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DT-ALPHA を用いた体積再結合進展過程における電子・イオン・中性粒子間エネルギーフロー調査

Investigation of the energy flow among electron-ion-neutral in volumetric recombining plasma formation using DT-ALPHA device

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Detached divertor can be formed by utilizing electron-ion recombination (EIR). Reaction rate of the EIR becomes large in low electron temperature (T_e) region, typically below 1 eV. However, electrons that flow into divertor region have much larger T_e required for EIR. Therefore, electron energy removal is indispensable for enhancing EIR in a divertor plasma. It has been considered that electrons loose their energy through electron impact excitation, ionization, and elastic collision in relatively higher T_e region, whereas temperature relaxation with bulk ions becomes main process of electron cooling in the region where $T_e < 5$ eV. To understand the detached/recombining plasma formation comprehensively, the amount of energy transferred through these collisional processes should be evaluated. However, such a investigation has not been conducted because it requires ion temperature (T_i) measurement as well as T_e measurement. In our previous work, an ion sensitive prove (ISP) was installed and first T_i measurement was conducted [1]. In the present study, validation of T_i measurement by an ISP was investigated. Then the amount of energy transferred among electrons, ions, and neutrals was evaluated.

Experiment was conducted using an RF plasma device DT-ALPHA [2]. In this experiment, a helium ionizing plasma was produced and diagnosed. Before evaluating energy flow, validity of the ISP measurement should be confirmed. Therefore, T_i was also obtained by the Doppler spectroscopy (T_i^{DP}). Figure 1 represents the dependence of T_e, n_e, and T_i on RF heating power P_H. As shown in Fig. 1, T_i^{ISP} has similar value with T_i^{DP} and showed a same trend on P_H. This result indicates that T_i measurement by the ISP was consistent with that by the spectroscopy. And this confirmation enables us to evaluate electron-ion-neutral energy flow. We evaluated amount of the energy due to several collisional process (electron impact excitation, electron impact ionization, electron-ion recombination, electron-neutral elastic collision, electron-ion temperature relaxation, ion-neutral charge exchange, and ion-neutral elastic collision). In the presentation, we will report detail of the energy flow evaluation, as well as results of ISP measurement.

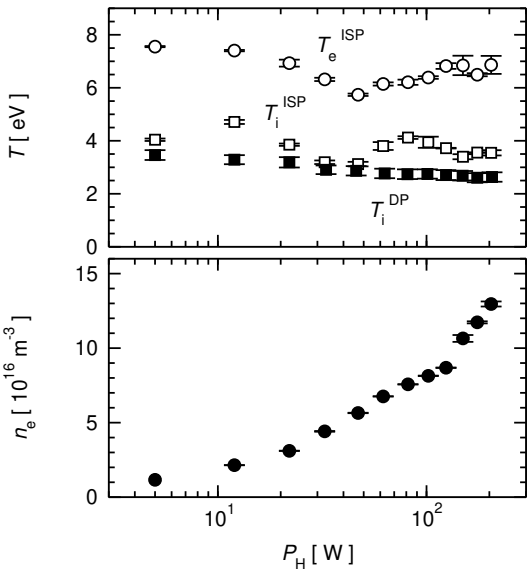

Figure 1: Dependence of T_e, T_i^{ISP}, T_i^{DP}, and n_e on RF heating power P_H. The target plasma was helium ionizing plasma.

[1] T. Kobayashi *et al.*, Plasma Fusion Res., **13**, 3401090 (2018).

[2] A. Okamoto *et al.*, Plasma Fusion Res., **3**, 059 (2008).