§47. Study of ECRH Effect on Impurity Behavior with Tracer-Encapsulated Solid Pellet Injection on LHD

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Studies of impurity behavior in magnetically confined plasmas are highly important, since it could determine the feasibility of controlled fusion. Especially for the realization of the practical fusion reactor, it is important to have an effective tool to suppress an impurity accumulation, which can trigger the degradation of the fusion power efficiency. In order to evaluate whether ECRH can suppress impurity accumulation, the effect of that on the impurity behavior was studied in LHD plasmas.

As a tracer of the Tracer-Encapsulated Solid Pellet (TESPEL), titanium (Ti) was injected into the LHD plasmas, which are sustained by NBI heating. A soft x-ray pulse height analyzer (PHA) and a VUV spectrometer (SOXMOS) are used to observe a temporal behavior of line emissions from the highly ionized Ti tracer impurity. The global (over the whole plasma) properties of Ti impurity confinement are studied with a decay time of Ti Kα emissions measured by the PHA. In the experiments, ECR pulse with the total injected power of ~ 0.9 MW and the duration of ~ 0.6 s was applied just after the TESPEL injection. The experimental data shown here are obtained under the condition of R_{ax} = 3.6 m, B_t = 2.75 T. As shown in Fig. 1, in the moderate density range (n_e= 1.5 - 3.0 x 10^{19} m^{-3}), the decay time of Ti Kα emissions (it can be considered as the global impurity confinement time) during the ECRH is smaller than that without ECRH. At the lower density, no significant differences of the decay time of Ti Kα between with and without ECRH are appreciable. The radial electric field (E_r), which can strongly affect the impurity transport [3]), could be varied when the ECRH enhances a non-ambipolar electron loss. Therefore, the radial electric field is also measured by a Ne CXRS measurement in these experiments. Figure 2 shows radial profiles of the E_r at t = 1.5 s (TESPEL is already injected at t ~ 1.15 s.) in the NBI-sustained plasma (n_e = 1.6 x 10^{19} m^{-3}) with and without ECRH. When the ECRH is applied, the E_r becomes positive, especially around ρ = 0.45 and the decay time of the Ti Kα emissions become faster than that without the additional ECRH. The impurity transport analysis using a 1D impurity transport code, MIST, is performed with the constant diffusion coefficient (D) and the E_r-dependent convective velocity (V_{conv}), which can be written as $V_{conv} = c_m$ x $Z_i E_r / T$ (c_m is a factor, which can be determined by the experiment). Figure 3 shows the comparison of the temporal evolution of the Ti Kα emissions with that calculated by the time-dependent MIST code. In this analysis, the value of D is fixed at 0.2 m^2/s. The model with the constant D and E_r-dependent V_{conv} can reproduce the experimental result well. To conclude, the ECH would be a useful tool for the control of impurity transport, since the strong ECH can modify the radial electric field, which has a strong influence over the impurity behavior.

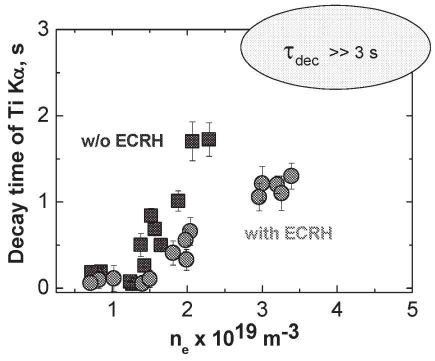

Fig.1. Comparison of the decay time of Ti Kα emissions measured by the PHA in the NBI-sustained plasmas with the 0.9 MW ECRH (solid circles) and without that (solid squares) as a function of line-averaged electron density. The data shown here are obtained in the case of R_{ax} = 3.6 m and B_t = 2.75 T.

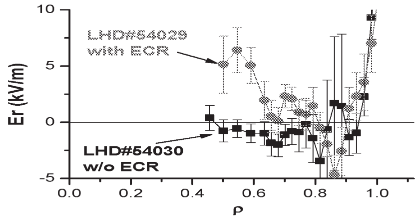

Fig.2. Radial profiles of the radial electric field in the NBI-heated plasma (solid squares) and that overlapped with 0.9 MW ECRH (solid circles). In both cases, the value of line-averaged n_e is ~ 1.6 x 10^{19} m^{-3}.

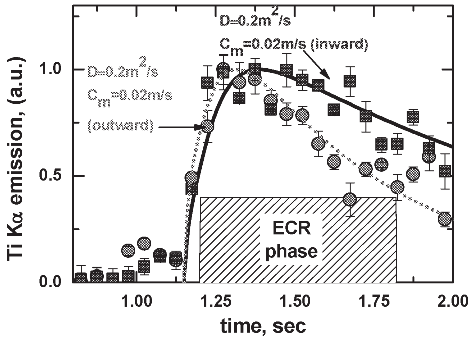

Fig.3. Comparison of the Ti Kα emissions measured by the PHA with those calculated by the time-dependent MIST code for NBI plasmas (solid squares) and NBI + 0.9 MW ECRH (solid circles).

References:

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2) Nakamura. Y. et al, Nuclear Fusion **43**, p.219, (2003).
3) Ida, K. et al, Physics of Plasma, **8**, p.1, (2001).