§26. 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 FY2010

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.

We had a workshop on plasma heating and diagnostics in February 22nd, 2011 under the keywords of " High power millimeter and Tera-Hertz wave source using a intense electron beam". The workshop is organized by three topical lectures and three reports as listed below. The participants distributed over wide area related to the millimeter wave technology. About 22 members joined the workshop. The viewgraphs of each presentations were summarized in the CD-ROM for convenience.

Presentations: Lectures

1. "For Development of a Tera-Hertz Gyrotron" by Prof. Weihua Jiang, Extreme Energy-Density Research Institute (EDI), Nagaoka University of Technology

   For the purpose of Tera-Hertz generation and its application, the development of a Large Orbit Gyrotron (LOG) using a relativistic electron beam is promoted under a collaboration between EDI of Nagaoka Univ. of Tech. and FIR Center of Univ. of Fukui. In the experiment, a pulsed electron beam with the energy of 400 keV was generated by a pulsed power generator "ETICO-IV" and injected into a cavity with a magnetic field up to 8 T, being controlled the beam shape and the pitch factor. A generated electromagnetic wave had a frequency of 130-140 GHz and over 1 MW output power. Simulation results by 3 dimensional PIC code indicated possible oscillation mode of TE_{14} and TE_{46}.

2. "Coherent Monochromatic Cherenkov Radiation Generation in THz Range by Femtosecond Electron Bunches in Impurity-Doped Semiconductor Tube" by Dr. A. Ogata, Institute of Scientific and Industrial Research, Osaka University

   A Cherenkov radiation can be generated when an electron beam passes through a dielectric-coated metal cylinder. When three lengths, that are the plasma wavelength of the dielectric, the radius of the tube and the bunch length of the electron beam, synchronize each other around a Tera-Hertz wavelength, a strong THz radiation can be resonantly generated, and its frequency becomes discrete. If the bunch length is shorter than that of the radiated wave, the radiation becomes coherent and the intensity is proportional to N^2, where N is the number of electrons included in the bunch. It is possible to obtain a quasi-coherent radiation by selecting parameters so that only the lowest component may be dominant.

3. "Generation of a Quasi-Coherent THz Wave by Coherent Cherenkov Radiation" by Dr. K. Kan, Institute of Scientific and Industrial Research, Osaka University

   Coherent Cherenkov Radiation (CCR) is a method in which a Cherenkov radiation generated by a electron beam is confined in the dielectric material and a strong coherent THz wave can be generated. The coherent THz wave could be applied to the source for material probing and imaging. On the other side, the technology of short pulse electron beams is also applied to the strong electromagnetic wave generation and the femto-second pulse radiolysis. They introduced their S-band linac with a photo-cathode RF electron-gun and the generation of femto-second electron beams. A THz wave generation using ultra-short pulse bunched electron beams was also reported.

Presentations: Reports

1. "Development of a High Power Sub-Tera Hertz Pulsed Gyrotron" by Dr. T. Saito, Research Center of FIR, Univ. Fukui.

2. "Efficient Electro-Optic Sampling Detection of Tera-Hertz Radiation via Cherenkov Phase Matching" by Dr. M. Tani, Research Center of FIR, Univ. Fukui.

3. "Electron Bernstein Wave Heating in the Microwave Spherical Tokamak, LATE", by Dr. M. Uchida, Kyoto Univ.