23P039-P

# Magnetic Island Experiment in Tohoku University Heliac II
# 東北大学ヘリアック装置における磁気島生成実験 II


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Effects of island width on a poloidal flow were surveyed in the Tohoku University Heliac (TU-Heliac). The poloidal flow was driven externally by a hot cathode biasing and $m$ = 3 magnetic islands were produced by two pairs of external perturbation field coils. The electrode current required for the poloidal flow jumping increased with growing the island width. The effect of the degradation of plasma performance to this dependency was also surveyed in limiter configurations. These dependencies suggest that the magnetic island located at the plasma periphery affects the poloidal flow as a drag term.


## 1. Introduction

Study of magnetic island effects on the transport is important, because it leads to the advanced control method for a plasma periphery in a fusion reactor. The perturbation field effects on the transport have been surveyed widely in LHD and DIIID [1-3]. For the research on island effects on confinement modes, Tohoku University Heliac (TU-Heliac) has advantages that (1) the island formation can be controlled by external perturbation field coils; (2) a radial electric field and particle transport can be controlled by the electrode biasing [4]. The purpose of this work is to survey the relationship between the threshold of the external driving force required for a plasma flow jumping and an island width. We also compared the threshold of the external driving force required for the plasma flow jumping in limiter configurations.

## 2. Experimental Setup

Experiments were carried out in the TU-Heliac. The He plasma produced by the low-frequency joule heating ($f$ = 18.8 kHz, $P_{out}$ ~35 kW) in the magnetic field is $B_0$ = 0.3 T and the discharge time was 10 ms, which was time of flattop of coil current for confinement. The $LaB_6$ electrode was inserted in plasma from a low field side for plasma biasing.

To generate $m$ = 3 islands at the plasma periphery, we used external perturbation coils. Four pair of upper and lower coils located at the toroidal angles $\phi$ = 0°, 90°, 180° and 270° that generated a cusp field at each toroidal angle [5]. In this experiment, we used only two pairs of external perturbation field coils at the toroidal angle $\phi$ = 0° and 180° to produce magnetic islands at fixed poloidal positions. Using these coils, $m$ = 3 island was generated on magnetic configuration that has a rational flux surface (n/m = 5/3) at $\rho$ ~ 0.5 [6].

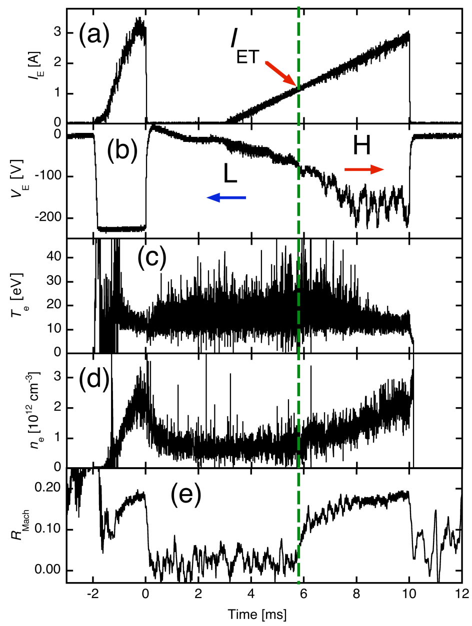


Fig.1. Typical time evolution of (a) $LaB_6$ electrode current, (b) electrode voltage, (c) electron temperature, (d) electron density measured by a triple probe and (e) Mach probe current ratio

## 3. Experimental Results

In order to study the effects of magnetic islands on plasma poloidal flow, we externally controlled the flow velocity by changing the electrode current with the current control power supply. Figure 1 shows (a) $LaB_6$ electrode current, (b) electrode voltage, (c) electron temperature, (d) electron density measured by a triple probe and (e) Mach probe current ratio. We adopted a sawtooth function for the current control power supply for the electrode. The electrode current started at $t = 3$ ms and was ramped up linearly up to 3 A at $t = 10$ ms. It is clear that the Mach probe current ratio (Fig. 1(e)) increased suddenly at $t \sim 6$ ms. It is also clear that after this time the temperature fluctuation was significantly suppressed (Fig. 1(c)) and, the electron density increased by a factor of 3 (Fig. 6(d)) which suggests the improved mode transition. Therefore we adopted the electrode current required for the transition $I_{ET}$ in Fig. 1 as the index for the island effect on the poloidal flow. Before $t = 0$ ms we applied the pre-biasing for the pre-ionization.

