§19. Experimental Study of Plasma Loaded Cyclotron Resonance Maser Using TPD-II Machine at NIFS

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Traditionally, cyclotron emission has been analyzed under the assumption that beam electrons are tenuous enough to neglect the effects of neutralizing ions. Previous researchers of cyclotron resonance maser (CRM) instability characterized by $\omega > \tilde{\Omega}$ have followed this model applicable to tenuous beams such as $\omega_b^2 \ll \tilde{\Omega}^2$, where ω, $\tilde{\Omega}$ and ω_b are, respectively, radiation angular frequency, relativistic cyclotron frequency and relativistic beam plasma frequency. There can be another extreme model for the electron gyration. Free gyration may be prevented by a restoring force caused by the charge separation between dislocated electrons and localized immobile ions, if $\omega_b^2 \gg \tilde{\Omega}^2$. The free gyration model applicable for $\omega_b^2 \ll \tilde{\Omega}^2$ results in the conventional understanding that the CRM instability is the unique principle of cyclotron emission from the electrons[1]. On the other hand, the constrained electron model for $\omega_b^2 \gg \tilde{\Omega}^2$ yields prediction that the Cherenkov instability in the azimuthal direction (CIAD) with $\omega < \tilde{\Omega}$ can be another principle of cyclotron emission in addition to the CRM instability[2,3].

We are trying to detect experimentally CIAD in addition to CRM instability in a beam-plasma system produced by differential pumping of DC discharge plasma source called TPD-II machine[4]. A TE_{011} cylindrical cavity made of SUS with resonant frequency near 3.456 GHz is installed, and the beam plasma with radius 4 mm goes through the two end holes on the axis of the cavity. In front of the cavity, three SUS circular plates with a pin hole that selects electron beam with a particular pitch angle to enter.

In Fig. 1 is shown the microwave circuit including the cavity. Gunn oscillator with oscillation frequency 2-4 GHz and output power 20 mW is FM modulated 0.1 % by a saw tooth signal. An example of the input and output signals detected by loop antennas at the side wall displayed on a digital oscilloscope is shown in Fig. 2. Loaded Q values around 6900 are measured. The critical coupling condition is explored. Beam density and axial magnetic field are changed up to 10^{13} cm^{-3} and 1.0 T. Our final goal is to detect change in ω of negative absorption from $\omega > \tilde{\Omega}$ to $\omega < \tilde{\Omega}$, with increase in the beam density.

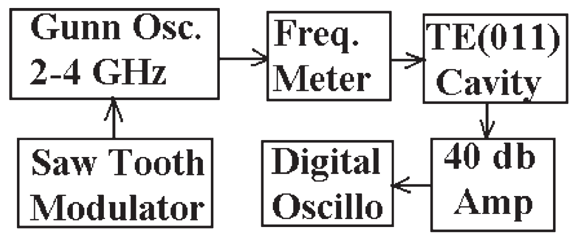

Fig. 1 Fabricated TE_{011} mode cavity and circuit.

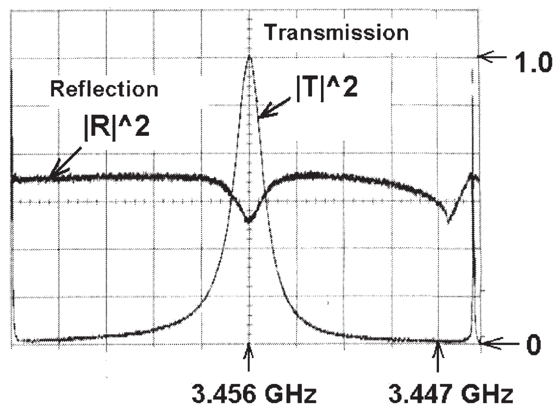

Fig. 2 Resonant curve of the TE_{011} mode Cavity.

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