مدينة زويل للعلوم والتكنولوجيا
Zewail City of Science and Technology

Study of Near and Far Fields of a Super-Gaussian Beam on a Step Discontinues Interface using FFT-BPM

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Abstract 1

This work presents accurate modeling of super-Gaussian field on a step discontinues dielectric interface. The propagation of super-Gaussian field is very difficult to be solved analytically [1]. However, in this analysis we present for the first time to the best of our knowledge the super-Gaussian field with oblique incidence at critical angle on a planar dielectric interface using fast Fourier transform based beam propagation method (FFT-BPM). The lateral field shift is also investigated.

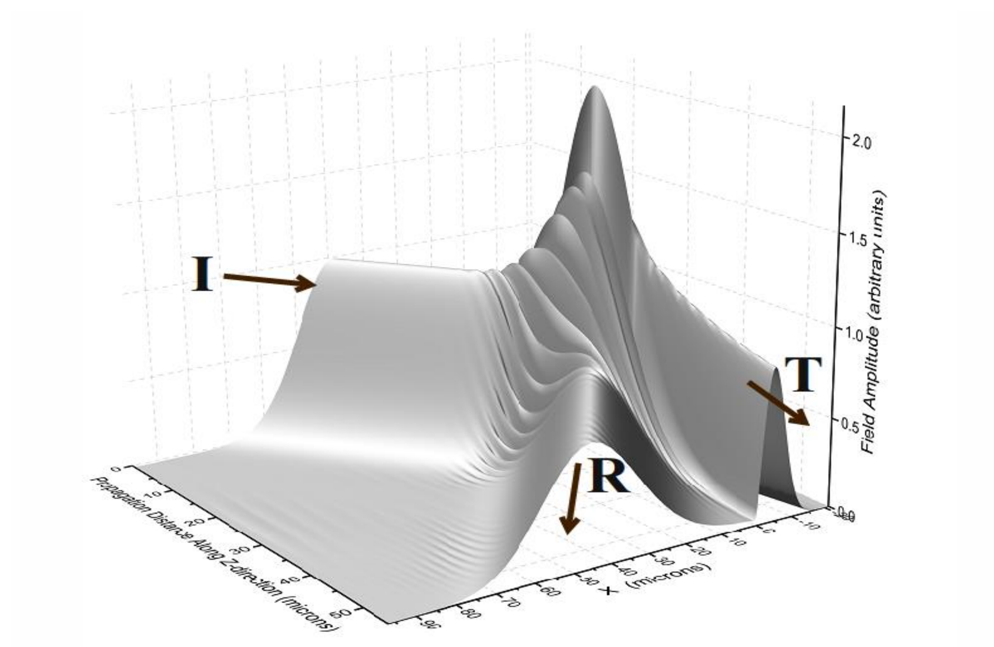

Fig. 1. color plot for the total field incident on a dielectric interface at critical angle.

Design and Simulations 2

- The propagation of super-Gaussian field attracts a lot of interest in recent years. In some cases it is called flat top beam; due to its flat peak shape. The field can be expressed as:

$$E_i(x_i, z_i) = A\exp(-(\frac{x_i}{w})^s) \qquad (1)$$

where A is the normalization factor, w is the field beam waist, and s is the super-Gaussian power which is an **even** integer.

- In the Gaussian case as shown in fig. 2, s is equal to 2. However, the super-Gaussian field is very difficult to evaluate its propagation in realm of analytical expression. In particular, the numerical methods are used to study the propagation features of super-Gaussian [1,2].
- However, the non-specular shifts for the beam weren't studied before. In this analysis we present the field interaction using the FFT-BPM [3].
- The FFT-BPM is a powerful method with angular spectrum representation of the electromagnetic field. The simplicity and powerfulness of the FFT-BPM are sought at the analytical and numerical levels [4].
- Figure 3 show the FFT-BPM algorithm [7-8].

