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Measurement of Plasmoid Characteristics using Interferometer
干渉計によるプラズモイドの特性評価

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The electron density of a plasmoid produced in a developed magnetized coaxial plasma gun device, which a linear plasma device is equipped with, is measured with an interferometer using a Zeeman laser at a wavelength of 633 nm. The line averaged electron density is estimated to be 1-2×10^{21} m^{-3} from the measurement.

1. Introduction

Control of transient heat and particle loads due to ELMs and its impact to divertor materials will be an important issue in future fusion devices. To simulate the harsh condition, extensive experiments have been conducted by using a laser [1], an electron beam [2], and a plasma gun [3]. It has been pointed out that simultaneous irradiation of a plasma and transient loads can lead to a synergistic effect that enhances the surface damages [4,5].

We are developing a plasma gun device combined to a steady-state linear plasma device. In this study, characteristics of a plasmoid produced by the plasma gun device were evaluated with an interferometer.

2. Experimental setup

Figure 1 is a picture of the magnetized coaxial plasma gun device developed in Nagoya University. A compact torus plasma with poloidal and toroidal currents is produced and is ejected in the direction of the arrow in Fig.1. The ejection of the plasma can be controlled with an external bias field coil. A tungsten coated material is used for an internal electrode in the gun to reduce the release of material from the electrode during the discharge. The gun is equipped with a magnetic probe and viewing ports for the interferometer (not shown in Fig.1) at the end part of the chamber.

Figure 2 is a schematic of the optical system of the heterodyne interferometer (actually the probe beam goes back and forth in a plasma). A He-Ne Zeeman laser, which oscillates orthogonal linearly-polarized components with a frequency difference $\Delta\omega$ of 208 kHz, is used as a light source. The Zeeman laser enables to build a heterodyne interferometer with a simple optical system. The laser beam is split into two: probe and local beams. Polarizers with orthogonal transmission directions

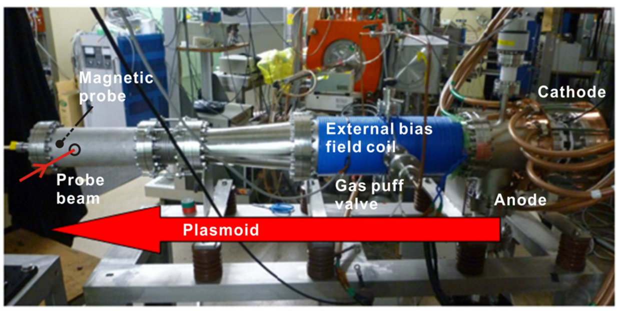

Figure 1: A picture of the developed plasma gun device in Nagoya University.

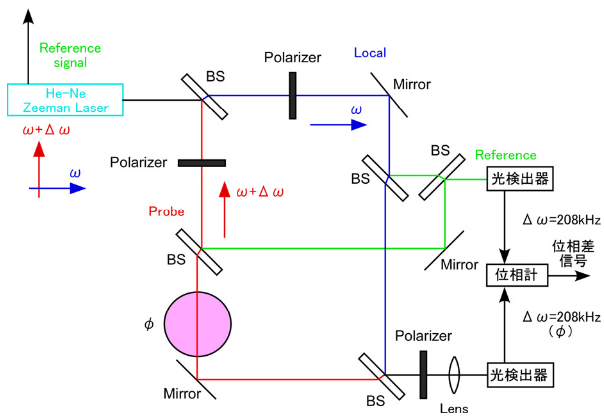

Figure 2: A schematic of the optical system of the He-Ne Zeeman laser interferometer.

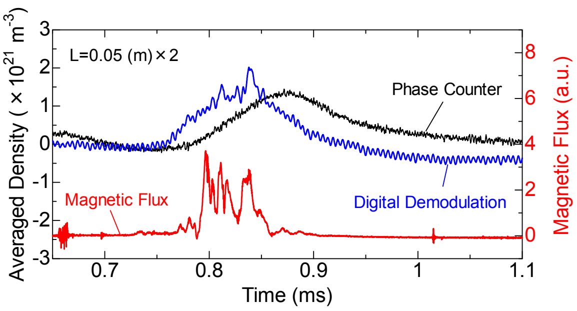

Figure 3: The temporal evolutions of the electron density measured with interferometer and the signal of a magnetic probe. The density is evaluated two methods: the analog phase counter and the digital demodulation technique.

at each chord select one of polarization components. Following polarizers whose transmission directions are 45 deg. against orthogonal linear polarizations, interference signals with a beat frequency of $\Delta\omega$ are detected with photodetectors. An analog phase counter [6] or the digital demodulation technique [7] are used for extraction of the phase shift.

3. Experimental Results

Figure 3 shows the temporal evolutions of the electron density and the magnetic flux measured with the interferometer and a magnetic probe, respectively. The reason of the smoothed signal with a delay time of about 50 μs of the density evaluated with the phase counter is expected to be an insufficient time response of the phase counter. It will be replaced with the one with a time response of 5 μs. Supposing that the plasma diameter is almost the same as the inner diameter of the chamber (~5 cm), the both density shows that the maximum electron density reaches 1.5×10^{21} m^{-3}. Some of variations of the density signal correspond to these of the magnetic flux. Hence these density variations are possible to reflect the structure of the plasmoid. Drifts of the zero line before and after the discharge are caused by mechanical vibrations. The frequency of a small oscillation during whole measurement time is the same as that of the beat frequency. When the beat signals have DC offsets, such an oscillation is superimposed on the actual density signal in the digital demodulation technique.

To confirm the validity of the measurement, the density measurement was conducted without ejecting the plasmoid to the measurement region. Figure 4 shows the measurement results of different bias voltages applied to the external bias field coil. The optimum voltage for the plasmoid ejection is 0.3 kV and the further voltage prevents the plasmoid from being ejected because the plasmoid is confined by the strong magnetic field around the birth place. The evaluated density decreases similar to the reduction of the magnetic flux in the case of a bias voltage of 0.4 kV. Applying a voltage of 1.5 kV, the plasmoid completely disappears from the line of sight of the interferometer. This indicates that the measured density is definitely originated from the plasma formation and its dependence on the bias voltage is reasonable.

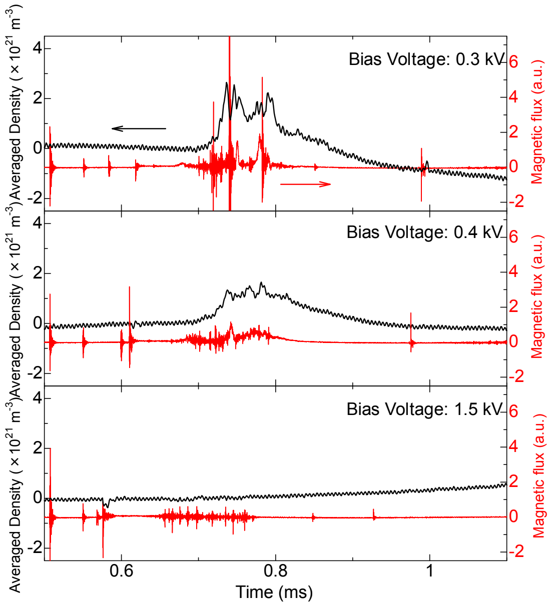

Figure 4: The temporal evolution of the electron density measure with interferometer and the signal of a magnetic probe.

4. Summary

The magnetized coaxial plasma gun device to study the synergistic effect of simultaneous irradiation of a plasma and a transient heat load on divertor materials is being developed. The Zeeman laser interferometer is installed and the electron density is found to be 1-2×10^{21} m^{-3}.

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