23P170-B

Design of an antenna system for millimeter wave transmission to an ESR echo experiment system, III
ESR エコー実験システムへのミリ波伝送用アンテナ系の設計 III

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An ESR echo experimental system is now being developed, where a high power gyrotron is applied as a radiation source. A transmission system consisting of a Vlasov launcher and six mirrors has been designed. It transmits the beam from the gyrotron to the ESR system. The Vlasov launcher convects the EM wave of the circular $TE_{0,2}$ mode oscillated in the gyrotron cavity to a linearly polarized Gaussian-like beam. The beam shape is farther fixed after reflection by the six mirrors and a Gaussian beam with the radius of 8 mm is injected into the ESR system.

1. Introduction

Development of high frequency and high power gyrotrons has been progressed in FIR FU. Their applications are measurement of fusion plasma, electron spin resonance (ESR) spectroscopy, a protein analysis and so on. Gyrotron FU CW VIIA has been developed as a radiation source of the ESR echo equipment for investigating the characteristic of the electronic spin system of a substance by high resolution of time under a strong magnetic field. In the ESR echo measurement, the incident EM wave is required to be a linearly polarized Gaussian beam with an appropriate diameter. The purpose of this research is design of a transmission system of delivering the EM wave from the gyrotron to the entrance of the ESR experiment system (ESR-ES), in which the EM wave is convected to a linearly polarized Gaussian beam.

2. Transmission system

Figure 1 shows a schematic of the transmission system. The radiation beam emitted by the Vlasov launcher is reflected by five ellipsoidal mirrors and one plane mirror delivered to the incident point of the ESR-ES. As a placed outside of the gyrotron radiation source, Gyrotron FU CW VIIA is applied. The oscillation mode of $TE_{0,2}$ with the frequency of 153 GHz is chosen to the ESR experiment. An EM wave propagated through a waveguide with the

