§13. Plasma Rotation at a Peripheral Region of the Central Cell in GAMMA10

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Recently, a plasma flow has been recognized to play an important role in magnetically confined plasma, especially in open magnetic systems. The relation between radial electric field and azimuthal plasma rotation should be investigated for the confinement study in high power ICRF heating. Various diagnostics have been utilized for the observation of rotational behavior in central cell in GAMMA10. A Mach probe is one of simple and costless diagnostic tools for plasma flow field. We can measure ion Mach number M_i in a peripheral region and an end-cell region in linear devices by using a Mach probe, though it could not be inserted in a hot and dense plasma core region.

The purpose of this research is to measure an azimuthal plasma flow by using an Mach probe in the peripheral region of GAMMA10 and to clarify the effect of radial electric field on the E×B drift and diamagnetic drift in the high power ICRF regime.

A Mach probe shown in Fig.1 was set at 1.2m apart from the center of GAMMA10 and moved radially in the peripheral region. It has three probe tips combining a para-perp and up-down type Mach probes.[1)-3)] Ion Mach number was derived from the following equation,

$$M_i = \frac{U}{C_s} = U \Bigg/ \sqrt{\frac{k_B(\gamma_e T_i + \gamma_i T_e)}{m_i}} = M_c \ln \frac{J_{up}}{J_{down}} \qquad (1)$$

Here, U and C_s, are plasma flow velocity and ion acoustic velocity, respectively. T_e and T_i are electron and ion temperatures, γ_e and γ_i are the specific heat ratios for electrons and ions, respectively, and m_i is ion mass.

We have measured Mach number of the plasma flow at r=20cm.[4),5)] Figure 2 shows typical waveforms of ion saturation current densities, J_{up} and J_{down}, and calcurated Mach number in high T_i mode operation in GAMMA10. As an ion temperature was higher than 100eVand an ion Larmour radius was much larger than the probe tip one, the formula of Eq.(1) for non-magnetized plasma can be used. Using the ratio of T_i/T_e = 10, the linear constant M_c in Eq.(1) was assumed to be 0.33.

Plasma flow was observed in the direction to the end cell with the Mach number of 0.4-0.6. When ECH power was applied during the ICRF heating, both of J_{up} and J_{down} increased due to electron heating. However, the Mach number decreased to 0.3-0.4. The decrease was caused not by the decrease of plasma flow velocity but by the change of flow direction.

By rotating the Mach probe we obtained dependence of the current density J_{up} on the angle between collecting tip surface and direction of axial magnetic field. The angle of the maximum is about 60deg, that is, the plasma flow consists of an azimuthal rotation and an axial flow and forms a helically winding flow. The direction of an azimuthal flow corresponded to that of E×B drift.

We should investigate a driving force of the axial plasma flow and the effect of the flow to the plasma confinement in GAMMA10. The effect of high-power RF heating on the plasma flow and the formation of radial electric field in the plasma should be pursued further.

[1] Ando, A., et al., Contributions to Plasma Phys., **46**, (2006) 335.
[2] Ando, A., et al., J. Plasma and Fusion Research, **81**, (2005) 451.
[3] Ando, A., et al., Thin Solid Films, **506-507C**, (2006) 692.
[4] Nemoto, K., et al., Trans. of Fusion Science and Tech., **51**, (2007) 223.
[5] Ando, A., et al., *ibid,* **51**, (2007) 217.

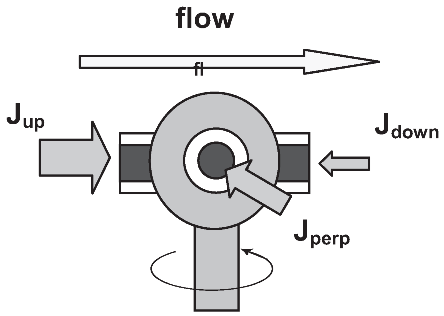

Fig.1 Schematic of Mach probe. The probe tips are separated 1.2cm to each other.

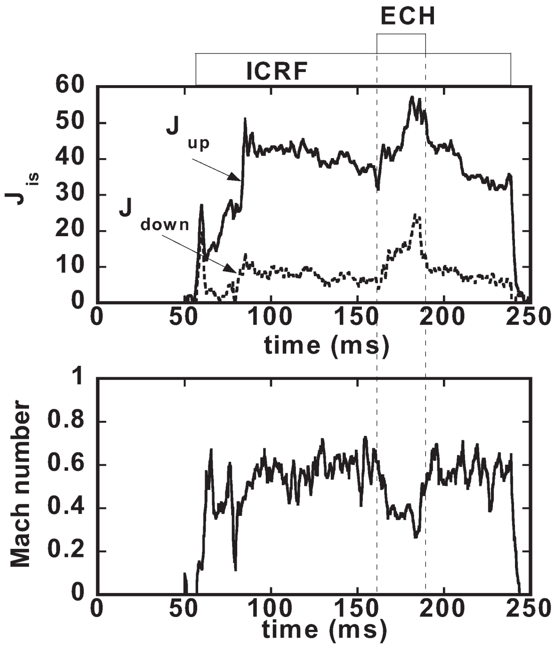

Fig. 2 Ion saturation currents J_{up} and J_{down}、by the Mach probe located at the peripheral region (r=20cm). The tip of J_{up} faces to the center of GAMMA10. (RF1: 100kW, 10.3+9.9MHz, RF2: 100kW, 6.36MHz).