§33. Observation of Te Pedestal in LHD

Ohyabu, N., Narihara, K.

Confinement degradation at higher input power is the major concern in the LHD research as in other toroidal confinement systems. In the design phase of the LHD, we have proposed high temperature divertor operation, where the edge plasma temperature is raised to a few keV by efficient pumping in order to enhance the energy confinement. We have a plan to install a powerful pumping system a few years later. In this year experiment, we have observed a temperature profile with high edge gradient (pedestal), similar to those of the tokamak H-mode discharges

In typical LHD discharges, a target plasma generated by ECH (84GHz, 2nd harmonics) is heated by NBI injection. Presently, the divertor plates and the first wall are stainless steel. Carbon tiles are used only for NBI armor plates. It has been observed that even without active pumping, discharges at B = 1.5 T exhibit fairly rapid decay of plasma density on a time-scale of ~ 400 ms. This fairly strong pumping exists only when the edge temperature is high (correspondingly the plasma temperature at the divertor strike point is higher than 10 eV) in hydrogen discharges. For helium discharges, the density does not decay because of nearly 100 % recycling and thus plasma operation is much easier. The profile shown in Fig.1 is from helium discharges. The observed phenomena described in this report are, however, not sensitive to the species of the bulk plasma. We have observed a relatively high edge temperature plasma, which is similar to the H-mode edge pedestal.

Figure 1 shows the temperature profile during the flat top of a typical LHD discharge. This profile is measured by the Thomson scattering along the major radius (R)(Z=0) at the poloidal plane where the plasma is elongated horizontally (Fig.1(b)). In Fig.1(a) , T_e is plotted as a function of R. A mild pedestal with a shoulder temperature (T_e^{ped}) of ~ 500 eV can been seen. In the outer region (2.8 < R< 3.0 m and 4.4 < R < 4.7 m) where the pedestal exists, the flux surface is expanded toward the X-points significantly (Fig.1(b)). Thus it may be more appropriate to plot it as a function of ρ (normalized effective radius) with an assumption that T_e is constant on the flux surface (Fig.1(c)). In this plot, much sharper T_e gradient at the edge appears. The estimated total thermal conductivity ($n_e \chi$) there is fairly low, typically ~2.0×10^{19} $m^{-1}s^{-1}$. Here we assume that $T_e(r) = T_i(r)$ (the ion temperature). Our T_i profile measurement is very limited at this moment. The T_i profile in the region 0.3< ρ< 0.9 for the low density discharges is presently available and is found to be close to that of T_e. The maximum shoulder temperature (T_e^{ped}) obtained to date is 650 eV. The width of the pedestal is ~4 cm in the Z direction (~0.10 in ρ), which appears to be much larger than the poloidal ion gyroradius (1.5 cm).

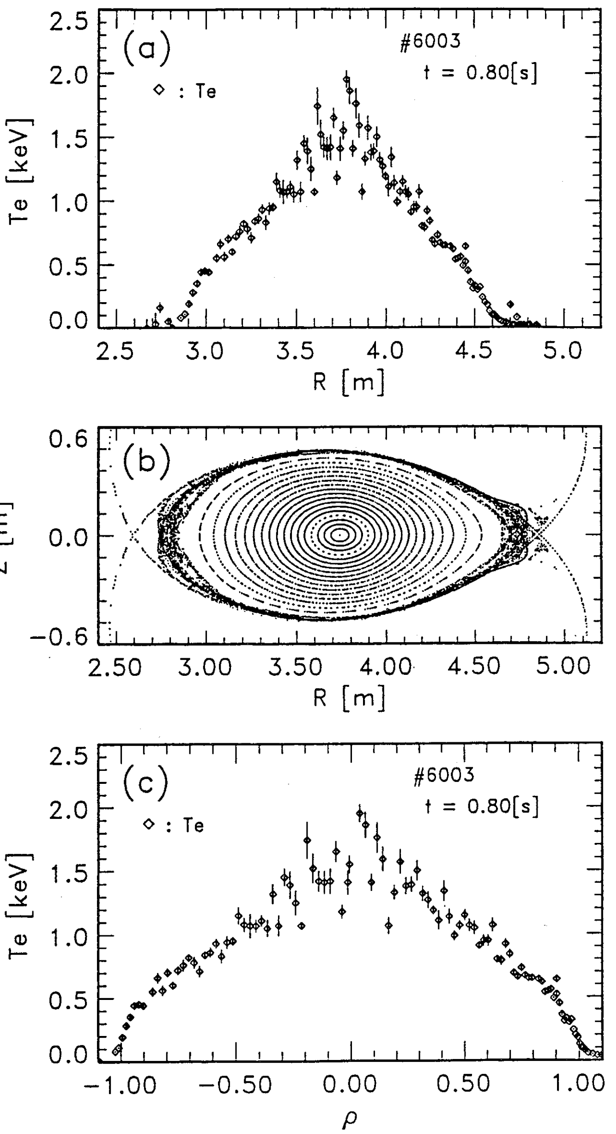

Fig. 1 : (a) A typical electron temperature profile (R_{ax} = 3.70 m, B=1.5 T, n_e (the line average density) = 2.2×10^{19} m^{-3}) measured by Thomson scattering. A pedestal, i.e., high∇T_e region is seen in the edge.
(b) The LHD magnetic configuration. The T_e profile is measured along the major radius (R axis) (Z=0)
(c) The electron temperature profile is plotted as a function of ρ, the normalized effective radius defined by $(\phi / \phi_{LCMS})^{1/2}$ where ϕ and ϕ_{LCMS} are the toroidal flux of the flux surface and that of the LCMS. The data points with negative value of ρ is from those in the inner region (R < 3.75m) in Fig.1(a).