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ヘリカル装置LHDとトカマク装置HL-2Aにおける周辺不純物輸送の比較

Edge Impurity Transport Study in Stochastic Layer of LHD and Scrape-off Layer of HL-2A

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LHD and HL-2A have distinct edge magnetic field structures in viewpoints of the connection length and the flux tube topology. In order to study the effect of magnetic field geometry on the edge impurity transport, a comparative transport analysis has been conducted between LHD stochastic layer and HL-2A SOL. For this purpose, the 3D edge transport code of EMC3-EIRENE has been implemented and profile measurements of carbon emissions have been performed using EUV and VUV spectrometers in the both devices.

Comparison of the simulation results shows clear difference in the screening process between LHD and HL-2A, as shown in Fig.1. HL-2A SOL has strong screening effect against the divertor impurity source at high density (collisionality). But almost no screening is available against the first wall source due to the residual thermal force at the upstream (above the X-point) even at the highest density just before detachment onset. LHD stochastic layer has screening effect against both divertor and first wall source. But the effect is weaker than the case of divertor impurity source of HL-2A SOL.

The effective impurity screening against the first wall source in LHD observed in the modelling is due to the presence of the poloidally distributed friction dominant region formed by a large number of poloidal turns (several hundred turns) of field lines in the stochastic layer before they reach the divertor plate. In HL-2A, on the other hand, one poloidal turn flux tube creates a poloidally asymmetric friction dominant region, i.e. only in the vicinity of the divertor plate. The ionization distribution of background plasma is also closely related to these different magnetic structures. The acceleration mechanism of background plasma and thus impurity flow along the magnetic field line is basically determined by the ionization distribution in the present modelling. However, further analysis is necessary on the flow formation, especially in the tokamak SOL. Since the recent research reports a significant acceleration of background plasma even at the midplane, the result might change the picture obtained in the present modelling.

The carbon emission measured in the stochastic layer of LHD indicates the screening effect at high density region. The result can be qualitatively interpreted by the present modeling, although the modeling shows a slight difference in the quantitative behavior of carbon in the stochastic layer of LHD. On the other hand, comparison of the carbon emission profile in HL-2A with the modelling is not straightforward. It is found that the impurity distribution in the HL-2A SOL is very sensitive to the impurity source location. In order to interpret the experimental observations a further study is necessary, in particular, on the impurity source distribution in the divertor plate and the first wall.

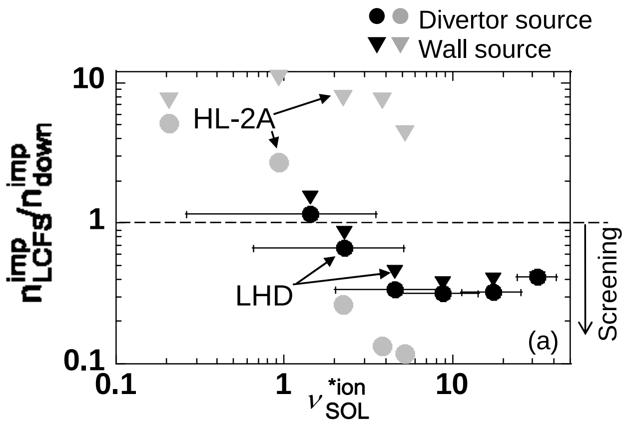

Fig.1 Ratio of $n^{imp}_{LCFS}/n^{imp}_{dowm}$ as a function of collisionality obtained by the 3D numerical simulation.. n^{imp}_{LCFS} and n^{imp}_{dowm} are the impurity density at LCFS and near divertor plates, respectively, summed up over all charge states (circles: impurity released at the divertor plate, triangles: impurity released at the first wall, black for LHD and grey for HL-2A).