

### §31. Two-dimensional Distribution of Impurity Line Emissions in LHD

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A schematic drawing of different poloidal cross sections observed by space-resolved flat-field EUV spectrometer is shown in Fig.1. The EUV spectrometer is placed at distance of  $X=13052\text{mm}$  along major radius direction ( $Y=0$ ) from the torus center denoted with "C". The two-dimensional distribution is recorded by scanning the observation chord between  $\varphi=-7^\circ - +7^\circ$ , of which the angles are limited by the LHD #1-O diamond port and the rectangular port of vacuum vessel extension between the LHD and the spectrometer [1]. Since the elliptical plasma cross section rotates with the horizontal angle, the X-point structures at inboard and outboard sides can be separately observed as seen in the cross sections denoted with  $\varphi=-2^\circ$  and  $\varphi=+2^\circ$  in Fig.1.

The structure of ergodic layer in horizontally elongated cross section ( $\varphi=0^\circ$ ) at  $R_{ax}=3.6\text{ m}$  is shown in Fig.2. The thickness of the ergodic layer,  $\lambda_{erg}$ , varies with the poloidal and toroidal angles exhibiting a complicated three-dimensional structure. The minimum thickness of ergodic layer appears at two poloidal locations near the helical coils, which are here defined as "O-point". The  $\lambda_{erg}$  increases not only with  $R_{ax}$  but also with  $\beta$  value. There exist four intrinsic divertor legs connecting X-point region to divertor plates. The total number of field lines in the inboard X-point directly connecting to the divertor plates, which does not mean the magnetic field strength, is much larger than that in outboard X-point, at least, in  $R_{ax}=3.6\text{m}$ .

The two-dimensional distributions have been measured in steady discharges over 10s with electron density of  $2 \times 10^{13}\text{cm}^{-3}$  and electron temperature of  $2\text{keV}$  [2]. Typical examples are shown in Fig.3 for HeII, CV, CVI and FeXX. Each figure is superimposed by three distributions in different vertical ranges, i.e., upper, middle and lower parts of LHD plasma, which are independently recorded in different discharges by changing the vertical angle of EUV spectrometer. The four impurity ions shown in Fig.3 have different ionization energies of  $54\text{eV}$  (HeII),  $392\text{eV}$  (CV) and  $490\text{eV}$  (CVI) and  $1582\text{eV}$  (FeXX). Seeing three images of Figs.3 (a)-(c) we find two important results. One is the strong intensity appeared in the bottom of the image. However, the reason is now unclear. The other is a trace of inboard X-point. It is clearly seen as a linear trace from left-bottom ( $Y=-200\text{mm}$  and  $Z=-400\text{mm}$ ) to right-top ( $Y=200\text{mm}$  and  $Z=500\text{mm}$ ). Compared to Fig.1, we can understand that the trace is originated in the emission from inboard X-point. The present result strongly suggests the presence of higher density, at least higher impurity density, near the inboard X-point.

Vertical distributions obtained at  $Y=0$  in Fig.3 are plotted in Fig.4. The Fe XX profile clearly indicates a function of magnetic surface, while the profiles of He II and C V show asymmetric ones reflecting a typical feature of stochastic magnetic field layer.

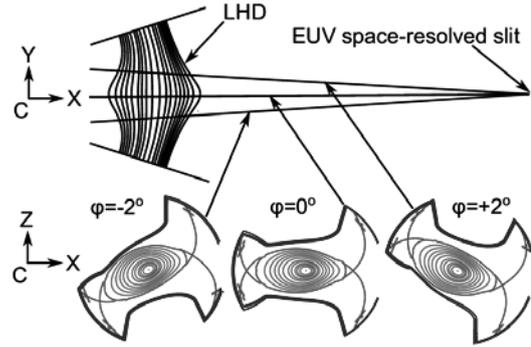


Fig.1 Poloidal cross sections at three different observation chords of space-resolved EUV spectrometer.

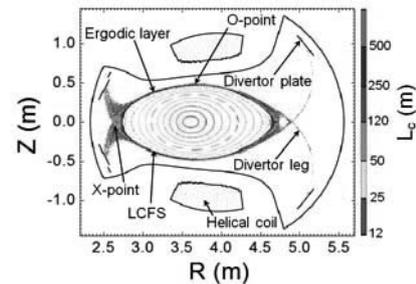


Fig.2 Magnetic field structure of LHD in  $R_{ax}=3.6\text{m}$ .

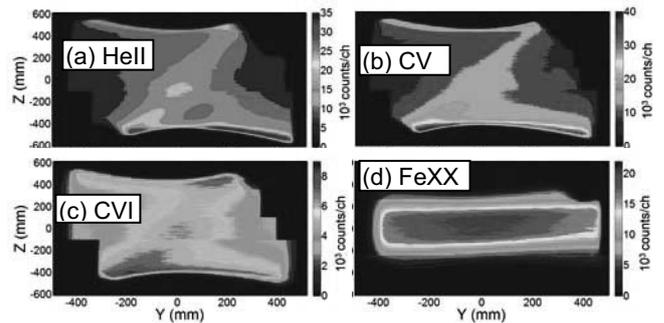


Fig.3 Two-dimensional distributions of (a) HeII ( $303.8\text{Å}$ ), (b) CV ( $40.3\text{Å}$ ), (c) CVI ( $33.7\text{Å}$ ) and (d) FeXX ( $132.9\text{Å}$ ).

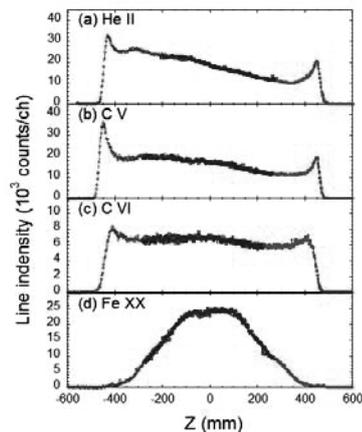


Fig.4 Vertical distributions of (a) HeII, (b) CV, (c) CVI and (d) FeXX at  $Y=0\text{mm}$  in Fig.2. Each profile is composed of three discharges traced in different colors.

- 1) Wang, E.H., Morita, S. et al., RSI **83** (2012) 043503.
- 2) Wang, E.H., Morita, S. et al., to be published in PST.