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Present status of the Nd:YAG Thomson scattering measurement system development for time evolution measurement of plasma profile on Heliotron J (2)

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(2)

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We are developing a new high repetition rate Nd: YAG Thomson scattering measurement system for Heliotron J. In this paper, we report design studies of the collective lens design and the high-speed data acquisition/analysis system. The former reduces heat load to the vacuum window by the laser beam and converges in plasma region due to improve spatial resolution. The latter system can collect and analyze the data with no delay right after the plasma discharge.

1. Introduction

To investigate improved plasma confinement mode, we need to know the temperature and density profiles and their time evolution. We are developing a new high repetition rate Nd: YAG Thomson scattering measurement system for Heliotron J. In Heliotron J, there is already TV Thomson scattering measurement system. It uses the high power ruby laser and only shoots a single shot so it can't measure time evolution. Nd: YAG Thomson scattering measurement system uses high repetition rate Nd: YAG lasers, so this makes it possible to measure the time evolution of plasma density/temperature profile[1, 2].

2. Development of the laser transmission system

Figure 1 illustrates the laser transmission system for Heliotron J. It shows the two Nd: YAG lasers refracted by the refraction mirror, the laser beam go through the extension pipes and the lasers crosses inside the vacuum vessel, the Heliotron J. The laser which did not be scattered goes straight ahead to the beam dump and be absorbed. The laser transmission system is composed by two Nd: YAG lasers, a He:Ne laser, refraction mirrors, a collective lens. The power of each Nd: YAG laser is 550mJ. The He: Ne laser is a visible laser and it is used for the axis alignment. We have to use some refraction mirrors to lead the laser beam into the vacuum vessel. We have to design the collective lens to converge the laser beam at the plasma cross-section. On developing the laser transmission system, we have to consider two issues. The first is to get a high S/N ratio by reducing the stray light level. We designed to set the entrance/exit vacuum windows for the laser beam from the plasma as far as possible by using extension pipes. We designed these pipes not to be interfered with the structure of Heliotron J and to keep the length from the vacuum vessel as long as possible. The second is to design the beam diameter. Since the Nd: YAG laser beam is so powerful, it may break the vacuum window because of its local heat load if the beam diameter is too small. On the other hand, to realize a high enough spatial resolution of the measurement system, the beam diameter should be kept narrow enough when the laser beam passes through the plasma. Therefore, we have to optimize the collecting lens design to satisfy these requests simultaneously.

In order to design the collective lens, it is necessary to check the beam divergence. Figure 2 shows the laser beam diameter for the two lasers as a function of the distance from the laser body. We checked the beam diameter with the laser alignment papers. We exposed the paper to the laser beam with 10cm interval. The result is the beam diameter gradually decreases as a function of the distance. To focus the beam at the plasma center, we designed a collective lens using the data of the laser beam diameter.

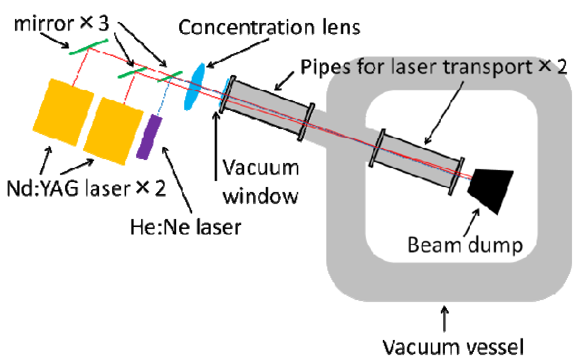

Fig.1 Schematic of the laser transmission system

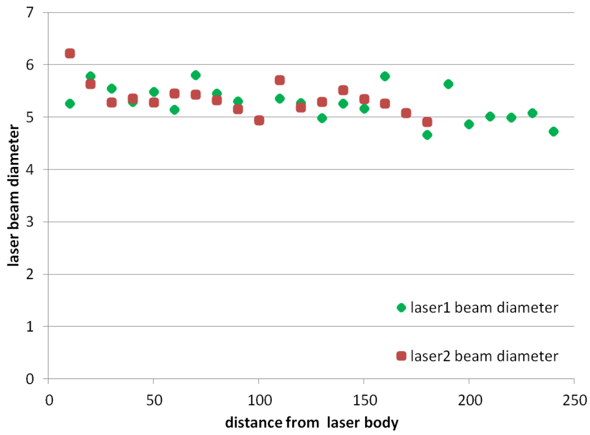

Fig.2 The laser beam diameter as a function of the distance from the laser

3. Development of the data acquisition system

On running plasma experiment efficiently, it is important to check result of the Thomson scattering measurement as soon as possible and to decide next discharge condition. In a usual data processing device, however, there are some cases where the data acquisition and analysis does not complete by next discharge. This happens because of the scheduling and interrupt feature of computer OS. We decided to introduce the Time Invariant Method (TIM) which can collect data within affixed time without command of OS. We are developing a data acquisition/analysis system which can process the high-speed scattering light signals based on CINOS. CINOS is an experimental data processing system, which has a multi-computing feature, can process input-output and computing with a given linear time. The output time depends on the acquisition time, so on usual computer, if the acquisition time delays, the output time will delay too. Additionally, if the delay of output time takes time until the next discharge, the data of that discharge could not be taken. But TIM finishes collecting data in a fixed time, so the output time will also be constant and it is a system that would not effect on plasma discharge[3].

4. Summary

We are developing the new high repetition rate Nd: YAG Thomson scattering measurement system for Heliotron J to measure the time evolution of electron temperature and density of plasma profile. This is because in investigating thermal transport, it is important to know the time evolution of electron temperature and density of plasma profile.

To realize a high S/N ratio, we designed and made an optimized laser transmission system. As for the data acquisition system, we are developing a new system using CINOS and TIM.

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