§17. Role of Plasma Fluctuation for EBW Current Ramp-up at the Electron Cyclotron Harmonics

Zushi, H., Bhattacharyay, R., Ryoukai, T., (RIAM, Kyushu Univ.),
Mutoh, T., Morisaki, T., Kubo, S.

1. Introduction

The physics of current ramp-up mechanism, that is, magnetic reconnection and a role of fluctuations on it, is still not clear. In CPD the sheet thermal Li beam and CCD imaging method have been used to get two dimensional density profile in the wide area [1-4]. This report describes the first result of visualization of the topological change in magnetic configuration during the rf driven plasma current ramp-up by imaging technique.

2. Experimental device

CPD is a spherical tokamak device whose diameter as well as height is ~ 1.2 m. Four toroidal coils produce the magnetic field of 0.29 T at the major radius R ~ 0.19 m. In a mirror configurations (decay index ~ 0.046, B_z ~ 40 G at R=0.2 m), 1.5–60 kW of RF power (8.2 GHz) is injected. The RF driven plasma current is measured with Rogowski coils installed inside the CPD chamber.

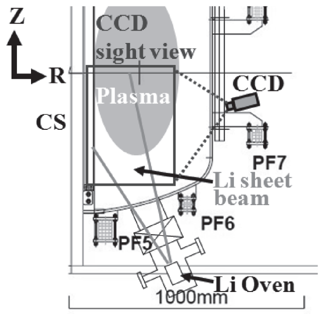

Fig.1 CPD and Li injector.

The Li beam injector is located at the bottom of the chamber, as shown in Fig.1. The full width at half maximum of the sheet beam is 40 mm in the toroidal direction. The image of LiI (670.8 nm) light intensity is detected with a CCD camera and 50 ch PMT array.

3. Results and summary

Plasma current (I_p) starts to ramp-up with the ramping up of rf power (P_{rf}). It is found that a current transition occurs, when P_{rf} exceeds a critical value (~ 22 kW). The transition occurs within 2-3 ms and the current abruptly increases from 1 kA (low I_p mode) to 2-3 kA (I_p transition mode), as shown in Fig.2. Below the critical P_{rf}, I_p is kept at a low level. Drastic changes are observed in the LiI images with and without current transition (see Figs.3). In low I_p mode (Fig.3(left)), a slab image extends towards the lower field side. The contours of the magnetic flux Φ(R, Z) are also superposed on the respective image of LiI(R, Z). When I_p reaches to a critical value, the image splits into two (inner and outer) parts vertically at R ~ 0.2 m. As shown in Fig.3(right), with the current transition a circular high intensity region appears near the mid plane, suggesting the establishment of the last closed flux surface LCFS via magnetic reconnection. The uni-directional Pfrirsh-Schlüter sheet current and the negative induced current may play an important role to split the image. The electron density n_e(R, Z) contours for the above two cases are shown in Fig.4.

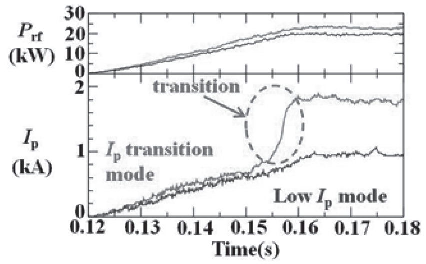

Fig.2 Two types of discharges with and without I_p transition

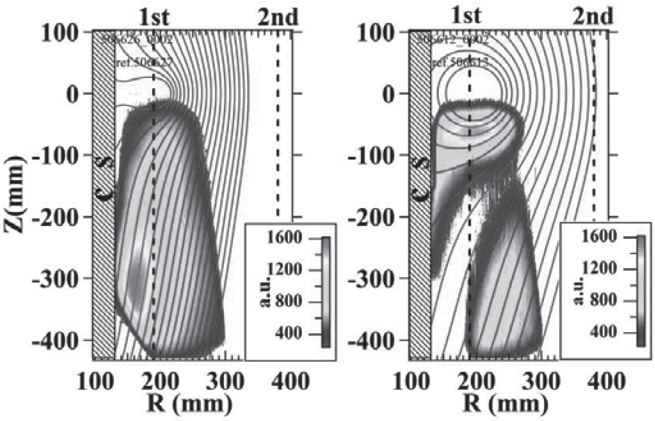

Fig.3 Li image in (left) low I_p mode (I_p ~ 1 kA) and (right) I_p transition mode (I_p ~ 2.5 kA)

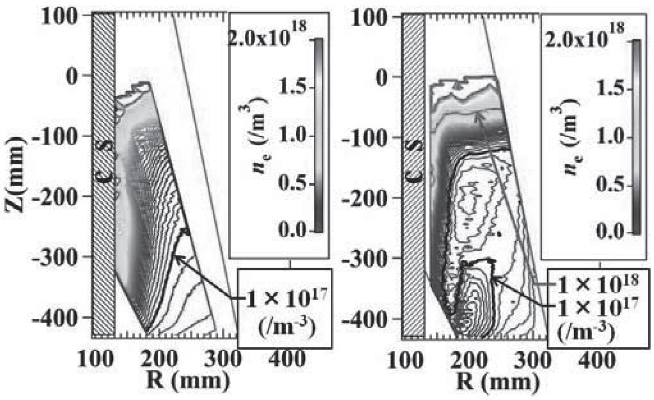

Fig.4 n_e(R, Z) in (left) low I_p mode and in (right) I_p transition mode

In summary, two dimensional electron density profile measurement has been performed using Li sheet beam imaging technique. A clear change is observed in plasma boundary as well as magnetic field topology associated with the transition of the current from low (~ 1 kA) to high (~ 3 kA) value.

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[2] R.Bhattacharyay, et al, PFR Vol. 2 S1103 (2007)
[3] R.Bhattacharyay, et al, Phys. Plasma **15** 022504 (2008)
[4] T. Kikukawa, et al., PFR **3** 010 (2008)