

Physics 23 Fall 2003
Lab 1 – Interference and Polarization

Introduction

In this experiment we observe interference patterns produced by light incident on two closely spaced narrow slits in an opaque screen (the Young two slit interference patterns) as a function of the width of the slits and the separation between them. The observed intensity patterns will be compared with computed intensity distributions. We also examine the effect of the state of polarization of the light on the interference of light and attempt to verify the Arago-Fresnel Laws of interference of polarized light:

1. Rays polarized orthogonally do not interfere.
2. Rays polarized identically interfere the same as unpolarized rays.
3. Rays polarized orthogonally and then repolarized in the same way do not interfere if the original source was unpolarized.
4. Rays polarized orthogonally and then repolarized in the same way do interfere if the original common source was polarized.

(Analogous Laws hold for right and left circularly polarized rays.)

Although we shall work only with light, similar two slit interference patterns would also be observed electron beams, since electrons can also exhibit wavelike behavior. It will easier to understand and to discuss the experiment by considering light as a wave. However, in your discussion you will be asked to consider your results as typical of both particle and wave interference, and will be asked to interpret your observations both ways, first by treating light as a wave, and then, by treating light as a beam of particles (photons).

References

For review:

1. Ohanian, Physics: Section pp 954-958 and 971-976
2. Tipler: pp. 1118-1120 and 11124-1126

Theory

Interference and Diffraction

When two waves of the same frequency and state of polarization overlap at some point in space, they interfere, that is, they form, at that point, a new wave whose amplitude is the sum, positive or negative, of the two waves. Consider two waves of equal amplitudes as shown in figure 1 at the top of the next page. If the waves meet in such a way that a positive maximum of one wave overlaps a positive maximum of the second wave, the new wave will have an amplitude twice that of the two interfering waves. This is called constructive interference. If a positive maximum of the first wave overlaps a negative maximum of the second wave, the amplitude of the new wave will be zero. Of course, all cases between these two extremes may also occur.

