## §8. Optimization of Directional Probes for Plasma Flow Measurements

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Plasma flow measurements have been one of important issues related to electric field and particle transport in the boundary layers of fusion–oriented devices. In a complicated magnetic field configuration, such as helical devices, the plasma flow may change drastically in its direction and is anticipated to be inclined to the magnetic field because of the strong magnetic shear and electric field. In these circumstances, the method using a directional probe is a good approach because its spatial resolution is the scale of its electrode, say about 0.5 cm. However, most of directional probes have been applied to measure the plasma flow along magnetic field so far.1–3) The purpose of this study is thus to investigate the optimization of directional probes for measuring plasma flow across the magnetic field.

There are two types of directional probes: one is a "magnetized" probe with a radius, $a$, greater than the ion gyroradius, $\rho_i$ ($a > \rho_i$); the other is an "unmagnetized" probe with $a < \rho_i$. A probe used in a fusion–oriented device should be large and is necessarily a "magnetized" probe, because the probe must be proof against heat load from the plasma with substantial density and temperatures of ion and electron. However, we first investigated the "unmagnetized" directional probe for measuring plasma flow across magnetic field because its ion saturation currents can be treated without difficulties in solving the magnetic sheath problem.

A directional probe was tested in an ECR plasma with an argon plasma density: $n \simeq 1 \times 10^{12}$ cm$^{-3}$, an electron temperature: $T_e \simeq$ 8 eV, and a magnetic field: $B \simeq$ 850 G, which was produced in HYPER-I.4) An electrode of the directional probe was a titanium wire of 1 mm in diameter, surrounded with a ceramic ($Al_2O_3$) pipe of 3 mm in outer diameter. By biasing the electrode, ion currents were drawn through a hole of 1 mm in diameter, located in the side of ceramic pipe. The direction normal to the hole, through which ions and electrons hit the electrode, was always normal to the magnetic field at any angle of the rotation about the probe axis. Then, one can measure the angular dependence of the ion saturation currents or the plasma flow across magnetic field. Note that, as mentioned before, this probe was "unmagnetized" since the ion gyroradius was about 8 mm for an estimated ion temperature: $T_i \sim$ 1 $eV$ ($a$ = 1.5 mm, $\rho_i \sim$ 8 mm, and $a < \rho_i$). Figure 1 shows the ion saturation currents ($I_s$) as a function of probe angle, where the difference of $I_s(\theta)$ and $I_s(\theta+\pi)$ (closed circles) is in accordance with a sine function (a solid curve). Then, the plasma flow velocity can be estimated on the basis of a free fall model.5) The result well agrees with $E \times B$ drift estimated from potential profile measurements.

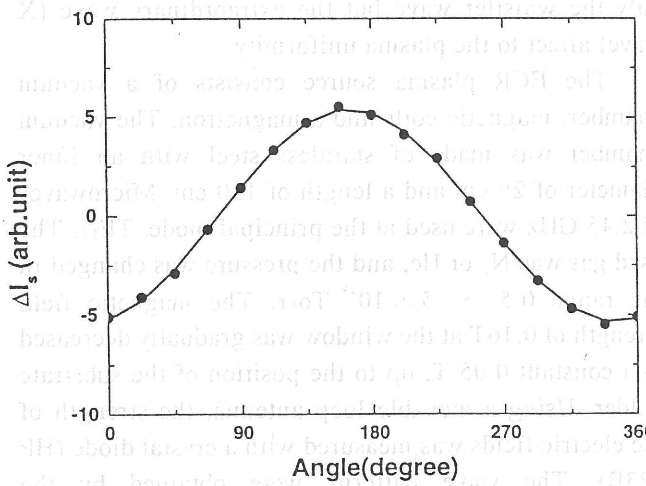


Fig. 1 Ion saturation current versus roation angle of directional probe

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