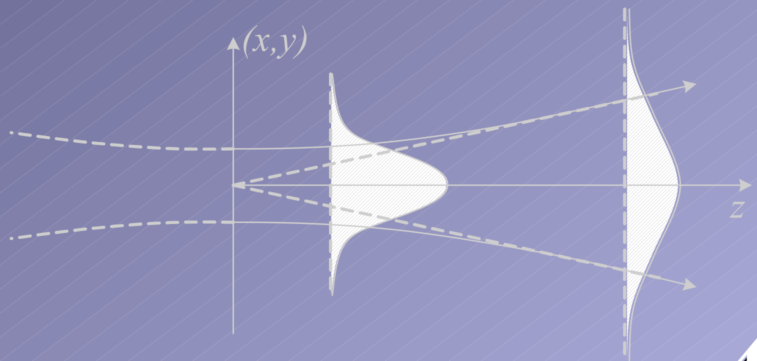
Diffraction of an Electromagnetic Gaussian Beam by Using UTD Concepts



Titipong Lertwiriyaprapa

Advisor: **Prof. Prabhakar H. Pathak**

ElectroScience LABORATORY

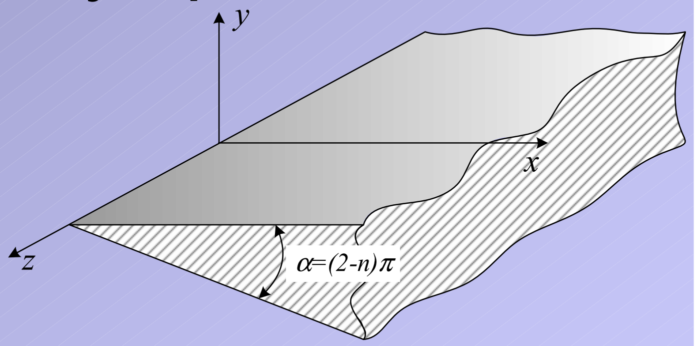
Outline

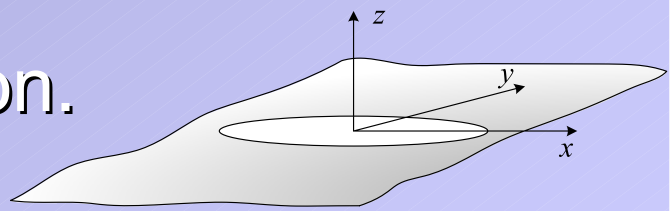
- Problem Statement
- Motivation
- Brief Introduction
  - What is Gaussian Beam (GB)?
  - How to get GB from CSP Field?
- Related Works on CSP-GB
- 3D CSP-GB Analysis for Diffraction by PEC Edges
  - Wedge
  - Half Plane, Keller Cone
  - PEC Slit
  - Circular Aperture
- Conclusion
- Future Work

ElectroScience LABORATORY

Problem Statement

- To essentially develop a Uniform Geometrical Theory of Diffraction (UTD) for Gaussian beam (GB) illumination.
- Conventional UTD is developed for ray optical illumination.
- Present work will be restricted for now to <u>straight</u> or <u>curved</u> wedge diffraction problems and to rotationally symmetric GB illumination.
- The extension to treat diffraction by other structures, e.g. smooth convex surfaces can proceed similarly.





ElectroScience LABORATORY

Motivation

- GBs and Gaussian pulses have been used successfully treating for a variety of wave propagation problems:
  - GBs have been utilized in optics to simulate laser outputs.
  - GB concept has been used in a different sense as wave packets in Quantum mechanics as well as in EM pulse propagation studies (Gaussian Wave Packet).
  - GBs can serve as EM field basis functions for aperture fields or currents as well as wave propagators.
  - In representing field at ray caustics in EM.
  - In Geophysical wave application.
- More recently, GBs have been used for analysis of:
  - Large reflector systems
  - Large apertures
  - Large antenna-radome structures

ElectroScience LABORATORY

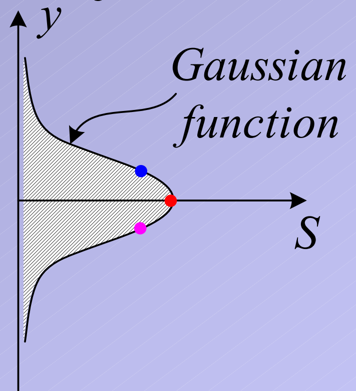
What is Gaussian Beam?

