§15. Study on Impurity Behaviour by a Multiple-tracer TESPEL Injection

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By injecting a tracer-encapsulated solid pellet (TESPEL [1]) with triple tracers, V, Mn and Co into a plasma of Large Helical Device (LHD), it was found in the high density case (n_e= 5-7×10^{19} m^{-3}) that the contamination of the intrinsic impurities was strongly suppressed, while all the three tracers were kept for a long time. In contrast to this, in the medium density case (n_e= 3-4×10^{19} m^{-3}) the intrinsic impurities were observed clearly, and the tracer impurities were observed to decay in order of ~0.5 s [2]. The tracers are deposited around ρ (≡r/a) = 0.6- 0.7 with width of ~2 cm in the plasma. The temporal impurity behaviors are analyzed with the STRAHL code calculation [3]. As an example, the temporal evolutions of the Co^{+25} ion density distributions are shown in Fig. 1. The Co^{+25} ions contribute mainly to the Kα emission. The experimental data of the Co Kα emission intensity are compared by integrating the local Co Kα emissivity calculated along the sight line following the experimental condition. The results are shown in Fig. 2. When the impurity diffusion coefficient *D* (spatially constant) of 0.1 m^2/s in case of the high density and 0.2 m^2/s in case of the medium density are assumed with keeping the same convection velocity of *V*= -2m/s (inward convection only in the plasma periphery), the simulation data fit relatively well with the experimental data. There was no any difference in the poloidal rotation velocity profiles measured by the charge exchange recombination spectroscopy for the high and medium density cases [2]. Thus, there is no essential difference in E_r for the high and medium density cases. From this viewpoint, we take the same *V* value for the high and medium density cases.

As for the suppression of the intrinsic impurities such as Fe in the high density case, there was a question whether the production of such intrinsic impurities is decreased or the transport of such impurities into the plasma core is really suppressed. For making clear this point, argon (Ar) supersonic gas puffing was implemented for simulating the intrinsic impurities together with the TESPEL injection. As a result, the Ar Kα emission was completely suppressed in the high density case, while it was clearly observed in the medium density case. This result shows the suppression of the intrinsic impurities is indeed working in the high density case, while the tracers deposited inside the plasma are kept for a long time. From the observation of the finite Ar Be-like emission intensity still in the high density case, it was found that Ar particles penetrated beyond the scrape-off layer even in the high density case.

1) S. Sudo *et al. Rev. Sci. Instrum.* **83** (2012) 023503.
2) S. Sudo *et al. Nucl. Fusion* **52** (2012) 063012.
3) S. Sudo *et al. Plasma Fusion Res.* **8** (2013) 2402059.

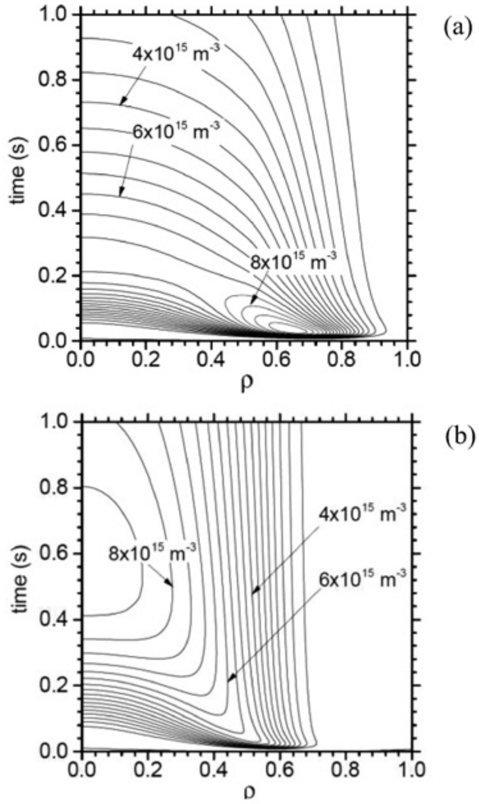

Fig. 1 Temporal developments of the He–like ion charge state density distributions of Co calculated with STRAHL for the medium (a) and high density (b) cases.

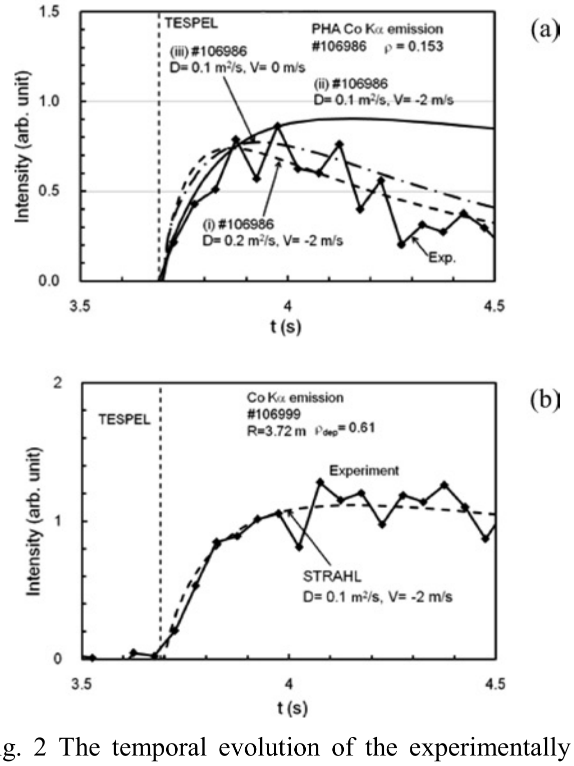

Fig. 2 The temporal evolution of the experimentally observed Kα line emissions of Co for the medium (a) and high density (b) cases. The emission data integrated along the line of sight calculated by STRAHL with *D* and *V* are also shown for comparison.