§2. Investigation of Plasma Boundary as the Ionization Location of Neutral Atoms

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The plasma boundary in terms of the neutral ionization is investigated for a detached plasma sustained by ECH (electron cyclotron heating). Since intense line radiation implies occurring vigorous atomic processes, the radial ionization location of neutrals can be approximated by the primary line radiation location. We first determine the electron temperature T_e and density n_e at such a location from a line intensity distribution of neutral helium. We then compare those parameters with the T_e and n_e profiles measured by the Thomson scattering system so that the primary line radiation location is located.

The temporal development of the discharge used for this study is shown in Fig. 1. Helium is used as the working gas and the gas-puff rate is feed-back controlled to follow the preset waveform of the line-integrated n_e measured by the interferometer. As the central n_e, n_{e0}, increases, the central T_e, T_{e0}, is lowered as seen in Fig. 1(b).

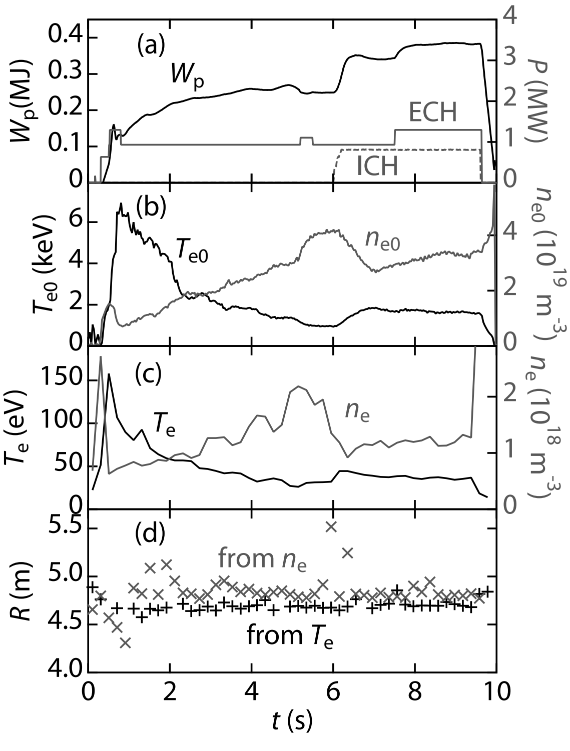

Fig. 1: Temporal development of the discharge used in the present analysis. The results of the spectroscopic analysis are also shown.

The divertor detachment is observed at around $t = 5$ s and terminated by the ICH (ion cyclotron heating) input at $t = 6$ s which is judged by the ion saturation current measured by the electrostatic probes on the divertor plates. It is observed that n_{e0} is stepwise increased during the detachment, and is gradually decreased after the re-attachment. Our interest is whether the ionization location of neutral atoms is displaced during the period of the divertor detachment. If the plasma shrinks as a result of the detachment, the ionization location could be inward shifted accordingly.

The nine emission lines indicated in Fig. 2 are used to determine T_e and n_e [1]. Figure 1 (c) shows the temporal variations of T_e and n_e determined from helium lines. The both results respectively show similar temporal variations to their central values in Fig. 1 (b). This result indicates that the primary ionization location is determined by neither local T_e nor n_e. It is noted that the agreement between the locations independently determined by T_e and n_e is satisfactory, that supports the reliability of the present diagnostic methodology.

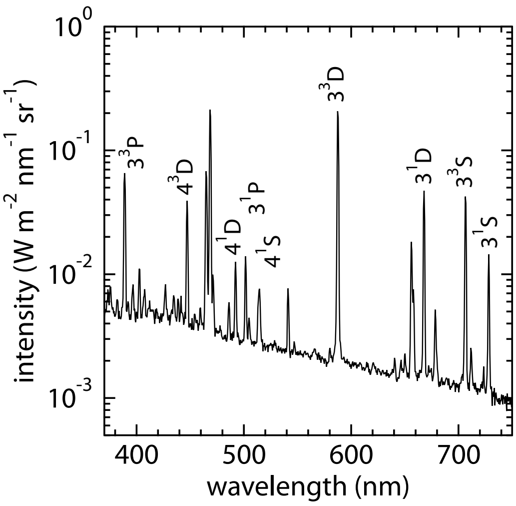

Fig. 2: Example of the measured spectra. The nine emission lines used in the analysis are indicated by the labels showing the upper state of the transition.

A remarkable characteristic is that the primary ionization location is virtually fixed as seen in Fig. 1 (d) while the T_e and n_e values change in the course of time. It is also noticed that no displacement of the emission location is seen in the period of the divertor detachment. These results suggest that the primary ionization location is determined by the magnetic field structure and is irrespective of the plasma conditions.

1) M. Goto and K. Sawada: J. Quant. Spectrosc. Radiat. Transf. **137**, 23 (2014).