§8. Workshop on Generation, Application and Measurement of High Power Millimeter Waves

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1. Objectives

Many devices and components over 100GHz frequency range have been developed day by day. The related information of the cutting-edge technologies in these fields should be consolidated constantly. In National Institute for Fusion Science, there are lots of millimeter wave devices such as gyrotrons, transmission lines and millimeter wave detectors for plasma experiments. The millimeter wave power is utilized not only plasma heating, but also electron temperature measurement through the electron cyclotron emission from the LHD plasmas. Since the millimeter wave technology, which includes power sources, detectors and components, is still developing, it is important to catch up with the leading edge of such technology for the improvement of ECH and ECE system. The objectives of this workshop are the information exchange between the researcher of millimeter wave and microwave technologies, the improvement of each millimeter wave systems through the workshop and development of combined research fields.

2. Activities in FY2005

The activities of this fiscal year were to research methods and computer codes to design and analyze millimeter wave devices and components, to establish the database, and to make CD-ROM archives. Front-line researchers made presentations of their latest research activities and computer codes. Through this process, the technologies of high power millimeter wave generation, application and measurement have been organized.

On the workshop, all participants from nine research institutes and universities presented their researches. The following researchers made detailed presentation of research results with the related computer codes.

Program and contents of the lectures are as follows.

(1) "Analysis of slow-wave electron cyclotron instabilities due to anomalous Doppler effect" by Dr. Kazuo Ogura (Niigata University)

It is shown that the slow-wave electron cyclotron instability due to the anomalous doppler effect occurs in addition to the Cherenkov instability in the interaction between axially injected electron beams and slow electromagnetic waves. Although this instability is excited through an electron cyclotron resonance, the electron energy perpendicular to the magnetic filed is not necessary because it is a slow cyclotron mode. The analysis includes the model in which the three-dimentional perturbation of the electrons is taken into account. the slow-wave cyclotron instability is analyzed on the actual boundary condition which is used in the real slow-wave microwave devices. Application to microwave sources is also discussed.

(2) "Recent topics of ECH analysis computer codes in Tsukuba University" by Dr. Yoshimori Tatematsu (Plasma Research Center, Tsukuba University).

In the plasma research center of Tsukuba University, a high power 28GHz gyrotron system was developed and installed for the production of electric fields in the plug region of GAMMA 10. It was necessary to design and manufacture a new transmission line for the gyrotron. A launcher of the antenna was designed by the electromagnetic code to produce a axially-symmetric field profile at the resonance. Using the launcher leads to the highest electric field production. Another application of the code is the design of the transmission system in the central-cell ECH system. The modification of the system resulted in the achievement of the highest temperature of the bulk electron,

(3) "Optimization of ECH system in LHD: Computer codes related ECH" by Dr. Shin Kubo (NIFS).

In LHD, the ECH system consists of many kinds of gyrotrons, transmission lines and antennas. A lot of computer codes, such as propagation analysis of electromagnetic waves in the waveguide and in free space, mirror design code, polarization analysis, ray tracing code of ECW, etc., have been developed and used for the system design, optimization and operation. He explained the principle, configuration, problems and calculation examples.

The attendances distributed over wide area related to the millimeter wave technology. About 20 members joined the workshop. (1) High power millimeter wave application to plasma heating: NIFS, Tsukuba Univ. Kyushu Univ. Kyoto Univ. (2) Generators of high power micro and millimeter waves: Fukui Univ. Niigata Univ. Kanazawa Univ. Tohoku Univ. (3) Millimeter wave technology: JAEA

This workshop was continued for two years. In future the main theme will be concentrated on the higher frequency range such as submillimeter wave (Tera Hertz) range. This expands RF technologies to the wider area; communication, remote sensing, biology applications and so on.