§23. High Power Millimeter and Tera-Hertz Wave Source Using an Intense Electron Beam

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i) Objectives

In LHD experiments, a Mega-Watt millimeter wave system is used for strong electron heating. In these days, millimeter wave and Tera-Hertz wave oscillators and some components have been progressively developed and applied to material and medical sciences. Particularly, electron beam devices realize not only high power and/or steady-state output, eg. gyrotrons and free-electron lasers, but Tera-Hertz output using high-harmonic operation. Besides, a new high-power and high-frequency oscillator using a high-current electron beam is extensively studied.

The objective of this workshop is to encourage the exchange of the state-of-the-art informations among the researchers of MM & Tera-Hertz waves and microwave technologies, for the improvement in each field and the development of combined research fields.

ii) Activities in FY2011

In this fiscal year, we intended to make intensive discussion of the latest research results and the new research trend of the generation, detection and application of MM & Tera-Hertz waves. Main themes in this fiscal year are as follows, 1. Present states of the development of millimeter- and TeraHertz-wave oscillators using electron beams like Gyrotrons. 2. High power millimeter- and TeraHertz-wave components for plasma heating and diagnostics.

We had a workshop in January 25th, 2012 under the keywords of "High power millimeter and Tera-Hertz wave source using a intense electron beam". The workshop mainly included recent research reports by the collaborators as many as possible. There were eight presentations, four were relevant to generation of electromagnetic waves such as millimeter- and TeraHertz waves using intense electron beams. Three reports were related to development of high power millimeter-wave components for electron cyclotron resonance heating and current drive in fusion plasmas. And one was high density plasma heating using microwaves.

The participants distributed over wide area related to the millimeter wave technology and its application. About 21 members joined the workshop. The viewgraphs of each presentations were summarized in the CD-ROM for convenience.

Presentations: Reports

1. "Electron Beam Bunching by Surface Wave Excitation and Induced Smith-Purcell Radiation"

   by Dr. K. Ogura, University of Niigata.

   An electron beam going through just above a grating like metal corrugated plate can produce electromagnetic wave. This phenomenon is called "Smith-Purcell radiation", which is noticeable as millimeter-wave and TeraHertz wave source. The analysis and experiment of the induced Smith-Purcell radiation on the cylindrical corrugated structure in Univ. Niigata was reported. So far 100GHz radiation was observed.

2. "Research of Inverse Cherenkov Radiations Using Smith-Purcell Effect"

   by Dr. K. Kan, Institute of Scientific and Industrial Research, Osaka University.

3. "Meta-Materials and Tera-Hertz Radiation"

   by Dr. M. Hangyo and D. Li, Institute of Laser Engineering , Osaka University.

   Meta-materials are artificial structures in which unit structures (Meta-atoms) smaller than the related wavelength are aligned, and realize an effective permittivity and permeability which materials in the natural world never have. The production of the meta-materials in the THz range and application to THz radiation using meta-materials are introduced.

4. "Possibility of Interaction between Quantum Beams and Tera-Hertz Waves"

   by Dr. N. Sarukura, Institute of Laser Engineering , Osaka University.

5. "Research and Development of a High Power Fast Millimeter-Wave Switch for Electron Cyclotron Current Drive"

   by Dr. M. Saigusa, Ibaraki University.

6. "Microwave and Millimeter-Wave Technologies in Institute for Applied Mechanics of Kyushu University"

   by Dr. H. Idei, Research Institute for Applied Mechanics, Kyushu University.

7. "Experiments of Electron Bernstein Wave Heating in LATE Spherical Tokamak",

   by Dr. Y. Noguchi, Kyoto University.

8. "Development of Electron Cyclotron Heating and Current Drive in Japan Atomic Energy Agency",

   by Dr. K. Sakamoto, Japan Atomic Energy Agency.

   Development of ECH and ECCD related technologies in JAEA were reported. They include a recent two frequency gyrotron (170GHz / 137GHz) development, high efficiency coupling of millimeter-waves to transmission lines, high frequency (5kHz) modulation of gyrotron output and development of an equatorial launcher for ITER. Development of a 1MW, 100s gyrotron for JT-60SA is also proceeded. Two frequency gyrotron (110GHz/138GHz) was designed and constructed.