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Electron density measurement using FIR laser interferometer in Heliotron J
ヘリオトロンJにおける遠赤外レーザー干渉計を用いた電子密度計測

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The first data of a new far infrared (FIR) laser interferometer were obtained successfully in Heliotron J. The time trace of a line averaged density ($\bar{n}_e$) measured with the FIR laser interferometer is quite similar to that obtained with a microwave interferometer being used in Heliotron J. However, the estimated value is a little bit larger than the measured value of the microwave interferometer. This difference can be attributed to different chord geometry of each interferometer system at different toroidal section, and the difference in measured $\bar{n}_e$ resulted from the different chord geometry is evaluated in cases of several density profiles measured with Thomson scattering diagnostics. These results are qualityvely consistent with the experimental results obtained with these two interferometers.

1. Background and objective

High performance plasma produced by using advanced fueling techniques is interesting and important in fusion plasma physics. In a helical device, Heliotron J, high performance plasmas ($\bar{n}_e > 5\mathrm{x}10^{19}\ \mathrm{m}^{-3}$) were obtained by using a supersonic molecular beam injection (SMBI) [1] and a high intensity gas puff (HIGP) [2]. In order to measure such a high density plasma, a new far infrared (FIR) laser interferometer has been developed in Heliotron J.

2. FIR laser interferometer system

A schematic diagram of the FIR laser interferometer is shown in Fig.1. An HCN laser (λ=337μm) is applied as a light source and the beam splitted into two beams. The optical system is a Michelson interferometer. The frequency of one beam (local beam) is shifted by 1 MHz by using a super rotating grating (SRG) [3] for heterodyne detection and another beam is used as probe beams. One probe beam passes through the plasma and another probe beam is used as a reference. The probe beams and the local beams are mixed and detected by Shottky barrier diode mixers. A time resolution of heterodyne detection depends on an

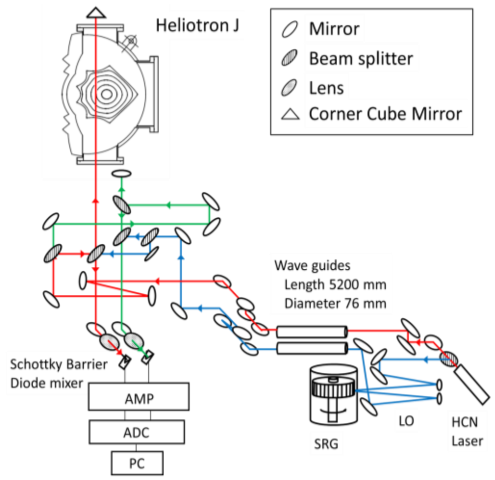

Fig.1. The schematic diagram of the FIR interferometer on Heliotron J

intermediate frequency between the probe beam and the local beam, and hence this interferometer can achieve 1-μs-time-resolution.

3. Result of measurement

The time trace of the line averaged electron density measured with the FIR interferometer ($\bar{n}_e^{FIR}$) is shown as a red line in Figure 2, together with a

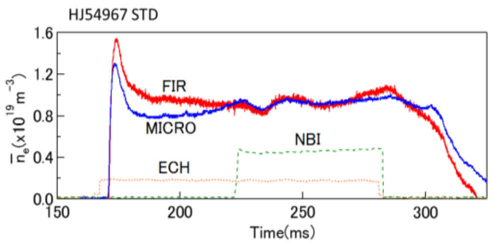

Fig.2. The time trace of $\bar{n}_e$. A red line indicates $\bar{n}_e^{FIR}$, a blue line indicates $\bar{n}_e^{MICRO}$. A green line indicate the timing and the intensity of NBI. An orange line indicate the timing and the intensity of ECH.

blue line indicating $\bar{n}_e$ measured by the microwave interferometer ($\bar{n}_e^{MICRO}$). In this shot, the plasma was heated by ECH, and NBI was additionally injected at the timing of 220 ms. These $\bar{n}_e$ are very similar, however $\bar{n}_e^{FIR}$ is higher than $\bar{n}_e^{MICRO}$.