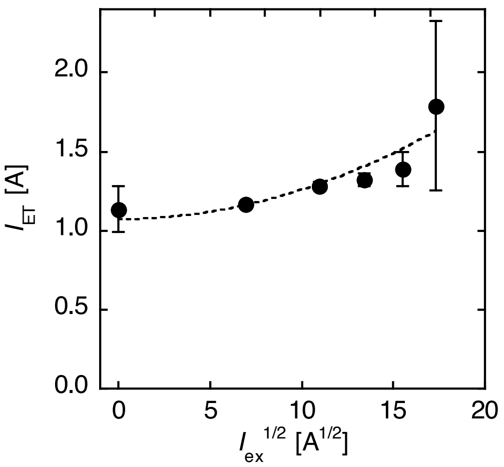

Fig.2. Dependency of the island width $I_{ex}^{1/2}$ on the electrode current required for the transition $I_{ET}$

The dependency of the island width $I_{ex}^{1/2}$ on the electrode current required for the transition $I_{ET}$ was shown in Fig. 2. It is clearly seen that the electrode current required for the transition $I_{ET}$ increased with growing the island width. However for the evaluation of this dependency we should take account of the degradation of plasma performance by islands. In order to study the effect of the degradation of plasma performance to the dependency of the island width on the transition, we also tried the biasing experiments in limiter configurations. The limiter was inserted from the bottom side of the plasma. We surveyed the dependency of the limiter position on the electrode current required for the transition $I_{ET}$, which was shown in Fig. 3. The

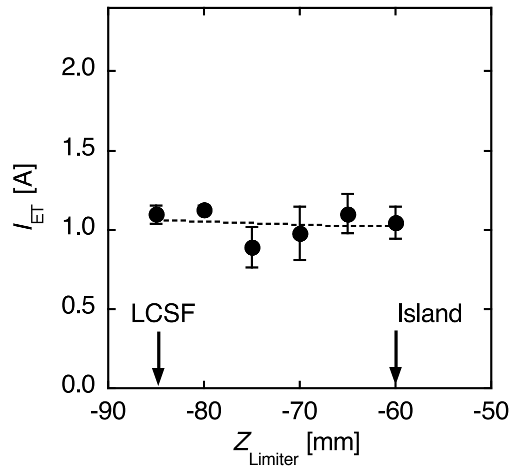

Fig.3. Dependency of the limiter position on the electrode current required for the transition $I_{ET}$

electrode current required for the transition $I_{ET}$ almost independent on the limiter position. In Fig. 3 the limiter position $Z_{limiter}$ = - 60 mm corresponds to the inside edge on the $m$ = 3 magnetic island and $Z_{limiter}$ = -85 mm corresponds to the last closed flux surface. The electrode current $I_E$ was proportional to a plasma driving force. These dependencies shown in Fig. 2 and 3 suggest that the magnetic island located at the plasma periphery affects the plasma poloidal flow as the drag term.

## 4. Summary

We surveyed the relation between the threshold of the external driving force required for a plasma flow jumping and an island width. The electrode current required for the transition increased with growing the island width at the plasma periphery. We also surveyed the effect of the degradation of plasma performance in the limiter configurations. The electrode current required for the transition $I_{ET}$ almost independent on the limiter position.

## Acknowledgments

This work was supported by the LHD Joint Planning Research programme at the National Institute for Fusion Science.

## References

[1] K. Narihara *et al.*: Phys. Rev. Lett. **87** (2001) 135002.
[2] N. Ohyabu *et al.*: Phys. Rev. Lett. **88** (2002) 55005.
[3] T.E. Evans *et al.*: Phys. Rev. Lett. **92** (2004) 235003.
[4] S. Kitajima, *et al.*: Nucl. Fusion, **46** (2006) 200-206.
[5] S. Kitajima, *et al.*: Plasma Fusion Res. **3** (2008) S1027.
[6] S. Kitajima *et al.*: Plasma Fusion Res. **5** (2010) S2041.