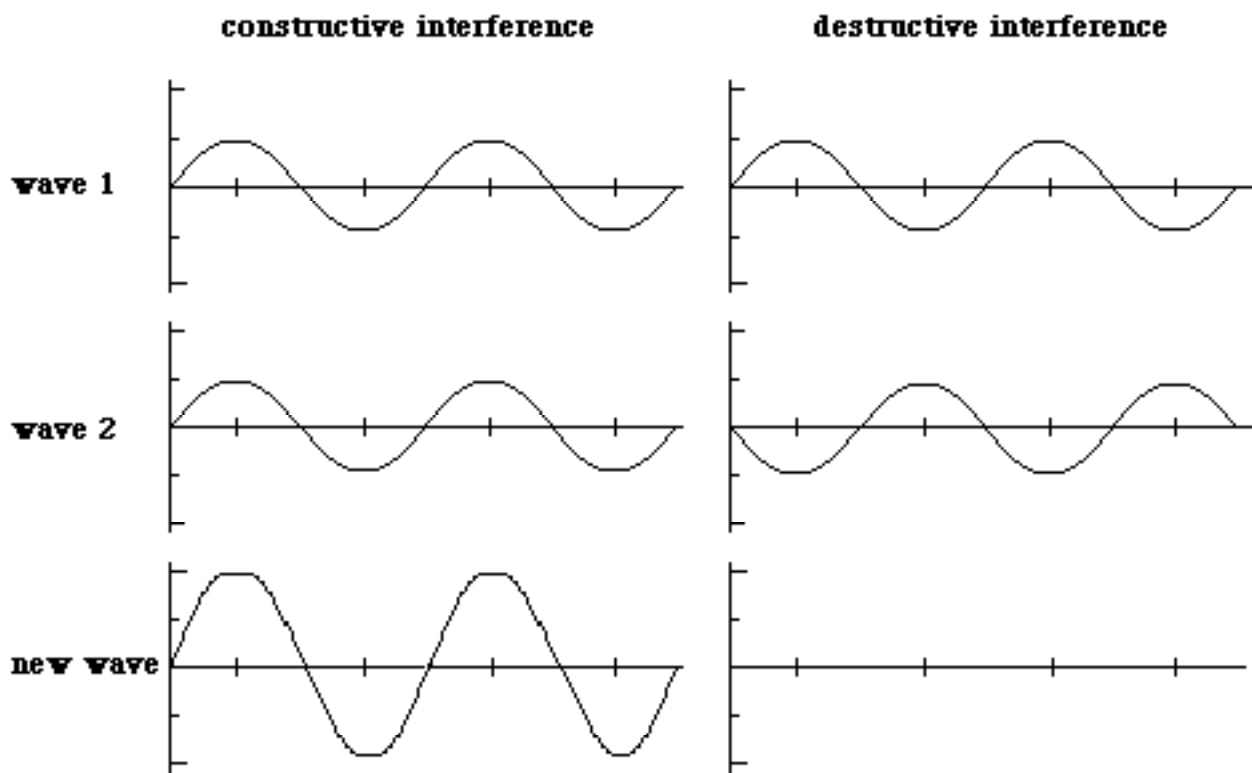


Figure 1

Now consider two infinitesimally narrow slits illuminated by a helium-neon laser as shown in figure 2. The laser light is coherent (all in phase) so that light at one slit will be in phase with the light at the other slit. From Huygen's Principle, each slit acts as a source of spherical wavelets which interfere producing regions of maximum brightness (maxima) alternating with regions of minimum brightness (nodes). This interference pattern of light waves cannot be seen in air as the pattern of water waves could be seen in a ripple tank. However, if the pattern is projected onto a screen, the alternating regions of light and dark can be observed, and the positions of the maxima and the nodes can be measured.

