§4. Development of Two Dimensional Thomson Scattering Measurement by Use of Multiple Reflection of Laser Light

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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 increase the scattered light and 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 2011, we improved the signal-to-noise ratio of the 3x3 Thomson scattered signals on the R-Z plane, enabling us to measure the 2-D profile of electron temperature without using any plasma reproducibility. As shown in Fig. 1, the 2-D (3x3) measurement system is composed of three sets of polychromators, collecting lens systems and optical fiber systems. The YAG laser beam was reflected three times by the mirror to cover the centeral area of out TS-4 merging tomamak (ST) plasma. The Thomson scattering signals from the 3x3 measuring points were successfully measured by nine collecting optics[1,2]. Figure 2 shows Thomson scattering signals at all nine measurement points which were measured by three polichromaters. Each three scattering signals were measured as a time series signals with interval time of 30nsec, which corresponds to laser flight length of 12m. 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, axial profiles of electron temperature were obtained at R= 0.4, 0.5 and 0.6m as shown in the bottom three figures of Fig. 2. These results indicates the significant improvement of the accuracy of our 2-D Thomson scattering method by multiple reflection and time-of-flight of laser.

1) Y. Ono, H. Tanabe, Y. Hayashi et al., Phys. Rev. Lett. 107, 1850991, (2011). 2) Y. Ono, Y. Hayashi, T. Ii, H. Tanabe et al, Phys. Plasmas 18, 111213, (2011).

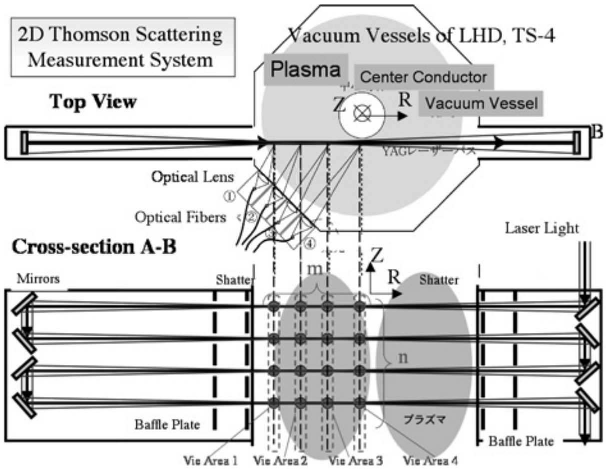

Fig. 1 The present experimental setup of 2-D Thomson Scattering measurement by multiple laser light reflection and its time of flight. The 3x3 scattering lights are covered by three filter-type polychromators (1058nm, and at 1053nm etc).

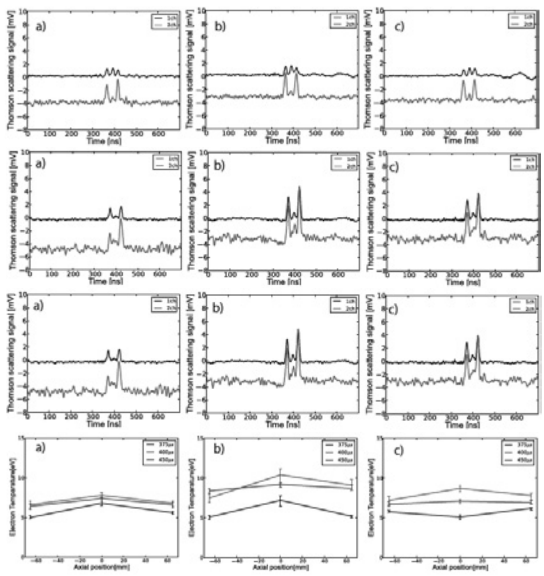

Fig. 2 Measured scattered signals on the R-Z plane : nine figures on the top three lines show the scattered signals at three axial positions: Z=-0.1, 0 and 0.1 as time series signals for the three radial positions: R=0.4m, 0.5m, 0.6m. The red and black lines represent the signals at 1058nm and at 1053nm, respectively） The three figures in the bottom line show the axial profiles of electron temperatures at the three radial positions at a) 375μs, b)400μs, c)450μs.