§10. Evaluation of the Radial Particle Flux Based on Atomic Hydrogen Density Measurements

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In order to analyze particle transport processes in magnetically confined plasmas, atomic hydrogen density distributions should be measured quantitatively. For this purpose, an experiment of laser induced fluorescence (LIF) tuned to Hα was carried out on CHS. The measured data were compared with results of a Monte-Carlo particle simulation code, DEGAS, to understand neutral particle behaviour.[1]

The convergence of the calculated values of atomic hydrogen densities by the DEGAS simulation code was examined before they were fitted to experimental values. It was found that more than 40,000 flights should be tracked by the DEGAS code for this case in order to suppress the scatters of calculated values to be below 5%. Therefore, the flight numbers were set to be more than 40,000. Calculations were performed for different atomic energies released from the wall with a uniform wall source distribution. When the energy was set at 3 eV, it was found that the sum of squared errors between the experimental values and the best-fitted calculated profile were minimum. The resultant best-fitted profiles are shown in Fig. 1 by the thick lines. In this case, plasmas were heated by NBI and had a parabolic electron density profile with a central value of $n_{e0}=3.4\times10^{19}$ m^{-3}. The position of the magnetic axis was at 0.92 m and the magnetic field was 0.9 T. Hatched regions bounded by the thin lines in Fig. 1 show the extent of ambiguity in the fitting of simulated profiles when the relative error of data points is taken into account. This extent corresponds to an energy range of 3±2 eV for the hydrogen atoms released from the wall.

The results of these and supplementary measurements of Hα emission intensities using CCD cameras and photomultipliers at various toroidal positions yielded local atomic hydrogen density distribution in the whole plasma. The distribution of the particle source rate was evaluated from the atomic hydrogen distribution, and then, the profile of the radial particle flux Γ was obtained from a particle continuity equation.

We attempted to evaluate a diffusion coefficient, D, and a convection velocity, v, by assuming the particle flux to be expressed as $\Gamma=-D\nabla n_e + n_e v$. By using experimental data of (Γ/n_e) and $(-\nabla n_e/n_e)$ obtained at two different times at fixed magnetic flux surfaces, D and v were evaluated. The resultant values evaluated at a normalized radius r/a= 0.7 were around D=1 m^2/s and v=-6m/s (inward flow). However, they are based on the data only for two instants of time, and possible error ranges of them are almost ±100 %. In order to evaluate transport coefficients in detail, we need data during transient periods of the electron density profile from one state to another.

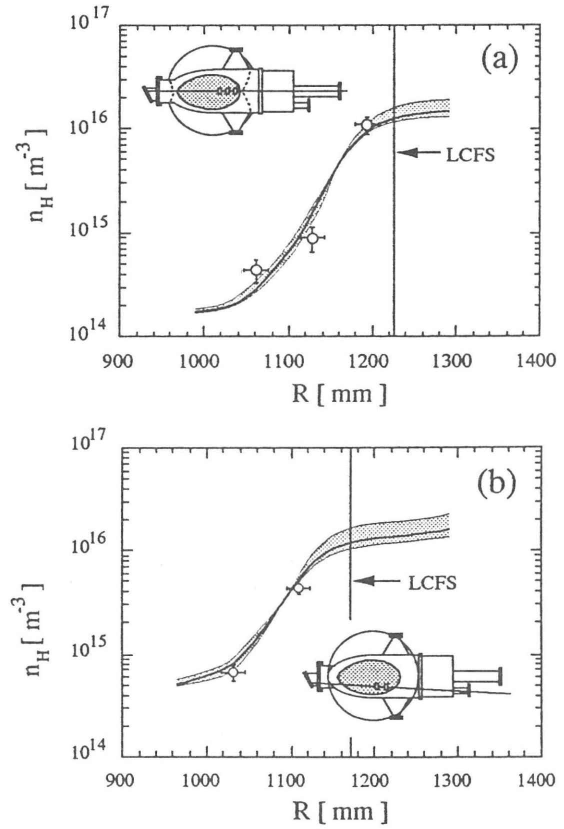

Fig. 1 Profiles of atomic hydrogen densities measured using LIF for (a) a center chord and (b) a lower chord, as shown in insets. Also shown are profiles calculated using the simulation code.

Reference

1) H. Takenaga, T. Nakao, K. Uchino, K. Muraoka, M. Maeda, H. Iguchi, K. Ida, I. Yamada, S. Okamura, H. Yamada, S. Morita, C. Takahashi and K. Matsuoka: Nucl. Fusion (submitted).