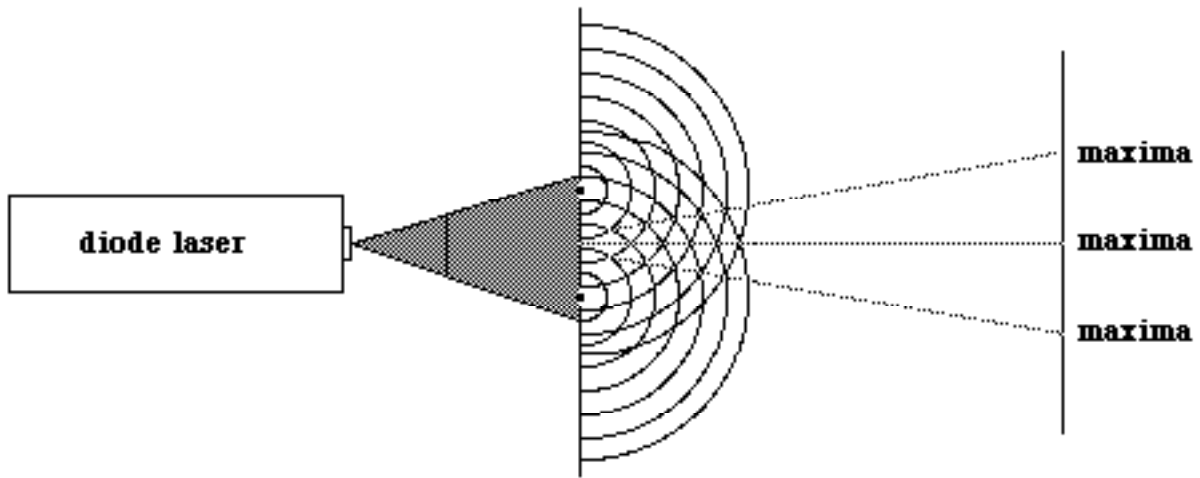


Figure 2

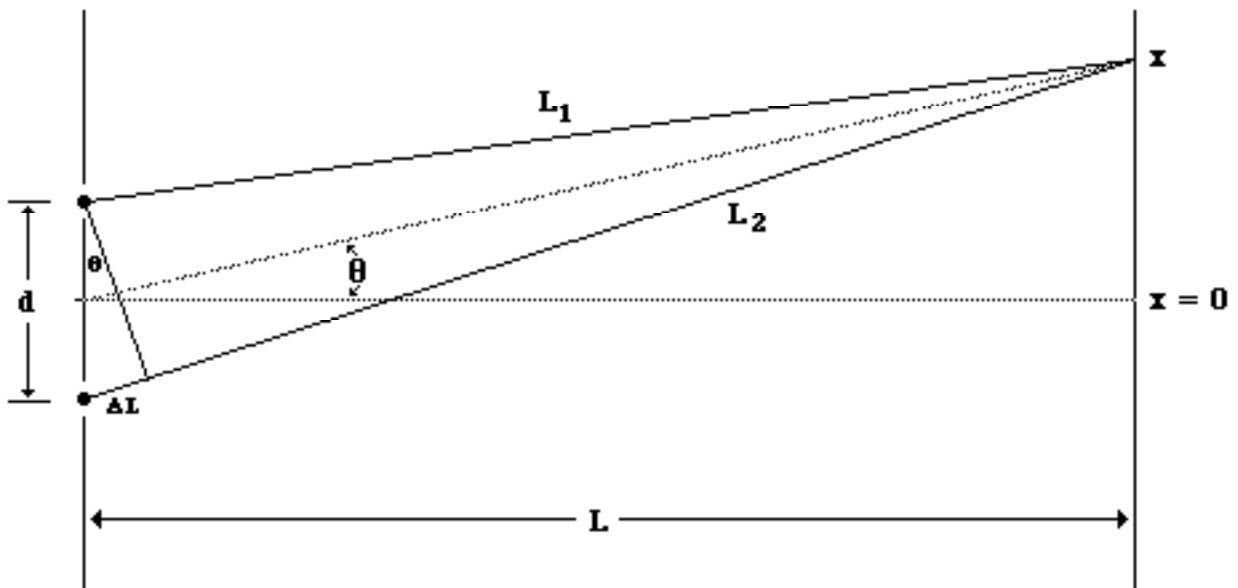


Figure 3

Let d be the slit separation and L be the distance from the slits to the screen as shown in figure 3. If $L \gg d$, then $L_1 \sim L_2 = L$ and the two angles shown are approximately equal. The path difference of the two waves at point x on the screen is $\Delta L = L_2 - L_1$. If the maxima falls on x , $\Delta L = n\lambda$ where λ is the wavelength of the light and n is an integer, positive or negative. If a node falls at x , $\Delta L = (n + 1/2)\lambda$. From the drawing $\Delta L = d \sin \theta = dx/L$. Thus, the condition for the location of a maximum on the screen is

$$n\lambda = d \sin \theta = \frac{dx}{L}$$

or

$$x = \frac{n\lambda L}{d} \quad (1)$$

where $n = 0, \pm 1, \pm 2$, etc. The central maximum corresponds to $n = 0$. The intensity of the light falling on the screen at any point x as a function of θ is given by the expression (derived in your text)

$$I_{\theta} = I_{\max} \cos^2 \theta \quad (2)$$

where I_{\max} is the maximum intensity and $\theta = (\pi d \sin \alpha) / \lambda$ is the phase angle between the light from the two slits. Thus, for two infinitesimally narrow slits, the pattern on the screen would look like that shown in figure 4.

