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2D visible imaging spectrometer for divertor plasma in LHD
LHDのダイバータ部２次元可視分光計測

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The 2D distributions of impurity radiation and emission from hydrogen have been measured at the edge stochastic layer, using visible imaging spectrometer, which has been newly installed in LHD. The impurity source distribution has been identified at the divertor plates indicating substantial chemical sputtering of the divertor plates. Along the divertor legs, the Doppler shift of carbon emission spectra has been detected, suggesting an existence of impurity flow along the field lines. During the detached phase, which is sustained with RMP application, the increase of the ratio of H_γ to H_β has been found to be localized around the LCFS, showing the increase of volume recombination process there.

1. Introduction

Impurity transport in the edge region is important to determine the influx to the confinement region as well as the radiation distribution at the detachment phase. In the many devices, it has been observed that the edge stochastic layer has impurity screening effects [1]. The mechanism is considered due to the friction force that drags the impurity towards background plasma flow direction, which is usually pointing to the divertor plates. On the other hand, it has been found that the application of resonant magnetic perturbation (RMP) field has stabilizing effect on the detached plasma [2]. Although the mechanism of the stabilization is not yet understood, the key parameters for the stabilization is found to be the distance between the edge radiation region and the confinement region, and the RMP amplitude. In order to investigate further detailed transport process and thus physics mechanism of the impurity transport as well as the radiation stabilization, a visible spectrometer system has been developed in LHD, which provides two dimensional measurements of impurity and fuel species (hydrogen) emission. The final goal of this work is to quantify the impurity screening effect and to identify the detachment stabilization mechanism. In the 17th experimental campaign in LHD, we have conducted the experiments for impurity transport and detachment with RMP application.

2. Experimental set up

Figure 1(a) shows a viewing area of the 2D visible spectrometer system, where the magnetic field lines and the envelope of the last closed flux surface (LCFS) are shown together with the spatial location of the individual channels. The number of

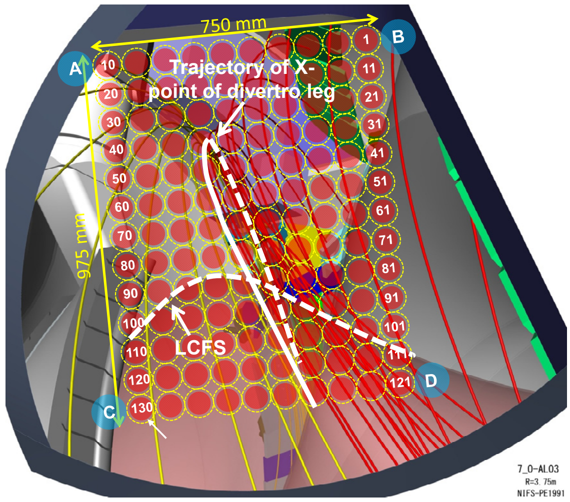

Fig.1 (a): Viewing area of the 2D visible spectrometer system. Magnetic field lines of divertor legs, trajectory of X-point of divertor legs and the envelope of LCFS are shown.

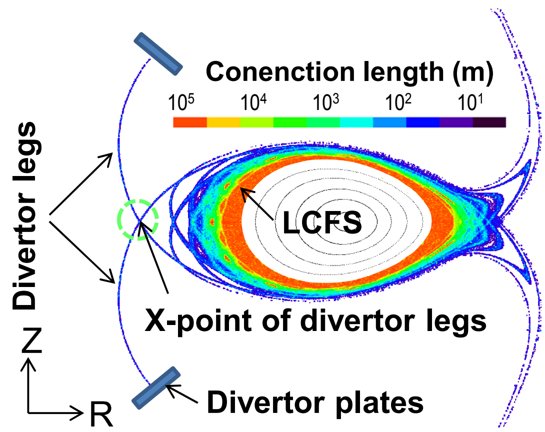

Fig.1 (b): Poloidal cross section of connection length distribution at the horizontally elongated cross section of LHD.

