§ 6. Cold Pulse Propagation in ECH Plasma on LHD

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Turbulence in plasma can contribute to the non-linear dependence between heat flux and temperature gradient. These complications violate the basic assumption of diffusive nature, and thus the transient transport analysis is recognized to valuably complement static analysis. A recent experimental progress on the formation of internal transport barriers (ITBs) has demonstrated a great improvement of the confinement of LHD plasmas as well as Tokamak one. The clarification of the ITBs physics is now one of the most important issues in confinement studies. In spite of the importance of transport in ITBs, there are only a few of the experiments for transient transport analysis in plasma with ITBs. For helical systems, such a analysis has not been reported. A first result of the transient transport analysis in helical plasma with ITB is presented.

The TESPEL is injected to the edge of eITB plasma (R_{ax} = 3.5m, B_{ax} = 2.854T, $\bar{n}_e = 7 \times 10^{18}\mathrm{m}^{-3}$), which is sustained by on-axis ECRH. The electron barrier survives a perturbation driven by TESPEL even if it is such that the line density increases 50%. The typical time evolution of the electron temperature profile is shown in Fig. 1. The structure in temperature profile (change of temperature gradient in the core region ($r/a \leq 0.2 - 0.3$) is still found 10ms after the TESPEL injection, when the magnitude of central temperature perturbation reaches its peak.

The heat diffusivity can be estimated by solving the following simple equation,

$$\frac{3}{2} n_e \frac{\partial \delta T_e}{\partial t} = \nabla \cdot \left(n_e \chi_{cp} \nabla \delta T_e - \frac{3}{2} n_e V_{cp} \delta T_e \right). \qquad (1)$$

Here the density perturbation is neglected. The heat pinch term is introduced as the index of the non-linearity of heat flux on temperature gradient and/or the off-diagonal transport effect. In fact, the heat pinch term is necessary to explain the cold pulse propagation in LHD. The transient analysis indicates the significant reduction of heat transport inside the barrier region. The heat diffusivity inside the barrier is smaller by a factor of 3-5 than that outside the barrier as shown in Fig. 2(a). This strong reduction agrees well with static (power balance) analysis. The transient analysis also indicates that the difference in sign of the heat pinch term between inside and outside the barrier (Fig. 2(b)). The heat pinch term is considered as the index of the turbulence effect, the transport is thus different qualitatively between inside and outside the barrier.

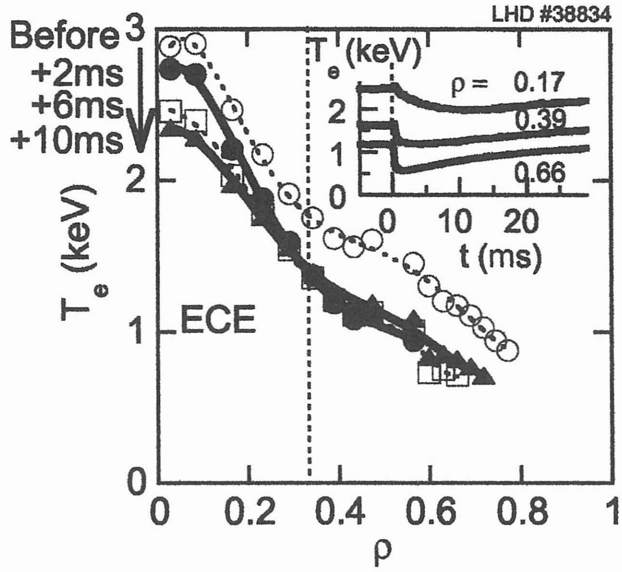

Fig. 1: Time evolution of electron temperature profile measured with heterodyne radiometer. The TESPEL is injected at t = 0ms.

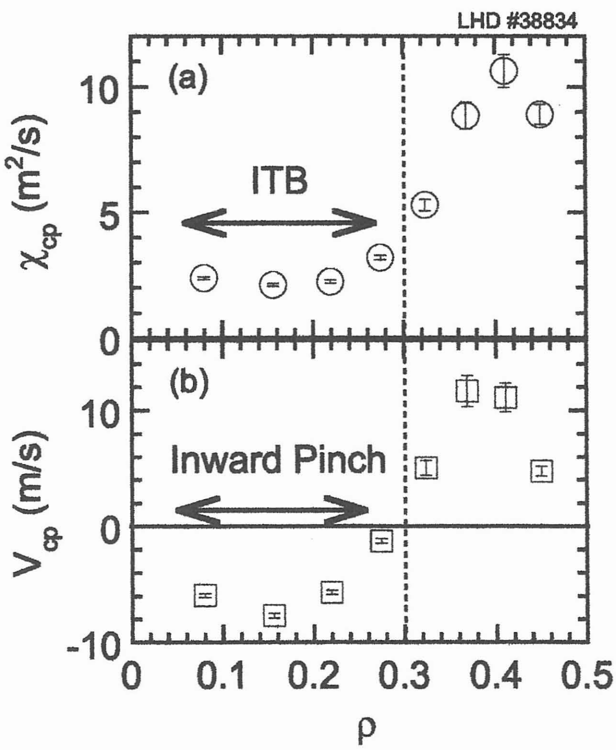

Fig. 2: Radial profiles of (a) heat diffusivity and (b) flow velocity estimated by eq(1).