§6. Development of External Control Knob for Improved Confinement Mode in TU-Heliac

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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 *etc*. 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[1]. The island effects on the plasma periphery by the external perturbation fields in TU-Heliac were surveyed[2, 3]. The fixed m = 3 magnetic island were produced by the two pairs of external cusp field coil shown in Fig. 1. The electron density decayed from the outer edge of the island after perturbation field applying. The radial profiles of electron temperature and plasma space potential in the island region revealed the magnetic island structure. The radial electric field at the inner edge of the island increased after perturbation filed applying. The positions of local maxima in the plasma space potential profile agree well with the position of the n/m = 5/3 rational surface. The potential profile in the island grew according to the perturbation field strength. The full width at half maximum of the potential profile depends on the square root of the perturbation field coil current.

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. Then we surveyed the relationship between the threshold of the external driving force required for a plasma flow jumping and the island width. When the electrode current exceeded a critical value, the Mach probe current ratio (poloidal flow velocity) increased suddenly. It was also clearly shown that after this time the temperature fluctuation was significantly suppressed and, the electron density increased by a factor of 3, which suggests the improved mode transition. 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.

We also surveyed the dependency of the island width ($I_{ex}^{1/2}$) on the saturated mach probe current ratio (steady-state poloidal flow in a configuration with islands), which was shown in Fig. 3. The saturated mach probe current ratio decreased with increasing in the island width. 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 poloidal flow as the drag term.

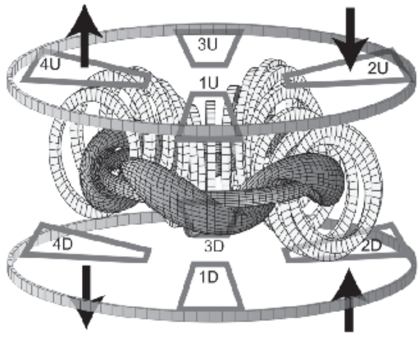

Fig.1. External perturbation coils set-up. Coils are located at toroidal angle φ = 0°, 90°, 180°, 270°, upper and lower location of toroidal coils.

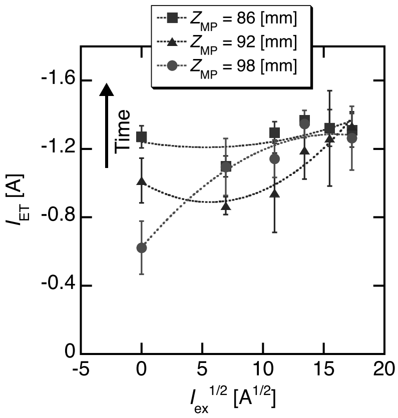

Fig.2. Dependency of the island width $I_{ex}^{1/2}$ on the normalized electrode current required for the transition I_{ET}

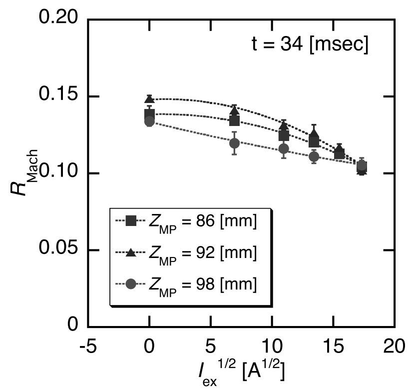

Fig.3. Dependency of the island width on the saturated mach probe current ratio

1) Kitajima, S. *et al.*: Nucl. Fusion, **46**, 200-206 (2006)
2) Kitajima, S. *et al.*: Fusion Sci. Technol. **50**, 201 (2006)
3) Kitajima, S. *et al.*: Plasma Fusion Res. **3** (2008) S1027