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Flow Structure Formation in an Ion Unmagnetized Plasma
イオン非磁化プラズマにおける流れ構造形成

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Plasmas in inhomogeneous magnetic fields become transition plasmas defined as intermediate state between magnetized and unmagnetized plasma. The transition plasma consists of unmagnetized ions and magnetized electrons, and We have observed ion streamline detachment and azimuthal plasma rotation in the HYPER-I device at the National Institute for Fusion Science. In this proceedings, we present the experimental results on plasma rotation control using coaxial cylindrical electrodes to study the effect of rotation on the flow structure formation.

1. Introduction

Ion streamline detachment from the magnetic field line is one of the characteristic phenomena in a diverging magnetic field. Several scenarios of detachment have been proposed, and the flow structure in the detachment region has been theoretically and numerically studied [1-5]. The experiments, however, have not been performed, so far, because of the difficulty of measurement.

Recently, the ion streamline detachment in a diverging magnetic field has been observed in the HYPER-I device at the National Institute for Fusion Science [6]. The detachment takes place when the non-adiabatic parameter of ion becomes order unity. An interesting characteristic of flow has been also observed: the plasma starts to rotate in the azimuthal direction in the detachment region, where the ions are unmagnetized. In the previous studies, it has been found that the plasma rotation is driven by the $\boldsymbol{E}\times\boldsymbol{B}$ drift. This result indicates that the plasma rotation play an important role to generate the plasma flow structure in the diverging magnetic field.

We have started the rotation control experiment and the effect on flow structure formation in a diverging magnetic field. In this proceedings, we present the preliminary results of the experiment carried out in the HYPER-II device at Kyushu University

2. Experimental Setup

The experiments have been performed in the HYPER-II device. The HYPER-II device consists of two different cylindrical vacuum chambers: one is the plasma production chamber with a diameter of 0.3 m and an axial length of 0.95 m, and the other is the diffusion chamber with a diameter of 0.76 m and an axial length of 1.3 m. The schematic diagram of the HYPER-II device is shown in Fig.1.(a), where the eight water-cooled magnetic coils produce a diverging magnetic field [see Fig.1.(b)].

The plasma is produced by ECR heating with a 2.45 GHz microwave. The resonance point is located at z = 0.3 m in this magnetic field configuration, where z denotes the axial position from the microwave launching position [see Fig. 1.(a)]. An argon gas is used.

Coaxial cylindrical electrodes are set in the plasma production chamber to control the radial electric field [see Fig.2.(a)]. A cylindrical shape of the electrode is adopted not to disturb the axial plasma flow. The azimuthal plasma rotation is driven by $\boldsymbol{E}\times\boldsymbol{B}$ drift with the radial electric field and the external magnetic field. The electrodes consist of three concentric cylinders (diameters are 30 mm, 90 mm, and 150 mm). The bias voltage is applied independently to each electrode. The bias voltages of the electrodes are set in order from the inside to the outside, to V_1, V_2, and V_3. The chamber wall is biased on the ground potential.

The current-voltage characteristics have been measured with a Langmuir probe introduced from the radial port at z = 1.12 m.

when the electrode is biased V_a and V_b (V_a : $V_1 = V_2 = V_3 = 0$ V; V_b : $V_1 = V_2 = V_3 = 30$ V).

The space potential is found to change in accordance with the biasing voltage. This result implies that the space potential may be changed by biasing the electrodes.

The radial electric field generated by applying bias voltages to the cylindrical electrodes may control the plasma rotation.

