§48. A New Method on Recycling Coefficient Measurement Using Impurity Pellet Injection in LHD

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A new method[1] for measuring the impurity recycling coefficient has been applied to hydrogen and helium plasmas using impurity pellets and absolutely calibrated high-spatial resolution bremsstrahlung measurement.[2] For the purpose of direct supply of the impurity particles inside the LCFS, an impurity pellet injector was installed on LHD.[3] In order to evaluate recycling coefficients of carbon, aluminum and titanium, the pellet were injected into a steady phase of NBI heated plasmas with R_{ax}=3.6m and the recycling coefficient was evaluated from a transient time response of bremsstrahlung intensities using an one-dimensional impurity transport code.

The impurity behavior was analyzed with a diffusive/convective model assuming that the transport of bulk ions is stationary and the functions (diffusion coefficient D, convective velocity V and recycling coefficient R) are constant in time. Then, the impurity particle flux in q^{th} charge state is given as follows;

$$\Gamma_q = -D_q(r)\frac{\partial n_q}{\partial r} + V_q(r)n_q \cdot \qquad (1)$$

Here, the recycling coefficient R is defined through Γ_{in}/Γ_{out} where Γ_{in} and Γ_{out} stand for the inward and outward fluxes at ρ=1, respectively. In the simulation, it is assumed that the particles reenter into the plasma in singly ionized state. In typical LHD plasmas with R_{ax}=3.6m, the particle transport coefficients D and V are reported as shown in Fig.1.[4] The D has a spatially constant value, and the inward V exists only at ρ>0.6 with the electron density gradient.

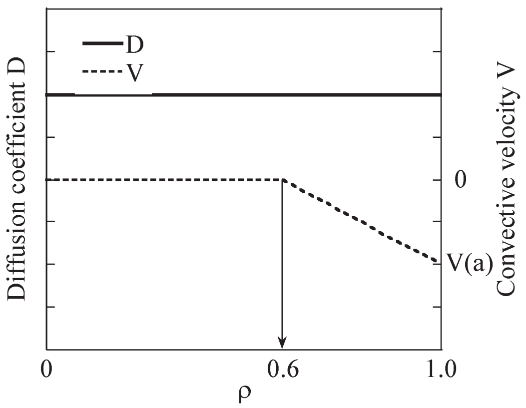

Fig.1 Spatial structure of transport coefficients D and V.

Figure 2 shows a carbon transport analysis in a helium plasma. In the figure, Z denotes the height of viewing sight on the bremsstrahlung diagnostic. In order to fit calculated bremsstrahlung intensities to measured ones, a good combination among D, V(a) and R should be selected. Additionally, the spatial structure of the D and V must be considered. For the evaluation of the R from the time evolution of absolute intensities, it is necessary to specify an exact particle source. As an initial condition in the simulation, the absolute amount of supplied particles must be given. Figure 3 summarizes the recycling coefficients of carbon in hydrogen and helium plasmas. This result indicates that the recycling process of carbon obviously differs between the two cases.

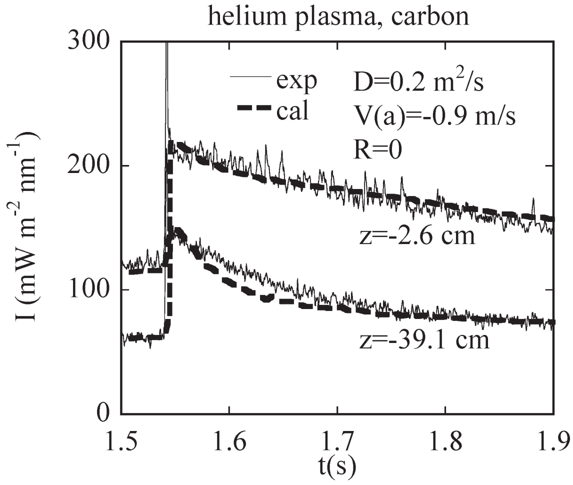

Fig.2 Time evolutions of measured (solid lines) and calculated (dashed lines) bremsstrahlung intensities for carbon pellet injection in a helium plasma.

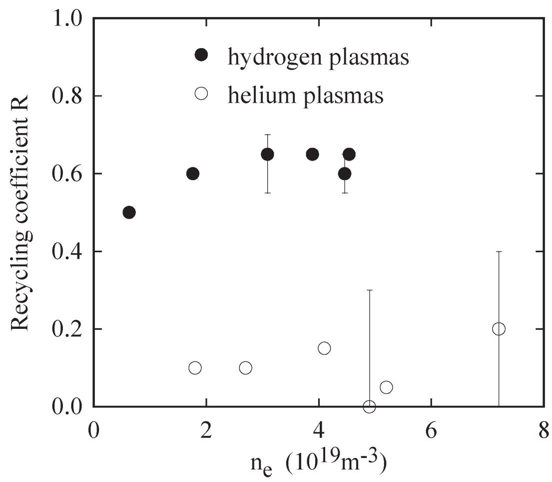

Fig.3 Summary of carbon recycling coefficients in hydrogen (●) and helium (○) plasmas.

In impurity transport studies, metallic impurities such as aluminum and titanium have been traditionally treated as a non-recycling particle. From the analysis on aluminum and titanium pellet injections, it was clearly confirmed that those elements behave as the non-recycling particle.

References
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2)Nozato, H., J. Plasma Fusion Res. Series **5**, 442 (2002).
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