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Edge impurity transport study in the stochastic layer of LHD

LHDの周辺ストキャスティック層における不純物輸送の流体モデリングと実験観測の比較

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Edge impurity transport has been investigated in the stochastic layer of LHD based on the three-dimensional (3D) edge transport code EMC3-EIRENE and on carbon emission profile measurement. The carbon emission profile of CIV in the VUV range shows clear signature of C^{3+} movement towards downstream at high density range. The transport simulation shows the strongest contribution of divertor carbon source to the CIV profiles and shows reasonable agreement with the experiments, implying screening effect. The newly installed visible spectrometer viewing divertor region shows clear difference in the spectrum depending on the location from the divertor legs, stochastic region and the last closed flux surface. The behavior is discussed in terms of the edge impurity transport.

1. Introduction

Understanding of edge impurity transport is one of the most critical issues in magnetically confined fusion devices. While the tokamak X-point poloidal divertor is being optimized in various aspects in the 2D (two-dimensional) axi-symmetric geometry [1], the non-axisymmetric tokamaks [2] or helical devices [3,4] are exploring a possibility of the 3D (three-dimensional) magnetic field geometry with toroidal symmetry breaking. The 3D configuration usually introduces the stochasticity of magnetic field in the edge region, where one expects substantial difference in the transport properties compared to those in the axi-symmetric tokamak scrape-off layer (SOL).

The previous works on the impurity transport in the stochastic layer in various devices show the tendency of impurity screening [5]. But the mechanism of the screening effect is not yet fully understood. In this paper, we investigate the impurity transport in the stochastic layer of LHD edge region using the 3D edge fluid transport code, EMC3-EIRENE [6,7], and the VUV, EUV, visible spectrometers.

2. 3D modelling results and spectrometer measurements of carbon

EMC3-EIRENE solves the set of fluid equations of particle, parallel momentum and energy, and provides 3D distribution of plasma parameters and impurity. The spectrometer viewing the LHD plasma from the outboard side measures the line integrated vertical profiles of emission from plasmas. Figure 1 shows the measured profiles of CIV for low (n_{LCFS}=1.1x10^{19} m^{-3}) and high (4.5x10^{19} m^{-3}) density discharges. Z=0 m corresponds to midplane and the figure shows the upper half profiles. It is seen that the profile becomes peaked at the edge (Z~0.48 m) and around the midplane with increasing density. Figure 2 shows the vertical profiles obtained with the modelling using the same viewing chord as the measurements. Since the detailed carbon source distribution is not known, several cases are tested, and the most probable profile is estimated with certain proportion of the various sources, as shown in Fig.2 (e). The modelling shows that in the almost all cases the profiles become peaked at the midplane and the edge. The results indicate the resultant impurity distribution is not very sensitive to the source location. The change of the profiles is due to the movement of C^{3+} carbon to the downstream region at the high density, and they populate around the X-point of the divertor legs and the periphery of the stochastic layer. The emission from the X-point is reflected as the increase of the CIV intensity around midplane, and the population at the periphery leads to the peaks at the edge (Z~0.48 m) due to the line integration effect. The obtained profile, Fig.2 (e), reasonably agrees with the experiments, suggesting impurity screening at the high density discharges. The modelling shows

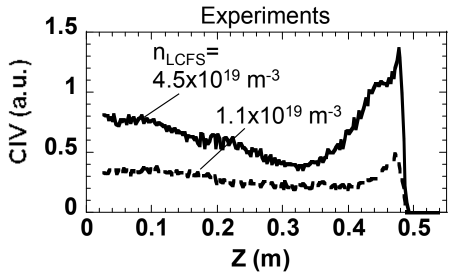

Fig.1 Line integrated vertical profiles of CIV intensity obtained with the VUV spectrometer.

