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Equilibrium Characteristics in Toroidal ECR Plasmas in the LATE Device
LATE装置におけるトロイダルECRプラズマの平衡特性

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In toroidal ECR plasmas without vertical field, the charge separation current is caused by the vertical drift of the electrons and the ions due to the field gradient and curvature. The present experiments show that the radial distributions of the charge separation currents flowing to the top and bottom electrodes and in the main plasma are all the same, namely, the currents flow only in the vertical direction. And we partly verify the model for a ion-flow toward the top surface that was proposed in the previous paper[1].

1. Introduction
The electron cyclotron resonance (ECR) pre-ionization is a standard method of initiation of tokamaks discharge. There is considerable interest in ECR plasmas and investigations of the behavior of it are very important.

In ECR toroidal plasmas immersed in a simple axisymmetric toroidal magnetic field the electrons and ions drift vertically due to the field gradient and curvature in the opposite direction each other. The vertical drift causes the charge separation current in the vertical direction. We found that the current circulated via the conducting vessel in previous paper[1]. This indicated that the equal currents of electrons and ions flowed to the top and bottom surface respectively. However the ions drift much slower than electrons because the ion temperature is much lower than the electrons temperature in the ECR plasmas. We proposed the model for a ion-flow toward the top surface to resolve the discrepancy.

In this paper we address whether the ion-flow model is the case or not.

2.Experiment Description
The previous paper showed that the total charge separation current flowing to the top and bottom surfaces were the same and the current circulated via the conducting vessel. We proposed the model for a ion-flow toward the top surface. The model is that the ions drift toward the top surface by the E×B drift and the vertical drift of the ions are accelerated in the vicinity of the top surface due to the steep space potential gradient.

We investigate the radial distributions of the charge separation current and examine the model for a ion-flow in the present experiments.

The experimental apparatus is shown in Fig.1.

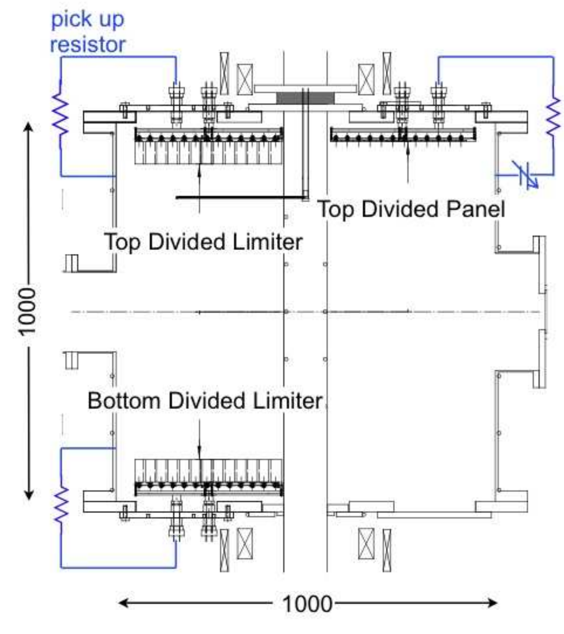

Fig.1. Experimental apparatus

The vacuum vessel of the LATE device is a cylinder with an inner diameter of 1000mm and a height of 1000mm. We produce the hydrogen plasmas using microwaves at 2.45GHz and 0.5～2.0kW. The toroidal field is 480G(R=25cm) and no vertical field is applied.

Firstly, we investigate the radial distributions of the charge separation current with three electrodes, the top divided panels, the top divided limiters and the bottom divided limiters. The panels are horizontal and the limiters are vertical, which both are divided into twelve at intervals of 3cm in the radial. They are set at the top and bottom of the vessel but the bottom panel is omitted because it detected no current in the previous experiment. Figuers.2(c) and 2(e) show the current density flowing to the top and bottom electrodes, respectively. We suppose that the panel detects the currents flowing to the area of the electrode plate and the limiter detects the current flowing to the annular area of the width of the plate. We also measure the plasma profiles of the electron temperature, density and space potential in the same plasmas with the Langmuir probe. Figuer.2(d) show the current density obtained by using the profiles of the electron pressure in the main plasmas.