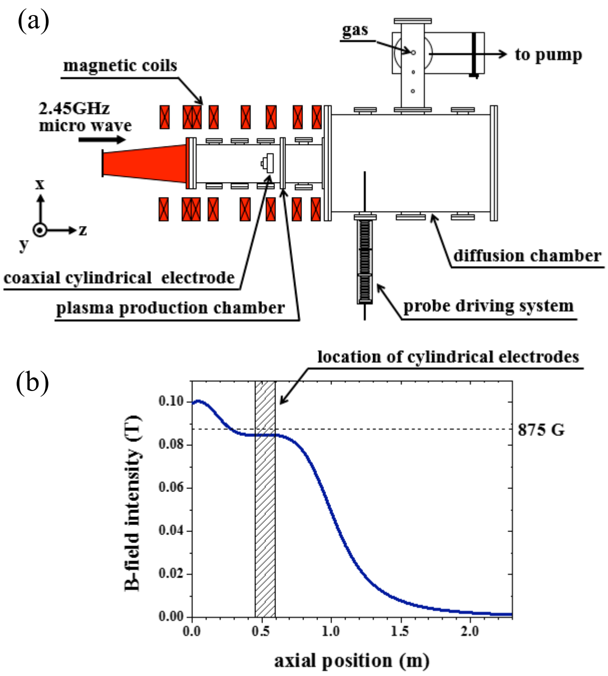

Fig.1. (a): Schematic diagram of the HYPER-II device.
(b): Axial profile of the magnetic field intensity along the chamber axis.

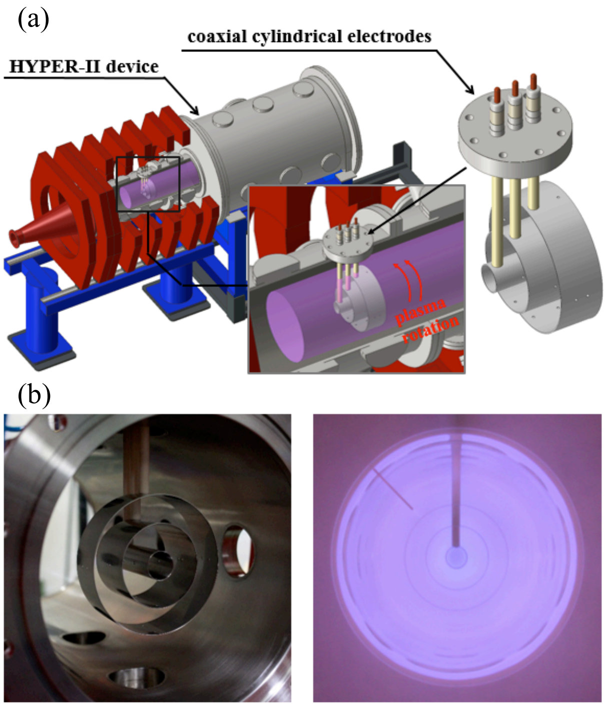

Fig.2. (a): 3-dimensional diagram of the HYPER-II device and the cylindrical electrodes.
(b): Photographs of the cylindrical electrodes and plasma produced in the chamber.

3. Experimental Results

Figure 3 shows the current-voltage characteristics

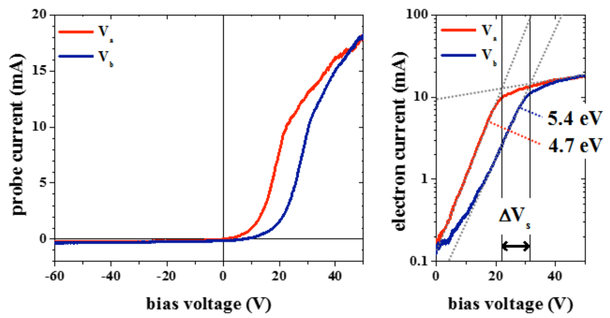

Fig.3. Current-voltage characteristics obtained in the HYPER-II plasma (argon).

4. Summary

We have carried out the plasma rotation control experiments using the HYPER-II device in order to study the effect of plasma rotation on the flow structure formation in an inhomogeneous magnetic field. It has been found that the space potential changes by biasing the cylindrical electrode in the plasma production chamber. The plasma rotation control may be possible by the cylindrical electrodes.

The whole flow structure including the axial flow will be measured in the future experiments.

Acknowledgments

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