

Laboratory #6**Week of February 17**

- Read: pp. 475-484 and pp. 497-512, of "Optics" by Hecht
 Do: 1. Experiment VI.1: Fraunhofer diffraction by rectangular and circular apertures
 2. Experiment VI.2: Fresnel diffraction by circular apertures

Experiment VI.1: Fraunhofer diffraction by rectangular and circular apertures

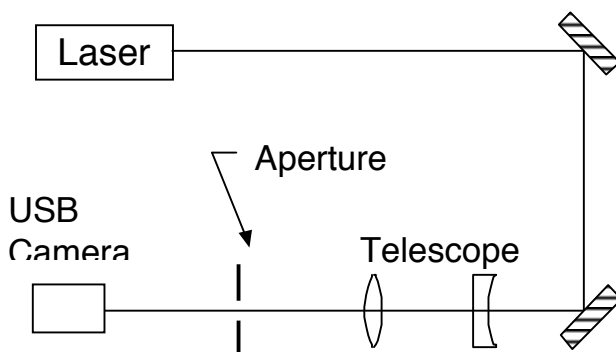
Expand the HeNe beam. Apply the beam to a small circular aperture. Observe the pattern at a distance of at least ~ 1 m from the aperture and measure the positions and intensities of the bright and dark regions (in the plane perpendicular to the beam propagation direction). Use the USB camera to take an image of the diffraction pattern and analyze the image. Compare the intensity distribution to the theoretical prediction and use it to calculate the radius of the aperture.

Repeat with a rectangular aperture.

Experiment VI.2: Fresnel diffraction by circular apertures

In this experiment you will explore the phenomenon of Fresnel diffraction from circular apertures. The schematic for this experiment is shown below. All the components in the third arm are mounted on an optical rail for ease of alignment. The telescope produces a large beam, which is needed for some of the apertures. The apertures are in a slide mount and can be held in a filter holder. You may want to use a 25-mm imaging lens to magnify the diffraction pattern (this should help when taking an image with the USB camera, though you must account for lens magnification in your image analysis).

Use one of the circular apertures to form a diffraction pattern. You should now see diffraction patterns as shown on p. 505 of Hecht. Those patterns are for apertures of different sizes, all measured at the same distance downstream. You can observe these different patterns from a single aperture size by moving your observing screen, or by moving your imaging/magnification lens. At a distance x from the aperture, the number of Fresnel zones m within the aperture (of radius R) is given by



$$m = \frac{R^2}{x\lambda},$$

assuming a plane wave input. The on-axis intensity will be nearly zero when there are an even number of Fresnel zones within the aperture. Thus, the positions of the on-axis intensity minima can be written as

$$x_n = \frac{R^2}{2n\lambda},$$

where n is an integer.

Use an aperture with a diameter of approximately 1 mm. First, verify that you can observe diffraction in the Fraunhofer regime – this is important! Use the USB camera to take images of several diffraction patterns in the Fresnel regime as you move the camera in toward the aperture. Measure the positions of each minimum and plot them versus $1/n$ to determine the aperture radius.

Equipment needed:

Item	Qty	Source (part #)
Helium-Neon Laser	1	Melles Griot 05 LHP 121
USB Camera	1	
Fresnel zone plate slide	1	
Circular and rectangular apertures	1	
Pinhole slide	1	
Optical Rail	1	Newport PRL-36
Rail carriage	5	Newport PRC-1
Mirror mount	2	Thor Labs KM1
Al mirror	2	Newport 10D10ER.1
100 mm lens	1	Newport KPX094
25 mm lens	1	Newport KPX076
-25 mm lens	1	Newport KPX043
Iris (adjustable)	2	Thor Labs ID12
Filter holder	1	Thor Labs FH2
Mounting posts	8	Thor Labs P3
Cards (for laser blocking)	limitless	
Laser block	1	
Ruler	1	