§44. Divertor Plasma Properties in LHD

Masuzaki, S.

Edge plasma control using the divertor for improvement of the core plasma performance is one of the major experimental goals in LHD. In the first and second experimental cycles, all experiments were performed under the open "natural" helical divertor (HD) configuration. One of the characteristics of HD configuration is the existence of the ergodic region surrounding the core plasma and the region with multiple thin curved layers surrounding the ergodic region.[1] The effects of this magnetic structure to the confinement and divertor function must be obvious.

For divertor plasma measurement, a Langmuir probe array (21ch), and a thermocouple array (28ch) were set on the divertor plate which is located at the torus inboard side of the poloidal planes, where the magnetic surfaces are horizontally elongated. Two divertor legs can be detected by this arrays(see Fig.1). The spatial resolution of the Langmuir probe array was designed to be 5 mm at the finest part to detect the narrow divertor channels. Profiles of the divertor particle flux (Γ_{div}), electron density ($n_{e,div}$) and temperature ($T_{e,div}$) were measured for various discharges.

Figure 2 shows a typical Γ_{div} profile and a magnetic field connection length profile obtained by calculation. Horizontal axis is the position along the probe array. Two peaks of Γ_{div} were observed, and their positions are agree with the divertor traces, that is, long magnetic field lines' positions. The same results were obtained in the discharges with other R_{ax}. It is found that the width of Γ_{div} profile is insensitive to plasma parameters, and is strongly restricted by the magnetic field structure. This agrees with previous calculation results of magnetic field tracing[2] qualitatively. The peak value of Γ_{div} profile is typically $1\times10^{22}m^{-2}s^{-1}$. This is roughly corresponding to the outward flux from core plasma, that is, N/τ_p. For the case of $N=<n_e>V=3\times10^{19}(m^{-3})\times30(m^3)=9\times10^{20}$ and $\tau_p=0.1(s)$, N/τ_p is $9\times10^{21}(s^{-1})$. When divertor wet area is assumed to be 1.6 m^2 from the profile of Γ_{div}, then particle flux to divertor is 1.6×10^{22} (s^{-1}). Electron temperature in divertor plasma is typically 20eV. Therefore, the heat flux to divertor is estimated to be 360 kW, with the assumptions of $T_{i,div}=T_{e,div}$. This is about a half value of radiation power. This initial experimental phase, Langmuir probe measurement was performed only one location in non axis symmetric HD configulation, thus detailed quantitative study of energy and particle balance is difficult. It is necessary to measure the plasma parameters at other typical locations simultaneously.

Figure 3 shows the $T_{e,div}$ as a function of $T_{e,edge}$ ($\rho=1$) measured with YAG Thomson scattering system, and it indicates that $T_{e,edge}$ is about 10 times higher than $T_{e,div}$. It is also shown that $T_{e,div}$ dependence on $T_{e,edge}$ changes at $T_{e,edge}$ = ~ 170eV. In the higher $T_{e,edge}$ region, the rising rate of $T_{e,div}$ becomes small. This critical $T_{e,edge}$ is also related to density decay phenomenon[2]. In the discharge of $T_{e,edge}$ < ~ 170 eV, no density decay was observed. The data in the high $T_{e,edge}$ region were obtained during density decay phase. This tendency is also observed in the discharge with B_t = 2.5 T. One possibility of the reduced $T_{e,div}$ rising is that during density decay phase, the energy loss in ergodic region increases due to ionization, radiation and charge exchange. Temperature pedestal observed at $\rho=0.9$ is possibly relating with this result.

1) Ohyabu, N., et al.: Nuclear Fusion, Vol.34, No.3 (1994)384.
2) Motojima, O., et al.: Physics of Plasmas, Vol.6, No.5 (1999) 1843.

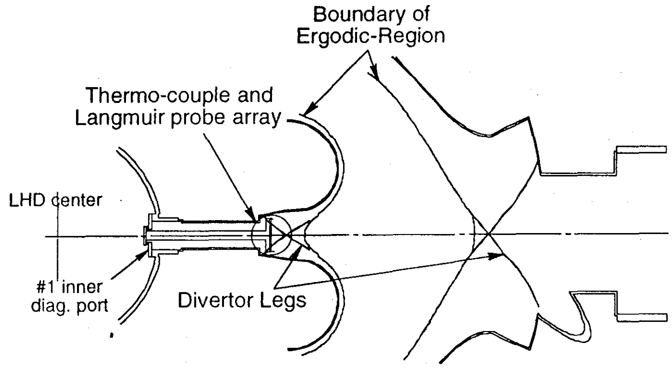

Fig.1 Cross-section view(perpendicular to helical coils at inboard side).

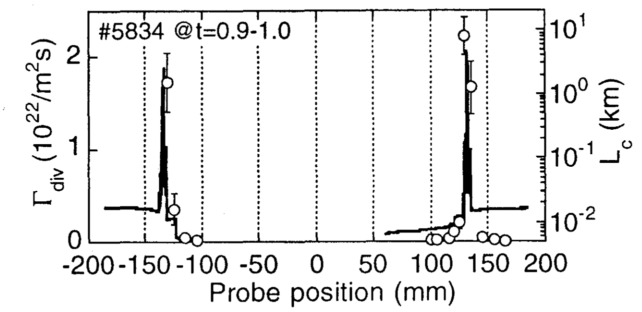

Fig.2 A profile of the particle flux to the dibertor plate(Γ_{div}) and connection length of magnetic field lines on which Langmuir probe and thermo-couple arrays are set. (#5834: Hydrogen discharge, NBI co and ctr. injection)

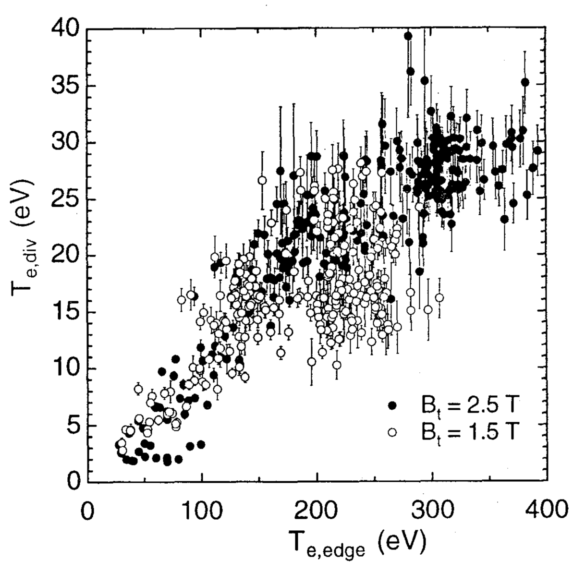

Fig. 3. $T_{e,div}$ as a function of $Te_{,edge}(\rho=1)$