§20. Development of Impurity Profile Diagnostics in the Ergodic Layer of LHD Using 3 m Normal Incidence VUV Spectrometer

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The effects of thick stochastic magnetic field layer located outside the core plasma of LHD called "ergodic layer" on the impurity transport have recently attracted attention. A precise measurement on the spatial profile of impurity line emissions in the ergodic layer is required to investigate the impurity transport in such stochastic magnetic field. The vacuum ultraviolet (VUV) lines from impurity ions are significantly emitted in the ergodic layer because the electron temperature around the last closed flux surface (LCFS) ranges from 10 to 500 eV. Therefore, space-resolved spectroscopy was developed to measure the intensity profiles of the VUV emission in wavelength range of 300-3200 Å from impurities in the ergodic layer.[1)]

Figure 1 shows a schematic drawing of the impurity diagnostics system in LHD using a 3 m normal incidence VUV spectrometer (McPherson model 2253) installed on a horizontal diagnostic port (#10-O). The optical axis was arranged perpendicular to the toroidal magnetic field in the bottom edge at holizontally-elongated plasma cross section to adjust the observable region to the ergodic layer. The wavelength resolution is 0.15 Å when an entrance slit is set to 20 μm in width and a 1200 g/mm grating is used. A back-illuminated CCD detector (Andor model DO435-BN: 1024×1024 ch) is placed at the position of exit slit. The size of the CCD is 13.3 × 13.3 mm^2 and the pixel size is 13 × 13 μm^2. The line dispersion of the spectrometer changes almost linearly from 0.0362 to 0.0370 Å/pix, while the wavelength changes from 300 to 3200 Å. The vertical profile of VUV emissions as a wavelength-dispersed image is projected on the CCD detector by a slit for spatial resolution called "space-resolved slit" mounted between the entrance slit and the grating in the spectrometer. A mirror unit which consists of a flat mirror and a cylindrical mirror was designed and installed between the spectrometer and the torus to switch the view angle. The sightline can be expanded to measure the full plasma profile with wider viewing angle if the mirror unit is used.

Figure 2 (a) shows the vertical profiles of CIV line intensity with the wavelength of 1548.20 × 2 Å. LCFS of the vacuum magnetic field is indicated with arrow. It is known that the spatial profile of the CIV intensity has a steep peak in the ergodic layer. CIV emission is released only in the outermost region of the ergodic layer in LHD plasmas because the low ionization energy of 65eV for C^{3+} ions causes less fractional abundance in the core plasma. Therefore, the peak of the intensity profile outside LCFS shown in Fig. 2 (a) is a result of line integration in a long path along the sightline through the ergodic layer at the bottom edge of the holizontally-elongated elliptical plasma. Figure 2 (b) shows the profiles of ion temperature T_i derived from the Doppler broadening of CIV spectrum. The T_i profile also indicates the edge T_i in the ergodic layer at corresponding vertical position.

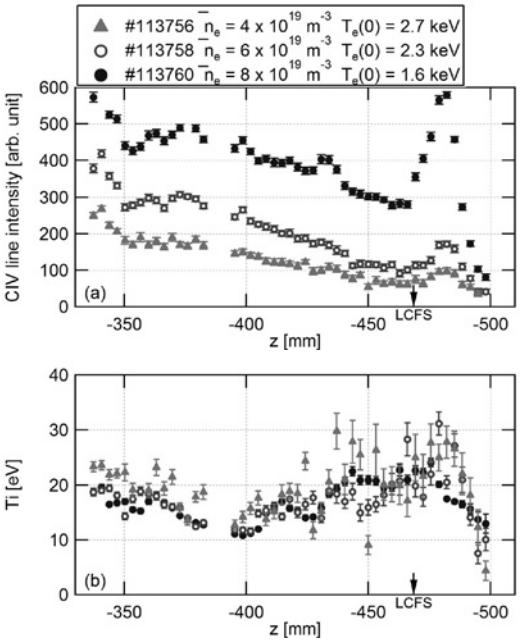

Fig. 2. Vertical profiles of (a) CIV line intensity and (b) ion temperature derived from the Doppler broadening of CIV spectrum.

1) Oishi, T. et. al.: *to be published in* Plasma and Fusion Research.

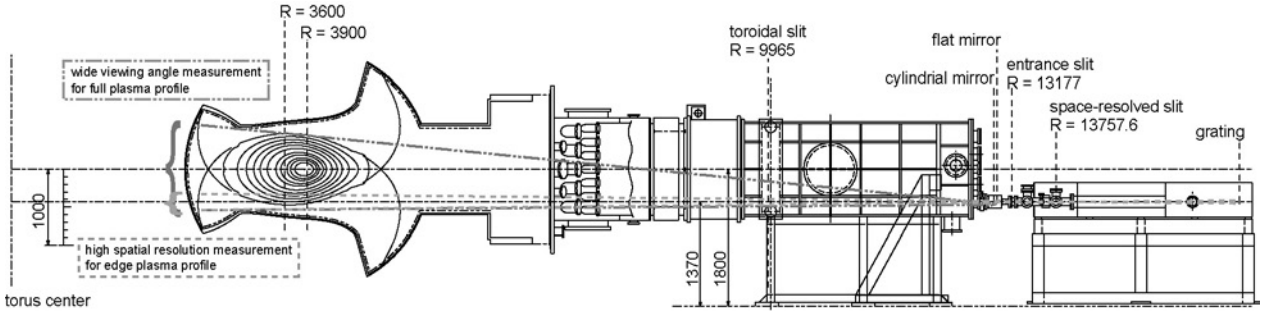

Fig. 1. Poloidal cross section of LHD and impurity diagnostics system for study of ergodic layer using space-resolved 3 m VUV spectrometer.