§38. Demonstration of Plasma Current Control by Electron Cyclotron Current Drive in LHD

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Plasma current control by electron cyclotron current drive (ECCD) is a promising scheme to modify the plasma performances through controls of local rotational transform and magnetic shear or direct suppressions of MHD instabilities [1]. In an inward shifted configuration of LHD, improvements of not only neoclassical transport but also anomalous one are observed. According to a linear MHD theory, on the one hand, it is predicted that some MHD instabilities affect plasma confinement in the inward shifted configuration. As one of the reasons for current good confinement in the configuration, some non-linear effects are considered. They may prevent MHD activities from growing further. However in order to extend an operation parameter range of LHD, MHD activities should be suppressed by some kind of ways because they must cause severe degradation of plasma confinement. ECCD has possibility that it can improve MHD properties without degradations of neoclassical and anomalous transports even in the inward shifted configuration. To improve plasma confinement by ECCD, two schemes can be pointed out. One of them is CO-ECCD which raise rotational transform and result in exclusion of low-order rational surfaces at plasma core region where magnetic shear is very weak. The other is CTR-ECCD which can enhance negative magnetic shear locally. Therefore, to control plasma current to arbitrary directions is preferable. The 2O port antenna (Fig.1) is more suitable than L port antenna for this purpose owing to 3-dimensional magnetic field structure of LHD.

In the 10th experimental campaign, ECCD is tried using 2O port antenna. Magnetic field strength, injection angle and wave polarization are optimized based on oblique ray-tracing code [2]. Fig. 2 shows temporal evolution of plasma currents in the experiment. Bootstrap current is contained in plasma currents, but that contribution is weak judging by balanced ECCD discharge. For CO- and CTR-ECCD discharges, directions of driven plasma current are consistent with linear theory. Therefore plasma current control by ECCD is demonstrated successfully. However, absolute values of plasma currents are still very low because of high electron temperature which lead to huge L/R time compared with ECCD duration. Also, a diffusion time of plasma current will reach several seconds which also longer than ECCD duration. To control rotational transform and magnetic shear until they affect plasma confinement, higher power and longer duration will be neede. Prospective ECCD density profiles which are estimated from ray-tracing and ECCD efficiency obtained in the DIIID are given in Fig.3. Combing this estimation and equilibrium calculation code, to evaluate modifications of rotational transform and magnetic shear is left as future work.

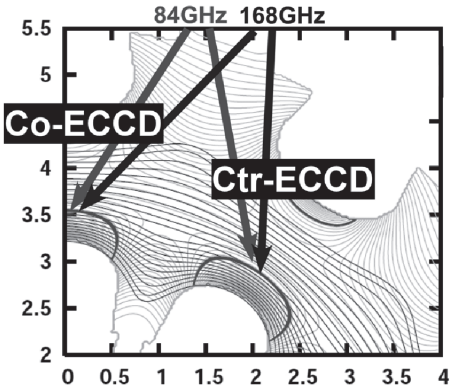

Fig.1. 2O port antenna configurations

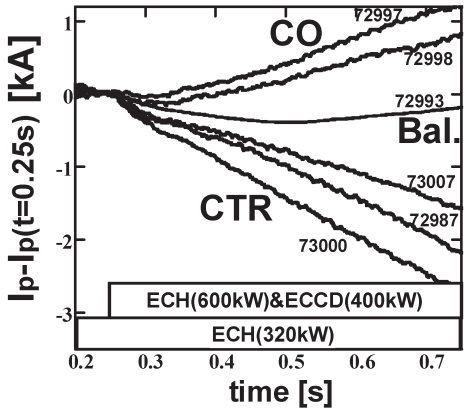

Fig.2. Temporal evolutions of total plasma currents

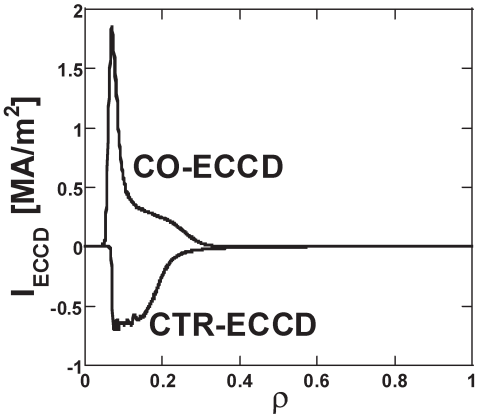

Fig.3. Estimated current density profiles by ECCD

References

1) R.Prater, Physics of Plasmas, vol.11 (2004) p.2349
2) T.Notake, NIFS Annual Report (2005-2006) p.81