



Contribution ID: 53

Type: Poster

## Formation of impurity transport barrier in LHD plasmas with hollow density profile

Friday, 21 October 2016 14:00 (4h 45m)

In the Large Helical Device (LHD), the  $n_e$  profile can exhibit a peaked, flat or hollow shape. For the purpose of heavy impurity control, it is important to investigate the effect of  $n_e$  profile on the impurity transport. Radial emissions profiles of  $\text{Fe}^{16+}$  through  $\text{Fe}^{23+}$  ions have been simultaneously measured in the Fe  $L_\alpha$  array. The total iron density ( $N_{\text{Fe}}(\rho)$ ) profile is then calculated for peaked and hollow  $n_e$  profiles with  $R_{\text{ax}}=3.6$  m and  $B_t=2.75$  T. When the  $n_e$  profile is peaked (hollow), the  $N_{\text{Fe}}$  also exhibits a peaked (hollow) profile. The  $N_{\text{Fe}}(\rho=0)$  at the peaked  $n_e$  profile is at least one order of magnitude higher than that at the hollow  $n_e$  profile over a wide  $n_e$  range. The result strongly suggests the iron transport in the plasma core is entirely different between the two cases.

A one-dimensional impurity transport code is employed to simulate the time-dependent iron density profile. Minimization process of the error between measurement and simulation determines the transport coefficients. The convective velocity ( $V$ ) is assumed to be proportional to the ion charge  $q$ . The iron transport is analyzed without assumption on the radial structure of transport coefficients because the Fe  $L_\alpha$  transitions are distributed in a wide radial range.

The diffusion coefficient ( $D$ ) profile is very similar between peaked and hollow  $n_e$  profiles, while the  $D$  gradually increases toward the plasma edge from the center. On the other hand, the profile of  $V$  averaged among  $\text{Fe}^{16+}$  through  $\text{Fe}^{23+}$ , is entirely different. In the peaked  $n_e$  profile, the  $V$  is inward and increases from the center to the edge. This indicates the impurity accumulation easily occurs with a peaked  $n_e$  profile. In the hollow  $n_e$  profile, an outward  $V$  is obviously observed inside  $\rho=0.8$ . Near the edge the  $V$  changes from outward to inward where the  $n_e$  gradient changes the sign from positive to negative. Due to this quick change in the  $V$  profile, the iron ions are pushed back outwards and concentrated near the edge. An impurity transport barrier is thus formed. As a result the large difference in the  $n_{\text{Fe}}(\rho=0)$  in the two cases can be well explained.

Since hollow  $n_e$  profiles are usually observed in high-temperature and low-collision plasmas with high NBI power input, the present result demonstrates that the control of heavy impurities is possible in LHD by controlling the  $n_e$  profile.

### Paper Number

EX/P8-5

### Country or International Organization

Japan

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**Session Classification:** Poster 8

**Track Classification:** EXC - Magnetic Confinement Experiments: Confinement