Development of ultra-fast charge exchange recombination spectroscopy for temperature and flow velocity fluctuation measurements in Heliotron J

S. Kobayashi¹, X. X. Lu², K. Ida³, T. Kobayashi³, M. Yoshinuma³, S. Kado¹, S. Ohshima¹, K. Nagasaki¹, H. Okada¹, T. Minami¹, S. Yamamoto¹, D. L. Yu⁴, Y. Nakamura², A. Ishizawa², S. Nishimura³, K. Nishioka⁵, S. Konoshima¹, T. Mizuuchi¹

¹ Institute of Advanced Energy, Kyoto Univ., Uji, Kyoto 611-0011, JAPAN
² Graduate School of Energy Science, Kyoto Univ., Uji, Kyoto 611-0011, JAPAN
³ National Institute for Fusion Science, Toki, Gifu 509-5292, JAPAN
⁴ Southwestern Institute of Physics, Chengdu, Sichuan, 610041, CHINA
⁵ Graduate School of Science, Nagoya Univ., Chikusa, Nagoya 464-8602, JAPAN

In magnetically confined fusion plasmas, many diagnostic techniques have been demonstrated to understand the heat/momentum transports due to turbulent fluctuations. In this study, we report on the development in ultra-fast charge exchange recombination spectroscopy (CXRS) for the temperature and flow velocity fluctuation measurements¹. The ultra-fast CXRS system consists of a combination of a high-dispersion Echelle grating monochromator with photographic lens (Bunkoukeiki: SPL-200) and a high speed camera with an 8×4 array of avalanche photodiode (Fusion Instruments Kft: APDCAM). The effective F number of the monochromator is 2.9 and the dispersion is 0.064 nm/mm. Each APD element has 1.6×1.6 mm size and the maximum quantum efficiency of 87%. In order to clarify the performance of the system in calculating the fluctuation components of the temperature and the flow velocity, a calibration test was carried out by simulating the fluctuated CXR emission experimentally. Two sets of monochromator (Nikon: P-250) were used to make the calibration light source whose spectrum width and central wavelength were modulated. One is a DC light source (λ_CWL = 468nm, Δλ_FWHM = 0.6nm) and the other is fluctuated one (f = 10Hz-10kHz) whose central wavelength is slightly shifted to that of the DC component. The fluctuation level of the central wavelength was calculated by applying a FFT method to the measured APDCAM signals, which was compared to the spectrum measurement with a CCD camera system. Even in the case that the amplitude of the fluctuation intensity is lower than 5%, the fluctuation level of the central wavelength with the ultra-fast CXRS system is consistent to that by the CCD camera measurement.