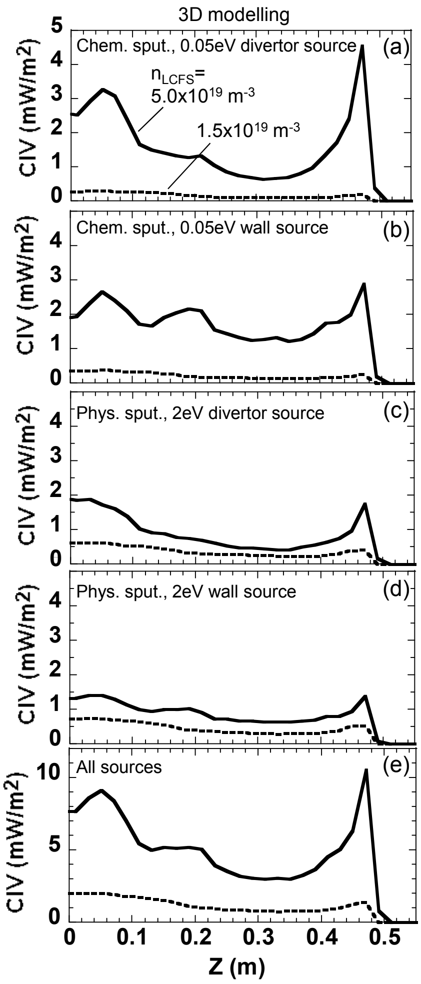

Fig.2 Line integrated vertical profiles of CIV intensity obtained with the 3D modellings for different source distribution.

that this screening is caused by the enhanced friction force at high density, which pushes impurity towards divertor region.

3. Experiments of Ne puff

In order to study the effect of impurity species on the transport, Ne puff experiments are ongoing. Figure 3 shows the viewing area of the newly installed visible spectrometer looking at the divertor region. The viewing chords are situated as it covers the divertor legs near divertor plates through stochastic region, up to LCFS, with increasing channel numbers. The obtained spectrum from 220 to 525 nm are shown in Fig.4 before and after Ne puff, for different channels. There appear clear differences of the spectrum response depending on the channels. The detailed analysis in terms of the impurity transport is presented at the conference.

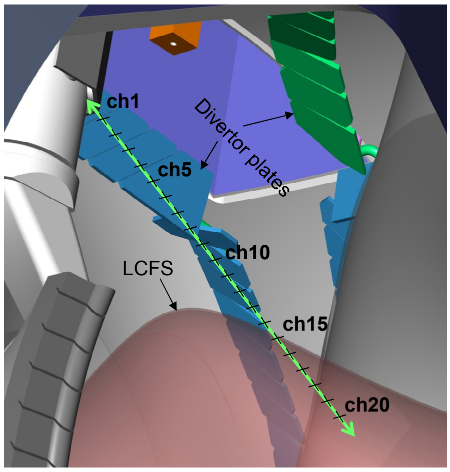

Fig.3 Viewing area of newly installed divertor spectrometer.

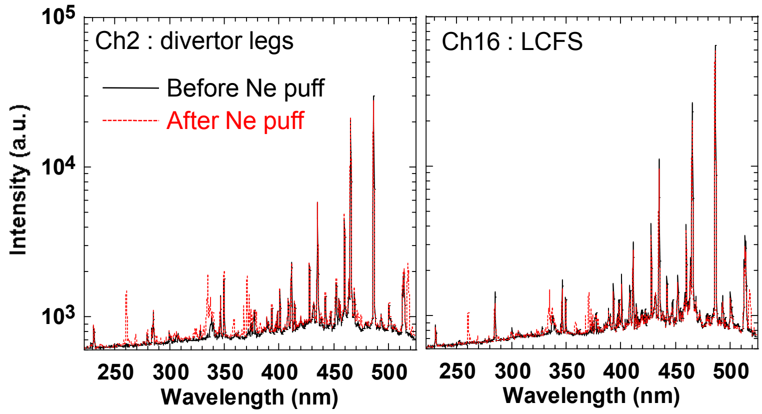

Fig.4 Spectrum for Ne puff experiments at the different channels. Black solid lines: before Ne puff, red broken lines: after Ne puff.

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