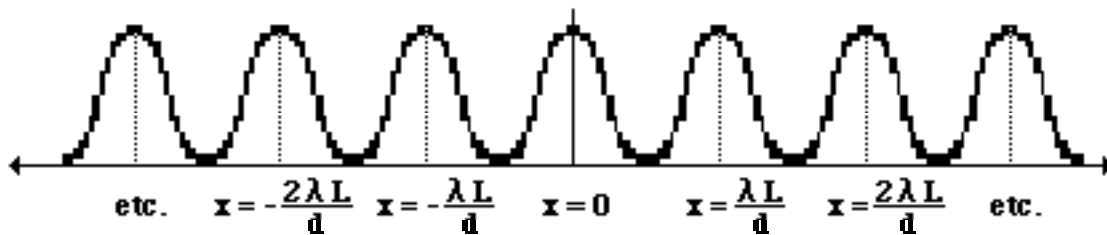


Figure 4

So far, we have only considered slits of infinitesimal widths. For such a slit, we can assume that only one point produces a spherical wavelet as shown in figure 5a. Thus, there is no interference between various points in the slit and the illumination of a screen placed in front of such a slit would be uniform. Consider now a single slit of finite width. In this case, each point in the slit is acting as a source of spherical wavelets which interfere with the wavelets from the other points as shown in figure 5b. To find the intensity pattern on the screen, we would add up the phase differences at each point. This calculation is done in your text and the result is

$$I_{\theta} = I_{\max} \left[\frac{\sin \theta}{\theta} \right]^2 \quad (3)$$

where a is the slit width and θ is the phase angle and is equal to $(\pi a \sin \alpha) / \lambda$. The space between

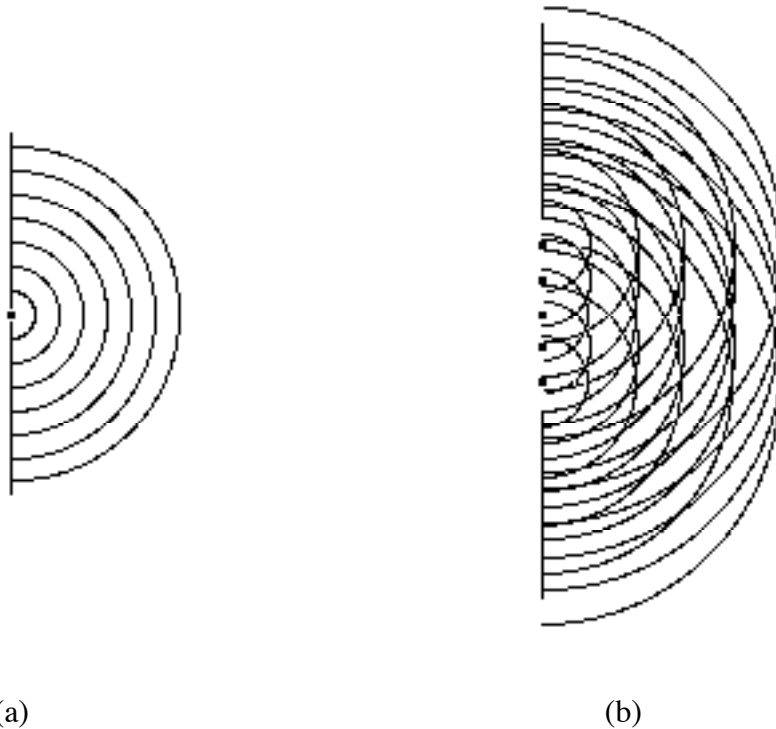


Figure 5

adjacent minima (dark bands) on either side of the central maximum is given by

$$\Delta x = \lambda$$

or

$$\Delta x = \frac{\lambda x}{L} = \frac{\lambda}{a} \quad (4)$$

One can thus use the space between the minima to find a from Δx , or vice-versa. From equation (4), it can be seen that the narrower the slit, the broader the central maximum. The patterns for a broad slit and a narrow slit are shown in figure 6. For a slit of infinitesimal width, the central maximum would be infinitely broad.



Figure 6

Now consider the effect the finite width of the slits will have on the two slit interference pattern. For slits of infinitesimal width, the diffraction maximum is infinitely broad and thus has no effect

on the height of the interference maxima. Thus, all such maxima have the the same intensity regardless of the value of n . For slits of finite width this is no longer true. The intensity pattern is modulated by the shape of the diffraction pattern as shown in figure 7.

