§8. Radial Structure of Edge Transport Barrier in Inward-Shifted Configuration of LHD

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In the magnetic configuration of LHD, H-modes were first achieved in high beta plasmas of $<\beta_{dia}>$>1.5% where $<\beta_{dia}>$ is the volume averaged beta value evaluated by diamagnetic measurement assuming the volume of the vacuum field [1,2]. In these high beta H-modes, however, ETB formation immediately leads to excitation of edge MHD modes after short quiescent phase (~ 10ms). The edge region where ETB is formed is in magnetic hill and is susceptible of ideal or resistive interchange instabilities. Excited edge MHD modes have the following mode structures as m/n=2/3, 1/2, 2/5 and so on, of which rational surfaces reside very close to LCFS or in the ergodic layer[3]. Recently, ETB was also achieved in medium beta regime of $<\beta_{dia}>$~0.9% (Fig.5) [4]. In this case, $<\beta_{dia}>$ increases in a quiescent phase for ~120ms without suffering intense edge MHD modes.

In some H-mode plasmas, the pedestal structure was observed in electron temperature profile [2]. The ETB zone extends into ergodic layer outside the last closed flux surface (LCFS) defined in the vacuum field. Moreover, ETB region is deformed by the presence of m/n=2/3 island related to edge MHD mode and has a plateau region. The radial profile of the rise in electron temperature across the transition indicates that the ETB or “pedestal” width averaged over the magnetic surface is fairly large (~10 cm) for the averaged minor radius of 64 cm, and is much larger than the poloidal ion gyro-radius for proton at ETB (~ 0.8cm), where Ti~Te (=0.1keV) is assumed and Bt=0.75T. Most of ETB plasmas in LHD exhibit strong density rise near the edge, having almost fixed gradient of electron temperature there. Figure 1 shows the radial profiles of electron density and temperature just before and after the transition at low toroidal field (Bt=0.75T). It should be noted that the shape of electron density profile in the H-phase is hollow and does not have a typical “pedestal” shape. The terminology “ETB” may be suitable to express the edge structure of density profile, instead of “pedestal”. This figure clearly indicates that ETB zone extends into ergodic layer defined in the vacuum field. The width of ETB defined by the distance between the plasma boundary determined from electron temperature profile and the layer where the density rise reaches the maximum isevaluated to be ~14 cm at Bt=0.75T. For ETB plasmas in LHD, the dependence of the ETB width on the toroidal field strength was investigated by scanning Bt from 0.5T to 1.5T on the condition that the rotational transform at ETB is fixed, that is, poloidal field strength is simply proportional to Bt. The ETB width has no clear dependence on Bt, as shown in Fig.2. In tokamak H-mode plasmas, the width is often compared with poloidal ion gyro-radius through a scan of the toroidal field strength and/or plasma current. In this Bt-scan, the electron temperature at ETB remains almost same around Te~0.1 keV. In ETB region of LHD, Ti ~ Te will be satisfied due to relatively high collisionality. The ETB width in LHD is much larger than poloidal ion gyro-radius. Above-mentioned fairly wide width of ETB may be caused by a long penetration length of neutrals. The other cause for thus expanded width of ETB may be ELM activities and/or edge MHD modes. These causes are not yet investigated systematically. The data of ETB width would supplement the database on the pedestal width in tokamak H-mode plasmas and contribute to understanding a dominant mechanism to determine the ETB width.

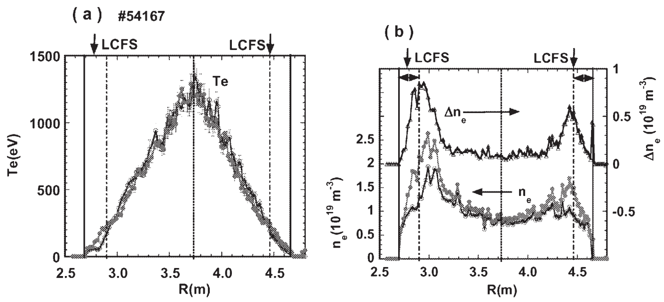

Fig.1 (a) Radial profiles of electron temperature just before (open circle) and after (solid circle) the L-H transition in the configuration of Rax=3.6m and γ=1.22 at Bt=0.75T. (b) Change of electron density profile and radial profile of the increment of electron density Δn_e across the transition.

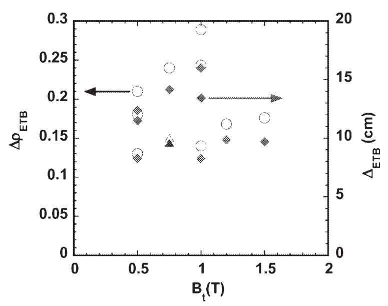

Fig.2 Dependence of ETB width on the toroidal field strength. Solid and open symbols respectively indicate the ETB width Δ_{ETB} and the width normalized by the averaged minor plasma radius $\Delta\rho_{ETB}$. Triangles correspond to the width derived from electron temperature profile and the others from electron density profile.

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