§17. ECH Effect on Tracer Impurity Transport in L-mode Discharge of LHD

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In a magnetic confinement fusion device, various impurities from low-Z material e.g. a helium ash, which is a by-product of a fusion reaction, to high-Z one e.g. tungsten, which is derived from a possible plasma facing component, will exist inside the plasma. When the amount of the impurities exceeds the acceptable level for some reason, e.g. due to the accumulation, it can cause a significant fusion reactor performance degradation. Therefore, it is crucially important to develop an effective scheme for controlling the amount of the impurities in the core plasma, especially for removing the impurities from the core plasma.

In the last 18th experimental campaign of LHD, we have demonstrated a drastic mitigation of the core impurity accumulation by applying an additional electron cyclotron heating (ECH) in the helical plasma. The demonstration experiment has been done in the high-density LHD discharge, where the impurity accumulation has been usually observed[1]. For this experiment, the major radius at the magnetic axis R_{ax} is 3.60 m, the averaged minor radius a is 0.63 m, the magnetic field at the axis B_{ax} is 2.750 T. An ion internal transport barrier is not formed in this discharge, and consequently no impurity hole is observed. Figure 1 shows typical waveforms of the demonstration experiment. As reference, the waveforms in the case without the additional ECH are also plotted in Fig. 1. As shown in Fig. 1, a tracer impurity, vanadium (V, Z = 23) is externally injected (here at t = 3.95 s) by using the TESPEL technology[2], and then the collisionality between the tracer impurity and the bulk ion in the core plasma will be in the PS regime. The plasma without the additional ECH shows clearly a strong accumulation and then it causes the reduction of the electron temperature in the core region, followed by the decrease in the intensity of the V Be-like line emission. This decrease could be attributed to the modification of the charge state distribution of the vanadium ion by the drop in core electron temperature. Meanwhile, when the 154 GHz ECH (P_{ECH} ~ 1.5 MW, r/a_{abs} < 0.5) was applied just after the TESPEL injection, the accumulation of the tracer impurity was almost completely mitigated. Even after the 154GHz ECH was switched-off, the intensity of V Be-like line emission was increased only slightly.

In order to gain a better understanding of the physical mechanism of the ECH effect on tracer impurity transport, further investigations on some parameters, such as the power and absorbed region of 154 GHz ECH will be carried out in the next LHD experimental campaign.

1) Tamura, N et al: Plasma Phys. Control. Fusion **45** (2003) 27.
2) Sudo, S. and Tamura, N.: Rev. Sci. Instrum. **83** (2012) 023503.

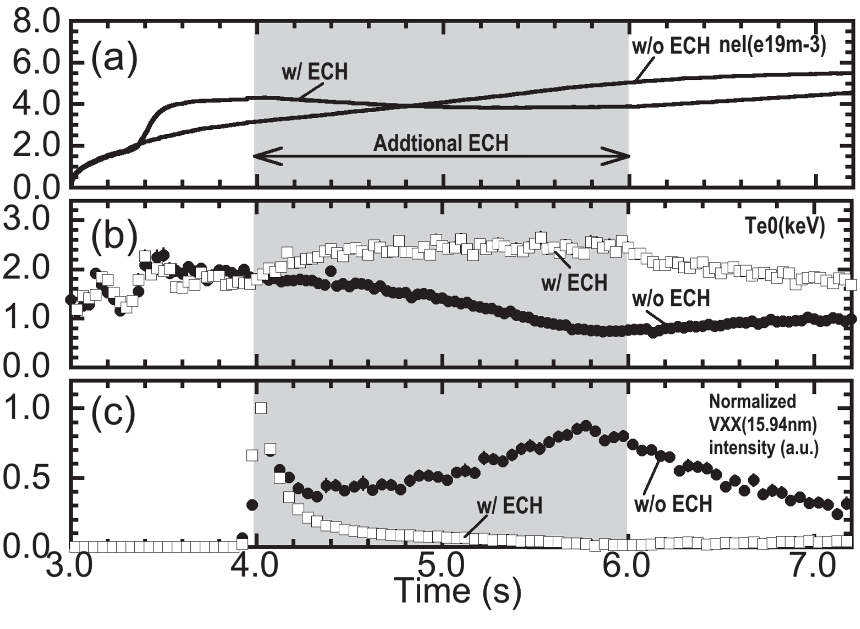

Fig. 1 Demonstration discharge of the mitigation of core impurity accumulation by applying the additional ECH (from t = 4.0 s to t = 6.0 s, P_{ECH} = 1.5 MW, ρ_{abs} < 0.5). As reference, waveforms without applying the additional ECH are also shown. The tracer impurity, vanadium was injected at t = 3.95 s by using the TESPEL technology.