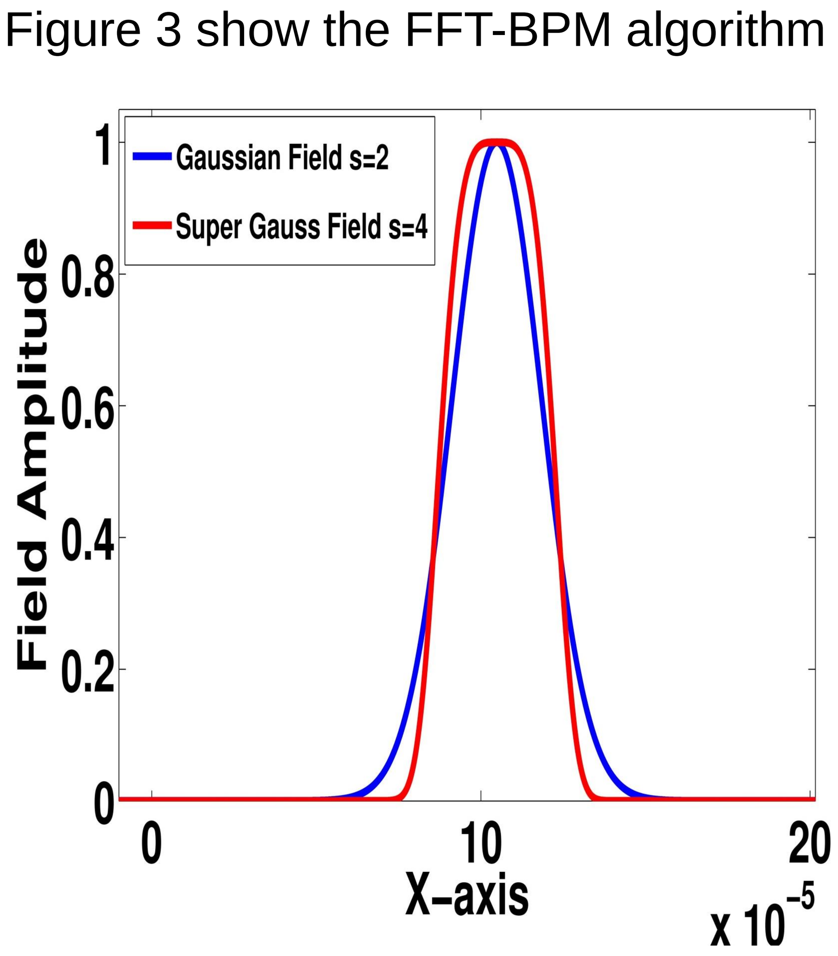

Fig.2 show the comparison between the Gaussian and super-Gaussian fields.

