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Present status of the Nd:YAG Thomson scattering system development for time evolution measurement of plasma profile on Heliotron J (3)

Heliotron Jプラズマの分布時間発展計測のためのNd:YAG トムソン散乱計測装置開発の現状 (3)

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We are developing polychromators for a new high repetition rate Nd:YAG Thomson scattering measurement system for Heliotron J. This Nd:YAG Thomson scattering system enables to measure time evolution of electron temperature and electron density simultaneously at 25 spatial points by 25 polychromators. Polychromators, containing five interferrence filters and five avalanche photo diodes, are used as spectral analyzers of scattered light. In this study, we make the optimized design of the polychromators, and make performance check of the polychromators.

1. Introduction

Measurement of electron temperature and density profiles of plasma is one of the important issues in magnetically confined plasma research. The popular methods of the multipoint Thomson scattering measurements are TV Thomson method, LIDAR Thomson method, and Nd:YAG Thomson method. Among them, Nd:YAG Thomson method is especially suitable for high-repetition operation.

Nd:YAG laser beams are injected into plasma and scattered by collision with electrons. Scattered lights show spectral broadening, from which the electron temperature is estimated. Total amount of scattered lights is a function of electron density.

In Heliotron J, plasma width along the laser beam is 25 cm, discharge pulse length is 200 ms. The Nd:YAG Thomson scattering system is designed to measure at 25 spatial points in the 10 ms cycle. Expected electron temperature is 10 eV - 10 keV, and density is greater than 0.5×10^{19} m^{-3}.

To make reliable measurement, spectral analysis of the scattered lights is an important factor. The purpose of this study is to design and construct spectral analyzer system that is optimized for the Nd:YAG Thomson scattering system, and to make performance check of the analyzer. In this study, polychromators are selected as a spectral analyzer.

2. Polychromator Design

One polychromator has five wavelength

channels and one Reileigh calibration channel with interference filters and avalanche photo diodes (APDs). The basic idea of the polychromator is shown in Fig.1. Interference filter is an optical filter that transmits particular spectral bands and reflects others. By these filters, the scattered lights are divided into five wavelength ranges. Then, the light signals are transformed into electric signals by APDs and transmitted to data-analyzing system.

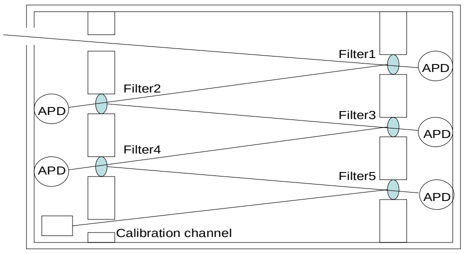

Fig.1 Basic idea of the polychromator

The combination of the transmission wavelength range for the five interference filters is optimized by a performance simulation code, so that the errors in temperature and density evaluation become minimal. The result is listed in Table 1.

Table 1. List of filter wavelength

Filter.1	700 - 845nm
Filter.2	845 - 960nm
Filter.3	960 - 1025nm
Filter.4	1025 - 1050nm
Filter.5	1050 - 1060nm

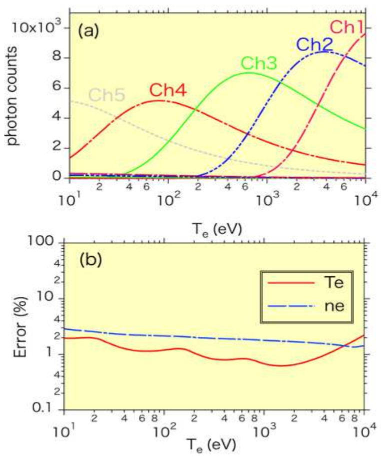

Fig.2 a)Photon counts for each channel
b) Fractional errors in the estimation of electron temperature and density

Estimation of scattered photon count for each interference filter as a function of the electron temperature is shown in Fig.2 a). The electron density is assumed to be 3×10^{19} m^{-3}, which is a typical value for Heliotron J plasma. At least two channels have enough count number to measure the accurate plasma profile between 10 eV and 10 keV. The expected errors, caused by bremsstrahlung, for the temperature and density are shown in Fig.2 b). Both errors are below 3%.

3. Performance Test for Polychromator

In this section, the method to make performance check of the polychromator is described. The equipment for this test consists of a light source, a monochromator, a light chopper, and a laser power meter. The light source, Apex Illuminator, and the monochromator are manufactured by Newport Co. Ltd. A test light of selected narrow band wavelength is produced by them. Then, the light is transformed into a pulse signal by the chopper, and goes into the polychromator. Changing the wavelength band of the monochromator, the intensity of the light is measured at the entrance of the polychromator and each interference filter channel. The transmission curves obtained from this test are used for the derivation of the electron temperature and density from the scattered light signal.

4. Summary

The design of the polychromator for the Nd:YAG Thomson scattering system in Heliotron J is reported. As a result of performance simulation, the optimized design of the polychromator is decided. To check the polychromator performance, test equipment has been prepared. We will accomplish performance test of polychromators soon, and the result will be discussed in the presentation.

Acknowledgments

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