Thomson scattering (TS) diagnostics is one of the most reliable methods for measuring the electron temperature ($T_e$) and density ($n_e$) profiles in fusion plasmas.

However, due to the small Thomson cross-section $\sigma_T = 6.85 \times 10^{-28} \text{ m}^2$, Thomson scattering is challenging for low densities plasma such as the GAMMA10 plasma ($2 \times 10^{19} \text{ m}^{-3}$) and a high temperature plasma at the LHD ($\sim 20 \text{ keV}$).

For increasing the scattering probability and the accuracy of electron temperature, a multi-pass Thomson scattering scheme is effective. It allows the laser pulse to be focused several times onto the scattering volume from backward and forward directions, thus increasing the scattering photon number into the detector.

In this study, we propose a newly scheme of multi-pass TS system by the use of a polarization optics. This scheme can be modified from the basic single pass Thomson scattering system by adding the high reflection mirror for cavity mirror, lenses used for image relaying the laser beam and polarization control devices.

The multiplication of the scattering light as a function of a pass number from the result of the optical design.

At the sixteenth pass configuration, scattering light was about six times larger than the single pass configuration.

The double pass system demonstrated in GAMMA10 has installed to the LHD Thomson scattering system.

We have successfully obtained the double pass Thomson scattering signal at the 16th campaign of the LHD experiment.

For the LHD TS system

$T_e$ from backward and forward TS signal

Open the new physics by using the multi-pass system

Forward scatter can be measured by use of the multi-pass system. This measurement improves the reliability of electron temperature at high temperature plasma higher than 30 keV.

By use of the multi-pass system we can get the information of the $T_e$ and $T_i$, spectrum separately.

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