§6. Development of Two Wavelength Spectrometer for the Measurement of He/H Ratio with Charge Exchange Spectroscopy

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Radial profiles of density ratio of helium to hydrogen ions are measured using charge exchange spectroscopy technique with two-wavelength spectrometer in the wide range of the density ratio of 0.05 - 5 in the Large Helical Device.

Figure 1 shows the experimental setup for helium/hydrogen density ratio measurement with charge exchange spectroscopy using two-wavelength spectrometer. The light from the plasma is led to the entrance of the dichroic mirror box and the light with longer wavelength ($\lambda > 495$ nm) is transmitted through the dichroic mirror, while the light with shorter wavelength ($\lambda < 495$ nm) is reflected. By using this dichroic mirror box, the light of one fiber from the plasma is separated into the two fibers for helium and hydrogen line measurements and is led to two-wavelength spectrometer in order to measure the density ratio of helium to hydrogen. The dichroic mirror box consists of dichroic mirror, two edge filters, three camera lenses, and three fiber holders. The two-wavelength spectrometer (Bunkou-Keiki CLP-400) consists of two f=400mm F=2.8 camera lenses and two gratings (1800/nm for helium and 1200/nm for hydrogen line) and CCD detector.

The 8 channels of the optical fiber array from the plasma are connected to this system and 16 spectrum on the CCD detector gives a radial profile of the helium and hydrogen density ratio at 8 locations. The diameter of the core is 200 μm and the diameter of the cladding is 250 μm. The interference between HeII and H_α spectrum in the CCD is eliminated by the dichroic mirror box arranged in front of the two-wavelength spectrometer. The back illuminated electron multiplying 640x512 pixel (12x12 μm) CCD camera (PixelVision PV652) is used as a detector to achieve a high frame rate, f_{ccd}, up to 200Hz with 21 pixel vertical binning. The amount of the light is adjusted in the wide range of two orders of magnitude by selecting the appropriate electron multiplying (EM) gain of the CCD detector and the F number of iris (from F = 1.4 to F = 16) in the camera lens, because the intensity of HeII line should be comparable to that of H_α at the detector in order to avoid the saturation of the signal on CCD.

Figure 2 shows the transmission of this system using dichroic mirror and red/blue edge filter in the two-wavelength spectrometer system. The edge wavelength of the dichroic mirror used in this system is 495nm, where the light with longer wavelength is transmitted and the light with shorter wavelength is reflected. As seen in Figure 2, there is 6 % transmission in the wavelength region of λ = 510 -520 nm. This is due to the leaked reflection (reflection of the light above the edge wavelength) from the dichroic mirror. In order to eliminate the interference between the lights from 1200/mm and 1800/nm grating, the additional edge filters of red and blue side are installed in the exit of dichroic mirror box. This is important to avoid the overlap of the HeII line (λ = 468.6nm) and H_α line (λ = 656.3nm). The edge wavelength of the longer wavelength cut-off (blue filter) and shorter wavelength cut-off (red filter) is 534 nm and 554 nm, respectively.

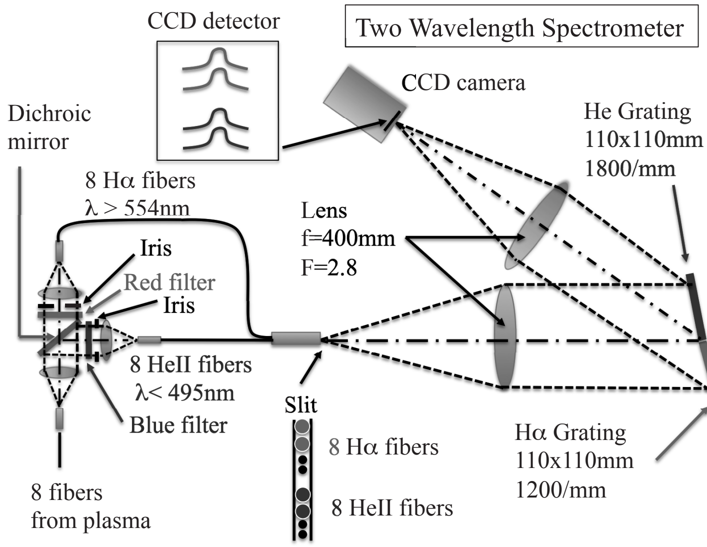

Fig. 1: Two-wavelength spectrometer for helium/hydrogen density ratio measurement with charge exchange spectroscopy.

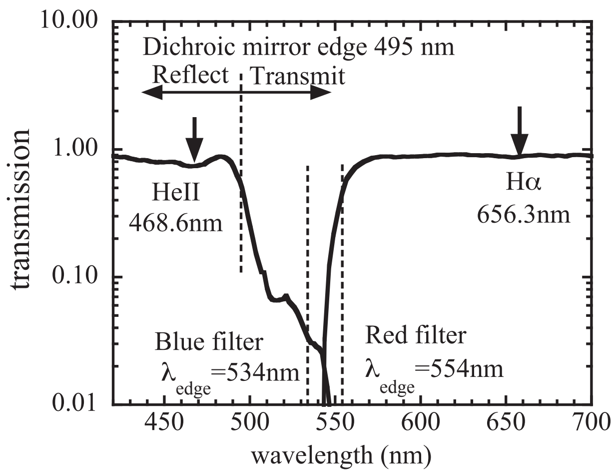

Fig. 2: Transmission of HeII channel and H_α channel through the dichroic mirror plus red and blue filter in the two-wavelength spectrometer system.