§16. Nonlocal Transport Phenomenon in the Plasma with a Flatten Core Electron Temperature Profile

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An electron heat transport is one of the most important issues in magnetically confined toroidal plasmas, because it can determine the performance of a fusion reactor. Therefore a full understanding of the electron heat transport is highly necessary for gaining a predictive capability to achieve high-performance fusion plasmas. Recent experiments and simulations in fusion research have revealed various features of the electron heat transport, such as its non-linearity. However, there still are a number of unsolved problems in the electron heat transport, as represented by its non-locality (here, 'non-locality' means an instant spatial interaction between two distant locations). A good example of the appearance of the non-locality in the electron heat transport is that an abrupt core electron temperature rise in response to an edge electron perturbation induced by a pellet injection and so on[1)]. This phenomenon is so-called "nonlocal transport phenomenon" and the spatio-temporal feature of the phenomenon is extremely far from the local 'diffusive' paradigm. And thus the non-locality in the electron heat transport is suggested as the cause of such a phenomenon.

Recent LHD experiments have revealed one of the unknown characteristics of the nonlocal transport phenomenon in the helical plasma. Figure 1 shows the temporal evolution of the electron temperature measured with the ECE radiometer at different normalized minor radii. For this discharge (LHD #130027), the major radius at the magnetic axis R_{ax} is 3.53 m, the averaged minor radius a is 0.61 m, the magnetic field at the axis B_{ax} is -2.805 T. Within the time displayed in Fig.1, the plasma is heated continuously by tangential NBIs (injected powers: ~ 1.6 MW in the co-direction, ~ 3.4 MW in the ctr-direction) and ECH with 77 and 154 GHz gyrotrons (total absorbed power ~ 2.95 MW). The line-averaged electron density just before the TESPEL injection is very low, 0.7 x 10^{19} m^{-3}. In order to achieve such a low density, perpendicular NBIs are not used in this experiment. As can be easily recognized in Fig. 1, the core electron temperature is increased in response to the TESPEL injection (t ~ 6.493 s). The increased electron temperature shows its peak at the time of ~ 6.505 s and gradually decreases to the level before the TESPEL injection. Figure 2 shows the radial profile of the electron temperature measured with the ECE radiometer just before and after the TESPEL injection. Although the ECH power is absorbed inside r/a ~0.2 as shown in Fig. 2, the electron temperature profiles show a very flat profile in the core region. This can be attributed to a stochastization of the magnetic field in the core region due to the decrease in the magnetic shear[2)]. Recently, a strong damping of the toroidal flow due to the stochastization of the magnetic field has been discovered in LHD[3)]. Therefore, the observation of the nonlocal transport phenomenon in the plasma with the flatten core electron temperature profile clearly suggests that the toroidal flow has almost no relationship with the nonlocal transport phenomenon. In order to reveal the nature of the non-locality in the electron heat transport, a further investigation on that will be carried out.

1) N. Tamura et al.: Phys. Plasmas **12** (2005) 110705.
2) K. Ida et al: Plasma Phys. Control. Fusion **57** (2015) 014036.
3) K. Ida et al: Nat. Commun. **6** (2015) 5816.

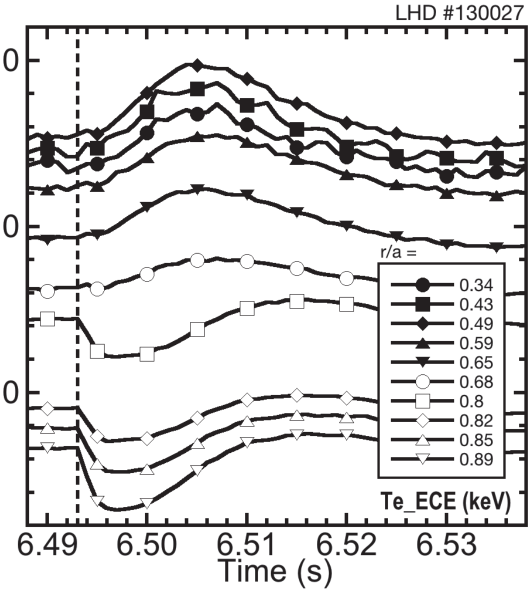

Fig. 1. Temporal evolution of the electron temperature measured with the ECE radiometer at different normalized minor radii. The vertical dashed line represents the time of the TESPEL injection for the edge cooling.

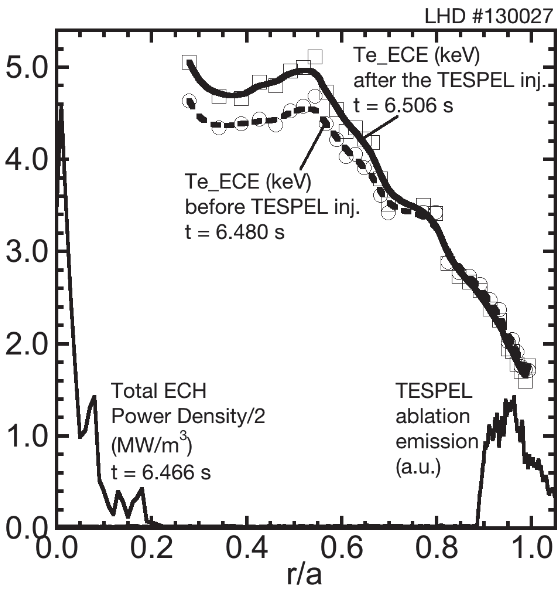

Fig. 2. Radial profile of the electron temperature measured with the ECE radiometer just before and after the TESPEL injection. The total absorbed ECH power density profile and the TESPEL ablation emission profile are also plotted.