§5. Influence of Closed Divertor on Ion Behavior in the LHD Edge and Divertor Plasmas

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Plasma flow and ion temperature (T_i) are the key parameters for characterizing the heat and particle transport in boundary plasmas. So far, plasma flow alternation was found on the experiment using multiple functions probe, which consists of Mach probes and an ion sensitive probe (ISP) in the LHD boundary plasma [1-3]. In this experimental campaign, influences of plasma density on spatial profiles of plasma flow in stochastic magnetic boundary layer and T_i and electron temperature (T_e) in divertor plasma were investigated by a movable multiple functions probe, which consists of Mach probes and an ISP.

In last experimental campaign, we observed both T_i and T_e decrease with increasing of n_e, and the decrease of T_i is larger than that of T_e. Although T_i was higher than T_e in low-density plasma, both temperatures became almost same with increasing the density[3]. 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 temperature change 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_z is neutral particle density. T_z is neutral particle temperature. Each $\langle \sigma v \rangle$ is rate coefficient for corresponding process. Figure 1 shows time evolution of T_i and T_e as analytical results of the energy balance equations. Evaluated relaxation times tend to short in high plasma density. The analytical results are qualitatively consistent with experimental ones. However, the relaxation time is strong influenced by gas pressure. This indicates the importance of neutral profile in the edge and divertor plasmas.

In Fig. 2, spatial profiles of T_e measured by the outer electrode of ISP compare between the open divertor configuration (#111620) and the closed one (#114209). In the closed divertor configuration, T_e tends to be low. Increase of n_e and neutral gas pressure in the closed configuration might explain the change of the profile. To clarify the change of the temperature profile, measurements of plasma density and temperature profile along the magnetic field line would be necessary. Investigation of spatial profile of neutral particles is also important.

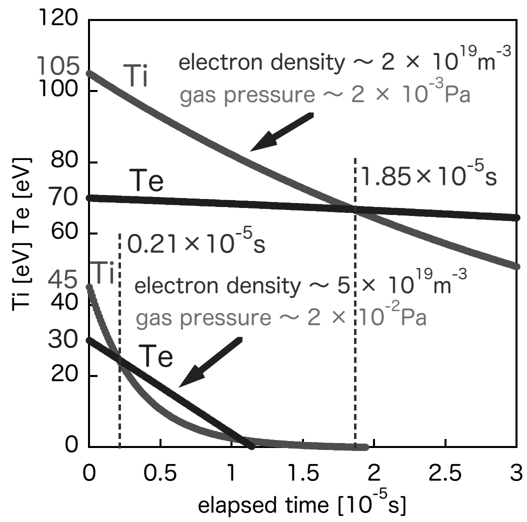

Fig. 1. Change of T_i and T_e in time for different plasma density and neutral gas pressure.

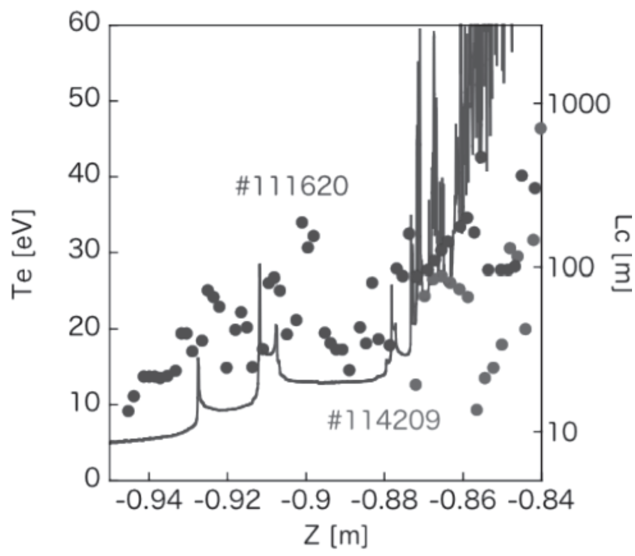

Fig. 2. Spatial profiles of T_e measured by the outer electrode of ISP for the open divertor configuration (#111620) and the closed one (#114209).

1) Ezumi, N., Kobayashi, T., Masuzaki, S. et al.: J. Plasma Fusion Res. Ser. **8** (2009) 429.
2) Ezumi, N., Todoroki, K., Kobayashi, T. et al.: J. Nucl. Mater. **430-432** (2011) 415.
3) Hayashi, Y., Ezumi, N. et al.: J. Nucl. Mater. DOI: 10.1016/j.jnucmat.2013.01.272.