§16. Exploration of Multi-charged Carbon Ion in RT-1

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The laboratory magnetosphere has been simulated in RT-1 at The University of Tokyo aiming for the futuristic plasma confinement configuration, as well as the investigation of planetary physics. The preceding experiments succeeded to demonstrate the inward diffusion[1)], which is the underlying mechanism for self-organization in a magnetosphere, through the observation of the peaked density profile. We conducted Doppler spectroscopy to measure the ion temperature.

Until the previous experiment, the observed valence of the carbon ion was up to C^{2+}. Figure 1 shows the dependence of the valence of carbon ion on the cold electron temperature in stationary state calculated from the rate equation with typical plasma parameters in hydrogen discharge in RT-1. The measured cold electron temperature was 30∼40 eV. The charge transfer between the neutral hydrogen gas (density $n_{\rm n}$) is considered in Fig 1(b). To realize the C^{2+} dominated state, the neutral gas density must be comparable to or more than the electron density.

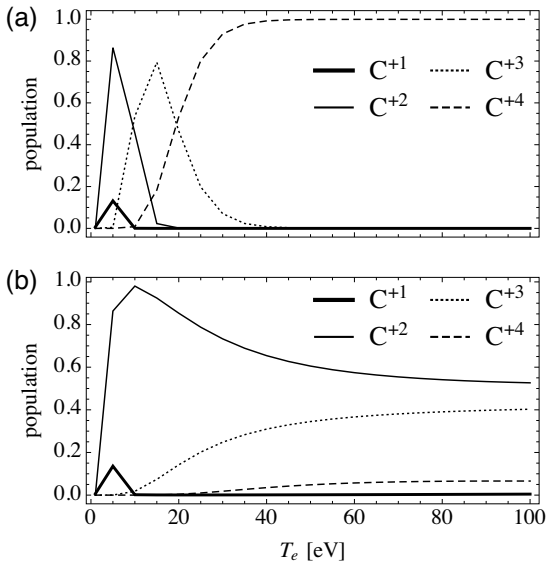

Fig. 1: Dependence of the valence of the carbon ion on the cold electron temperature. (a): $n_{\rm n} = 0$, (b): $n_{\rm n} = n_{\rm e}$

In the recent experiment, C V transition (227.091 nm) was observed (Fig. 2). Figure 3 shows the radial profile of C III (464.742 nm) and C V spectra. Two spectra were measured by the different spectrometers. The result shows that the radial peak positions of the intensity are different. Additionally in the latest experiment, we observed C II spectrum (426.726 nm).

Since we have the electron and the ion temperature profiles, we anticipate to evaluate the neutral gas density profile from the profile of the carbon ion in different charge states. Recently we observed betatron acceleration of ion pertinent to the inward diffusion[2)]. In order to formulate the appropriate energy transport equation of ions, we need to identify the loss mechanism for the ions competing with the betatron acceleration. Assuming the charge exchange loss as the major loss mechanism and the plausible neutral density profile, our energy transport equation succeeded to replicate the observed ion temperature profile. The validation of the assumed neutral density profile is the essential task.

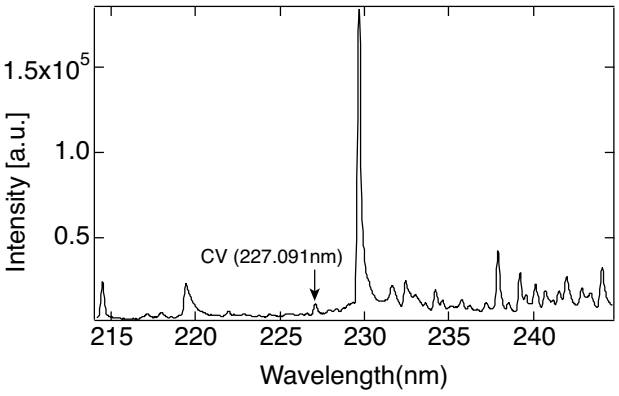

Fig. 2: C V spectrum

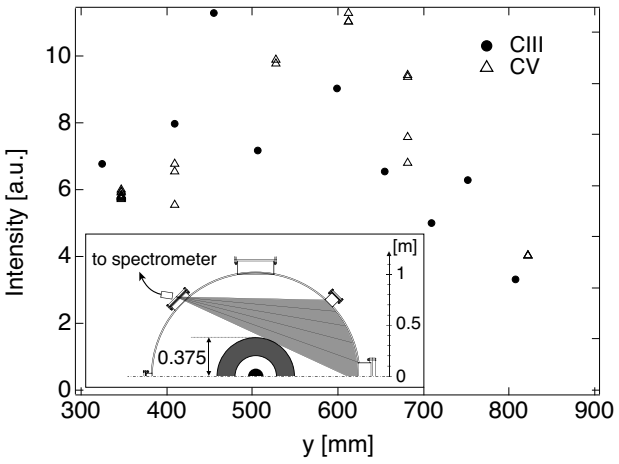

Fig. 3: Radial intensity profiles of C III and C V. The inset figure illustrates the line of sight for the spectroscopic measurement in RT-1.

1) Saitoh, H. *et al. Phys. Plasmas* **21**, 082511 (2014).

2) Y. Kawazura, Z. Yoshida, M. Nishiura, H. Saitoh, Y. Yano, T. Nogami, M. Yamasaki, A. Kashyap, T. Mushiake and N. Sato. in preparation (2015).