Contribution ID: **60** Type: **Oral**

Observation of carbon impurity flow in the edge stochastic magnetic field layer of Large Helical Device and its impact on the edge impurity control

Friday, 21 October 2016 09:10 (20 minutes)

Stochastization of edge magnetic fields has been extensively studied not only for the ELM mitigation but also for the plasma detachment and the impurity transport. Large Helical Device (LHD) has a thick stochastic magnetic field layer called "ergodic layer"located at the edge plasma with three-dimensional structure intrinsically formed by helical coils. Recently, reduction of the parallel impurity transport, so called "impurity screening", has been studied in LHD. The theoretical modelling explains that the parallel momentum balance on impurity ions in the ergodic layer determines the direction and quantity of the impurity flow, which can be the key mechanism driving the impurity screening. Therefore, precise profile measurements of the impurity flow are required to examine the validity of the theoretical modelling on the impurity transport in stochastic magnetic field layer.
Space-resolved VUV spectroscopy using a 3 m normal incidence spectrometer has been developed to measure the impurity emission profile in a wavelength range of 300 - 3200 angstrom. A full vertical profile of C^3+ impurity flow is evaluated from Doppler shift of the second order of CIV line emission (2 x 1548.20 angstrom) at a horizontally-elongated plasma position of LHD for a hydrogen discharge with R_ax = 3.6 m, B_t = 2.75 T, n_e = 6.0 x 10^13 cm^-3 and P_in = 10 MW. It is found that the the carbon flow at the top and bottom edges in the ergodic layer has the same direction toward outboard side along the major radius direction. The flow velocity increases with the density at both the top and bottom edges of the ergodic layer.
The simulation result of C^3+ impurity flow parallel to the magnetic field lines calculated with a three-dimensional simulation code, EMC3-EIRENE indicates that the major radius component of the flow has the same direction toward outboard side at the top and bottom edges in the ergodic layer. The experiment and the simulation agree with each other quantitatively, which concludes that the parallel flow in the ergodic layer can be well explained by the presently used theoretical modelling. In particular, the impurity screening driven by the friction force between impurity and bulk ions can be more effective at higher electron density range. The density dependence of the flow in the modelling can be also clarified by the experimental result.

Paper Number

EX/7-2

Country or International Organization

Japan

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Session Classification: RF & SOL Physics

Track Classification: EXD - Magnetic Confinement Experiments: Plasma–material interactions; divertors; limiters; scrape-off layer (SOL)