§20. 2D Distribution of Hydrogen/impurity Radiation in Stochastic Layer during Detachment Transition in LHD

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Understanding of transport of fuel and impurity species in the edge region of magnetically confined fusion devices is one of the critical issues for realization of future reactors, in terms of fueling efficiency, divertor recycling process, impurity screening and control of edge radiation etc.The transport of fuel and impurities is largely affected by the magnetic field structure. Helical devices usually have a complex magnetic field structure due to the intrinsic non-axisymmetric configuration as compared to tokamaks.

In the Large Helical Device (LHD), there appears a stochastic layer in the edge region, which is induced by an overlap of different modes of the magnetic field spectrum produced by the helical coils [1)]. The stochastic layer is connected to the divertor plates through divertor legs, which rotate in poloidal direction as moving along toroidal direction, according to the helicity of the helical coils.

2D distributions of hydrogen/impurity radiation have been measured in the edge stochastic layer of LHD during detachment transition, using a newly developed visible spectroscopy system with 130 channel optic fiber array, which can obtain spatial distribution of many different line emissions simultaneously. The spectroscopy system views the edge region to resolve magnetic field structure, such as divertor legs, X-point, stochastic layer, LCFS and divertor plates. The field of view of the fiber array is shown in Fig.1 (a) together with the magnetic field lines of the divertor legs, the trajectory of X-points, an envelope of the LCFS and divertor plates. In Fig.1 (b), the images of 130 channel fiber array are overlaid. The connection length distribution in a poloidal cross section is plotted in Fig.2, where the geometry of the edge magnetic field structure such as divertor legs, stochastic layer and the LCFS, is readily recognized. As comparing Fig.1(a) with Fig.2, one can relate the field line structure in the field of view to those in Fig.2 as indicated in the figure.

An entire picture of the temporal evolution of the emission distribution is obtained by picking up the intensity of each line and reconstructing a 2D image, as shown in Fig. 3, where the distributions of CII and H_α are plotted for the different time frames. At the attached phase of t = 5.05 sec, the CII emission is distributed from the divertor plates towards the upstream region, as shown in Fig.3 (a). The H_α shows also a spatial pattern similar to the CII, as shown in Fig.3 (b). At t = 6.10 sec, where the divertor particle flux is suppressed significantly after the roll over around t = 5.7 sec, and the radiated power starts to increase rapidly toward the radiation collapse, it is clearly observed that the CII emission "detaches" from the divertor plate and moves toward the LCFS. At t = 6.25 sec, where the discharge is terminated by the radiation collapse, the CII emission penetrates inside the LCFS. As to the H_α, the similar behavior is observed as those of CII, while the clear "detachment" of the emission from the divertor plates is observed only at the last frame of t = 6.25 sec. The results characterize the detachment transition in LHD, as a helical device with edge stochastic layer.

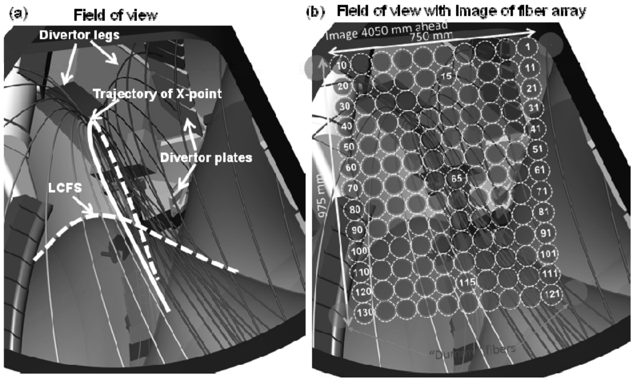

Fig.1 (a) Field of view of the fiber array with magnetic field structure indicated. (b) Field of view with images of 130ch fiber array overlaid.

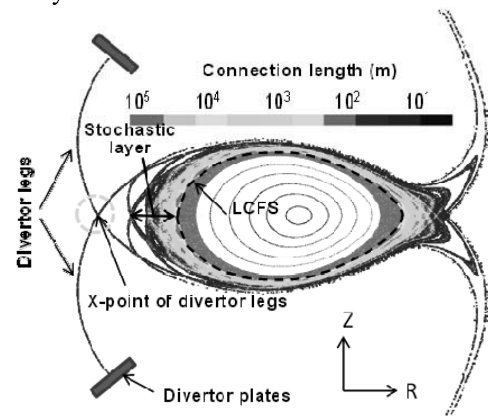

Fig.2 Poloidal cross section of the connection length distribution.

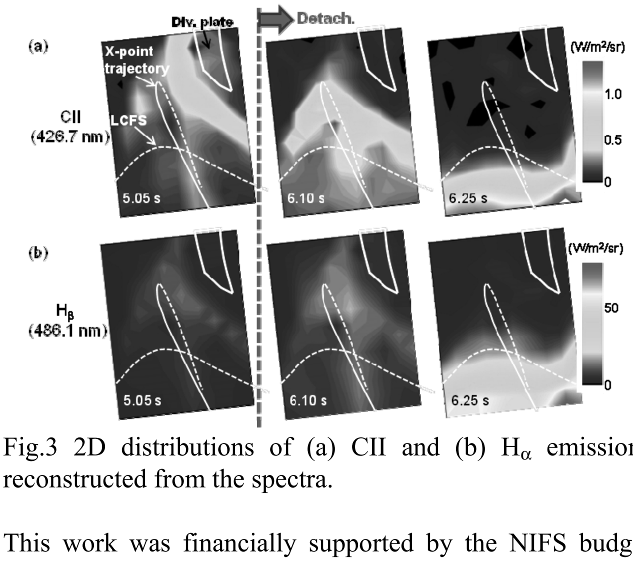

Fig.3 2D distributions of (a) CII and (b) H_α emissions reconstructed from the spectra.

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1) Ohyabu, N. et al., Nucl. Fusion **34** (1994) 387.