§53. Characteristics of the 2nd Harmonic EC-driven Current in LHD

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In LHD, ECCD experiments have been performed by using EC-waves with the frequency of 84 GHz. The EC-wave beam injection systems of LHD furnishes 2-dimensionally movable mirror which enables the beam direction control. One of the beam injection system which is used for the ECCD experiment described in this report is composed of two inner-vessel mirrors which focus and control the direction of the EC-wave beam radiated from the waveguide transmission line. The injection system is installed at a bottom port (1.5L-port), and the beam is injected from the low magnetic field side (LFS). In the ECCD experiment, the position of the magnetic axis of the plasmas was set at 3.75 m and the magnetic field at the magnetic axis was 1.5 T, that is, the second harmonic resonance field for the frequency of 84 GHz.

Figure 1 shows an example of the time evolutions of plasma current in the cases of ECCD and ECH. The EC-wave beam was injected from 0.5 s to 1.1 s with toroidally oblique injection angle in the right-hand circular polarization for ECCD, and with normal injection to the flux surfaces in the X-mode polarization for ECH. Injection power was 310 kW, aiming at the plasma axis in both cases. By the ECCD, the plasma current was clearly driven up to 3 kA while no significant current was seen by the ECH.

The EC-wave beam direction was toroidally scanned keeping the beam aiming position along the magnetic axis. The plasmas were generated and sustained by the EC-wave power of 310 kW. The scanning means that the parallel component of the refractive index N// at the magnetic axis was scanned. As seen in Fig. 2, the total plasma current changes its direction according to the change of the sign of N//, and the direction agrees with the prediction from the Fisch-Boozer theory in the case of the beam injection from the LFS. The total plasma current shows negative and positive peaks against negative and positive variations of N//, respectively. The peak values are about +-1 kA. The driven current is lower than that seen in Fig. 1 mainly due to too low electron density for the N// scanning experiment.

Long pulse ECCD experiment with 9.6 s pulse duration was performed because the current diffusion time in LHD plasma was evaluated to be in seconds order. The EC-wave power was 110 kW and N// was set at -0.2, with the right-hand circular polarization. The result is plotted in Fig. 3 exhibiting that it takes about 2 seconds for the plasma current to be saturated and stable at about -5 kA. Counter-direction NBI beams from NBI#2 and #3 are applied from 2 to 4 seconds for the motional stark effect (MSE) measurement to measure the rotational transform profile. The MSE measurement is a quite powerful tool to investigate the plasma current profile and its time evolution. So far, existence of an inductive current flowing at around ρ = 0.6 compensating the EC-driven current at the plasma core at the beginning of ECCD timing is suggested from the analysis of the MSE data. Precise time evolution of the current profile will be investigated in the next experimental campaign.

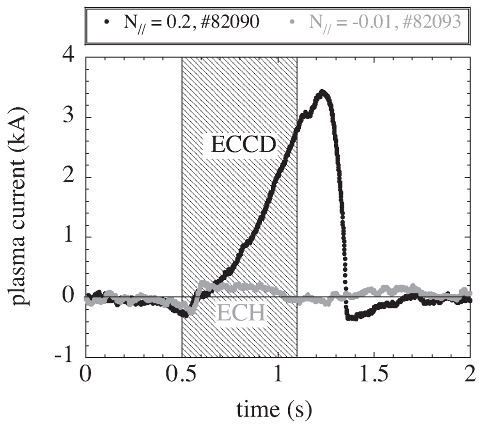

Fig. 1 Time evolution of the plasma current in the cases of ECCD and ECH.

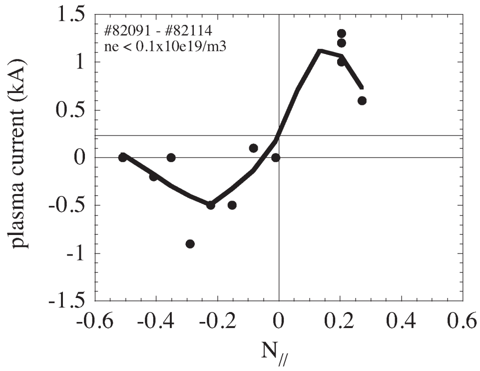

Fig. 2 Dependence of EC-driven current on the parallel component of the refractive index.

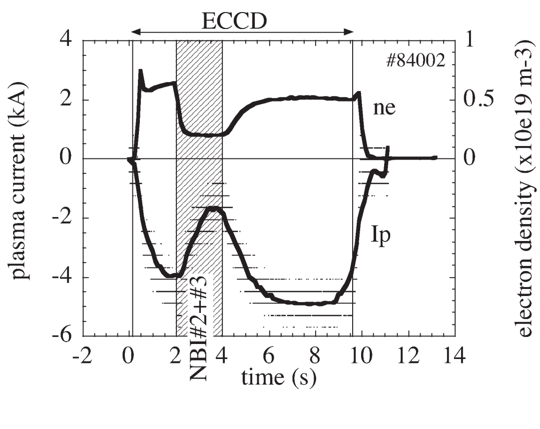

Fig. 3 Time evolutions of the plasma current and the electron density in the long pulse ECCD experiment.