§30. Development of High-Speed Spectrometer using Multi-Channel Photomultiplier

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In order to observe fluctuations synchronized with an ion cyclotron frequency heating (ICRF), a high-speed spectrometer using a multi-channel photomultiplier system has been developing. Since the frequency response and the wavelength shift of the emission light from the plasma fluctuated by ICRF, is expected quite high (~ 100 MHz) and small (~ 0.01 nm), respectively, this diagnostic system aims to achieve quite high temporal and wavelength resolutions.

On the other hand, in the case of a development of an electrodeless electric thruster using a helicon plasma, the spectrometer with the above-mentioned specification is also useful. In the case of the electric thruster study, the spectrometer can measure the ion velocity by the Doppler shift of the ion emission light. Since the typical ion velocity of the electric thruster is about tens of km/s, the resolution of the spectrometer must have ~ 0.01 nm order. In recent years, the research group in Tokyo University of Agriculture and Technology, using a helicon plasma device named Large Mirror Device (LMD)[1], tried to measure the Doppler shift using a high-resolution monochromator with a photomultiplier, but it was difficult to have a good reproducibility and an accuracy.

In order to solve these problems of LHD and LMD experiments, our group have proposed to develop a spectrometer using a magnifier optical system and a multi-channel photomultiplier (Hamamatsu Photonics, H2760-20: 32 channel) as shown in Fig. 1. The multi-channel photomultiplier can obtain the spectrum simultaneously with no mechanical error, and it has enough sensitivity and temporal resolution.[2] For this purpose, the magnifier optics adjusts the reciprocal liner dispersion to obtain the spectrum by several channels of the multi-channel photomultipliers.

In this year, the preliminary test of the magnifier optic system have been done. Figure 2 indicates the optic system. The spectrometer was quite high resolution (Ritu Oyo Kougaku Co. Ltd., Czerny-Turner type MC-150: focal length of 1,500 m, 2,400 lines/mm grating, 0.006 nm resolution, reciprocal linear dispersion of 0.25 nm/mm). Two cylindrical lenses (w-1 and w-2) work as the magnification of the wavelength resolution, and s-1 works as a collimator.

Figure 3 shows an experimental result of the magnifier optics. In this experiment, a tunable diode Laser (TOPTICA Co. Ltd., TA100: linewidth of ~ 1 MHz, wavelength range of 663.5 ~ 669.3 nm, and wavelength resolution of 0.25 GHz) was used as a light source. It is found that the reciprocal linear dispersion was magnified about 80 times.

In addition, we have been developing amplifier arrays for multi-channel photomultiplier. Since the current signals from each channel are quite small, a high-gain and compact amplifier arrays are needed.

In the next fiscal year, we plan to develop the improved magnifier optical system and the photon-counting system, and observe the spectrum in an Ar discharge in LMD.

1) Shinohara, S. et al.: J. Appl. Phys. **35** (1996) 4503.
2) Kamio, S. et al.: Rev. Sci. Instrum. **83** (2012) 083103.

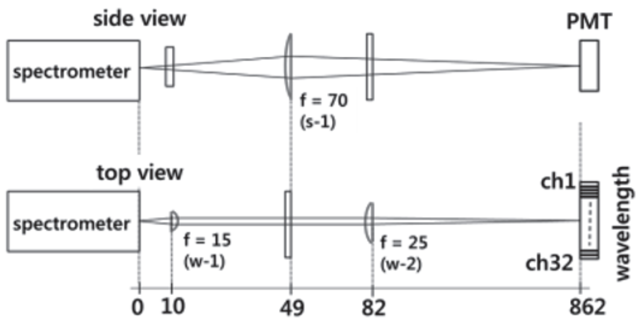

Fig. 2. Magnifier optical system.

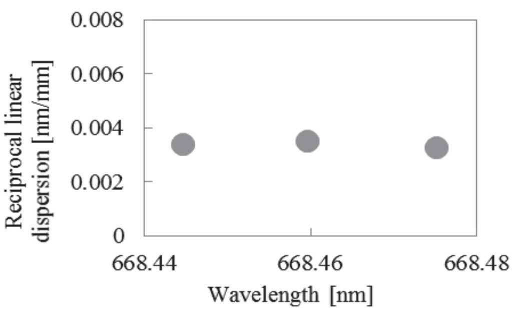

Fig. 3. Preliminary result of reciprocal linear dispersion using tunable diode Laser.

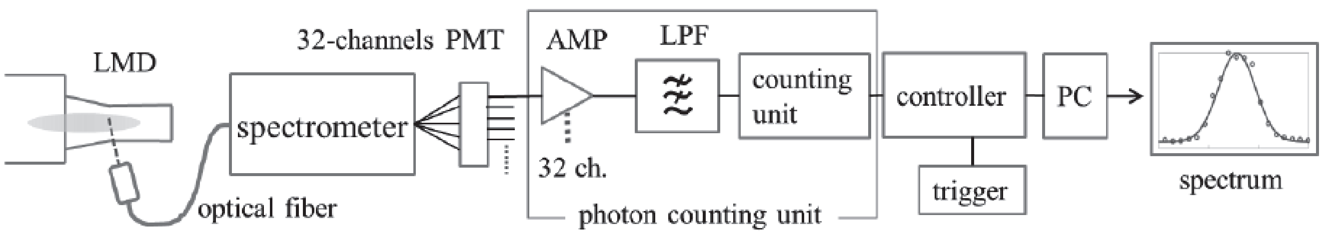

Fig. 1. Multi-channel photomultiplier spectrometer developed in TUAT.