§25. Hydrogen Spectroscopy in Plasma Decay Phase of CHS

Goto, M., Morita, S., Ozaki, T., Shirai, Y. (Grad. Univ. Advanced Studies), Torus Exp. Group

We have measured the temporal variation of the excited level population densities of neutral hydrogen atom by observing the Balmer series lines in plasma decay phase.

After turning off the NBI pulse, plasmas are typically maintained for several tens of millisecond. Since the magnetic surface for the confinement is steadily formed, the electron density slowly decays rather than the electron temperature. The behaviors of the electron density and H_α line intensity are shown in Fig. 1.

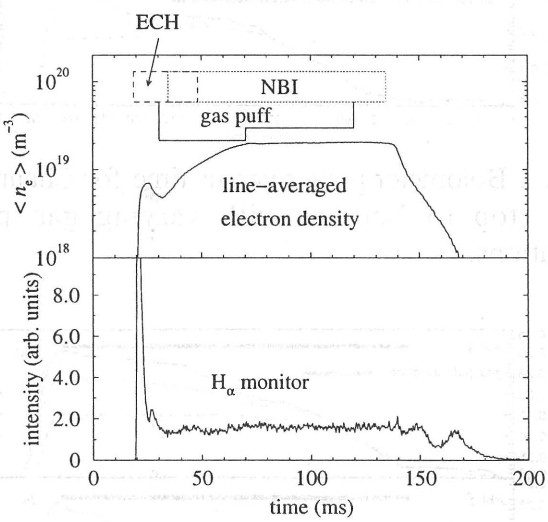

Fig. 1. Electron density and H_α behaviors.

Figure 2 shows the time dependence of the excited level population distribution profile. During the NBI pulse (t = 130–140 ms), the population density of the level having the principal quantum number $n = 3$ is the largest, and it decreases rapidly with increasing n. The higher level populations grow up with time, and then show the 'population inversion' among $n = 3$ to 5 levels at t = 160–170 ms.

According to the collisional-radiative (CR) analysis, the population of each level consists of two components; one is proportional to the ground state density and the other is to the ion density. They are called ionizing and recombining plasma components, respectively.

The experimental results are compared with the CR model calculation and it is found that the t = 130–140 ms data can be explained by only the ionizing plasma component and t = 160–170 ms data by the recombining plasma component. Since the population distribution profile of the recombining plasma component heavily depends on the electron temperature and density, they can be determined. In this case, they are 0.3 eV and 3×10^{18} m^{-3}, respectively.

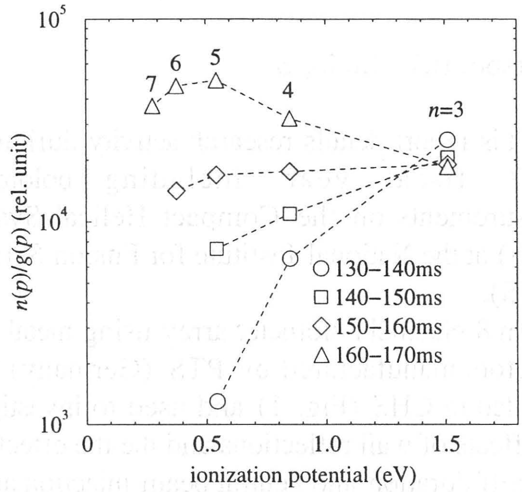

Fig. 2. The time dependence of the excited level population distribution profile.

The data of the intermediate time region are explained by the sum of the two components. Take the data of t = 140–150 ms for example. When the electron temperature, electron density and the ground state density are 3 eV, 9×10^{18} m^{-3} and 1.5×10^{16} m^{-3}, respectively, and the ion density is equal to the electron density, the $n = 3$ level population is dominated by the ionizing plasma component and the $n = 5$ and higher levels by the recombining plasma component. The $n = 4$ population is almost equally contributed by both of them. This situation is shown in Fig. 3. For this analysis the experimental data are normalized to the result of the calculation at $n = 3$.

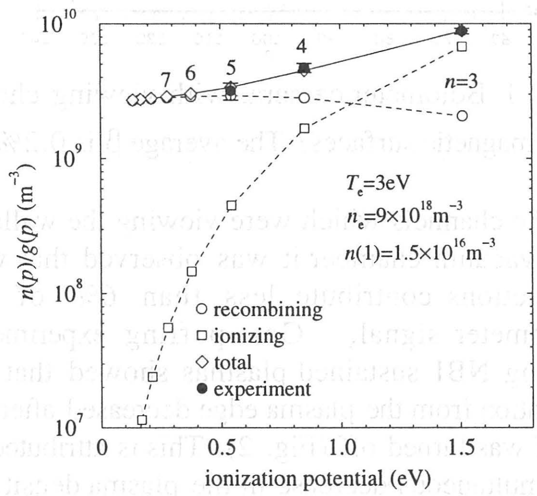

Fig. 3. The population distribution profile at t = 140–150 ms.