University of Al-Mustaqbal
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# Laser in medicine

## Practical Experiences

## Third Stage

## Studying the Properties of a Gaussian Beam ( TEM )

## Lec 3

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## Experiment: Studying the Properties of a Gaussian Beam ( TEM )

### Objective

To study the properties of a Gaussian beam in its fundamental TEM mode, including beam waist, divergence, and intensity distribution.

## Experimental Tools

1. **Laser Source**: A laser emitting a Gaussian beam in ( TEM ) mode (e.g., He-Ne laser or diode laser).

2. **Optical Bench**: For alignment and stability.
3. **Beam Expander**: Optional, for controlling beam size.
4. **Lens**: Convex lens for focusing the beam.
5. **Beam Profiler or Camera**: To measure the beam intensity profile.
6. **Power Meter**: To measure beam power for intensity calculations.
7. **Translation Stage**: For precise movement along the beam propagation axis.
8. **Screen and Ruler**: For measuring beam size manually.
9. **Software**: Optional, for image analysis and Gaussian fitting.
10. **Measurement Tools**: Caliper and micrometer to measure physical distances.

## Work Steps

1. Place the laser on the optical bench, ensuring it emits a Gaussian beam in TEM .
2. Align the laser beam along the optical axis using mirrors and an alignment tool.
3. Place the beam profiler at a position close to the laser output.
4. Measure and record the beam's intensity distribution to determine the beam waist ( $\mathbf{w_0}$ ).

5. Move the beam profiler to different distances along the beam path.
6. Measure the beam diameter (**2W**) at each position.
7. Use the measurements to calculate the divergence angle ( **θ** ) using the formula: $\theta = \lambda \pi w_0$ where **λ** lambda is the wavelength of the laser.
8. Place a screen perpendicular to the beam path at a fixed position.
9. Record the intensity distribution using the beam profiler or camera.
10. Verify the Gaussian intensity profile: $I_{(r)} = I_0 \, e^{\{-2 \, r^2 w^2\}}$ where **r** is the radial distance from the beam center, **w** is the beam radius, and $I_0$ is the peak intensity.
11. Insert a convex lens into the beam path.
12. Measure the beam diameter before and after the lens to observe the focusing properties.
13. Calculate the focal point and beam parameters at focus using the lens maker's equation.

**Conclusion**

1. Verify that the beam exhibits Gaussian characteristics such as:
   - Symmetric intensity distribution.
   - Intensity decreasing exponentially with radial distance.
2. Confirm the relationship between beam waist, divergence, and wavelength.
3. Demonstrate focusing behavior, showing that the beam parameters align with Gaussian optics theory.

# Discussion

1. **What is the main objective of the experiment?**
   A) To measure laser power
   B) To study Gaussian beam properties
   C) To build a laser source
   D) To analyze diffraction patterns
   E) To measure beam polarization

2. **The fundamental mode of a Gaussian beam is known as:**
   A) TE mode
   B) TM mode
   C) TEM mode
   D) HE mode
   E) TM01 mode

3. **record the beam's intensity distribution to determine the :**
   A) The radius
   B) Wavelength
   C) beam waist ( $\mathbf{w_0}$ ).
   D) The distance
   E) divergence angle

4. **The divergence angle θ of a Gaussian beam is calculated as:**
   A) $\lambda w_0$
   B) $w_0\lambda$
   C) $\lambda\pi w_0$
   D) $\pi w_0/\lambda$
   E) $2\lambda w_0$

5. **The intensity distribution of a Gaussian beam follows which formula?**

   A) $I_{(r)} = I_0$ r^2 w^2

   B) $I_{(r)} = I_0$ e^{-2$r^2$ $w^2$}

   C) $I_{(r)} = I_0$ w^2 / r^2

   D) $I_{(r)} = I_0$ \sin^2(wr)

   E) $I_{(r)} = I_0$ e^{-r^2 / w}

6. **Which of the following tools is used to measure the beam intensity profile?**

   A) Power meter

   B) Screen

   C) Beam profiler or camera

   D) Translation stage

   E) Lens

7. **The convex lens in the Gaussian Beam ( TEM ) experiment is used to:**

   A) Align the laser beam

   B) Expand the beam size

   C) Focus the beam

   D) Measure the beam divergence

   E) Adjust the wavelength

8. **Measure beam power for intensity calculaations:**

   A) Align the beam

   B) Power Meter

   C) Focus the beam

   D) Measure beam divergence

   E) Capture intensity profiles

9. **An optional tool for Gaussian Beam Experiment :**

A) Lens

B) Micrometer

C) Beam Expander

D) Software

E) C And D

10. **The laser should emit a beam in which mode?**

A) TE
B) TM
C) TEM
D) HE
E) LP

11. **Beam diameter at various positions helps calculate:**

A) Wavelength
B) Divergence angle
C) Focal length
D) Beam waist
E) Intensity profile

12. **The beam diameter before and after the lens is measured to:**

A) focusing properties.
B) Measure divergence
C) Find the intensity profile
D) Align the optical bench
E) Test the power meter

13. **The Screen and Ruler is used to Measure :**

A) Focus the beam
B) beam size manually
C) Align the laser
D) Stabilize the setup
E) Calculate divergence

14. **The intensity of a Gaussian beam decreases exponentially with :**

A) size

B) radial distance

C) wavelength

D) beam power

E) directions

15. **A symmetric intensity distribution indicates:**

A) A diffraction beam

B) A Gaussian beam

C) A multimode beam

D) A highly divergent beam

E) An astigmatic beam

16. **Beam divergence is inversely proportional to:**

A) Beam waist size

B) Laser wavelength

C) Beam intensity

D) Beam diameter

E) Laser power

17. **the Optical Bench is used for :**

A) Lens diameter

B) alignment and stability

C) Beam power

D) Screen position

E) Laser power

18. **For precise movement along the beam propagation axis :**

A) intensity distribution

B) beam waist

C) Translation Stage

D) Gaussian profile

E) A divergent beam

19. **it used for image analysis and Gaussian fitting.**

A) lens

B) Software

C) Divergence calculations

D) Beam power

E) Translation stage

20. **it used for controlling beam size:**

A) Wavelength

B) Beam Expander

C) Focal length

D) Beam waist

E) Intensity profile