§15. Plasma Rotation at a Peripheral Region of the Central Cell in GAMMA 10

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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 obtain 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. M_i is represented as a ratio of ion flow velocity U_p to ion acoustic velocity C_s,

$$M_i = \frac{U_p}{C_s} = \frac{U_p}{\sqrt{(\gamma_e T_e + \gamma_i T_i)/m_i}} , \quad (1)$$

where T_e and T_i are electron and ion temperatures, respectively, and m_i is ion mass. γ_e and γ_i are the specific heat ratios for electrons and ions, respectively. The purpose of this research is to measure an azimuthal plasma flow by using an Mach probe in the peripheral region and to clarify the effect of radial electric field on the E×B drift and diamagnetic drift in the high power ICRF regime.

Calibration experiments were carried out in the HITOP device of Tohoku University.[1) - 3)] It consists of a large cylindrical vacuum chamber (diameter D = 0.8m, length L = 3.3m) and a high power, quasi-steady MPDA was installed at one end-port as a source of a fast-flowing plasma. A directional Langmuir probe (DLP) was used to measure dependence of an ion saturation current on the angle θ between a plasma flow and the normal to a plane probe surface by rotating the probe around its axis. The obtained data showed good agreement with the Hutchinson's PIC simulation results, and the calibration factor M_c was derived in various T_i / T_e.

Figure 1 shows the schematic of GAMMA10 and axial magnetic field strength. A Mach probe was set at 1.2m apart from the center of the device and moved radially in the peripheral region, as illustrated in the figure. We have measured Mach number of the plasma flow at r=20cm.[4),5)] An ICRF heating was applied with an input power of 190kW. By rotating the Mach probe we obtained dependence of the Mach number on the angle between collecting tip surface and direction of axial magnetic field, as shown in Fig.2. The angle of maximum Mach number is not 90 deg, which corresponds to pure azimuthal rotation. These data show clearly that 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. Maximum value of the Mach number reached 0.4 and the flow was subsonic. This value was lower than the Mach number of 2 in the end cell region.[5)] Considering the ion temperature of nearly 400eV by ICRF heating, the plasma flow velocity was almost 100km/s. The pitch angle of the flow increased with the increase of RF input power.

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.

References
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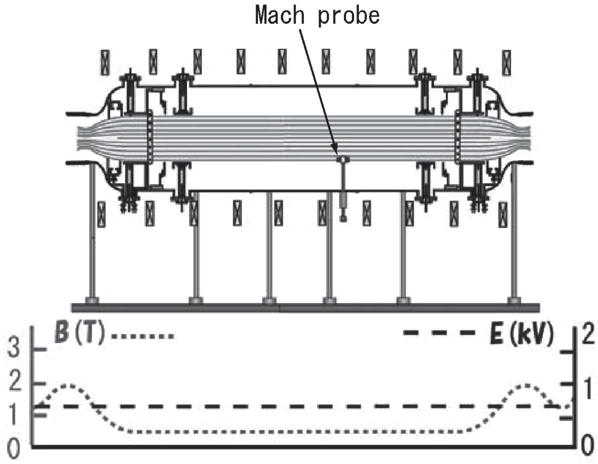

Fig.1 Schematic of GAMMA10 and position of the Mach probe.

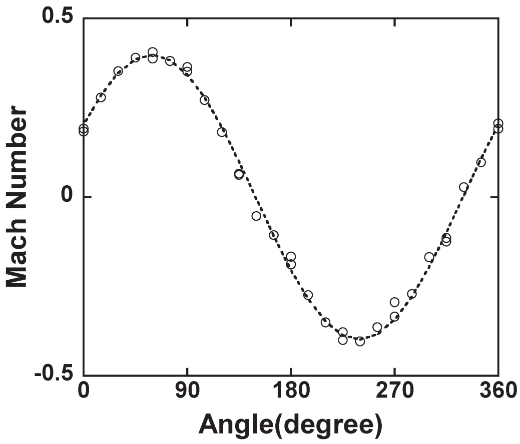

Fig.2 Dependence of Mach number on the inclined angle between collecting tip surface and axial bagnetic field.