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Polarization based laser beam combining for improvement of accuracy on the LHD Thomson scattering system

偏光レーザービーム結合によるLHDトムソン散乱装置の高精度化

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The polarization based beam combining from multiple lasers is developed for an improvement of time resolution and an accuracy of the LHD Thomson scattering system. Two or multiple beams from the different aperture of laser heads are combined to the coaxial beam line in time series by optical components of this beam combining scheme. We have installed this type of beam combining method for the LHD Thomson scattering system from 15th experimental campaign. In the presentation, we will discuss the detailed design and performance of polarization based laser combining.

1. Introduction

Thomson scattering (TS) diagnostics is one of the most reliable methods for measuring the electron temperature (Te) and density (ne) profiles in fusion plasmas. TS system installed in Large Helical Device (LHD) was put into the operation from 1998 and has been obtained numerous data of Te and ne data from LHD experimental cycles [1]. The LHD TS system measures Te and ne profiles of plasmas along the major radius at a horizontally. It has several Nd:YAG lasers which wavelength is 1064nm for a flexible multi-laser operation. Thomson scattered light is collected with a large (1.5 mx1.8 m) spherical mirror and analyzed by polychromators that have five wavelength channels. A partial high reflected coat mirror is adapted to make the bundle beam emitted from multi-lasers. This mirror was developed in DIII-D tokamak[2]. The laser beams are packed along a common beam path by packing mirror and partially overlap in the far field where they are focused to a common point inside the LHD vessel. However, each laser beam passes in the LHD vessel is not same. Electron density profiles measured by each lasers have different errors due to misalignment of each laser beams and corrective optics. A comparison of electron density profile in time line is difficult in this situation.

To minimize the multiple-laser error requires a special arrangement of the laser optical system. A newly beam combining technique was created to send pairs of the lasers co-axially into the plasma. This scheme employs high performance polarizing optics to combine each pair of orthogonally polarized laser beams. The LHD Thomson scattering system adapts an oblique backscattering configuration. Polarization loss for the amount of scattering light can minimize in this scheme.

2. Polarization based laser beam combining method

A schematic diagram of newly beam combing method of polarization based system is shown in figure 1. It is seen that both lasers enter with horizontal polarization. Input 2 from laser2 is prepared for the polarization beam splitter (PL) by rotating the beam using a Half-wave plate (QR). This then reflects at the PL. Input 1 from laser 1 on the other hand passes though the PL and hence lasers 1 and 2 are now made co-axial.

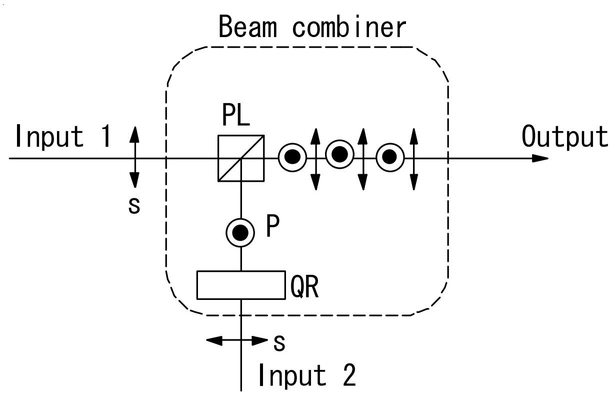

Fig.1. A schematic diagram of polarization based beam combining method. PL: polarizer, QR: Half-wave plate

3. Experimental result

To evaluate the effect of polarization for Thomson scattering signal, Rayleigh scattering signal was measured as a function of polarization angle. A Thomson scattering signal has same action of a Rayleigh scattering signal for the polarization.

We can assume the response of Thomson scattering signal from LHD plasma by this measurement. Figure 3 shows a Rayleigh signal as a function of polarization direction at the laser output. From this figure at the polarization direction of 90 degree a Rayleigh scattering signal is decreased to 85% of maximum value at 0 degree. This loss can tolerate for the benefit of coaxial beam line of two lasers.

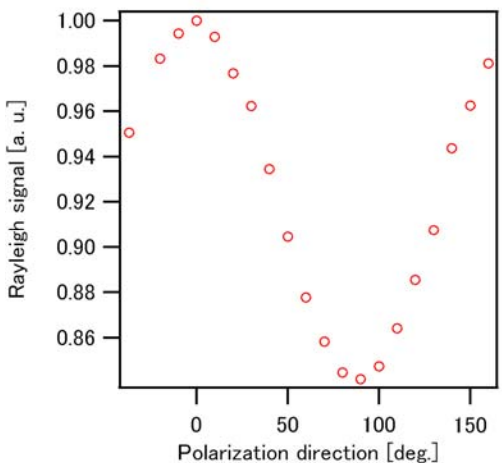

Fig.2. Sensitivity of polarization direction for Rayleigh scattering signals.

In LHD 15th experimental campaign we install this beam combining method into LHD Thomson scattering system. Figure 3 shows a normalized ne profiles measured by coaxial laser of laser1 and laser2 and off axial laser of laser3 which uses a packed mirror for beam bundling. This figure show the good agreement of ne profiles of laser1 and laser2. In contrast ne profile measured by laser3 has a difference from coaxial lasers. It shows the coaxial beam combining is effective for reliability of ne profile measurement by use of Thomson scattering.

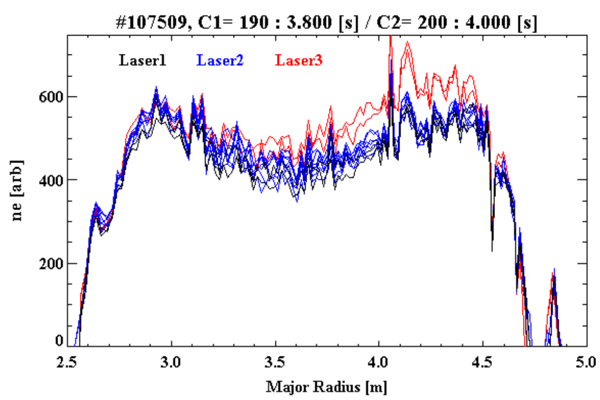

Fig.3. Normalized ne profiles measured by coaxial laser of laser1 and laser2 and off axial laser 3.

4. Summary

The polarization based beam combining from multiple lasers is developed for an improvement of time resolution and an accuracy of the LHD Thomson scattering system. Two or multiple beams from the different aperture of laser heads are combined to the coaxial beam line in time series by optical components of this beam combining scheme. We have installed this type of beam combining method for the LHD Thomson scattering system from 15th experimental campaign. In the presentation, we will discuss the detailed design and performance of polarization based laser combining.

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