§3. Detailed Electron Velocity Distribution Function Measurement by Thomson Scattering

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This study aims to investigate anisotropy of electron temperature in low collisionality plasma. It is considered that the anisotropy affects the plasma pressure profile and the plasma current caused by the pressure gradient. We applied the double-pass Thomson scattering to measure electron temperatures along two different directions. The YAG laser beam is reflected after passing through plasma and injected again collinearly (but propagates oppositely) with the first pass. Thomson scattering spectra resulting from the first pass and second pass allow us to measure electron temperature along the direction perpendicular to the magnetic field (hereinafter called $T_{e\perp}$ measurement) and electron temperature along the direction approximately 12 degrees inclined from the magnetic field, respectively. The $T_{e\perp}$ measurement had a large error under the configuration of LHD in case the $T_{e\perp}$ exceeds 4 keV. In this fiscal year, a method for accurate $T_{e\perp}$ measurement was considered.

It is crucial for accurate electron temperature measurement by Thomson scattering to increase the number of detected photons and to calibrate the spectral transmission of the optics. In order to achieve the above two things at the same time, we proposed to inject a ruby laser beam which is collinear to a YAG laser beam normally used in LHD Thomson scattering system. In this report, the improvement of accuracy in the electron temperature measurement by using the Thomson scattering spectra resulting from the YAG laser and the ruby laser beams is shown.

Figure 1 shows (a) spectral transmission of the optics, (b) Thomson scattering spectra from the plasma with the electron temperature of 10 keV and (c) number of detectable photons resulting from the YAG laser and the ruby laser beams as a function of the $T_{e\perp}$, respectively. The spectral channels 1-3 are used to resolve the spectra resulting from the second pass. In case the $T_{e\perp}$ exceeds 4 keV, the number of photons detected by ch 4-6 decrease with approximately the same ratio and that by ch 7 is relatively small. This causes a large error in the $T_{e\perp}$ measurement by using only YAG laser beam under the configuration of LHD. On the other hand, the ratio of the number of detected photons by ch 5 to ch 7 depends strongly on the $T_{e\perp}$(see Fig. 1 (c)). Figure 2 shows the expected measurement error in $T_{e\perp}$ obtained by a numerical simulation. Using a ruby laser beam allows us to improve the accuracy of measurement especially in case that the $T_{e\perp}$ exceeds 7 keV.

In addition, the spectra resulting from the YAG laser and the ruby laser beams at a certain spectral channel change with approximately the same fraction in case the spectral transmission of the optics degrades. Therefore, it is also possible to measure the electron temperature from the ratio of the Thomson scattering spectra resulting from the YAG laser beam to the ruby laser beam. Then, the spectral transmission of the optics can be calibrated using the Thomson scattering light from the plasma during the discharge. Therefore, even if the spectral transmission of the optics would be degraded during the annual campaign due to neutron flux from the deuterium plasma discharge in LHD, the electron temperature measurement could be calibrated during the plasma discharge.

It was concluded that the Thomson scattering measurements by injecting the YAG laser and the ruby laser beams collinearly into the LHD plasma allow us to improve the accuracy of electron temperature measurement for a high temperature plasma and to calibrate the electron temperature measurement during the plasma discharge at the same time. It will provide the detailed electron velocity distribution function measurement such as anisotropic electron temperature measurement.

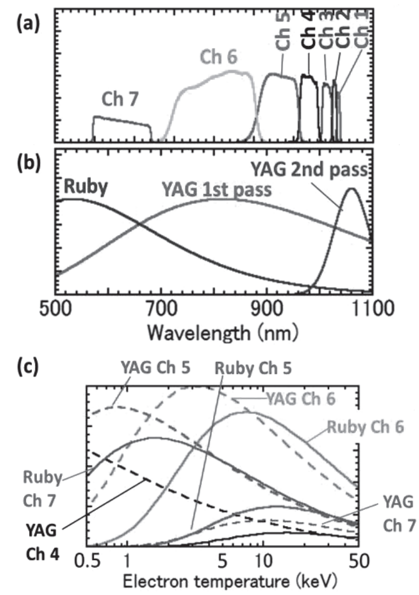

Fig. 1. (a) spectral transmission of the optics, (b) Thomson scattering spectra from the plasma with the electron temperature of 10 keV and (c) number of detectable photons resulting from the YAG laser and the ruby laser beams as a function of the $T_{e\perp}$, respectively.

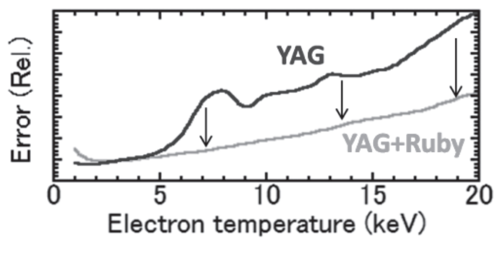

Fig. 2. Expected relative measurement error in $T_{e\perp}$.