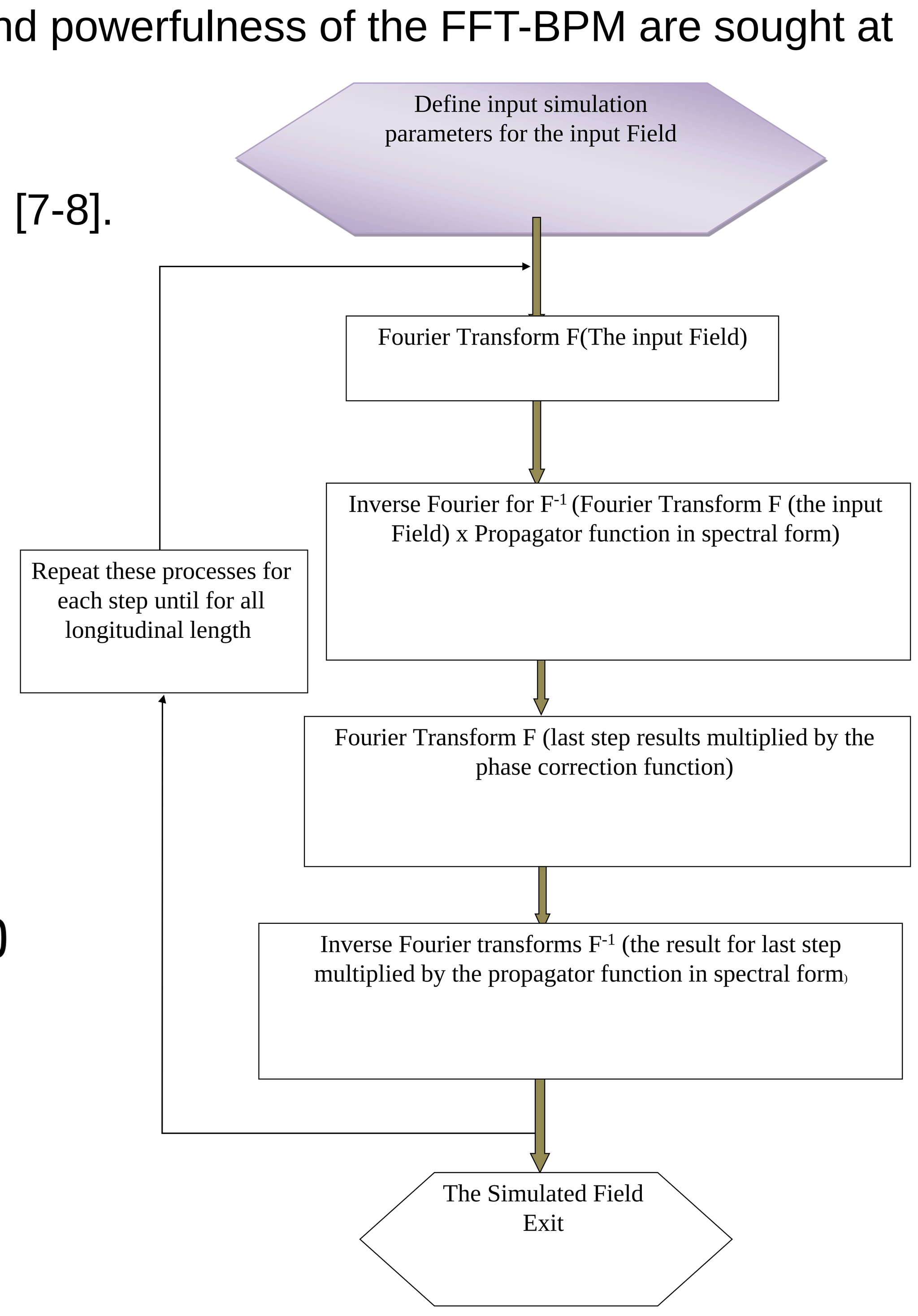

Fig.3 show the FFT-BPM algorithm.

Numerical Results 3

- Figure 4 shows the schematic diagram for a super-Gaussian field impinges on a dielectric surface. The plane x=0 is the step discontinues interface between two dielectric media having refractive indices n_1 and n_2 with $n_1 > n_2$.
- Consider a Gaussian and super-Gaussian beams with the same properties: the wavelength in the denser medium λ_1 is equal to 1.55 μm, w=20λ_1, x_d=5.2w, n_1= 1.5152, and n2=1. The beam's axis makes an angle $\theta_i = (\pi/2) - \theta_c = 48.7017°$.
- Figure 5 shows the total field propagation overview on a dielectric interface with s=2 (Gaussian field). However, Figure 6 shows the total field propagation on a dielectric interface at s=4 (super-Gaussian).
- The incident field intersection with the interface at the point Z_{go} point which represents the geometric optics point. However, the reflected and transmitted fields are shifted from this point by some distances called lateral shift (Goos-Hanchen) [6].
- This is due to the interference between the transverse wave vectors under the phase changes.
- In this analysis, the Goos-Hanchen shift is equal to 5.0296 μm and 5.63μm for the Gaussian and in super-Gaussian fields' respectively.

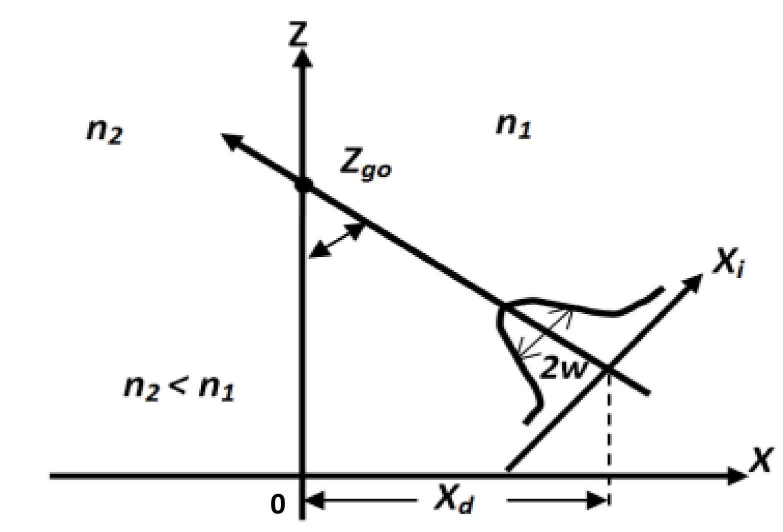

Fig.4 Schematic diagram of super-Gaussian field incident on a dielectric interface.

