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Plasma loading on the slow-wave excitation antenna of the magnetospheric plasma device RT-1

磁気圏型プラズマ装置RT-1における 遅波励起用アンテナのプラズマ負荷特性

Yoshihisa Yano[1], Zensho Yoshida[1], Haruhiko Saitoh[1], Junji Morikawa[1] and Atsushi Fukuyama[2]
矢野善久, 吉田善章，齊藤晴彦，森川惇二，福山　淳

[1]Grad. Sch. of Frontier Sci., Univ. of Tokyo, [2]Dep. of Nuc. Eng., Kyoto Univ.
5-1-5, Kashiwanoha, Kashiwa, Chiba 277-8561, Japan
東大新領域　〒277-8561　千葉県柏市柏の葉5-1-5

The first antenna loading experiment in the magnetospheric configuration was conducted by using a test antenna for the slow-wave excitation. In the experiment, a weak radio-frequency wave, the frequency was 1MHz – 3MHz and the power was lower than 0.1W, was transmitted into the plasma from the 3-turn circular antenna which was installed at the high field side of the ICRF resonances. Then the plasma loading resistance was evaluated from a comparison between the antenna resistance with and without the plasma. The results agree qualitatively with a wave calculation. The maximum plasma loading resistance was about 22Ω at 3MHz and 2.0Ω at 1MHz, which is considered to be sufficient.

1. Introduction

The Ring Trap-1 (RT-1) device can confine a high-beta plasma in a magnetospheric configuration which is realized by a levitating superconducting coil. So far, we have verified that very high beta plasma, whose local beta value exceeds 70%, is stably confined in the RT-1 device with an electron cyclotron heating (ECH) system. So the high beta plasma in RT-1 is composed of hot electrons whose temperatures are 10 - 50 keV and whose densities are 10^{16} - 10^{17} m^{-3}[1] .

As a next step of the RT-1 project, we are planning to heat ions by using an ion cyclotron heating (ICH) system. Then two-fluid effects will be experimentally examined [2] when the ion beta value is sufficiently high.

Although the ICRH system has already become a basic plasma heating method in other types of fusion device (Tokamak etc.), there have been no previous ICRH systems in dipole configuration like RT-1. In the magnetospheric configuration, the magnetic field strength (0.01-0.3T) and plasma density (10^{16} - 10^{18} m^{-3}) is much smaller than other configurations. These features generally result in low plasma impedance such as a resistance and a reactance. If the plasma impedance is much less than the impedance of antenna itself, almost all of the energy is wasted to heat the antenna and the RF matching circuit become very difficult to be designed. Therefore, in this experimental research, the loading resistances of the RT-1 plasma when a slow wave is excited are examined and a feasibility of the ICRH system is considered.

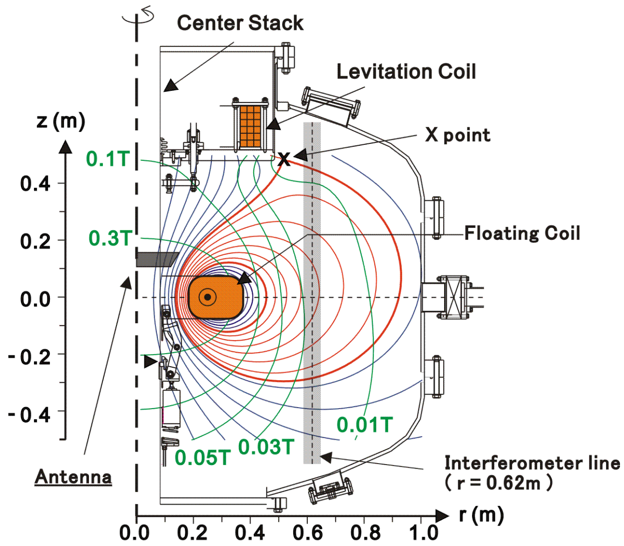

Fig.1. Cross-sectional image of RT-1. The magnetic field lines, the magnetic field strength, the antenna location and the interferometer sight lines are drawn.

2. Experimental Setup

2.1 *Test Antenna*

Three-turn circlular antenna, made from stainless steel wire, is installed around the center stack in order to launch a slow wave from the high-field side of the ICRF resonances. There were no faraday shields (F. S.) at the beginning of the experiment. At the latter half of the experiment, about 2/3 part of the antenna was faraday-shielded. A range of a tested frequency was about f=1-3 MHz (|B|=0.0656–0.197 T for a hydrogen ion cyclotron resonance).

2.2 *Target Plasma*

Hydrogen plasma heated by 8.2GHz ECH system was mainly used as a target. The floating coil was usually supported.

