§14. Development of Gundestrup Type Directional Langmuir Probe for Flow Measurement in Edge Plasma Region of LHD

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In recent years, plasma flow in edge/divertor plasma region of magnetic fusion devices has drawn a deep interest because of its possible role in impurity control and in improved confinement. In the Local Island Divertor (LID) configuration of LHD with the magnetic axis R_{ax}=3.75m, the existence of high speed parallel flow of which Mach number is approximately 1 is expected from the calculation using EMC3 code. Although the importance of plasma flow measurement has been recognized, it has not so far been carried out in the edge plasma region of LHD. In several tokamaks, a multi-electrode probe called Gundestrup is being used and is regarded as a powerful tool for plasma flow measurement.[1, 2] We have designed and constructed a Gundestrup type directional Langmuir probe (GDLP) for the fast scanning probe system installed at the 1.5-L lower measuring port of LHD. Conventional Mach probes are capable of measuring parallel flow velocity but are insensitive to perpendicular component. In contrast, the advantage of Gundestrup type probe is that it can measure plasma flow velocity components in directions parallel and perpendicular to the magnetic-field line simultaneously.

Figure 1 shows the picture of the head part of newly developed GDLP. It consists of a single Langmuir probe equipped on the flat end of the cylindrical head to measure plasma density and electron temperature and an eight-channel directional Langmuir probe array to measure plasma flow. The head is constructed from boron nitride (BN), which is a good insulating body, and is 13mm in diameter. It has eight openings 1mm in diameter equally spaced at 45-degree intervals around its circumference, and each of the openings acts as a directional Langmuir probe. The depth of each opening is 1mm. Most of the body is covered by graphite tube 20mm in diameter and the tube wall thickness 2.5mm (See the black parts of Fig. 1). The collector electrodes are made of isotropic graphite 2mm in diameter, and the one used as a single Langmuir probe is dome-shaped (See the electrode on top of the head in Fig. 1).

In order to determine the direction and the magnitude of plasma flow, the polar distribution of ion saturation currents collected by the eight electrodes is used.[3] The intuitive explanation of this model is that if flow is present then larger ion saturation current is expected on the side of the probe that faces upstream than that which faces downstream. Since we have demonstrated that ion flow velocity at an arbitrary angle with respect to magnetic field can be measured by a directional Langmuir probe with the HYPER-I device[4] at the research and development experiment building, the calibration experiment of GDLP using the HYPER-I plasma is planned before installing it to LHD. The goal of this study is to establish the plasma flow measurement method using the GDLP and to enhance the knowledge of particle transport in the edge/divertor plasma region of LHD.

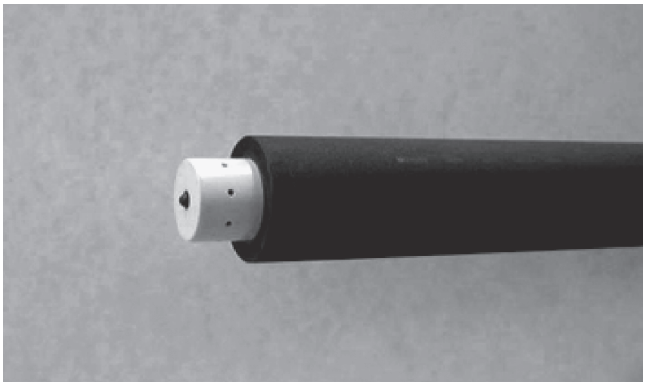

Fig. 1 The Gundestrup type directional Langmuir probe.

References

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