§11. Spectroscopic Measurements of a Electron Temperature and Electron and Ion Densities in the TPD Recombining Plasma

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A new cathode which was composed of La_2O_3 needles was constructed and tested in the TPD-II device. Spectroscopic observation of a produced plasma revealed its availability. An intense glowing plasma resulting from contact of the helium plasma with a neutral helium atom was generated as well. This plasma was known to be classified into a recombining plasma, in which emission spectra from high-lying levels and radiative recombination continuum,

$$He^+ + e \rightarrow He + h\nu, \quad He^{2+} + e \rightarrow He^+ + h\nu$$

were observed. Figure 1 shows a typical spectrum near the Lyman series limit of neutral helium. The emission coefficient of the radiative recombination continuum is given as the following

$$\varepsilon(\lambda) = \frac{h^7}{8\pi^{9/2} m^3 e^6} \frac{c^2}{\lambda^5} \frac{g}{g^+} \sigma n_e n_z \left(\frac{E_H}{kT_e}\right)^{3/2} \exp\left[\frac{1}{kT_e}(\chi - \frac{ch}{\lambda})\right]$$

in units of [erg/s/cm^3/sr/cm(wavelength)]

where λ is the wavelength of the emitted photon, E_H the ionization energy of hydrogen atom, n_z the ion density, χ the ionization energy from the ground state, g and g^+ the statistical weight of the ground state and the ion, respectively, σ the photo-ionization cross section, the remaining notations have the usual meanings. A plot of $\varepsilon(\lambda)\lambda^5/\sigma$ vs. the photon energy in neutral helium is shown in Fig. 2. The broken line shows the exponential fitting. The electron temperature can be obtained from the tangent of the straight line. Furthermore, if the ion density was assumed to be the same as electron density, they were calculated from the electron temperature and the absolute emission coefficient. The absolute measurements were performed by a 2m vacuum UV monochromator which was calibrated by a branching ratio method. Similarly, a doubly ionized helium density was also calculated from T_e, n_e, ant $\varepsilon(\lambda)$. Accordingly, the electron temperature and the electron (=He^+ density) and He^{2+} densities were estimated at 0.47 eV, 8.8×10^{13}cm^{-3}, 3.4×10^{11}cm^{-3}, respectively.

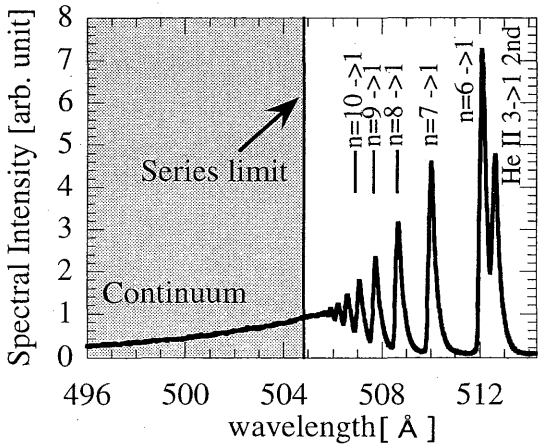

Fig. 1 Spectrum near the Lyman series limit.

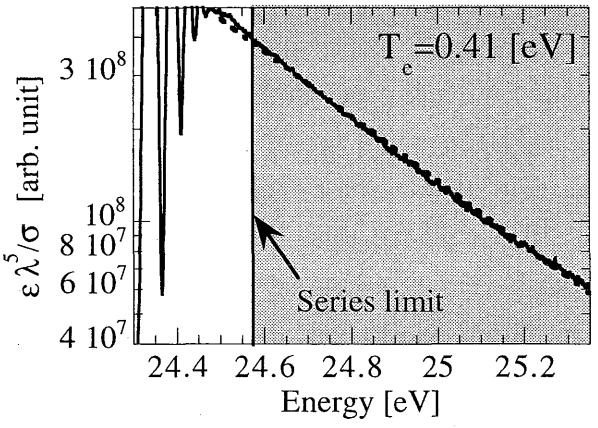

Fig. 2 Plot of $\varepsilon(\lambda)\lambda^5/\sigma$ vs. energy. The electron temperature was estimated from the tangent of the straight line.