2.3 *Resonance Method*

Resonance method is used to evaluate the plasna loading impedance. A change of the impedance after the plasma is discharged is measured.

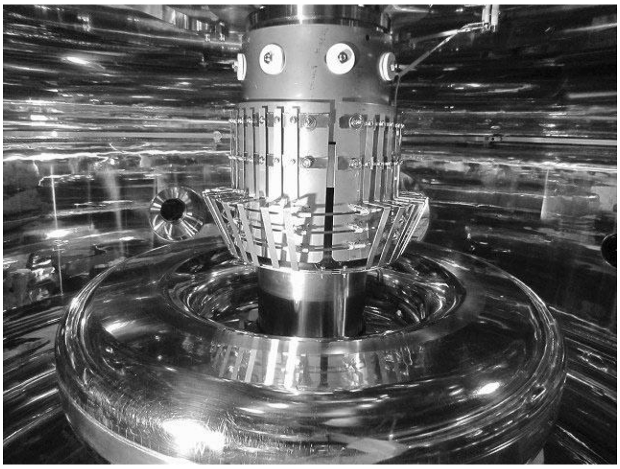

Fig.2. Photograph of the test antenna and the floating coil. About 2/3 part of the antenna is faraday-shielded.

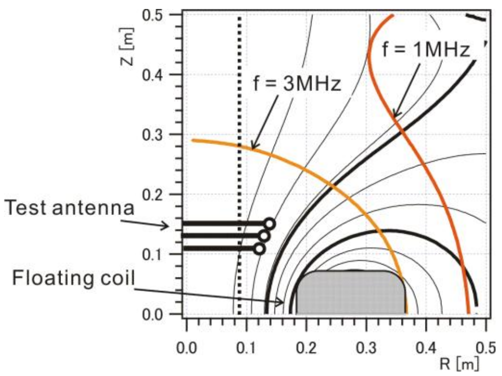

Fig.3. The geometry of the test antenna. The ICRF resonances for f=1, 3MHz are shown.

3. Experimental Result and Consideration

Experimental results are shown in Fig. 4. The maximum loading impedance is higher than 20Ω at f=3 MHz and 2.0Ω at f=1MHz. The plasma loading resistance was decreased about 50% by the F.S effect. Although the plasma density is dramatically improved when the floating coil is levitated, the resistance is not increased.

Experimental results say that the plasma loading resistance is related to the plasma density when the filling gas pressure is lower than 20mPa. This is well explained by the wave calculation code (TASK/WF code). On the other hand, when the pressure is higher than 20mPa, the resistance is related to not the density but rather the filling gas pressure. We guess that the plasma density near the antenna is much different from the density where the interferometer is seeing when the filling gas pressure is very high.

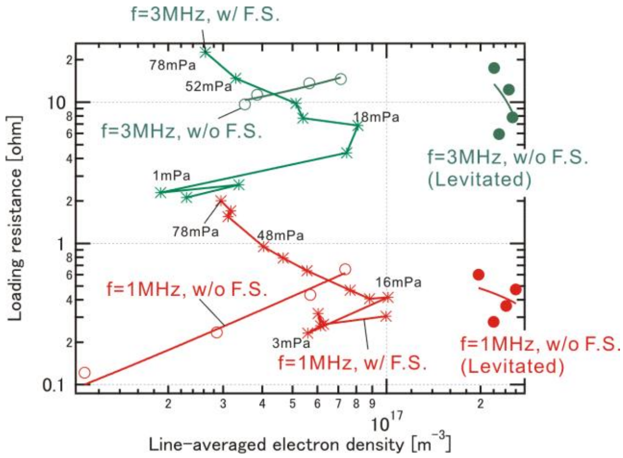

Fig.4. Experimental results of the plasma loading resistance. Vertical axis means the loading resistance and the horizontal axis means the line-averaged density (at r = 0.62 m). Marks ∗, ○ and ● respectively denote those with the faraday shield (F.S,), those without F.S. and those when the floating coil is levitated without F.S. The filling hydrogen pressure is also shown.

4. Summary

The first antenna loading experiment in the magnetospheric configuration was conducted. We found that the maximum observed resistance is more than 20Ω at f=3 MHz and 2.0Ω at f=1MHz. Then the sufficient feasibility of ICRH system in RT-1 is ensured. More experimental results and detailed comparison between experiments and calculations are shown in the presentation.

References

[1] H. Saitoh et al., 23rd IAEA Fusion Energy Conference (2010).

[2] Z. Yoshida et al., Physics of Plasmas 17, 112507 1-7 (2010).

[3] D. Q. Hwang and R. W. Gould, Phys. Fluids 23, 614 (1980);