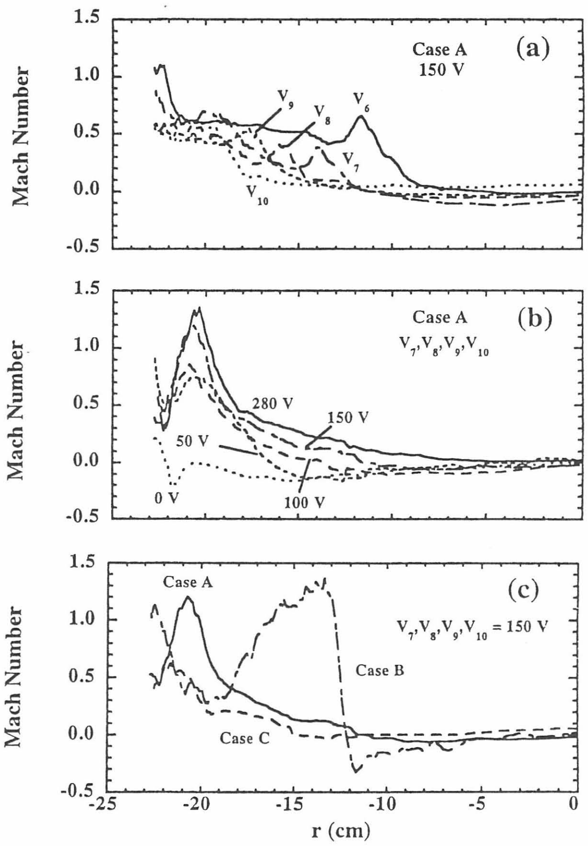

Fig. 1. Radial profiles of Mach number M, changing (a) position of biased electrode, (b) biased voltage V_b and (c) magnetic field configurations.

Reference
[1] S. Shinohara, H. Tsuji, T. Yoshinaka and Y. Kawai, Surf. Coat. Technol. **112**, (1999) 20.
[2] S. Shinohara, N. Matsuoka and Y. Yoshinaka, Jpn. J. Appl. Phys. **38**, (1999) 4321.