§ 27. High Purity Mode Operation of Gyrotron FU VA and Generation of Intense Gaussian Beam

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High frequency gyrotrons are characterized by their ability to deliver high powers in millimeter to submillimeter wavelength range[1-3]. For many applications like plasma scattering measurements where more intense radiation sources are required, the gyrotrons are the most promising candidates in this region of the electromagnetic spectrum.

Unlike the molecular vapor lasers, the gyrotrons generate diverging beam of radiation with TE_{mn} mode structure. It is therefore necessary to convert the output radiation into a Gaussian beam (TEM_{00} mode), which is suitable for an effective transmission and can be used as a well-collimated probe beam. In this respect, a high purity mode operation is a prerequisite for effective conversion of the output radiation into the Gaussian beam.

A quasi-optical antenna is a suitable element for the conversion system under consideration since it is applicable to several TE_{0n} and TE_{1n} modes. It should be noted, however, that the far-field of the linearly-polarized beam produced by the antenna consists of side lobes and a main beam, which is similar to a bi-Gaussian beam. A Gaussian beam can be obtained by converting the main beam. A con-focal mirror system with different focal lengths in different directions is used for the conversion.

Gyrotron FU VA consists of a gyrotron tube and a helium-free superconducting magnet. This magnet can produce a magnetic field up to 8 T without using liquid helium. The tube is demountable, because we will try to optimize all components, the cavity, the transmission waveguide and the output window. The window is made of quartz plate with the thickness of 3.175 mm and relative dielectric constant of 3.83.

In order to avoid conversion of the cavity mode to spurious modes, the cavity has an optimized design with nonlinear up-tapers and a rounded iris at the output. The resonance calculation using a scattering matrix formalism (SM-code) was performed taking into account the complete gyrotron geometry including the pumping sections (slots) and the window.

The radiation patterns are measured by two-dimensionally (x-y plane) moving pyro-electric detector array over the gyrotron window. The intensity profiles of radiation pattern for TE_{03} mode and TE_{13} mode are shown in Fig.1. These patterns are not so affected by the diffraction at the output aperture of waveguide because they are measured in the far-field region ($z > z_f = ka_w^2 \sim 200$ mm).

The patterns for these modes agree well with the intensity profiles calculated. This demonstrates that Gyrotron FU VA can produce outputs of high purity mode. Such a feature is favorable for converting a gyrotron output into a Gaussian beam.

The first element in the quasi-optical system is the quasi-optical Vlasov antenna which consists of stepped-cut launcher with radius 9 mm and length of the step 100 mm and a parabolic reflector whose focal length is 21.75 mm. This is followed by an ellipsoidal mirror (Fig.2).

The quasi-optical antenna converts the gyrotron output into a linearly-polarized beam. While the mirror collimates it. In order to observe the intensity profiles, we have constructed an array of 7 pyroelectric detectors. The measured intensity profiles are shown in Fig.3. The quasi-optical system can convert the gyrotron output into bi-Gaussian beam.

(a) (b)

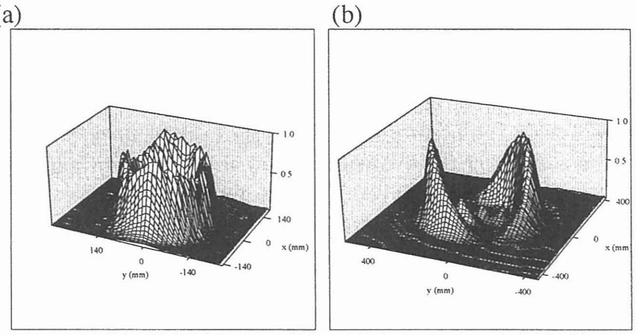

Fig.1 Intensity profiles of radiation pattern; (a) for TE_{03} mode and (b) for TE_{13} mode.

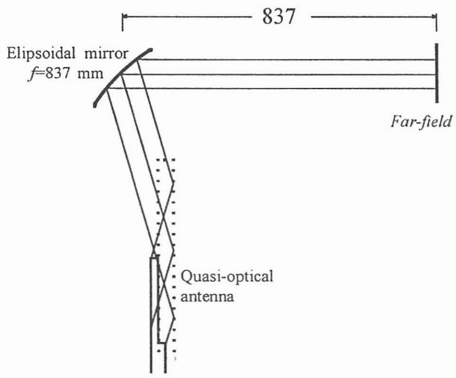

Fig.2 Quasi-optical system.

(a) (b)

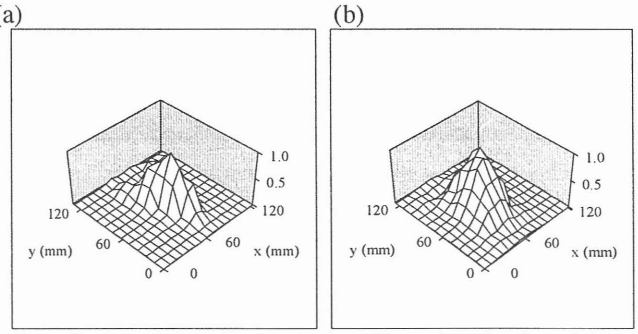

Fig.3 Measured intensity profiles of output beam. (a) for TE_{03} mode and (b) for TE_{13} mode.

References

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