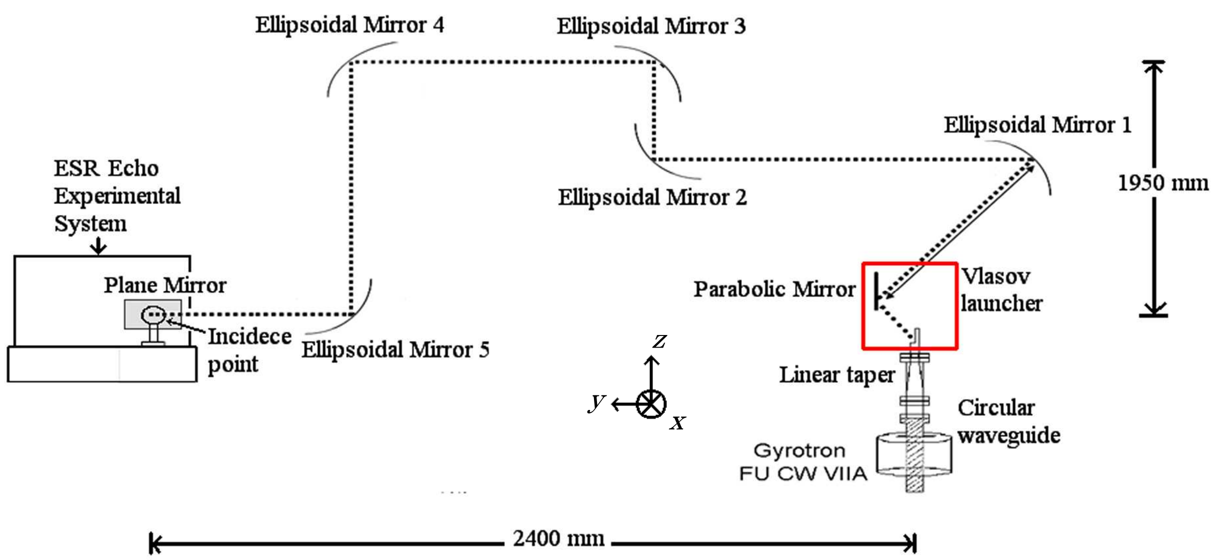

Fig.1 Transmission system

diameter of 28 mm in the gyrotron and radiated from the window. A linear taper attached outside of the gyrotron window reduces the waveguide diameter from 28mm to 10 mm. The Vlasov launcher consists of a step-wise waveguide with the diameter of 10 mm and a parabolic mirror. The EM wave is convected by the Vlasov launcher and a Gaussian-like beam is radiated by the launcher. If radiated beam is directly transmitted to the ESR-ES, the beam size becomes very large since the beam expands. Therefore, five ellipsoidal and one plane mirror are installed to keep the beam size small enough to make the beam radiated mirror sizes as small as possible. In result, the mirror sizes are also kept small. According to the requirement in the experiment, the beam spot size *w* is set to be about 10 mm at the entrance of the ESR-ES.

3. Vlasov launcher

We manufactured the Vlasov launcher and confirmed its performance. The radiation pattern of the beam launched from the Vlasov launcher was observed with an IR camera as the temperature increase on a vinyl chloride plate placed perpendicular to the beam propagating direction. Figure 2 shows a radiation pattern at the distance of 300 mm from the Vlasov launcher. Vertical and horizontal sizes are equivalent to 100 mm in Figure 2. An oval pattern was observed, which indicates the Vlasov launcher well converted the EM wave to a Gaussian-like beam.

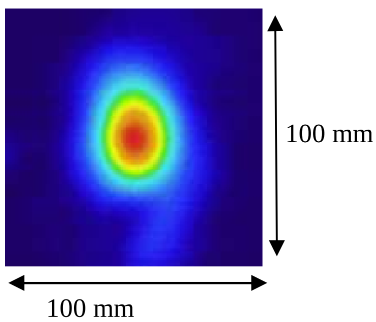

Fig. 2 A radiation pattern of the beam radiated from the Vlasov launcher in measurement with an IR camera

4. Design of the ellipsoidal mirrors

The Gaussian-like beam radiated from the Vlasov launcher is delivered to the entrance of ESR-ES after reshaped to a Gaussian beam by five ellipsoidal mirrors. The surfaces of the mirrors have bean designed by calculation of the beam profile at the entrance. The calculation was performed with a code based on Fresnel-Kirchhoff's diffraction theory. Figure 3 shows a calculation result of a Poynting flux distribution at the incident point. The coordinated *x*,*y*,*z* is defined in figure 1. It is almost circular. Figure 4 shows its profile the Poynting flux along *y*-axis in Figure 3. The profile is fitted to a Gaussian distribution and the fitted spot size *w* is 8 mm, which is within the desired value. Moreover, Figure 5 shows the three components of the electric field and, *y* component is the dominant. Therefore, the beam is almost linearly polarized along *y*-axis. The almost linearly polarized Gaussian beam can be injected to ESR-ES by the designed transmission system.

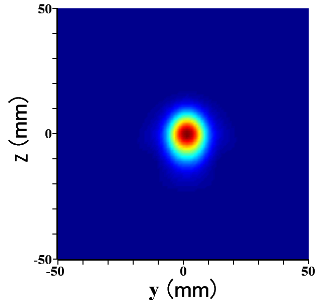

Fig.3 Poynting flux distribution in an incident point

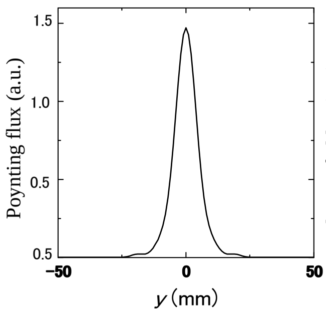

Fig.4 Calculated Poynting flux along *y*-axis

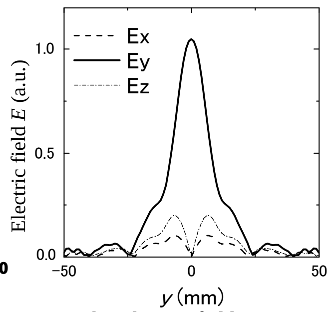

Fig.5 The electric field components of the radiation beam

5. Conclusion

We have designed the transmission system which delivers the radiation from the gyrotron to ESR-ES after converting it to a Gaussian beam. The almost linearly polarized radiation beam with the spot size of 8 mm was obtained in calculation. This system will be now manufactured and completed at the end of this year.