§1. Imaging Spectrometry for Measuring Visible Impurity Radiation Emitted from the Carbon Head of a Movable Limiter

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A new imaging spectroscope has been developed for measuring visible radiation profile emitted from LHD plasmas. The imaging spectroscope can directly measure the two-dimensional profile of the visible radiation spectrum by using a prism-grating-prism (PGP) element which provides high diffraction efficiency and good spectral linearity. In a conventional system for measuring the two-dimensional radiation spectrum, an expensive bundle fiber array, a spectroscope and a delicate lens-fiber optical attachment are necessary. Figure 1 shows the schematic view of the imaging spectroscope. Using this instrument, we can simply and easily measure the two-dimensional spectrum only by mounting lenses and the PGP element between an objective lens (C-mount) and a CCD (Charge Coupled Device) camera. We can simultaneously observe the spatial and spectral information of the radiation by the detected intensity profile on the CCD chip mounted in the camera.

For confirming the availability of this spectroscope, we preliminary measured the radiation spectrum from a tangential port (6-T) when a movable limiter was inserted into the ergodic layer (ρ=1.02, ρ is the normalized minor radius) around the LCMS (Last Closed Magnetic Surface). Figure 2 gives a plasma image in a movable limiter discharge observed by another CCD camera mounted in the tangential port for monitoring LHD plasmas, showing a bright emission close to the carbon limiter head (lower side of the image) and a bright stripe from the limiter head. We optimized the position of the entrance slit installed in the spectroscope so as to observe the spectrum emitted from the area shown as gray rectangle in Fig. 2.

Figure 3 shows the observed spectrum of visible radiation in the limiter discharge. In the lower side, CIII and CII line emission can be clearly identified, indicating the localization of the carbon ions near the carbon limiter head. From this spectrum, we can find that the bright stripe from the limiter head was originated from CIII line emission (λ=465.4nm). The carbon ions emitted from the limiter head can move along the magnetic field lines in the plasma periphery. The relatively high electron temperature around the LCMS (T_e > several tenth eV) can induce the CIII line emission along the magnetic field lines. In the region close to the limiter head, the electron temperature can be lower than that around the LCMS due to the impurity line radiation (especially carbon ions), causing the observable intensity of the CII line emission near the limiter head (lower side of the measured spectrum) compared to that of CIII line emission.

Reference
1) G.M. McCracken et al, Nucl. Fusion **38**, (1998) 619

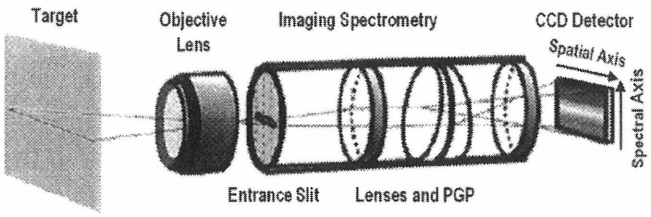

Fig.1. Schematic view of the imaging spectroscope showing also the spatial and spectral mapping with an area detector.

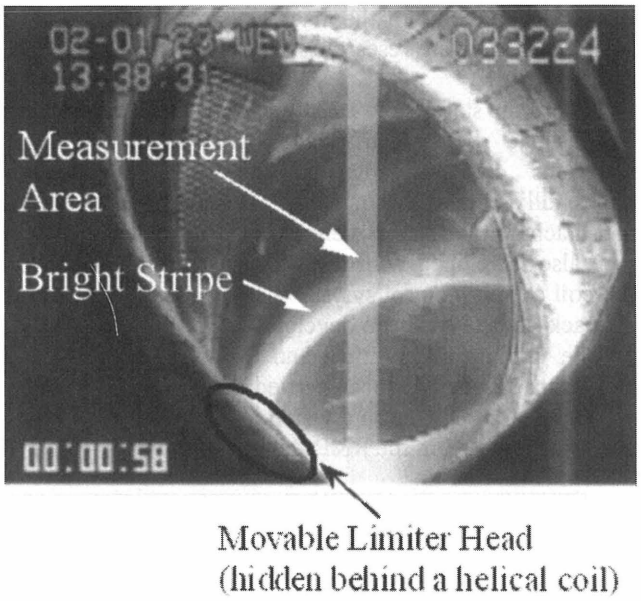

Fig.2. Plasma image taken by a tangentially viewing CCD camera, when the movable limiter was inserted around the LCMS. A bright emission in the lower side of the image and a bright stripe from the limiter head were clearly observed.

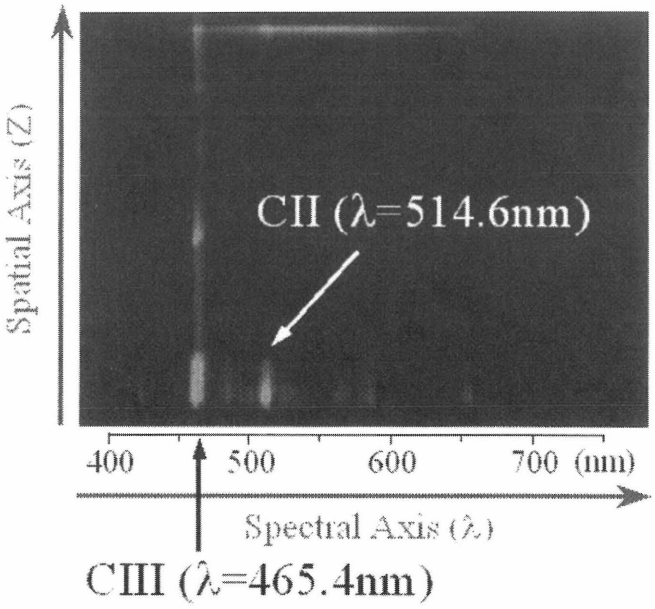

Fig.3. Visible radiation spectrum measured with the imaging spectroscope when the movable limiter was inserted around the LCMS, showing the significant CIII line intensity near the limiter head and on the bright stripe.