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EX/P5-18: Low Concentration of Iron as First Wall Material in LHD Plasmas with Edge Ergodic Layer

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Experiments of Large Helical Device (LHD) have been successfully conducted during past 14 years, based on the first wall fully covered with rectangular protection plates made of stainless steel, basically having no serious impurity problem. The impurity behavior of iron has been quantitatively studied with a spectroscopic system newly developed for measuring two-dimensional distribution of extreme-ultraviolet (EUV) impurity lines. The iron density in core plasmas is found to be fairly low, at least five orders of magnitude smaller than the electron density. The highest density of iron is observed during impurity accumulation triggered by pellet injection. The central density of Feˆ23+ ions analyzed from FeXXIV profile reaches 2.6x10ˆ9cmˆ-3 during the impurity accumulation phase with appearance of a large inward convective velocity of V=-6m/s, whereas it is only 3x10ˆ8cmˆ-3 before the accumulation occurs. No accumulation is observed for light impurities. The accumulation is mainly caused by the density gradient. These results are very similar to tokamak ones, but only the value of the iron density is different between tokamaks and LHD. The stochastic magnetic filed layer of LHD can effectively fulfill its function as the impurity screening in collisional regime of 10<L_K/L_ee<100, where L_K is the Kolmogolov length and L_ee the electron mean free path. In 3D edge transport simulation the impurity screening is observed in the edge boundary region, where the L_K is nearly 10m. The iron with slower velocity is ionized at outer region of the stochastic layer where the parallel thermal gradient (i.e. thermal force) is smaller. Therefore, larger values of L_K/L_ee for heavier ions like iron enhance the friction force along magnetic filed, leading to an efficient impurity screening. In LHD the radiation loss from iron is smaller than 1MW in usual discharges (P_NBI=20-30MW), which is often comparable to radiation from carbon originated in divertor plates. These transport processes interacted with magnetic field structure are of primal reason why the density of iron impurity is fairly low in LHD. The screening effect developed in edge stochastic layer intrinsically existing in LHD works well for materials of the first wall. The present result strongly suggests tolerant use of high-Z materials to the first wall of LHD-type reactor.

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