§2. Plasma Flow Measurement at Peripheral Region with ICRF Heating in GAMMA10

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Recently, a plasma flow has been recognized to play an important role in magnetically confined plasmas, 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.

We have measured ion Mach number M_{i} and flow direction at the peripheral region of the confined plasma in GAMMA10 by using a 4-tip type Mach probe with high power ICRF and ECRH at plug/barrier section. The main objective of the research is to investigate the temporal change in direction of plasma flow and Mach number with high power ICRF. Especially in this year, we have studied the characteristics of the Mach probe.

Mach number is calculated from the ratio of the upstream ion saturation current density (J_{up}) to the downstream (J_{down}) and the normalized drift velocity (v_f) described by the following formula:

$$R = \frac{J_{up}}{J_{down}} = \exp\left(K v_f\right) \quad , \qquad (1)$$

where, $v_f = v / \sqrt{ZT_e / m_i}$, K is a calibration factor depending on the magnetic flux density, collisionality of charged particles and neutrals, viscosity of plasmas, ion temperature and so on. Generally, the K value is given experimentally, since it is difficult to estimate the K value correctly in various plasma flow conditions. Therefore, in this study, we numerically estimate the K value from the PIC (Particle In Cell) method for various experimental conditions.

Figure 1 shows the configuration of a Directional Langmuir Probe (DLP) considered in this study. The shield wall is placed behind the collector. The effects of the shield wall on the probe measurement were simulated. Fig. 2(a) shows the two-dimensional distribution of ion density around the probe with the parameters of $v / \sqrt{ZT_e / m_i}$ =1.6 and T_i/T_e=2.0. The simulation was performed two- dimensionally using a cylindrical coordinate. The probe is placed on the center of the numerical grid (z = 0) and flowing ion flux comes from left-hand side. The ion flux density flowing onto the probe surface, $\boldsymbol{\Gamma(v,\cos\theta)}$, is calculated by the PIC method and is shown in Fig. 2(b). Here, it is normalized by the product of ion density and ion sound velocity on infinite distance. The numerically obtained K value is about 1.2 which is coincident with the experimentally obtained value.

We should optimize further the simulation code and improve the accuracy of the numerically obtained K value.

In addition, we should perform the simulation with the same parameters as GAMMA10 and compare the results between experiment and simulation results.

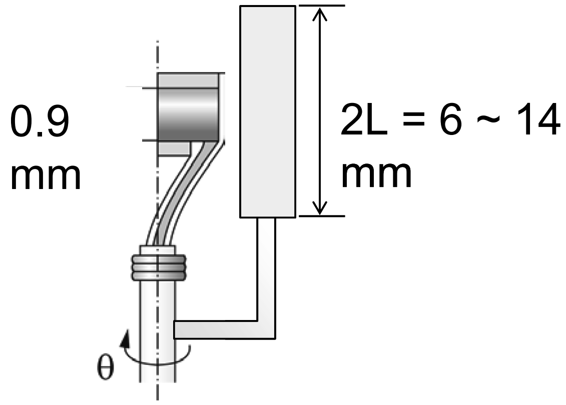

Fig. 1. Configuration of a directional langmuir probe. The shield wall is placed behind the collector.

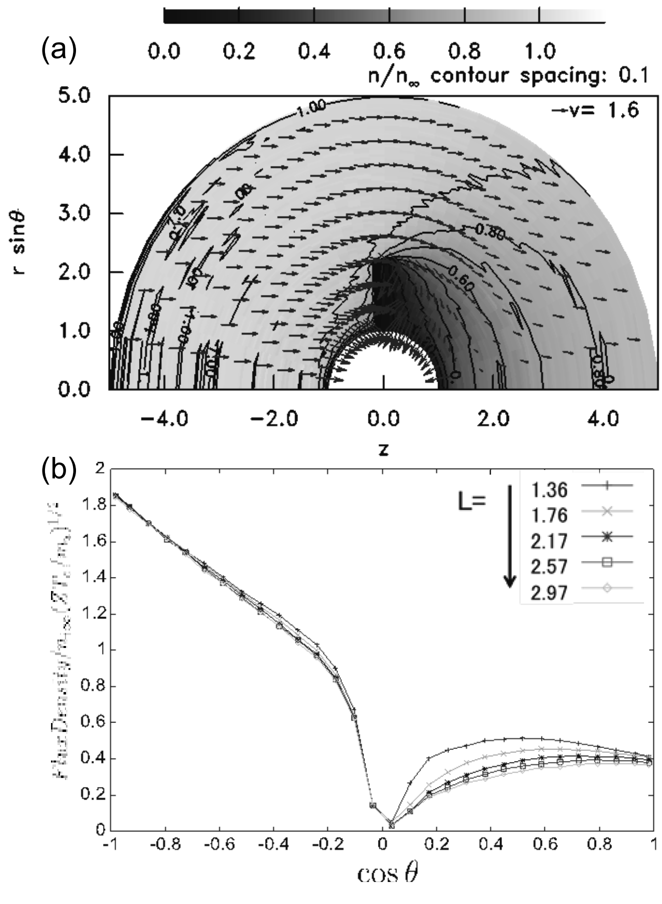

Fig. 2 (a) Simulated two-dimensional distribution of ion flow direction and density around the probe. (b) Angular dependence of ion flux density obtained from the result of (a). The simulation was performed with the parameters of v=1.6,T_i=2.0, λ_{De}=0.01,V_p=10.