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Excitation experiment of electron Bernstein wave with injection of X waves from strong magnetic field in the Internal Coil Device Mini-RT

内部導体装置**Mini-RT**における強磁場からの**X**波入射による
電子バーンシュタイン波の励起実験

Makino Wataru, Uchijima Kenichiro, Hosaka Yuichiro, Morikawa Junji and Yuichi Ogawa
牧野　航, 内島健一朗，保坂友一朗，森川惇二，小川雄一，

Graduate school of Frontier science, The University of Tokyo
5-1-5, Kashiwanoha, Kashiwa 277-8568, Japan
東大新領域　〒277-8568　千葉県柏市柏の葉5-1-5

The Mini-RT device is an internal coil device that confines high beta plasma with dipole magnetic field made by magnetically levitated High Temperature Superconducting coil. In this device, plasma has been produced by electron cyclotron heating (ECH) by using 2.45GHz microwaves. Usually, it is hard to generate and heat high density plasma with ECH because of the existence of the cutoff density. However, in this device, overdense plasma has been observed. The application of electron Bernstein wave (EBW) on high efficient plasma heating in the Mini-RT device is expected.

1. Introduction

The fusion experimental devices such as spherical tokamak, helical, internal coil device aim to generate and heat high beta plasma. In these devices, ECH by EBW was experimentally investigated to study techniques for high density plasma heating over cutoff density. In the toroidal plasma, X or O mode electromagnetic waves are injected and send to the electron cyclotron resonance layer for the purposes of ECH or electron cyclotron current drive (ECCD). But in the overdense plasma, these methods cannot be used because of the existence of the cutoff density. In center of high beta plasma, electron density is high and electron plasma frequency is several times higher than electron cyclotron frequency. Compared with X or O mode waves propagation conditions, EBW has no limit on the density. Therefore, ECH and ECCD by EBW are expected. At various devices, these methods have been verified. But a lot of the verifications used indirect measurements. We have conducted experiments aimed at elucidating the mechanism of EBW by direct measurement in the internal coil device Mini-RT.

2. Mini-RT

The Mini-RT device is an internal coil device that has major radius of R=0.5m and height of about 0.7m. The Mini-RT device can generate a dipole magnetic field of coordination by energizing the superconducting coil. This magnetic field confines high beta plasma. The major radius of the internal coil is 0.15m and its weight is 16.8kg. The maximum coil current is 50kAturns, and the typical magnetic field strength at the internal coil is 0.1 T. A Copper coil is above the superconducting coil. It is possible to control the plasma parameters and confinement region by applying a levitation coil current. Plasma has been generated and heated with ECH by 2.45GHz microwaves. It is possible to produce plasma whether internal coil is levitated or supported, and overdense plasma which has twice density of cutoff density has been generated with HTS coil magnetically levitated [2].

3. Electron Bernstein wave (EBW)

In this section, EBW characteristics and methods to convert electromagnetic wave to EBW are shown.

First, EBW has next characteristics listed below:
- -No cutoff density
- -Resonance at the harmonics of ECH

These two features make it possible to generate high beta plasma. Furthermore, EBW has other characteristics listed below:
- -Electrostatic waves
- -Convert electromagnetic waves into EBWs at UHR
- -Short wavelength
- -Longitudinal waves
- -Negative group velocity

EBW is excited by feeding X-wave to the UHR. So, in the plasma, there are electromagnetic waves fed from outside. These features are clues about identification of EBW in experiments.

Second, it is well known that there are three methods to convert electromagnetic wave to EBW.
- -①Perpendicular injection of X-wave from high

field side (SX-B conversion)

-②Perpendicular injection of X-wave from low field side (FX-SX-B conversion)

-③Oblique injection of O-wave from low field side (O-X-B conversion)

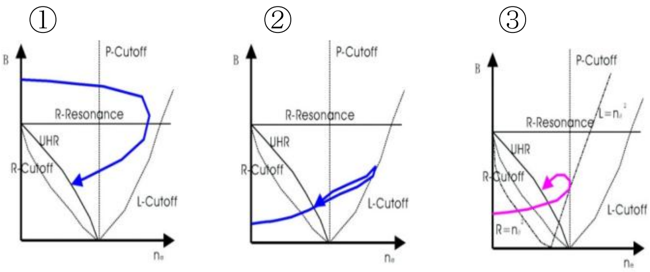

Fig 1: three methods to convert EMW to EBW

Previous studies in the Mini-RT device, EBW excitation experiments by Perpendicular injection of X-wave from low field side have been performed [4]. We have started a new planning for SX-B conversion.

