Experiment 3 Circular Aperature Diffraction 圓形邊緣繞射

Translation: J D White (Bench 6)

1. Theory (See Online Links)

2. 實驗儀器 (Laboratory instruments)

Chinese	English Name	Label
氦氖雷射(含雷射架)	Helium-neon laser (with laser frame)	HeNe
45 deg 反射鏡組	mirror group,	
光學桌(含空壓機)	optical tables (including air compressor)	
可調式光圈	adjustable aperture,	
支撐棒	support rods,	
支撐座	support base,	
	pinhole (100μm) + Holder	PH
	Single axis stage with micrometer	X-stage
	Paper Screen	SCR
	Photodiode	PD
	Objective Lens (10x)	OBJ

3. 實驗目的 (Purpose)

- To observe the diffraction pattern of a small hole and to use the information to calculate the laser wavelength
- To observe the optical phenomina associated with Fresnel Zone and Fresnel Zone Plates

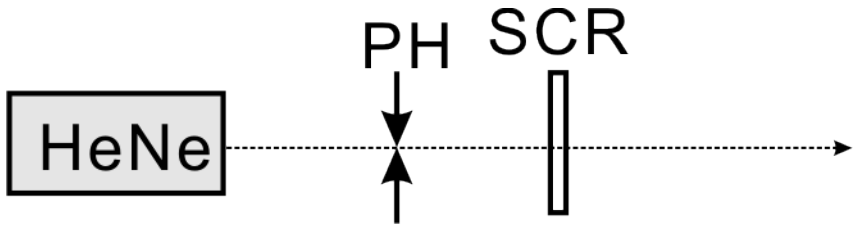
4. 實驗步驟 (Procedure)

4.1 圓孔繞射 Circular Aperture Diffraction (Farfield)

a. Collimate laser so height parallel to the optical table

b. Place Spatial filter (100 um pinhole, don't mount objective lens) in the beam path (PH).

1. Place the support rods, seat and stage on the Optical Table.
2. Place the screen on rail after spatial filter
3. Adjust the x-y position of the pinhole so that the laser beam passes through and you can



diffraction rings on the screen

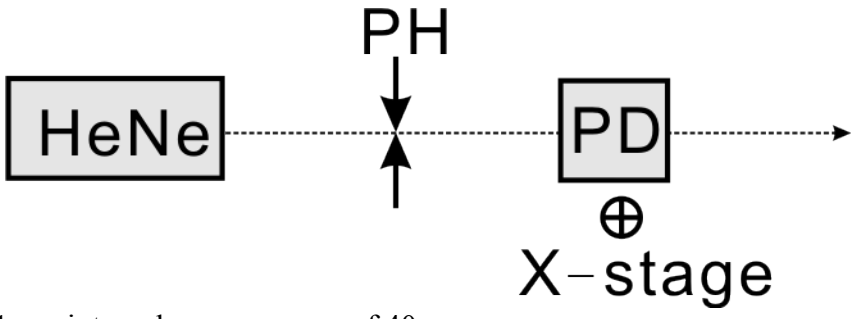
c. Taking into account the radius of the pinhole (b), the radius of the diffraction rings (y), distance between the screen and pinhole (L), the order of the Airy Fringe (m), making use of equation 6 (reproduced below), calculate the wavelength of light (λ) and its standard deviation (σ)

$$m\lambda \;=\; b\sin(\theta) \;\approx\; b\tan(\theta) \;=\; b\left(\frac{y}{L}\right) \;\rightarrow\; \lambda = \frac{b}{m}\frac{y}{L} \quad (6)$$

d. Compare your calculation results with the actual wavelength of 632.8nm.

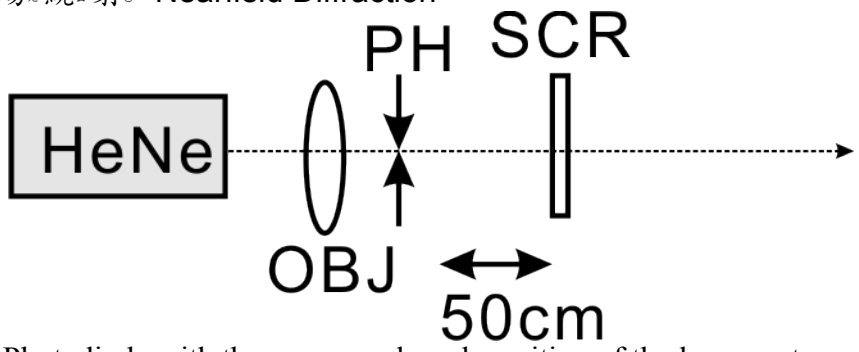
4.2 圓孔繞射強渡量測 Intensity of Diffraction into the Airy Rings

a. Replace the screen with the Photodiode mounted on the X-stage (to allow movement perpendicular to the laser beam
b. Map the intensity as a function of position (x) measured from center of diffraction pattern.



Measure in 1mm intervals over a range of 40 mm.

4.3 圓孔近場繞射 Nearfield Diffraction



a. Replace the Photodiode with the screen and mark position of the laser center on the screen. The separation between the screen and the Pinhole should be ~ 50 cm
b. Insert the 10x objective lens and the pinhole. Adjust the XY position of pinhole so the laser still hits the same point on the screen
c. Using the micrometer (z-axis), approach the objective lens to the pinhole. Observe how the pattern changes on the screen. When the distance between the objective lens is in the farfield (Fraunhofer Conditions), the center of the pattern will be a bright spot.
d. Continue to rotate the micrometer. When the conditions of the distance between the objective lens and a pinhole are in the near-field (Fresnel) conditions, the center will become a dark spot.
e. Record the positions on the micrometer when the bright spot becomes a dark spot. Do this for 5 bright/dark spot changes.
f. Use equation (5), reproduced below to calculate the size of the distance between the focal spot of the objective lens and the aperature (g)

$$\Delta g = \lambda \times \left(\frac{g}{r_o}\right)^2 \rightarrow g = r_o\sqrt{\frac{\Delta g}{\lambda}} \quad (5)$$

5. Experiment Data 實驗記錄

5.1 圓孔繞射 Circular Aperture Diffraction (Farfield): Dark Fringes

b (已知 known) [mm] =	L [mm] =

Step	m	y (mm)	λ [nm]	d_i
1	1.22			
2	1.64			
3	2.23			
4	2.68			
5	3.24			

<λ> =	<σ(λ)>=	λ=<λ>±<σ(λ)>=	e=

5.2 圓孔繞射強渡量測 Intensity of Diffraction into the Airy Rings

aperature diameter (d) =0.1mm (Measurement every 1 mm)

Location																			
Intensity																			

Location																			
Intensity																			

5.3 圓孔近場繞射 Near-field Diffraction

a. Dark Fringes: Repeat Measurement 5x

Measurement	Δg	g	<g>
1			
2			
3			
4			
5			

b. Moving the micrometer in one direction, sequentially record the positions of 5 dark fringes

Measurement	Δg	g	
1			
2			
3			
4			
5			