4. Influence of different chord geometry on $\bar{n}_e$

The difference of each line averaged density can be attributed to different chord geometry of these systems because these interferometers are installed at different toroidal sections as shown in Fig.3. In addition, the chord of FIR interferometer doesn't pass through the center of the Heliotron J plasma. As a result, $\bar{n}_e^{FIR}$, for instance, can be higher than $\bar{n}_e^{MICRO}$ in case of a hollow density profile.

Here, we estimate the difference of $\bar{n}_e$ in these interferometer measurement on the assumption of different density profiles which are based on the profiles experimentally measured with Thomson scattering diagnostics. Figure 4 shows the fitted curves to the density profiles obtained with Thomson scattering measurement at the timing of 190, 210 ms (ECH only) 250 ms and 270 ms (ECH +NBI). A strong hollow density profile was observed in the initial phase of this discharge, and then the hollowness became weak as time advances. Local density n_e along these chords in these cases are also shown together with the chord arrangements in Fig.3. The estimated value for $\bar{n}_e^{FIR}/\bar{n}_e^{MICRO}$ are compared with the measured value in Fig.5. The differences of the $\bar{n}_e^{FIR}/\bar{n}_e^{MICRO}$ is about 10 %, which can be explained by the different chord geometry in the FIR interferometer and the microwave interferometer.

5. Summary

The FIR interferometer was constructed in Heliotron J and the first data were successfully obtained. The time trace of $\bar{n}_e^{FIR}$ is quite similar to that of $\bar{n}_e^{MICRO}$ but $\bar{n}_e^{FIR}$ is higher compared with $\bar{n}_e^{MICRO}$. These chords of interferometers arranged in different toroidal section, and for instance $\bar{n}_e^{FIR}$ can be higher than $\bar{n}_e^{MICRO}$ in case of a hollow density profile. For this reason, the dependence of $\bar{n}_e$ on the chord geometry was evaluated, then $\bar{n}_e^{FIR}/\bar{n}_e^{MICRO}$ is found to be higher in case of a hollow density profile than a flat density profile, and this result is consistent with the results of the measurement with the FIR- and the microwave interferometer.

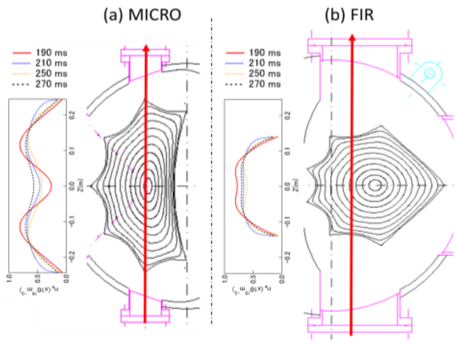

Fig.3. The chord geometry of (a) the microwave interferometer and (b) the FIR laser interferometer and local density along the chord in several cases of different density profiles.

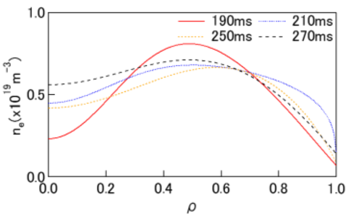

Fig.4. The density profiles in HJ54967.

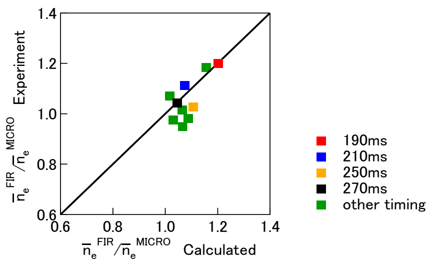

Fig.5. The relationship between $\bar{n}_{eFIR}/\bar{n}_{eMICRO}$ obtained experimentally and by calculation based on the profiles obtained with Thomson scattering measurement.

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