In the case of SX-B conversion, we have to be careful of new issues. One of those is existence of L-cutoff. Figure 2 shows the two types of density profiles in the Mini-RT, and these give the reflective index profiles perpendicular to magnetic field (Fig.3). With growing of density, SX wave touches L-cutoff and X wave cannot propagate (Fig.3 a). Therefore, we need to pay attention to the density distribution.

4. Objective

We try to set up new antenna on the high field side in order to measure electromagnetic field at ECRF . An objective of this work is to investigate SX-B mode conversion in Mini-RT device and to compared with the measurement result of previous researches.

5. Measurement system

Figure 4 shows Mini-RT plasma measurement system. Measurement of electromagnetic field at ECRF is focused. In the Mini-RT device, waves at frequencies lower than 2.45 are injected to diagnose wave propagation in overdense plasma. In this study, diagnostic X-mode waves at 1 GHz and 10 W are injected from the high field side.

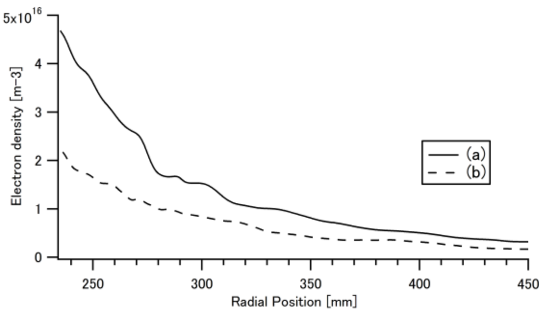

Fig. 2 density profiles

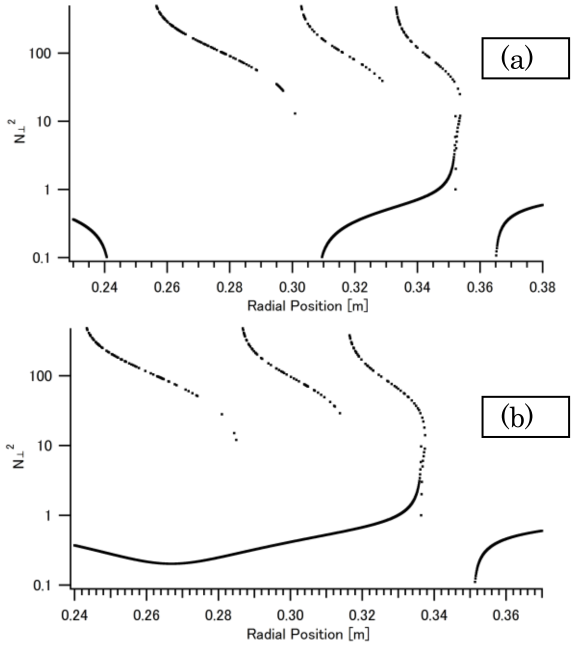

Fig.3 $N_\perp{}^2$ profiles

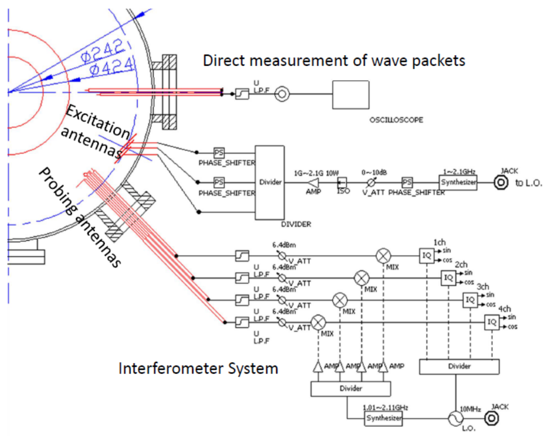

Fig.4 measurement system in the Mini-RT

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