channels is 130, and they cover the divertor plates, divertor legs, stochastic layer, and the confinement region. Fig.1(b) shows the poloidal cross section of the magnetic field line connection length distribution at the horizontally elongated section, where the locations of the divertor plates, divertor legs, X-point of divertor legs, LCFS are indicated, in order to provide correspondence between the

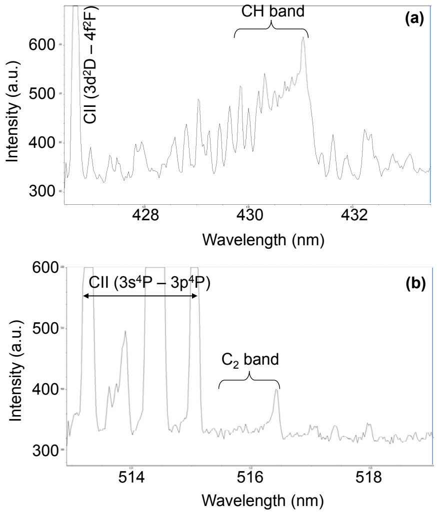

Fig. 2. (a) CH band and (b) C_2 band detected with the 2D spectrometer at the channels viewing the divertor plates (#121178, #121184).

field of view of Fig.1(a) and the magnetic field structure.

3. Experimental results

For the present experimental campaign, we have conducted systematic density scan experiments to study impurity transport of carbon and Neon. In order to quantify the impurity source at the divertor plates, it is important to identify the corresponding emission lines. Figure 2 shows the spectra of CH band and C_2 band obtained with the spectrometer

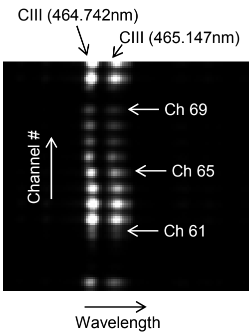

Fig.3. CCD image of CIII (464.742, 465.147 nm) at channel 61 to 69, indicated with red spots in Fig.1.

system. We have found that these lines are observed only at the channel viewing at the divertor plates (Fig.1) and increases with density, indicating the existence of the chemical sputtering of the carbon, which is considered to be dominant carbon source in LHD. For the Neon transport, we have puffed a certain amount of Neon and the emission line NeI has been also detected. The spectrometer system has been calibrated, so that the quantitative estimation of the carbon and neon source is possible and will be conducted in near future.

In order to identify the existence of the friction force, it is important to investigate the impurity flow behavior. For this purpose, Doppler shift of the carbon emission has been investigated. Figure 3 shows CCD image of the carbon emission CIII (464.742, 465.147 nm) from the channels 61 to 70 ch, which crosses the divertor leg X-point, as shown in Fig.1(a). There is clear Doppler shift observed, i.e., ch 61 to 65 shifts to longer wavelength and ch 66 to 69 shift to shorter wavelength. Since the connection of divertor leg field lines to the divertor plates changes its direction around ch 65, the qualitative change of the shift is considered to reflect the carbon flow parallel to the divertor leg field lines. An estimation of the flow velocity is underway.

The detachment stabilization experiment with RMP application has been also conducted. The reconstructed 2D image of the ratio H_γ to H_β during the detached phase is plotted in Fig.4, which is an indicator of volume recombination. It is found that the after the detachment transition, the ratio increases along the LCFS, indicating the existence of volume recombination of hydrogen with very low temperature. At the conference, the 2D distribution of CIII and CIV will be presented and the detailed detachment transition scenario will be discussed.

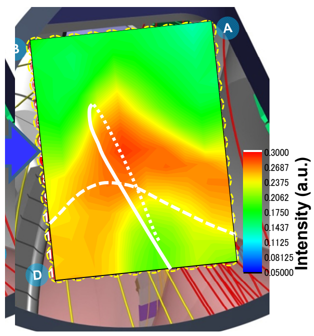

Fig.4: Reconstructed 2D distribution of the ratio H_γ to H_β during detachment phase obtained by the spectrometer.

Acknowledgments

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References

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[2] M. Kobayashi et al.: Nucl. Fusion **53** (2013) 093032.