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Density fluctuation measurements of GAMMA10 plasma by using the Fraunhofer Diffraction method
フラウンホーファー回折法によるGAMMA10プラズマの密度揺動計測

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One of the techniques to study plasma instabilities in nuclear fusion plasmas is Fraunhofer diffraction (FD) method. We applied FD method to plasma density fluctuation measurement in GAMMA10. Measuring frequency spectra of the density fluctuation by measuring of FD signal are carried out.

1. Introduction

Instabilities in plasma are one of the major cause of plasma confinement degradation in nuclear fusion plasma. There is a density fluctuation measurement method using dispersion of electromagnetic wave. Fraunhofer diffraction (FD) method is one of the forward scattering methods. In this study, we applied FD method system to the density fluctuation measurements in the central cell plasma of the GAMMA10 tandem mirror.

2. FD method system

Scattering methods with microwave to infrared lasers have been used for the study of low frequency instabilities. In these conventional scattering methods the frequency spectrum is obtained by frequency analysis of the scattering wave. The wave number spectrum is obtained by varying the scattering angle and using the Bragg relation. The scattering angle has to be larger than the divergence angle of the incident beam in order to avoid stray light. In the FD method, on the other hand, a heterodyne detection method is applied to the scattered wave and to the incident beam so that detection is possible within the undeviated incident beam, i.e. within the divergence of the probing beam. Therefore, this technique makes it possible to investigate long wavelength waves, which are considered to be more relevant to anomalous transport. We show a diagram of FD method system in Fig.1.The FD method system is located at the east side of the central cell, at z = 2.4 m, where z is the axial distance from the central cell midplane. A beam of 70 GHz frequency is focused on the plasma centre by a fused quartz lens. The frequency shifted FD signal and the unshifted transmitted wave are focused via another lens onto beam directed GaAs Schottky barrier diode mixers bonded to gold bow-tie antennas which form a monolith with a fused quartz substrate. Rectangular waveguide antennas in the TE_{10} mode are installed on the reverse side of the diode detectors. The aperture of the waveguide antenna functions as a spectrometric slit in the plane of observation. The intermediate frequency signals from the mixers are amplified by low noise amplifiers and fed to data processing systems.

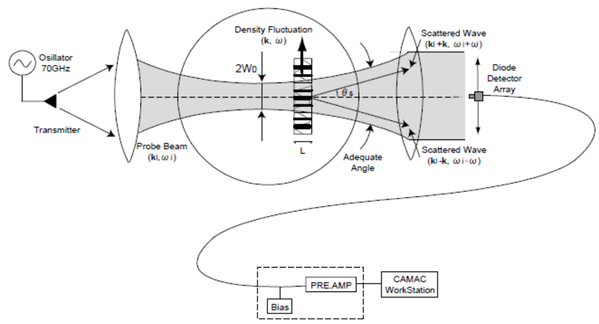

Fig.1. FD method system.

3. Experimental results

When fundamental electron cyclotron heating (ECH) is applied in the plug region (P-ECH), an ion confining potential is created owing to the formation of a potential depression in the thermal barrier. The P-ECH produces warm electrons at the end mirror cells. A fraction of heated electrons is driven out of the end mirror through the loss cone along the magnetic field lines. The plug potential increases owing to the existence of warm electrons, while the potential of the floating end plates decreases.

Figure 2 shows the time evolution of FD signal of center cord of channel (a) and the density fluctuation of it (b) at the central cell. The sampling time is 1 μs. We can clearly observe the density fluctuations. P-ECH and barrier-ECH are applied between 151 ms and 174 ms and between 151 ms and 200 ms, respectively.

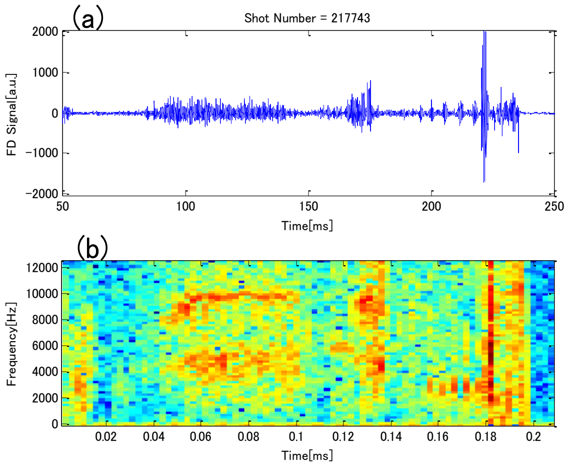

Fig.2. Time evolution of the FD signal (a) and the density fluctuation (b).

In Fig.2 (b), two frequency peaks of density fluctuation, 5kHz and 10kHz, are confirmed without P-ECH. When P-ECH is applied, density fluctuation is suppressed.

4. Summary

The FD method was applied to the GAMMA10 tandem mirror in order to measure the density fluctuations in the central cell plasma. Then, we observed the low frequency fluctuation without application of P-ECH. The fluctuation suppression was observed with application of P-ECH. We are now reconstructing the total FD method measuring system to obtain the eight channels of FD signals, simultaneously, and to get the wave number of the density fluctuations.

References

[1] A.Mase, A. Itakura, M. Inutake, K. Ishii, J.H. Jeong, K. Hattori, S. Miyoshi , Nucl. Fusion 31(1991) 1727