§24. Study on Hydrogen Recycling in LHD

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Understanding of hydrogen recycling in a torus machine is one of most important issues for the steady state operation in a future fusion device. An objective of this research is to study hydrogen recycling properties in LHD from both a macroscopic viewpoint such as global particle balance and a microscopic viewpoint such as an effect of co-deposition on hydrogen absorption. In this time, we studied global particle balance focusing on density pump out during electron cyclotron heating (ECH).

Global particle balance is analyzed using the following equation:

$$\frac{dN_i}{dt} + \frac{dN_0}{dt} = \Gamma_{fueling} + \Gamma_{pump} + \Gamma_{wall}, \qquad (1)$$

where N_i and N_0 are the total number of ions and neutral particles, respectively, and $\Gamma_{fueling}$ is a fueling rate, Γ_{pump} is a pumping rate of external pump units and Γ_{wall} is a wall pumping rate. N_i is assumed to be the same as the total number of electrons in the plasma.

Figure 1 shows results of global particle balance analysis. ECH power of 1.1 MW was applied from 2 s to 3 s to low density (~1.5×10^{19}m^{-3}) and high density (~3.0×10^{19}m^{-3}) plasmas, which were sustained by NBI (P_{NBI}~2MW). The vertical axis indicates hydrogen content of plasma, neutral and wall, and fueling amount and pumping amount, which means time integral of each term of equation (1). In the low density plasma, hydrogen content of the plasma decreased by 1.4×10^{21} (i.e. density pump out) but neutral hydrogen content and pumping amount changed little. The hydrogen content of the wall (i.e. wall pumping amount) increased corresponding to the decrease in the plasma content. In the high density plasma, on the other hand, the decrease in plasma content during ECH was only ~0.3×10^{21}. The effect of density pump out due to ECH in the high density plasma became weaker than that of the low density plasma. It seems that the neutral hydrogen content increased corresponding to the decrease in the plasma content and the wall pumping did not work during ECH. In the latter phase of ECH, the hydrogen content of the wall decreased. This means the wall saturated globally even though the hydrogen content of the wall during ECH was less than that before the plasma initiation.

The ion flux to the divertor plate increased during ECH in both low and high density plasmas as shown in Fig. 2. The charge exchange (CX) neutral flux was also increased due to ECH. The CX flux of the low density plasma is higher than that of the high density plasma as shown in Fig. 3. This may be attributed to the difference in the wall pumping during ECH in low and high density plasmas. The detailed investigation of relation between the density pump out and the wall pumping is a subject for a next experimental campaign.

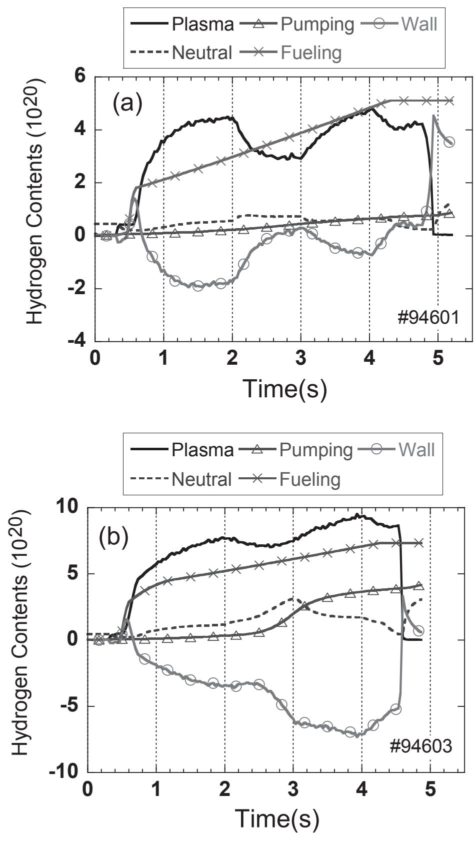

Fig.1 Global particle balance in (a) the low density plasma and (b) the high density plasma. ECH power applied to the NBI plasma from 2 s to 3 s.

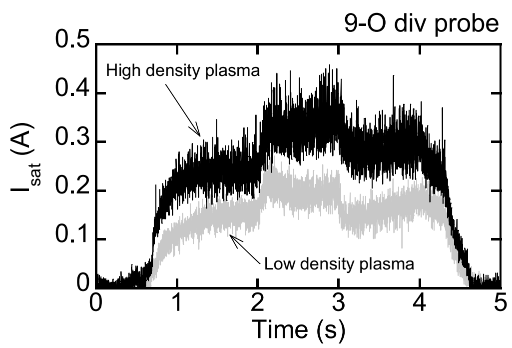

Fig. 2 Time evolution of ion saturation current at the divertor plate in the low and high density plasmas.

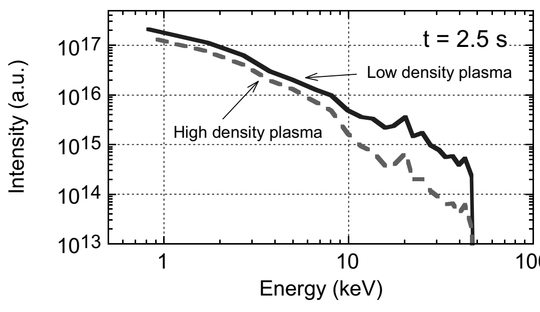

Fig. 3 Spectra of charge exchange neutrals during ECH.