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Density dependence of ion and electron temperatures in the LHD divertor plasma
LHDダイバータプラズマにおけるイオン・電子温度の密度依存性

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It is important to understand the edge and divertor plasma characteristics in order to operate high performance plasma in fusion devices. Ion temperature (T_i) and electron temperature (T_e) are the key parameters for characterizing the heat and particle transport in such boundary plasmas. So far, probe measurements have been done in such region, using a multiple functions probe [1-3]. In this study, we measured density dependence of T_i and T_e in the divertor plasmas in the Large Helical Device (LHD) by using a multiple functions probe designed for measuring these parameters.

Figure 1 (d) shows line-averaged electron density ($\bar{n}_e$) dependence of T_i and T_e measured in the divertor leg in LHD for 18 scans for different 9 shots.

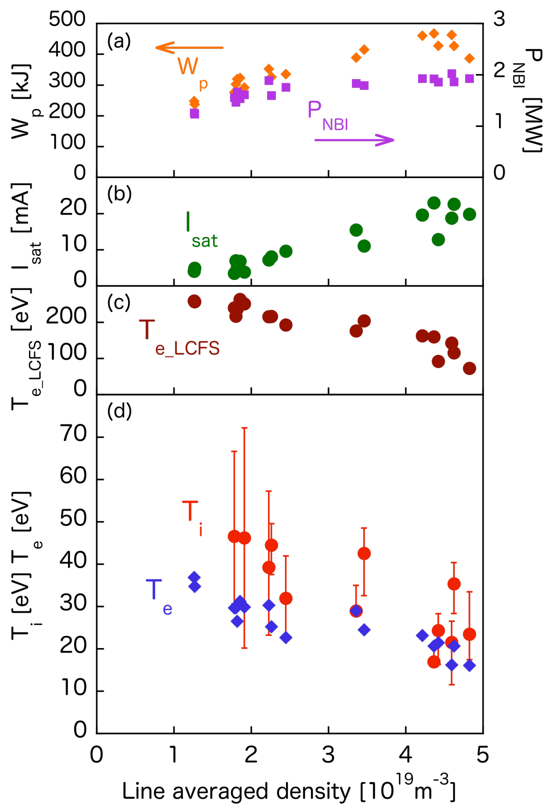

Fig. 1 Dependences of T_i and T_e in the LHD divertor legs on line-averaged density

As shown in Fig. 1 (d), both T_i and T_e decrease with increasing of $\bar{n}_e$, and the decrease of T_i is larger than that of T_e. Although T_i is approximately twice T_e at $\bar{n}_e \sim 2\times10^{19}$ m^{-3}, T_i and T_e become almost the same temperature at $\bar{n}_e > 4\times10^{19}$ m^{-3}. T_i and T_e in the divertor leg are almost proportional to electron temperature at the LCFS, as shown in Fig.1 (c).

The tendency that $T_i \sim T_e$ at high density might be explained by taking into account energy relaxation between ions and electrons. Generally, ion energy losses in the boundary region are caused by charge exchange and elastic collisions with the neutral particles. Electron energy losses are caused by excitation and ionization.

In order to evaluate the energy balance of ions and electrons quantitatively, we consider the energy balance equations of ions and electrons as follows;

$$n_i V \frac{dT_i}{dt} = -\frac{n_i(T_i - T_e)}{\tau_T^{ei}} V - n_i n_z \langle\sigma v\rangle_{cx+in} (T_i - T_z) V \quad (1)$$

$$n_e V \frac{dT_e}{dt} = \frac{n_e(T_i - T_e)}{\tau_T^{ei}} V - n_e n_z \langle\sigma v\rangle_{ioniz} E_{ioniz} V - n_e n_z \langle\sigma v\rangle_{excit} E_{excit} V \quad (2)$$

where, τ_T^{ei} is relaxation time between ions and electrons. n_i, n_e and n_z are ion, electron and neutral particle density. T_z is neutral particle temperature. Each $\langle\sigma v\rangle$ is rate coefficient for corresponding process.

In this presentation, we will discuss the comparison of the experimental result with analytical one using above calculations.

References

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