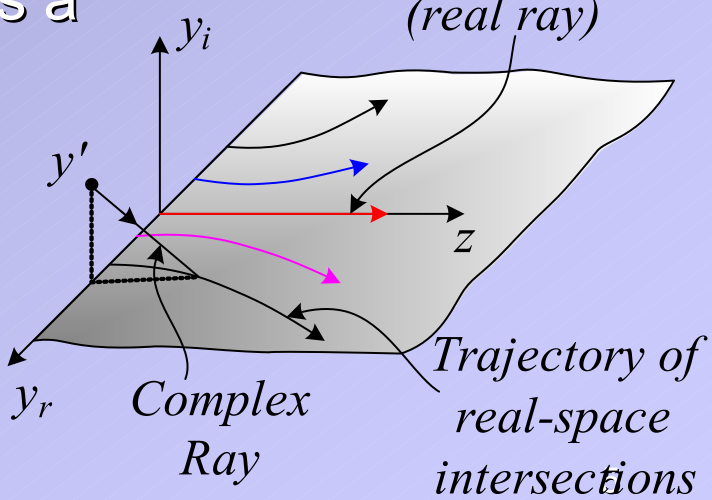
- In optics, a **Gaussian beam**, named in honor of Johann Carl Friendrich Gauss (1777-1855), <u>is a beam of light whose electric field intensity distribution is a Gaussian function</u>*.

$$\boxed{E(y,z) = E(0)e^{-(y/w)^2}}$$

- The field is described in terms of local plane waves with complex phase moving along complex ray trajectories**.
- The observable field, given by the real-space intersections of the complex rays, defines a Gaussian beam**.

$$\boxed{w(z) = w_o\sqrt{1+(z/z_R)^2}} \qquad \boxed{z_R = \frac{\pi w_o^2}{\lambda}}$$





[*] http://en.wikipedia.org/wiki/Gaussian_beam
[**] L. B. Felsen, Topics in Applied Physics vol. 10.

What is Gaussian Beam?

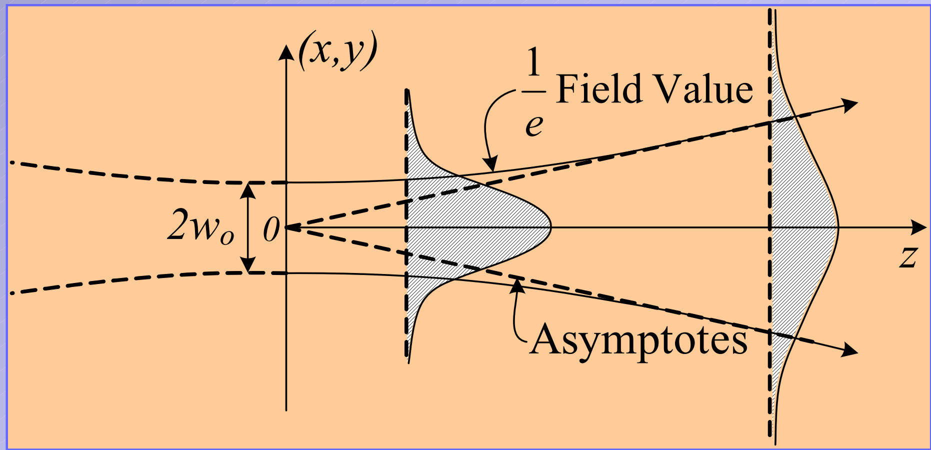
(CONTD.)

