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Gaussian Beam for Antennas Field Pattern Synthesis

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***Abstract* – The paper presents a rapid analysis method of THz double elliptical mirror system based on the Gaussian beam (GB) expansion and tracking, working frequency at 119 GHz. Gaussian far-field pattern is firstly expanded into a series of sub-GBs making use of point matching (PM), then tracking GBs successively with specular reflection is to obtain near field and far field pattern. Synthesis results of mirror reflection, compared with Physical optics (PO), reaching to -60dB proves the correctness of the system modeling and analysis method.**

***Index Terms* — Expansion and tracking, field pattern, Gaussian beam, point matching, THz antenna.**

I. Introduction

Electromagnetic field in the space of bunching propagation can be described utilizing GB, which is considered as waveguide or transmission line theory in quasi-optical system. In millimeter and sub-millimeter frequencies, we can make use of paraxial transmission and focused characteristics of GB [1] to show mirror reflection process, which firstly expand feed profile into a series of GBs and then traversal track each reflection process, and superposition all GBs will eventually obtain the synthesis near or far reflection field.

Traditionally Gabor's expansion [2] uses shifted spectral and spatial windows for getting expansion coefficients. But expansion on a flat leads to results that GB far away from the mirror don't appear secondary reflection and restoration results compared with PO have wide margins for lack of portion energy. PM [3], based on sampling theorem solving matrix equations for coefficients, contains clearly more energy for location in the phase center.

The paper presents a rapid analysis method that expanding far field pattern of feed into GBs using PM and tracing each beam [4] applied in double-elliptical mirror system at 119 GHz, compared synthesis results of reflection with PO.

II. Analysis Method And System Model

The all antenna field can be seen as synthesis of a series of GBs. Expansion the far-field into GBs is equivalent to the following relation

$$\vec{E}(\theta,\phi)=\sum_{n=1}^{N}C_n\vec{E}_n(\theta,\phi) \qquad (1)$$

Where C_n is the expansion coefficients of nth GB, N is the total number of expansion GBs, $\vec{E}_n(\theta,\phi)$ is the nth vector GB basic function.

Each expansion coefficient can record amplitude and phase information of field in GB axis direction, which will eventually decides whether restoration the original signal or not. In PM method, coefficients are obtained by solving matrix equations, which is given by

$$[V_n]_{N\times1}=[Z]_{N\times N}\times[C_n]_{N\times1} \qquad (2)$$

Where N is the number of sample points. V_n is the nth sample value of far-field pattern. Z is orientation matrix in which each row is relationship of GB polarization vector with others.

When the far-field pattern of feed is expanded into a set of GBs, tracing GBs into the mirror needs to set up reflection model so that we can solve out GBs reflection parameters according to polarization parameters of incident beam. Model refers to law of reflection in reflection point where we set up the incident, reflection, and main curvature coordinate system at the same time. Analysis each GB reflection process in turn will synthesize out total emergent field at last.

The system model of double-elliptical mirror system is shown below Fig. 1.

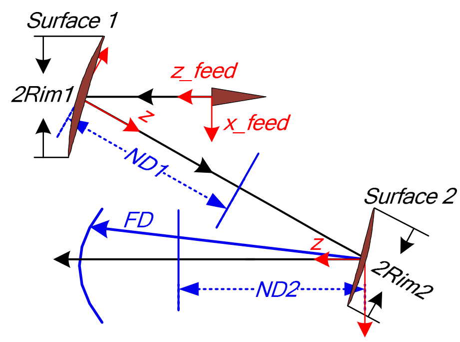


Fig. 1. System model of double elliptical mirror system.

Where Rim1 and Rim2 are the radius of the elliptical mirror, respectively, ND and FD are scanning distance of near and far field. Due to focus characteristics of the first elliptical mirror, we can make the radius of second surface is less than the first to get better utilization rate of the near field.

III. Result Comparing

We built a quasi-optical system, which is composed of two ellipsoid mirrors, working frequency at 119 GHz. System and mirror parameters are shown as below

(1). The feed is defined by Gaussian far-field profile with decay value -6dB in 9 degree shown in Fig. 2.

