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Development of Cost-Effective/Wavelength Tunable Polychromator System with Two Angled Filters for Thomson Scattering Diagnostics

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We develop a cost-effective polychromator system with two angled filters for Thomson scattering diagnostics. We successfully reduced the number of interference filters to less than half by using the angle of incidence dependence of the transmitted wavelength. While the existing polychromator uses one interference filter to separate one wavelength, we successfully separated 5 wavelengths by using 2 interference filters.

We are studying magnetic reconnection as a new heating method for initial plasma for nuclear fusion power generation. When two antiparallel magnetic field lines approach each other, they reconnect together due to electrical resistance at the reconnection (X) point. The reconnection electric field accelerates electrons, forming negative potential well in the downstream for ion acceleration. Several heating elements are suggested as the electron heating characteristics of magnetic reconnection, such as Joule heating near the X point and outflow heating, but the mechanism is still unclear.

To clarify the electron heating characteristics of magnetic reconnection, we started using two-dimensional Thomson scattering measurement. It can reliably measure electron temperature and electron density without contacting plasma. To measure them on a line near the X point, a one-dimensional Thomson scattering measurement system is being developed. At each measurement point, a polychromator is needed, and 5 wavelengths are needed to separate. However, each interference filter is expensive, costing more than $1800 each, so the cost increases significantly as the number of measurement points increases. Therefore, the purpose of this study is to develop a cost-effective polychromator to save costs.

Figure 1 shows the schematic of the cost-effective polychromator system with two angled interference filters (1059 nm, 1050 nm). The scattered light incident on this polychromator is reflected between two interference filters. They are positioned at two different angles: 7 degrees and 3.5 degrees respectively. Because of their difference in angle, the scattered light reflected between them gradually increases with its angle of incidence. In Figure 1, the scattered lights for Channel 1-5 are indicated by the red, blue, green, yellow, and purple lines.

This new polychromator can reduce the number of interference filters required by less than half in the conventional polychromator, which needs one filter to separate one wavelength. Using this method, we can reduce the huge costs of polychromators, because the number of interference filters becomes less than half, $1800 each.

Figure 2 shows the performance of this new polychromator system. The response of the detector (APD) in each channel is measured by changing the wavelength from 1000 nm to 1065 nm. From Figure 2, we successfully separated 5 wavelengths.

The next step is to develop a wavelength-tunable polychromator. By adjusting the angle of interference filters, the polychromator can cover shorter wavelengths, which can detect scattered light changing widely with plasma temperatures. It needs an interference filter with a larger diameter and smaller refractive index.

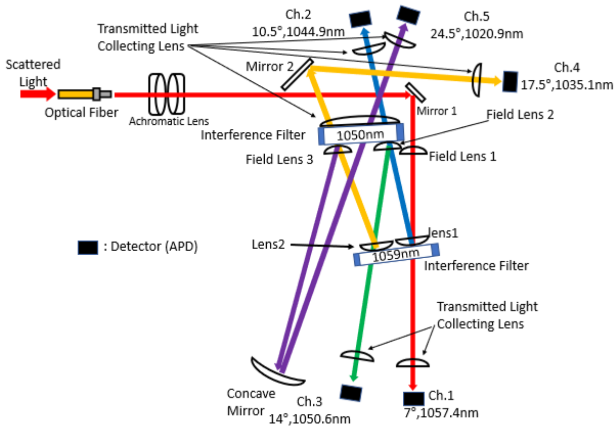

Figure 1. Schematic of polychromator system with two angled interference filters (1059 nm, 1050 nm).

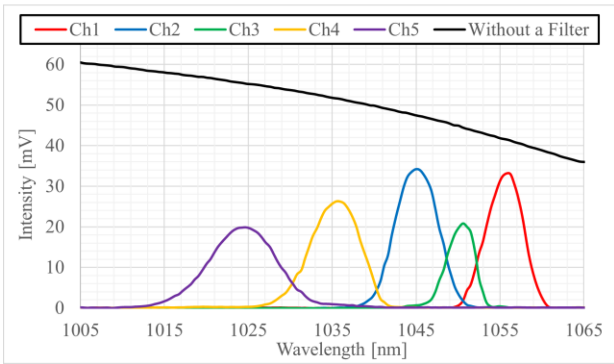

Figure 2. Wavelength characteristics of polychromator system with two angled interference filters.