POLARIZATION-REVERSAL INDUCED DAMPING OF LEFT-HAND POLARIZED WAVE WITH HIGH ORDER RADIAL MODE ON ELECTRON CYCLOTRON RESONANCE

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ABSTRACT

Propagation and absorption of high-frequency electromagnetic waves in the range of electron cyclotron resonance (ECR) frequency are experimentally and theoretically investigated for the case of an inhomogeneously magnetized plasma column, where a left-hand polarized wave (LHPW) is selectively launched. The LHPW with second order radial mode is found to be absorbed at the ECR point due to the polarization reversal to a right-hand polarized wave (RHPW). On the other hand, the LHPW with first order radial mode keeps the left-hand polarization and passes through the ECR point. These results can be well explained by the dispersion theory including the effects of the radial boundary condition.

INTRODUCTION

The behavior of electromagnetic waves with ECR frequency in magnetized plasmas has been one of significant research subjects for electron heating, plasma production, and so on. Only the RHPW has been considered to be related to ECR phenomena. However, recent experimental results demonstrate that the LHPW is unexpectedly absorbed near the ECR point [1]. In addition, it is reported that the absorption region of the LHPW is more localized than that of the RHPW. Since the localized and efficient wave absorption is demanded for electron cyclotron current drive and formation of the local confining potential structure in the field of thermonuclear fusion, it is hoped that the absorption phenomenon of the LHPW can be applied to these applications. The aim of the present work is to clarify the absorption mechanisms of the LHPW near the ECR point. A brief result of this work has been reported earlier [2].

EXPERIMENTAL RESULTS AND DISCUSSION

The experiments are performed in the Q_T-Upgrade Machine of Tohoku University, which has a cylindrical vacuum chamber about 450 cm in length and 20.8 cm in diameter. The plasma about 6 cm in diameter is produced by a direct current discharge between an oxide cathode and a tungsten mesh anode in low-pressure argon gas and coaxially fills the cylindrical vacuum chamber. The electron density and temperature are 9×10^{10} cm^{-3} and 2.5 eV, respectively. The LHPW (w / 2π = 6 GHz, 150 mW) is selectively launched in a high magnetic-field region by a helical antenna, and propagates toward the ECR point satisfying the condition of $w / w_{ce} < 1$, where $w_{ce} / 2\pi$ is electron cyclotron frequency. The wave patterns are obtained with an interference method through movable dipole antennas, which can receive each component of the wave electric field, i.e., E_x, E_y, and E_z.

The observed interferometric wave patterns of E_x and E_y show that the greater part of the launched LHPW is absorbed near the ECR point due to a polarization reversal from the LHPW to the RHPW. In addition, the other part of the LHPW penetrates the ECR point without suffering the polarization reversal. The radial profile of E_z shows that the LHPWs with fundamental (n = 1) and second order (n = 2) radial modes are excited in the plasma column. The absorbed and penetrating LHPWs at the ECR point are identified to be a slow wave for n = 2 and a fast wave for n = 1, respectively, by comparing with the dispersion relations in bounded plasmas. In addition, the wave polarizations determined by the dispersion relations are calculated in order to interpret the polarization reversal. It is clarified that the polarization reversal from the LHPW to the RHPW can be theoretically explained by the dispersion relation in bounded plasmas for n = 2. As a result of the polarization reversal, the LHPW with n = 2 is efficiently absorbed near the ECR point. On the other hand, it is found that the fast wave of n = 1 mode keeps the left-hand polarization. These results could play important roles in the efficient and localized electron heating and so on.

REFERENCES

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