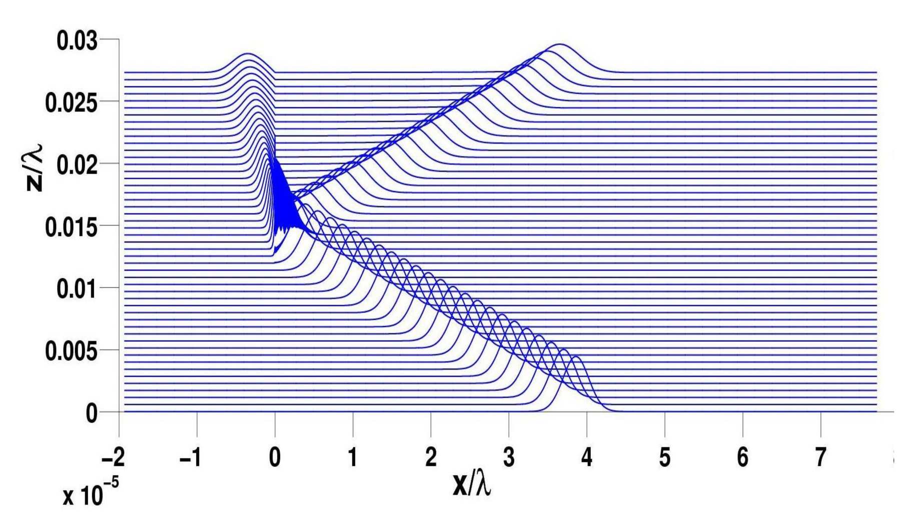

Fig.5 he total field propagation on a dielectric interface at s=2.

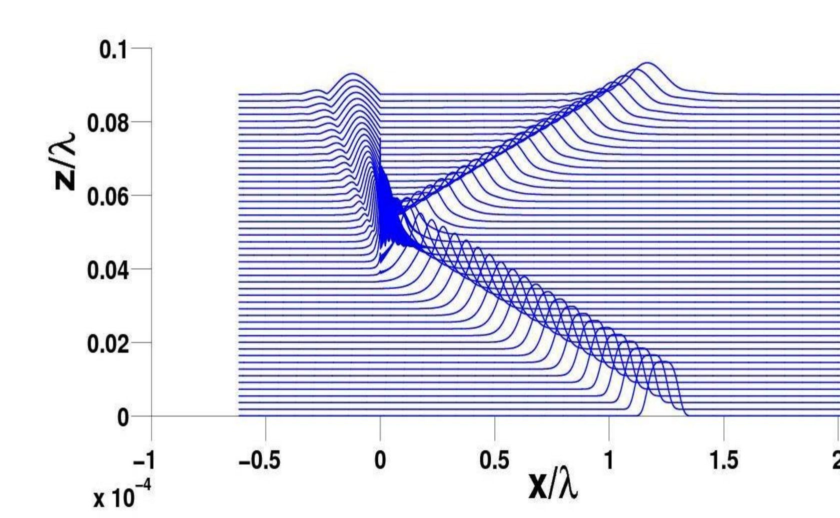

Fig. 6 The total field propagation on a dielectric interface at s=4.

Conclusion 4

This analysis describes the super-Gaussian beam interaction on a planar dielectric interface between two homogenous mediums. The obtained results are in accordance with the theory of the non-specular phenomena of the electromagnetic field interaction at the same situation. Additionally, they are in a good agreement with theoretical predictions and significant improvement over the previously published results is achieved. The suggested work has profound implications for future studies of Super fields' interaction at dielectric interfaces.

References 5

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