(2). The Rim1 and Rim2 that are the radius of elliptical mirror are equal to 50mm and 40mm respectively. The utilization rate of near field is significant meanwhile good emergent field can also be obtained.

(3). The near field scanning distance ND1 and ND2 are same 150mm. The far field scanning distance FD is 7.9333m. The distance between phase center of feed to the first mirror is 0.1082m. The center distance between two mirrors is 0.2682m. The near scanning lengths are 0.1m and 0.08m.

(4). The feed is expanded into total 1173 GBs based on PM, and then such 1173 GBs are tracked into the first and second reflector simultaneously. All GBs reflect on the mirrors because of convergence effect of the first mirror.

The near and far field calculation results of expansion and tracing are compared with PO simultaneously in the Phi=0 and Phi=90 degree, which are given by Fig. 3.

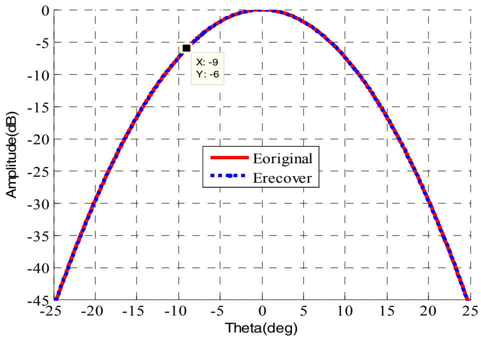
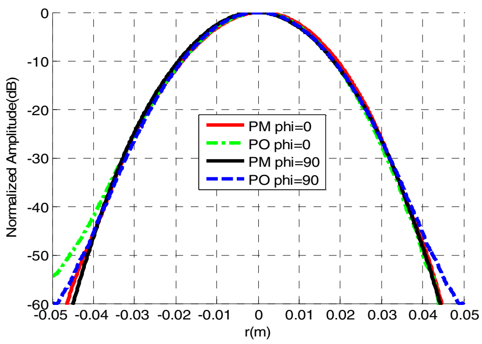
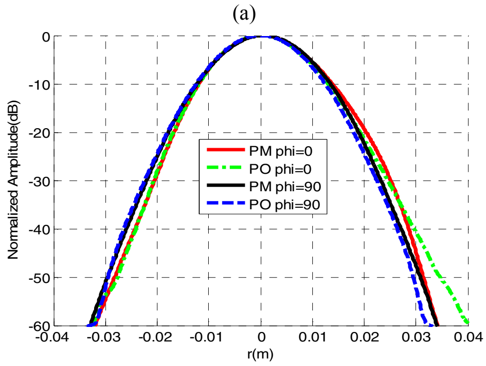


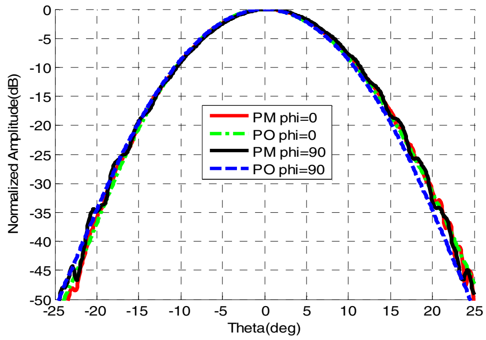
Fig. 2. Far field Gaussian pattern of feed expansion and restoration in input plane based on PM, compared the result with original far field distribution.



(a)



(b)



(c)

Fig. 3. (a) and (b) are the near field scanning result after the first mirror and the second mirror, respectively, (c) is the far field scanning result after the second mirror.

IV. CONCLUSION

The far field pattern of Gaussian feed is expanded into a series of GBs based on PM and restored successfully, compared the restoration result with original Gaussian field distribution indicated the validity of the PM method, which can be applied to all far field pattern expansion and restoration in the input plane. Meanwhile, choosing the number of expansion GBs will determine trade-off between computation accuracy and time.

Make full use of the focused characteristics of elliptical mirror, thus it leads to have smaller size of the second mirror. We compare the field scanning results after the first and the second mirrors with PO in Phi=0 and Phi=90 degree. The computation results of near and far field match into -60dB and -50dB respectively, which shows a good agreement between the analytical results and the related integral data.

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