- GBs are paraxial wave solutions of Maxwell's equations.
- GBs are valid in near and far zone of their waist.

$$E(r) = E(0)e^{-(\rho/w)^2}$$

$$w(z) = w_o\sqrt{1+(z/z_R)^2}$$

$$z_R = \frac{\pi w_o^2}{\lambda}$$

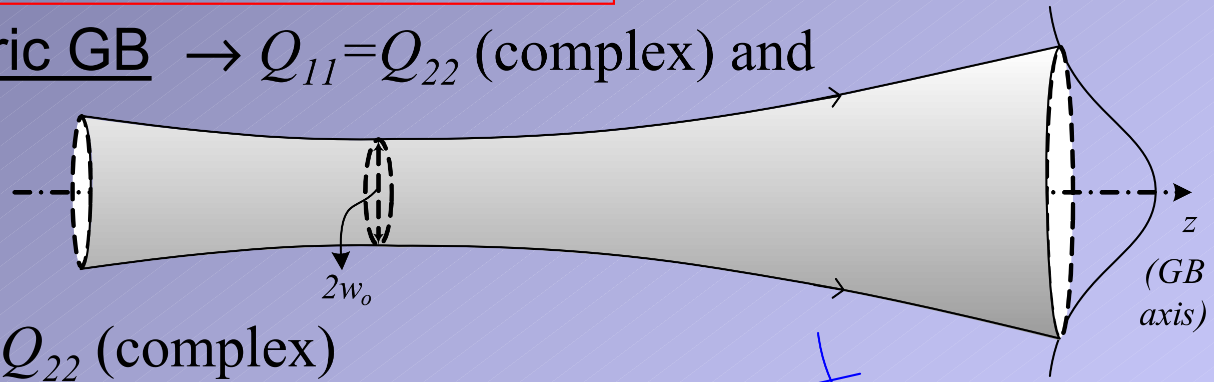


Astigmatic Gaussian Beam Field

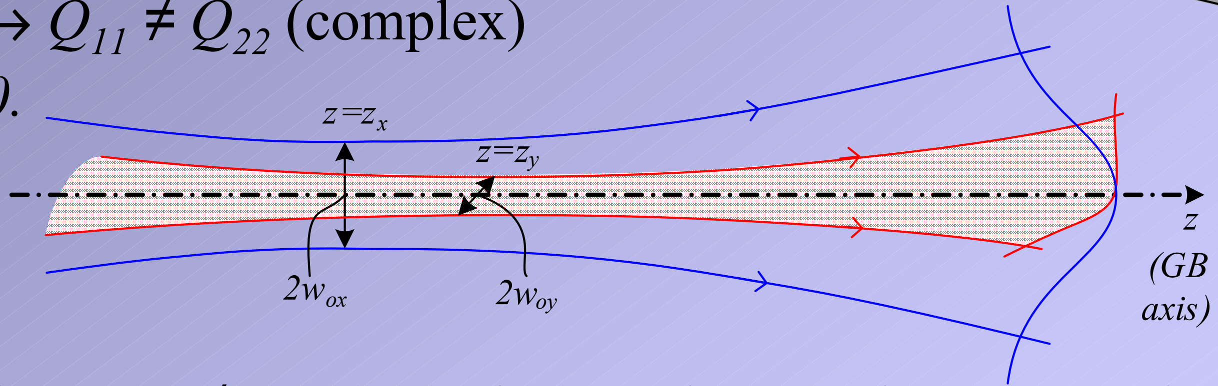
- A Gaussian Beam (GB) Field is described by

$$\boxed{\overline{E}(x,y,z)=\overline{E}(0)\sqrt{\frac{Det[Q(z)]}{Det[Q(0)]}}\,e^{-jk\left(z+\frac{1}{2}[\Lambda]^{T}Q(z)[\Lambda]\right)}}\qquad [\Lambda]=\begin{bmatrix}x\\ y\end{bmatrix}\qquad \boxed{Q(p)=\begin{bmatrix}Q_{11} & Q_{12}\\ Q_{21} & Q_{22}\end{bmatrix}}$$

- Rotationally Symmetric GB $\rightarrow Q_{11}=Q_{22}$ (complex) and $Q_{12}=Q_{21}=0$.



- Elliptical GB $\rightarrow Q_{11} \neq Q_{22}$ (complex) and $Q_{12}=Q_{21}=0$.



- Astigmatic GB $\rightarrow Q_{11} \neq Q_{22}$ (complex), and Q_{12} and Q_{21} are real.
- General Astigmatic GB $\rightarrow Q_{11} \neq Q_{22}$, and all Q_{ij} are complex.