§21. Numerical Study of Impurity Transport in the Edge Stochastic Layer of LHD

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Impurity transport in the edge region is important to determine the influx to the confinement region. 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. In order to confirm this mechanism, we need detailed comparison between numerical simulations and measurements. For this purpose, an extreme ultraviolet spectroscopy has been developed to measure two dimensional distribution of impurity emission [2)]. The measurements enable detailed comparison between impurity emissions with magnetic field structure. Figure 1 shows the viewing area of the spectroscopy in relation to the magnetic field structure of LHD toroidal cross sections, i.e., toroidal movement of divertor leg X-point at the inboard and outboard sides.

In order to compare the measurements with the transport simulation and thus study the impurity transport, 3D edge numerical simulation has been conducted based on the parallel momentum balance equation for impurity together with particle balance for each charge state of impurity and Ohm's law that provides parallel electric field. First, the background plasma transport is calculated taking into account the detailed 3D magnetic field structure as well as first wall and divertor plate geometry. Then the impurity transport is analyzed as a trace impurity transport model with a certain impurity sputtering coefficient and injection energy at the divertor plates. The computation results are processed to give a synthetic image that can be directly compared to the experimental observations. Figure 2 shows the 2D distribution of carbon emission CIV (31.2 nm) for different magnetic field configurations (magnetic axis, R_{ax}), (a) inward shifted case (R_{ax}=3.60 m) and (b) outward shifted case (R_{ax}=3.75 m), respectively. In the case of the inward shifted case, the divertor recycling at the inboard side is relatively high, and this leads to the large impurity source along the divertor plates at the inboard side. This effect is reflected in the 2D distribution in Fig.2 (a), where the stripe extending from the bottom left to top right is visible, which corresponds to the trajectory of the divertor leg X-point at the inboard side. At the same time, the stripe from top left to bottom right is also visible, which corresponds to the trajectory of the divertor leg X-point at the outboard side. In the experiments, however, the stripe due to the divertor leg X-point at the inboard side is found to be much more dominant. In the computation, a better matching with the experimental results is obtained if the friction force term is enhanced than predicted based on the current transport model. In the case of outward shifted case, the divertor recycling distributes toward top and bottom region of the divertor plates, and thus the inboard side recycling is weakened. For this reason, the stripe from top left to bottom right is more pronounced, reflecting outboard X-point trajectory. This is found to be in good agreement with the experimental results.

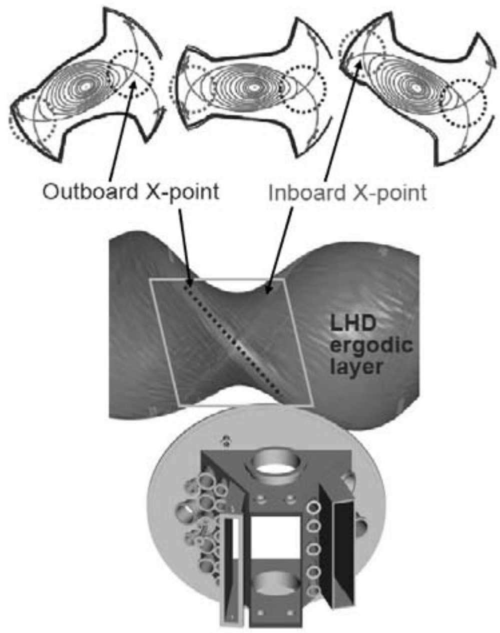

Fig. 1. Viewing area of the spectroscopy in relation to the magnetic field structure of LHD toroidal cross sections, i.e., toroidal movement of divertor leg X-point at the inboard and outboard sides. The doted and dashed lines in the middle figures indicate the trajectories of outboard and inboard divertor leg X-point.

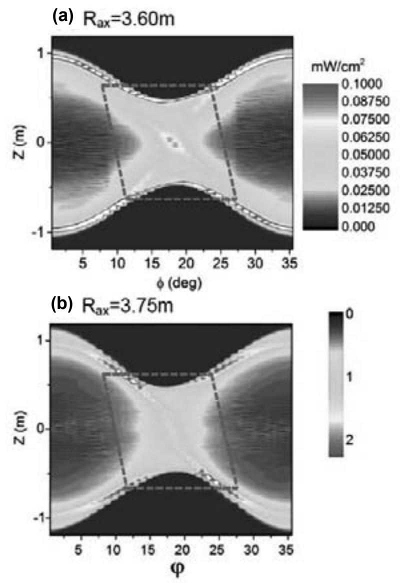

Fig. 2. Synthetic images obtained from numerical simulation of CIV (31.2 nm) for (a) inward shifted case (R_{ax}=3.60 m) and (b) outward shifted case (R_{ax}=3.75 m), respectively.

1) Kobayashi, M. et al.: Nucl. Fusion **53** (2013) 033011.
2) Huang, X., Morita, S. et al.: Rev. Sci. Instrum. **85** (2014) 043511.