As shown in Figs2.(d) and 2(e), the radial distributions of the current density in the main plasma (Z=240,-8,135,240,390mm) are the same, and they are also coincident with the current density flowing to bottom limiter.

The result is consistent with the picture that the charge separation current is caused by the vertical drift due to the field gradient and curvature. That is, the charge particles drift due to the field gradient and curvature and due to the E×B drift, and only the former causes a current. The current flows only in the vertical direction in the main plasma and to the bottom limiters. Then its radial distribution is independent of Z-position with no horizontal flow. In this experiment the picture is confirmed.

As shown in Figs2.(c), the currents flowing to the top limiters is quite small just as the previous experiments. The current density to the top panels are larger than the current density to the bottom limiters, which is suggested that the panels detect the current flowing to a larger area than the plate. The previous paper showed that the total current flowing to the top and bottom surfaces were the same. Figuer2.(c) shows that the radial distribution of the current density of ions flowing to the top electrodes are also the same.

Secondly, in order to examine the energy of the ions in the vicinity of the top electrodes, we measure V-I characteristics of the electrodes (panels). Figuer.2(a) shows the radial distribution of the floating potential of the V-I characteristics. Figuer.2(b) shows the profile of the space potential in the vicinity of the electrodes. Both radial distributions suggest that the ions energy increases at R=14cm～20cm in the vicinity of the top surface due to the steep space potential gradient.

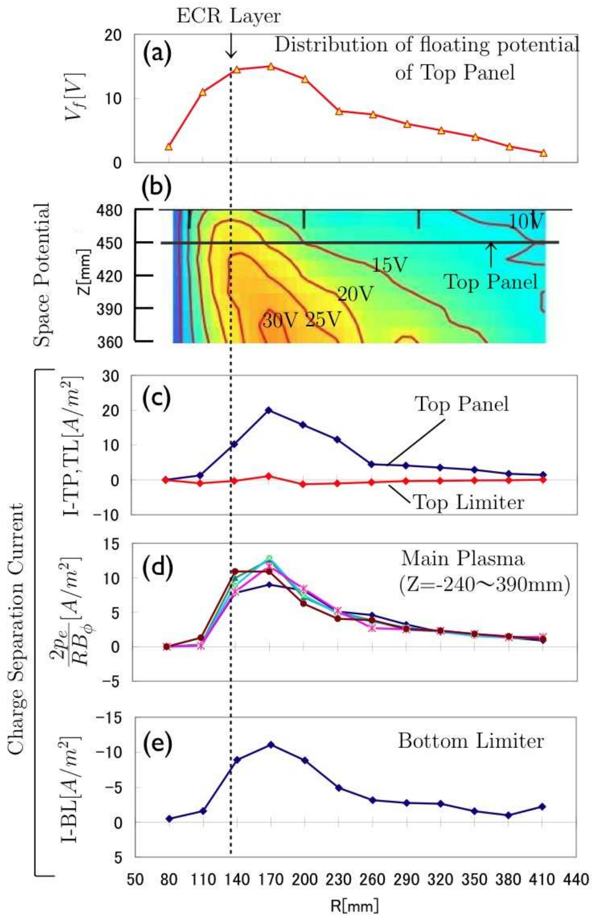

Fig.2. Comparison radial distributions of (a)-(e).
(a): Floating potential measured with the top panels.
(b): Profile of the space potential in the vicinity of the top panels. (c): Current flowing to the top divided panels.
(d): Current obtained by the profiles of the electron pressure in main plasma(Z=240,-8,135,240,390mm).
(e): Current flowing to the bottom divided limiters

3. Summary

The present experiments show that in the toroidal ECR plasmas without a vertical field the charge separation current flows only in the vertical direction throughout the plasma from bottom to top. The results also suggest that the ions energy increases at R=14cm～20cm in the vicinity of the top surface, which is consistent with the model for a ion-flow toward the top surface.

References

[1] S. Nishi, T. Sakabe, M.Uchida, H. Tanaka and T. Maekawa: Plasma Phys. Control. Fusion **52** (2010) 125004