§ 18. Large Toroidal Current Experiment in LHD

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Some experiments of current carrying Helical plasma have been carried out[1][2][3] though the Helical plasma does not need the toroidal current to sustain its confinement magnetic field. In this study, the toroidal current in LHD plasma is driven by neutral beam injection in the equilibrium with magnetic axis \( R_{\text{ext}}=3.75 \text{m} \) and coil pitch parameter \( \gamma_c=1.25 \). The direction of the current is positive which makes the rotational transform increase.

As shown in Fig.1, the toroidal current \( I_p=100[\text{kA/T}] \) is obtained without any disruptions and termination of discharges. The magnetic fluctuation shows that the \( m/n=1/1 \) mode increasing with toroidal current and it does not saturate in the experiment (Fig.2). The low-frequency oscillation with 20~25[Hz] is observed in some diagnostics which are the magnetic flux \( \Phi \), electron temperature \( T_e \), stored energy \( W_p \) and \( I_p \) and so on (Fig.3). In the internal measurement by ECE and SX, reversal surface does not be observed clearly. The magnetic flux measured by the saddle loop array suggests the existence of \( m=1 \) mode with low-frequency oscillation. It is found that the relationship between the low-frequency oscillation and flattening of the electron temperature measured by Thomson scattering. After \( t=2.5[s] \), the flattening suddenly appears and keeps still as shown in Fig.4. The calculated rotational transform with \( I_p=100[\text{kA/T}] \) is also shown in Fig.3(b). The position of the flattening is corresponding to the location of the rational surface of \( \ell/2\pi=1.0 \). This means that the magnetic island with \( m/n=1/1 \) mode appears in this time, when the low frequency oscillation occurs. These phenomenon appears at low density region \( n_e>1.0 \times 10^{19} \text{m}^{-3} \).

The profile of rotational transform has important key to study the current driven mode. From the result of MHD stability code TERPSICHORE[4], it is shown that the equilibrium without \( \ell/2\pi=1.0 \) surface is destabilized by current driven \( m/n=1/1 \) mode. For investi-

Fig. 1: Time evolution of plasma current

Fig. 2: Magnetic fluctuation of \( m/n=1/1 \) component

Fig. 3: Low frequency perturbations (a) toroidal current (b) magnetic flux (c) electron temperature (d) stored energy

Fig. 4: Transition of \( T_e \) profile (a) \( t < 2.4[s] \) without flattening (b) Flattening appears at \( t > 2.5[s] \). \( \ell/2\pi \) profile in \( I_p=100[\text{kA/T}] \) is also shown.

References
4) W. A. Cooper, Plasma phys. and Controlled Fusion 34, (1992) 1011