Development of Multi-wavelength-range Fine-resolution Spectrometer for Hydrogen Atomic and Molecular Emission Lines

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A technique based on the Zeeman patterns appeared in the emission line shapes has been applied to a spatially resolved measurement of hydrogen atoms [1,2] and molecules [3] in magnetically confined plasmas for fusion research. A simultaneous measurement of line shapes of the hydrogen Balmer series and Fulcher bands is demanded for the study of the dynamics of neutral hydrogen in the periphery region of the plasmas and for a comparison with the collisional-radiative model of hydrogen [4]. Since it is difficult to achieve it with conventional spectrometers, we are developing a multi-wavelength-range fine-resolution (MF) spectrometer. We have already developed such a MF spectrometer for the Balmer-α, -β, -γ lines and the Q branch of the Fulcher-α $v = 2$ - 2 vibronic transition band and applied it to the LHD plasma, the details of which will be published elsewhere. Here, we report a brief summarization of this work and the improved version of the MF Spectrometer for the purpose of additional simultaneous observation of the $v = 0$ - 0 vibronic transition of the Fulcher band. A schematic image of the improved MF spectrometer is shown in Fig.1. The light introduced by optical fibers at the entrance slit is collimated by a concave mirror (Mc, $f = 1143$ mm) and incident on a grating (2400 grooves/mm). The diffracted light beams are focused by five concave mirrors (M_α, $M_{ful}^{v=2}$, $M_{ful}^{v=0}$, M_β, M_γ; $f = 1143$ mm) on a CCD camera. We optimize the positions of all the optical components using a ray-tracing calculation by minimizing the aberration mainly caused by off-axis reflections at the concave mirrors. From the calculation, the instrumental widths for these five wavelength ranges are predicted to be less than 0.015 nm with the entrance slit width of 20 μm.

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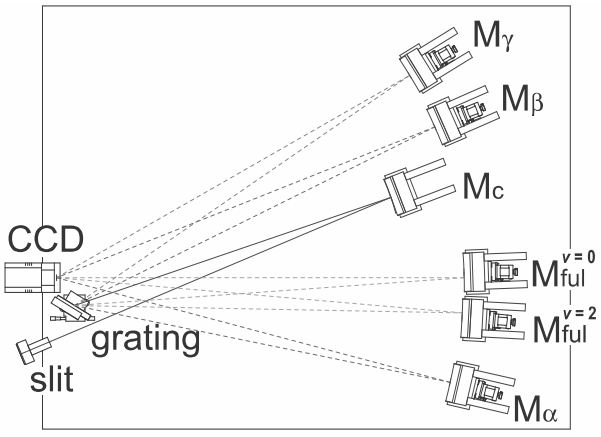

Fig.1 A schematic image of the improved MF spectrometer.