§11. Application of Millimeter Wave Technology to Plasmas

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The objective is to discuss an ongoing R&D of heating technology by millimeter wave at the domestic institutions and the related international progress with collaborators who engage in the study using gyrotrons, klystrons, free-electron lasers, and REBs. In the workshop, we focused the program with special subject and reviewed to increase the mutual understanding.

In the present workshop, Y. Terumichi reviewed "Electron cyclotron resonance heating (ECRH) of plasmas in the various configurations of magnetic field". After the shutdown of WT-3 tokamak, a new research program started. Using the toroidal coils of WT-2 tokamak, the small linear machine for ECRH experiments and the 3.7 GHz gyrotron testbed for ECRH in the spherical tokamak were constructed as shown in Fig. 1. The gyrotron consists of the metallic cylinders with the commercial size, the evacuating system, simple magnetic coils and the MIG. The oscillation frequency designed is 3.8 GHz of the lowest frequency among the existing gyrotrons.

An ECRH method is the most simple method to produce plasmas. By evacuating the vacuum vessel and introducing the working gas with well-adjusted pressure and the microwave power with several ten watts, plasmas production starts easily near ECR region in the vessel. We have a interest in the property of ECR plasmas for different magnetic field configurations such as a mirror, a cusp, a stuffed cusp, a quadruple fields and a spherical tokamak. The common characteristics among the cusp, the stuffed cusp and the quadruple magnetic field configurations are formation of closed ECR surface. The magnetic field strength decreases inside the ECR surface. The experiment started with expectation of unique plasma formation without hot electrons inside ECR surface. Here, the old ECRH experimental result in simple mirror such as ELMO and TPM was used as a reference.

An ECRH in the cusp configuration has been tried by injecting 2.45 GHz microwave power through the spindle cusp. In the experiments, asymmetric production of plasmas with respect to the plane including the line cusp and plasma production without hot electrons were observed.

On the spherical tokamak configuration, a motivation is the formation of the spherical tokamak by current with only ECRH and sustaining of plasmas which overcomes the radiation barrier. By using 2.45 GHz/5kW RF injection only, around 3 kA of plasma current was achieved and maintained more than 1 sec in the optimized vertical field. The electron density exceeded the cutoff density, which suggests the electron Bernstein wave heating.

The near-term plans on high power experiments by a new antenna for 2 GHz RF injection which enable Bernstein mode heating through O-X-B mode conversion process were reported.

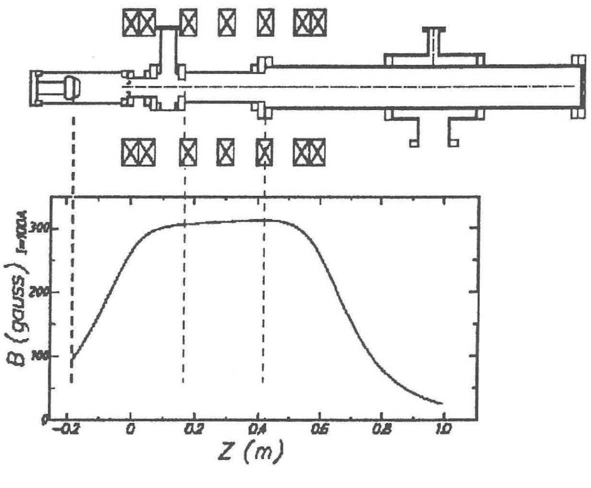

Fig. 1: The 3.8 GHz gyrotron testbed for the spherical tokamak. (a) emission belt: diameter=34 mm, width=4 mm (b) cavity: entrance diameter=56 mm, cavity diameter=95.6 mm, length=270.4mm (c) waveguide: diameter=133.8 mm, slit width for evacuation= 10 mm