§9. Effective Screening of Iron Impurity in Ergodic Layer of LHD with Metallic First Wall

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In LHD operated with metallic (stainless steel) first wall, it is found that the iron density, n_{Fe}, at plasma core is fairly low ($n_{Fe} \leq 10^8 cm^{-3}$) in general neutral beam (NB) heated discharges, while the iron quickly increases with appearance of impurity accumulation when multi-hydrogen ice pellet is injected. The result indicates that the screening effect developed in the ergodic layer works well for iron ions coming from the first wall [1].

A typical example of the 2-D distribution [2] on edge iron emissions is shown in Fig.1 for three different magnetic axes of (a) R_{ax}=3.6m (FeXVI: 335.4Å), (b) R_{ax}=3.70m (FeXVI: 335.4Å) and (c) R_{ax}=3.75m (FeIX: 171.075Å). As the FeXVI and FeIX locate in the vicinity of LCFS and the ergodic layer, respectively, those can be a typical index of iron influx to the plasma core and the ergodic layer. The intensity of line emissions is expressed in different colors defined by bar code on the right hand side. We then notice that the main emissions are consisted of two parts at top and bottom edges and the vicinity of X-points. The strong emission at the top and bottom edges is simply caused by long observation chord in the 2-D measurement. The emission enhanced at X-point can reflect the magnetic field structure in the vicinity of X-points. The FeXVI intensity in Fig.1(a) is enhanced along a diagonal line from left-bottom (Y=-20cm and Z=-40cm) to right-top (Y=20cm and Z=50cm) suggesting the emission from inboard X-point. In the result from R_{ax}=3.75m configuration of Fig.1(c), however, the trace of FeIX is entirely different, suggesting the emission from outboard X-point. The number of magnetic field lines connecting to divertor plates is a function of magnetic axis position. It changes when the magnetic axis moves from R_{ax}=3.60m to 3.75m. The different structure of iron emissions from X-points between R_{ax}=3.60m and 3.75m reflects the structure of magnetic field lines near X-points. Therefore, we suppose that the iron ions coming from the first wall move downstream at first and then move upstream through the vicinity of X-points.

The density of Fe^{15+} ion, n_{Fe}^{15+}, which can be related to the influx to the core plasma, is analyzed from the measured 2-D FeXVI distribution. In the analysis the 2-D emissions are simply divided into two parts of O-point and X-point and the intensity in each part is reconstructed to the local emissivity. The Fe^{15+} density is thus obtained as the value averaged over the whole plasma volume. The result is plotted with open circles in Fig.2(a). The Fe^{15+} ions located near LCFS in the ergodic layer, i.e. L_c>200m (L_c: connection length), decrease with density, suggesting the reduction of the iron influx to the plasma core. The result of the simulation is also plotted with solid line, which is normalized to the experiment at $n_e=1.5 \times 10^{13} cm^{-3}$. Both the results clearly indicate that the impurity screening by the ergodic layer works well to the iron.

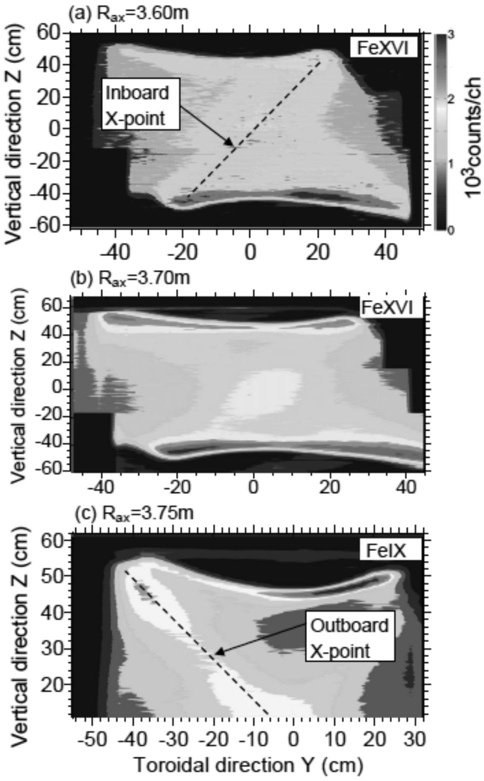

Fig.1 2-D distributions of (a) FeXVI at R_{ax}=3.60m, (b) FeXVI at R_{ax}=3.70m and (c) FeIX at R_{ax}=3.75m.

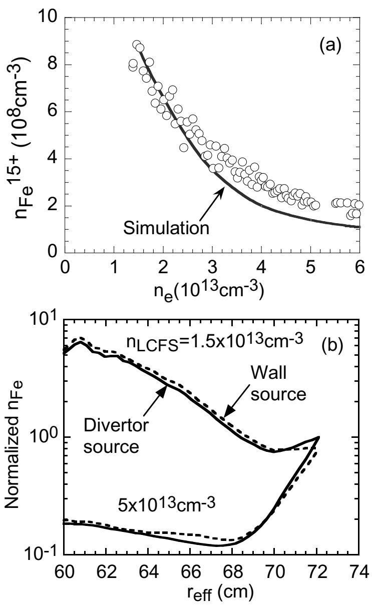

Fig.2 (a) 2-D averaged Fe^{15+} density (measurement: open circles and simulation: solid line) and (b) total iron density profiles normalized at plasma edge (r_{eff}=72cm) in R_{ax}=3.60m simulated with two different densities at LCFS.

1) Morita, S., Dong, C.F. et al., 24th IAEA FEC, San Diego, 8-13 Oct. 2012 (EX/P5-18).
2) Wang, E.H., Morita, S. et al., RSI **83** (2012) 043503.