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Measurement of High-Frequency Density-Fluctuations with Microwave Reflectometer in GAMMA 10

GAMMA 10におけるマイクロ波反射計を用いた高周波密度揺動の測定

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We have studied the excitation mechanism of the Alfvén Ion Cyclotron (AIC) waves in GAMMA10. AIC waves are excited owing to temperature anisotropy of the plasma. Up to now, magnetic probes have been used for the measurement of AIC waves in the peripheral region. In this study, we used reflectometer to measure the density fluctuations due to AIC waves in the core region. We constructed microwave reflectometer system. Ordinary mode (O-mode) horn antenna was newly installed on GAMMA10. We measured radial profile of the density fluctuations and also the z-profile of the density fluctuations by using an axial array of horn antennas.

1. Introduction

We have conducted the experiments for forming a high-temperature and high-density plasma in GAMMA10. Magnetically confined plasma is heated perpendicularly by a strong ion cyclotron range of frequency (ICRF) wave. Plasmas with strong temperature anisotropy are produced by ICRF heating. Alfvén ion cyclotron（AIC）waves are excited spontaneously in such plasmas. The magnetic probes installed in the peripheral region have been mainly used for measurement of the AIC waves. The frequency spectrum of the magnetic probe signal installed is shown in Fig.1. A peak of 6.36 MHz is the frequency of heating ICRF wave and discrete peaks on the left side are those of the AIC waves. AIC wave causes pitch angle scattering of ions to the magnetic field line, and has big influence on the ions in GAMMA 10. The excitation mechanism of AIC wave is not clear until now.

In this research, the excitation mechanism from detailed spatial and time behavior of the AIC wave in the inside of plasma, measurement using a microwave reflectometer was performed. Four horn antennas were installed in the vacuum vessel of the GAMMA 10 central cell. We measure the spatial profiles of density fluctuations in the direction of the magnetic field line and radial directions. The correlation between the magnetic probe and the reflectometer signals is observed.

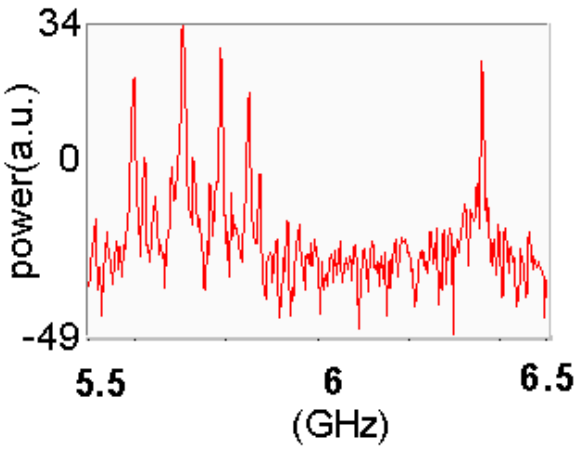

Fig.1. Power spectrum of AIC waves (t=79ms). The waves measured by a magnetic probe. The left peaks are AIC waves and right peak is ICRF.

2. Principle of homodyne reflectometer

Outline of homodyne reflectometer is shown in Fig.2.The flow of signal processing is as follows. The wave from electronic oscillator is divided into a reference wave and the incidence wave in a directional coupler. The incidence wave enters into plasma with a horn antenna through a circulator. When incident electromagnetic waves reach cutoff layer, a refractive index will be set to 0. The wave is reflected and returns to horn antenna again.

Theoretical cutoff frequencies of each polarization (O-mode and X-mode) are shown in Fig.3. In this figure, thick line and thin line indicate in the each case of the central density of $2.0\times10^{18}m^{-3}$ and $1.5\times10^{18}m^{-3}$ respectively. The experiment was conducted with the Frequency oscillator indicated by double-headed arrow in Fig.3. The reflected waves from plasma are injected to mixer through circulator from the horn antenna. Incident wave and reflected wave are detected by square-law, and transmitted to an oscilloscope. This signal is Fourier-transformed and the density fluctuation in plasmas is detected.

