§36. Development of Two Dimensional Thomson Scattering Measurement System

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The Thomson scattering method is the most reliable diagnostics for electron temperature measurement and its two dimensional (2-D) measurement is expected to solve magnetic reconnection in TS-4 experiment and electron transport in LHD experiment. We have developed a new cost-effective 2-D Thomson scattering measurement system using multi-reflection of a single laser light and its time-of-flight effect. A new characteristics for our system are as follows: (1) multiple reflections of laser light to cover m x n (2-D) measuring points on r-z plane, (2) usage of time-of–flight of laser light to save the number of polychromators and detectors, and (3) flexible usage of laser path length to control the delay times of scattering signals from those measuring points. They enable us to develop a low-cost 2-D Thomson scattering system using a single Laser and polychromators equivalent to the 1-D system, because the scattering lights from n measurement points are measured by a single polychromator.

In 2009, we optimized the 2-D (3x3) measurement system and measured for the first time the 3x3 Thomson scattered signals using three polychromator, collecting lens system and optical fiber system. Its laser beam was reflected three times by the mirror to cover the center area of out TS-4 spherical tomamak (ST) plasma. The Thomson scattering signals from the 3x3 measuring points were successfully measured by those collecting optics and polychromator system. Figure 1 shows the three Thomson scattering signals measured with equal time intervals of 30nsec corresponding to laser flight length of 12m. Figure 2(bottom) shows the time evolutions of Thomson scattering signals at three radial positions: r=360mm, 540mm and 620mm. The time axis indicates the axial position because of the time-of-flight measurement. Those signals are used to calculate the electron temperature by Gaussian fitting. Finally, 2-D contour of electron temperature were obtained as shown in Fig. 2(bottom). This successful result supports the validity of our 2-D Thomson scattering method by multiple reflection and time-of-flight of laser. The remaining problem is 1) suppression of plasma light and 2) improvement of laser beam quality along the long laser beam path. Under the present experimental condition, we will check the upper limit of reflection number of laser beam.

1) S. Ito , T. Sumikawa , E. Kawamori , Y. Ono, “Development of Multipoint Thomson Scattering Measurement System Using Multiple Reflections and Time-of-Flight of Laser Light, IEEJ Trans. Fun. Mat. 128-A, (2008), p.499.

2) Y. Ono et al., “Ion and Electron Heating Characteristics of Magnetic Reconnection in TS-3 and UTST Merging Startup Experiments”, Fusion Energy 2008, EX/P9-4, 2008.

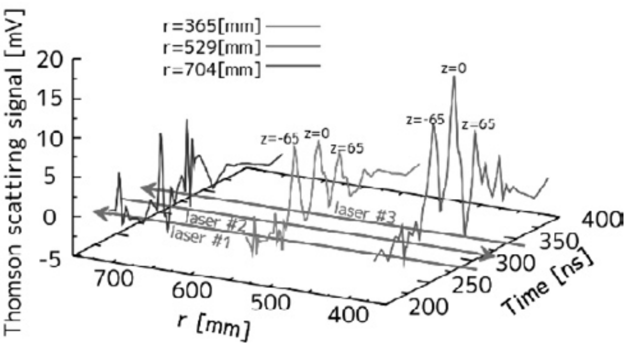

Fig. 1 The laser beam path and measuring points for the present 3x3 2-D Thomson scattering measurement in the poloidal flux contour of ST plasma (top), the measured 2-D contour of electron temperature (middle) and the Thomson scattered lights as a function of wavelength for Gaussian fitting (bottom).

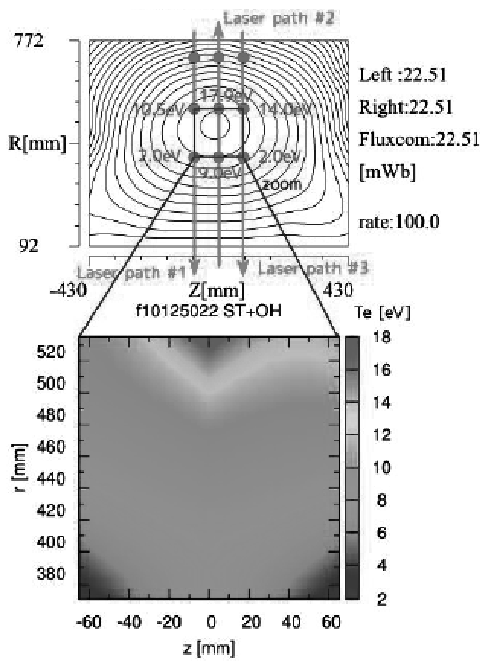

Fig. 2 Measurement points for the proposed 2-D Thomson scattering measurement (top) and r-z profile of the measured electron temperature (bottom)