§5. Development of Spectroscopy Method Using a Collisional-radiative Model in the GAMMA 10 Plasma

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Neutral hydrogen atom and impurity emission spectra from plasmas have been measured in order to investigate the neutral particles and impurity behaviors in the tandem mirror GAMMA 10. Ultraviolet and visible (UV/visible) spectroscopic system is designed and used for observing the neutral particles and impurity ions emission behaviors. A multi-channel spectrometer (StellarNet Inc., EPP2000) can measure the complete wavelength range (200-1000 nm) of UV/visible impurity spectra in a single plasma shot. We successfully observed the UV/visible spectra of the emission intensities radiated from neutral hydrogen atom and some impurities by using the spectroscopic system. We investigated the emission intensity ratio of neutral hydrogen emissions in the pellet ablation clouds on the pellet injection experiments. We compared the observed intensity ratio with the calculation results of collisiontal-radiative (CR) model. When the pellet is injected into the plasma, hydrogen line emissions intensities increase compared with those without pellet injection. We measured the emission spectra with changing the electron cyclotron heating (ECH) power. With increasing ECH power, both the plasma electron temperature and hydrogen emission intensity from the pellet ablated cloud increase. In the CR-model, the collision and radiation effects are considered.[1-2] The model can determine the population density of the each excited state. The population densities of the excited states are calculated from rate equations. Then, we assume a quasi-steady state and calculate the effective population rate coefficient as a function of the electron density and temperature. Finally, we can obtain the relationship between the intensity ratio and the effective population rate coefficient ratio as follows:

$$\frac{I_{ij}^{z}}{I_{kj}^{z}} = \frac{R_{i\_eff} A_{ij}^{z}}{R_{k\_eff} A_{kj}^{z}}, \qquad (1)$$

Here, I_{ij}^{z} , R_{i_eff}, and A_{ij}^{z} are the emission intensity for *i-j* transition, the effective population rate coefficient, and radiation transition rate, respectively. Further suffix *z* is the charge state and *i* , *j*, and *k* are the energy levels. We can obtain the spectral intensity ratio from the calibrated spectroscopic system. R_{eff} is a function of the electron density and temperature; hence, these parameters can be obtained. The CR-model of hydrogen calculation results is shown in Fig. 1. We have applied the spectral line intensity data of $H\alpha$ and $H\beta$ to the CR-model. The measured intensity ratio of $H\beta$ / $H\alpha$ was approximately 0.25. Then, the electron density is estimated as about 10^{12} cm^{-3}. This is the same as the results of microwave interferometer measurements. However, this is not the electron density of pellet ablation cloud. We have to measure more detail of the pellet ablation cloud with higher spatial resolved spectrograph.

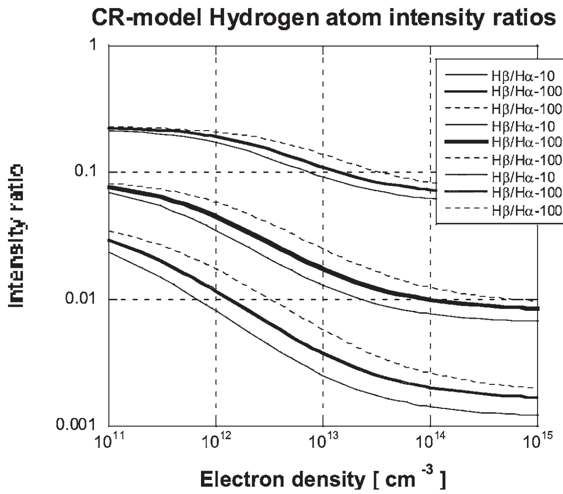

Fig. 1: CR-model calculation results for hydrogen atom emissions intensity ratios.

1) K. Sawada, et al., J. Appl. Phys. **73** (1995) 2913.
2) K. Sawada, et al., J. Appl. Phys. **73** (1993) 8122.