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LHDのエルゴディック層における炭素不純物の発光強度・イオン温度・フロー速度の空間分布

Spatial profiles of emission intensity, ion temperature and flow velocity of carbon impurities in the ergodic layer of LHD

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Effects of edge stochastic magnetic fields on the impurity transport have attracted attention widely. Reduction of the cross-field impurity transport, so called “impurity screening”, has been observed in Large Helical Device (LHD) which has a thick stochastic magnetic field layer called “ergodic layer” located outside the core plasma. Theoretically it is said that a parallel impurity momentum balance in the ergodic layer determines direction and quantity of the impurity flow, which could be one of key mechanisms of the impurity screening. Therefore, a precise measurement on the spatial profile of impurity flows is required as an experimental approach to investigate the impurity transport in such stochastic magnetic field.

A space-resolved spectroscopy using a 3 m normal incidence vacuum ultraviolet (VUV) spectrometer was developed to measure the VUV emission profiles in wavelength range of 300-3200 Å from impurities in the ergodic layer [1]. The optical axis is perpendicular to the magnetic axis at a horizontally-elongated poloidal cross section. Vertical profiles of emission intensity, ion temperature and ion flow are derived by measuring the Doppler profile of impurity line spectra. Observed flow velocity is a projection along each observation chord, which is approximately directed along the plasma major radius.

The impurity flows were derived by the Doppler shift of the CIV spectra with the wavelength of 1548.20 × 2 Å. The VUV spectroscopy was attempted for hydrogen discharges with magnetic axis position of R_{ax}, = 3.60 m at toroidal magnetic field of B_t, = 2.75 T. Figure 1 shows a vertical profile of the flow velocity of carbon impurity ions measured for a high-density discharge with the line-averaged electron density of 6.3×10^{13} cm^{-3}. The horizontal axis, Z, indicates positions of observation chords evaluated at the major radius, R, of 3.60 m. The impurity flows toward outboard direction were clearly observed around Z = ±480 mm close to top and bottom edges of the horizontally-elongated poloidal cross section of the plasma. The directions of the flows are consistent with those calculated by a three-dimensional simulation code EMC3-EIRINE qualitatively. The code predicts that a friction force between bulk ions and impurity ions becomes dominant in the parallel impurity momentum balance in the ergodic layer when the electron density increases [2]. It results in impurity flows toward the divertor plates causing the impurity screening phenomena.

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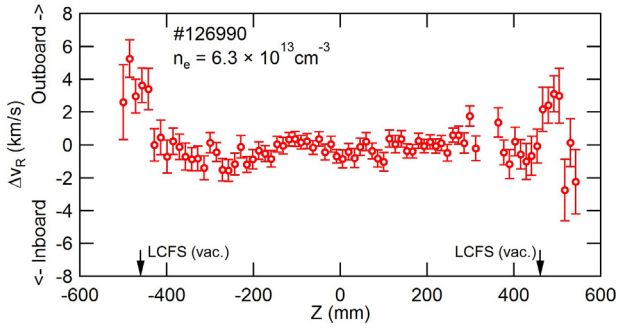

Figure 1. Vertical profile of the flow velocity of carbon impurity ions in the ergodic layer derived by the Doppler shift of the CIV spectra with the wavelength of 1548.20 × 2 Å.