§35. Possible Influence of $t = 1$ Surface on Te Pedestal Formation

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In most of the magnetic configurations of LHD, the magnetic surface of $\bar{\iota} = 1$ is located at the plasma edge region. For example, it exists at $\rho \simeq 0.9$ in the cases of the magnetic axis, $R_{ax} = 3.60\,\mathrm{m}$ and $R_{ax} = 3.70\,\mathrm{m}$, or at $\rho \simeq 1.0$ in the $R_{ax} = 3.90\,\mathrm{m}$ case. Here, $\rho = (\Phi/\Phi_a)^{1/2}$ and Φ is the toroidal magnetic flux. Table 1 shows the plasma volumes and the positions of the $\bar{\iota} = 1$ surface in some R_{ax} cases.

In the T_e profiles of LHD plasmas, the sharp T_e gradient (pedestal) normally appears at the edge region. Figure 1 shows the T_e and $\bar{\iota}$ profile in the case of a hydrogen plasma of $R_{ax} = 3.60\,\mathrm{m}$. This $\bar{\iota}$ profile is calculated for the configuration without any plasma. The location of the high ∇T_e region can be interpreted to be around $\bar{\iota} = 1$ island. Some flattening in T_e profile in this figure can be seen around $\bar{\iota} = 1.0$ and possibly 0.5 surfaces and it is caused by islands generated by an error field. In this profile, the gradient outside the $\bar{\iota} = 1$ surface is larger than the gradient in the inside region by about 50%. In addition, during the expanding phase of low density NBI discharges, a pedestal appears in the core ($\rho \simeq 0.8$) while the $\bar{\iota} = 1$ surface determines the boundary of the T_e profile (Fig.2). Moreover, we also found a steep T_e gradient just outside of the external imposed island ($m/n = 1/1$). Thus the $m/n = 1/1$ island or $\bar{\iota} = 1$ surface may play some role in formation of the temperature pedestal.

Figure 3 shows the electron temperature at the pedestal, $T_e^{ped}(\rho \simeq 0.9)$ for different configurations and fields. The average electron density and the NBI input power are fixed at $2.0 \times 10^{19}\,\mathrm{m^{-3}}$ and 3 MW respectively. A fact of low T_e^{ped} at $R_{ax} = 3.9\,\mathrm{m}$ may be explained as follows. The $\bar{\iota} = 1$ surface is located at $\rho \simeq 1$ and thus the gradient can exist only inside the $\bar{\iota} = 1$ surface. The gradient inside the $\bar{\iota} = 1$ surface appears to be weaker than that of outside. From the simplified transport relation, $n\chi\nabla T \simeq P_{total}/S$ and $T_e^{ped} \simeq 0.1a\nabla T$ (P_{total} : input power, S : plasma surface area, a : minor radius), $n\chi_{ped}\,[\mathrm{m^{-1}s^{-1}}] \simeq 4.2 \times 10^{18} \cdot P_{total}[\mathrm{MW}]/T_e^{ped}[\mathrm{keV}]$. For example, in the case of $R_{ax} = 3.60\,\mathrm{m}$ and $B = 2.5\,\mathrm{T}$, the effective $n\chi_{ped}$ is estimated to be about $1.8 \times 10^{19}\,\mathrm{m^{-1}s^{-1}}$. From this limited data set, we also found fairly weak B dependence of T_e^{ped} and $n\chi_{ped}$.

R_{ax} [m]	V [m^3]	$\bar{\iota} = 1$ surface
3.60	29.3	$\rho \simeq 0.9$
3.70	27.5	$\rho \simeq 0.9$
3.75	25.6	$\rho \simeq 0.93$
3.90	21.5	$\rho \simeq 1.0$

Table.1. volumes of LHD plasmas and positions of the $\bar{\iota} = 1$ magnetic surface for the configurations tested in the experiment

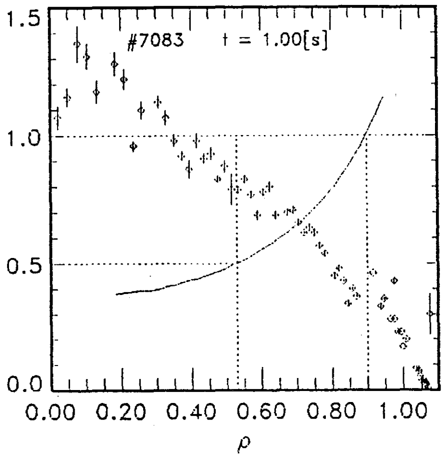

Fig.1. T_e and $\bar{\iota}$ profile ($R_{ax} = 3.60\,\mathrm{m}$, $B = 2.75\,\mathrm{T}$ H plasma)

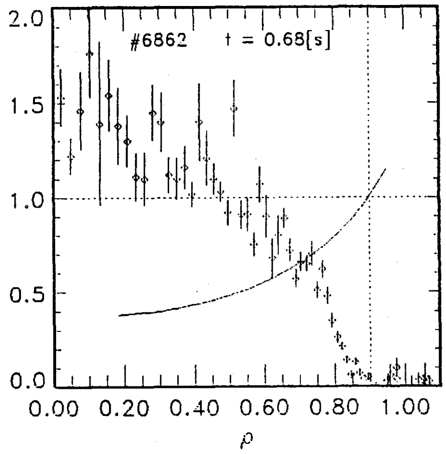

Fig.2. T_e and $\bar{\iota}$ profile during the expanding phase of the NBI plasma ($R_{ax} = 3.60\,\mathrm{m}$, $B = 2.50\,\mathrm{T}$, He plasma)

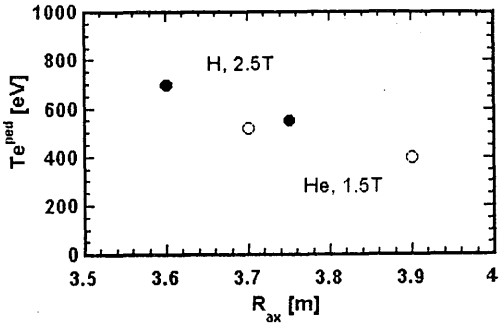

Fig.3. T_e^{ped} in various magnetic configurations