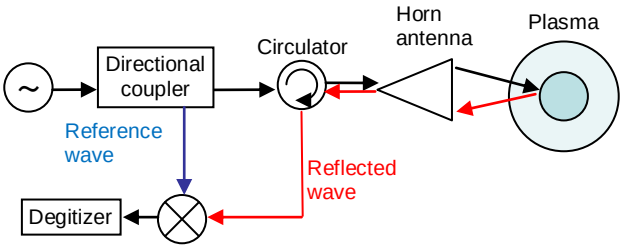

Fig.2. Outline of homodyne reflectmetory

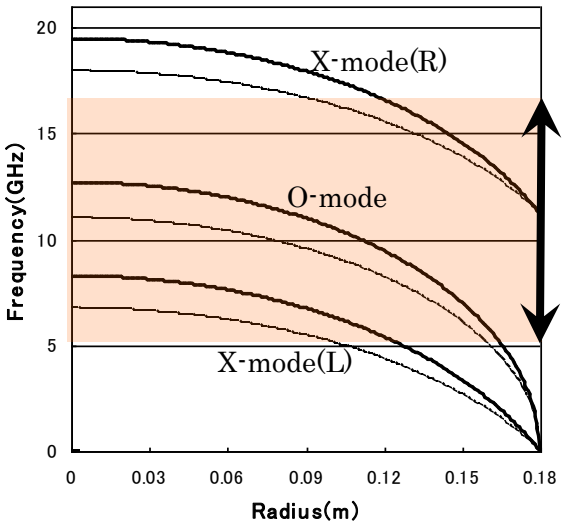

Fig.3. Theoretical cut off layer of each polarization.

3. Experimental result

Figure4 shows the temporal evolution of the raw signals of the reflectometer system and magnetic probe (a), the frequency spectra of those signals (b) and the coherence between both signals (c).The period where correlation is strong, and the place with no correlation exist. It seems there are different characteristics between the density fluctuations in the core region and magnetic fluctuations in the peripheral region.

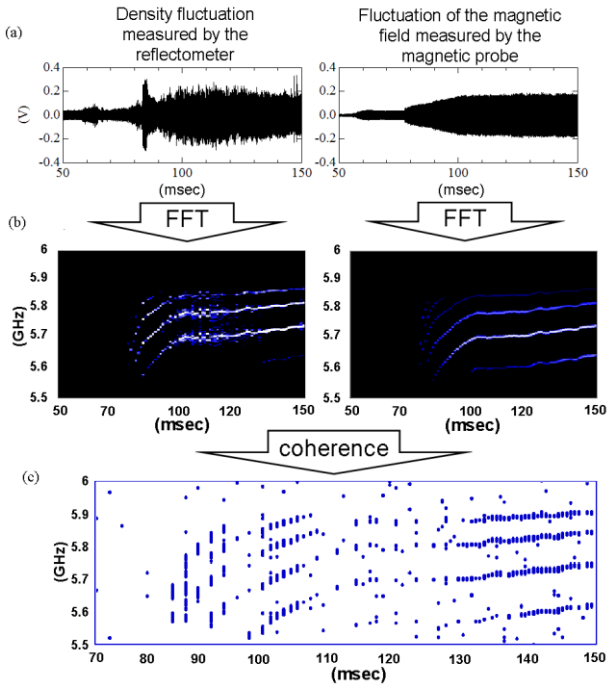

Fig.4. Coherence between signals of reflectometer and magnetic probe. (a)row signals of the reflectometer system and magnetic probe, (b)frequency spectra of those signals, (c)coherence between both signals.

4. Summary

Reflectometer system has been constructed and used in GAMMA10 for the measurement of the density fluctuation due to ALC waves. Four horn antennas have been installed parallel to the magnetic field line. We observe the same frequency of AIC waves in radial direction and coherence between the density fluctuation in the core region and magnetic fluctuations in the peripheral region.

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