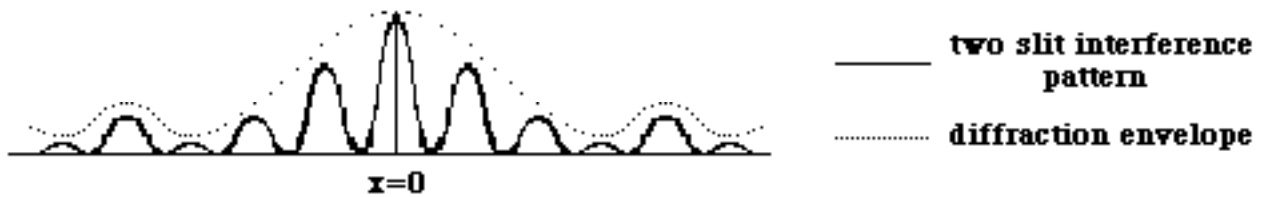


Figure 7

The interference maxima still occur at the same places, but their amplitudes are affected by the the diffraction pattern. The dotted line in the figure is called the envelope and represents the shape of the single slit diffraction pattern. In this case, the intensity as a function of θ is given by the expression

$$I_{\theta} = I_{\max} \cos^2 \theta \left[\frac{\sin \theta}{\theta} \right]^2 \quad . \quad (5)$$

Linear and Circular Polarizers

Linearly polarized light has its transverse electric field oscillating a single direction perpendicular to the direction of propagation of the beam. We can use polaroid sheet to convert natural unpolarized light into linearly polarized light, or to change the axis of linearly polarized to a different direction, or to convert circularly polarized light into linearly polarized light. In all of these operations, the polaroid sheet acts as a polarizing filter. It absorbs all of the incoming light with a component of electric field in one direction, while allowing the light with components of electric fields pointing in the perpendicular direction to pass through. That is, it acts as a differential absorber of light for light polarized in orthogonal directions.

Circularly polarized light has an electric field that rotates in the plane perpendicular to the direction of propagation, in either a clockwise or a counter clockwise sense when viewed along the direction of propagation. If you were able to take a snapshot of the instantaneous state of the beam in space at a given instant of time, the tip of the electric vector in the beam would lie on a left or right handed helix, corresponding to what is called either left or right circularly polarized light. Some substances have different indices of refraction for light linearly polarized with the electric vector along two orthogonal directions, parallel and perpendicular to the 'grain' of the material. Such 'birefringent' materials have a 'fast' axis of propagation and a 'slow' axis of propagation. The fast propagation occurs when linearly polarized light propagates with its transverse electric field along the direction of the material that has the lower index of refraction. A sheet of such a material can be chosen to have a thickness such that the fast and slow components enter the sheet in phase and

emerge exactly ninety degrees out of phase. Sheets of this thickness are called 'quarter wave plates'. Cellophane is the birefringent material we use here to convert linearly polarized light into circularly polarized light. The linearly polarized light entering the sheet is polarized at forty five degrees relative to the fast (or slow) axis of the cellophane. Thus the entering ray consists of two in phase, perpendicular electric fields. After passing through the cellophane sheet, the fast component emerges with its phase ninety degrees ahead of that of the slow component. Since two perpendicular simple harmonic oscillations ninety degrees out of phase with each other are equivalent to a single circular motion, the emerging light is circularly polarized. It will be left or right circularly polarized, depending on whether the fast axis of the plate is oriented clockwise or counter-clockwise by forty five degrees in the transverse plane relative to the direction of the electric field of the incoming linearly polarized radiation.

Using polaroid sheet we can transform circularly polarized (or in fact any) light into linearly polarized light. Using quarter wave plates we can transform linearly polarized light into either right or left circularly polarized light. These devices have many useful applications. Examples are shown in the polaroid specification sheet attached to the end of this writeup.

Experimental Purpose

In the theory section of this writeup, the following theoretical relationships were stated.

1. For diffraction from a single slit:

- a. the space between adjacent minima on either side of the central maxima is given by the expression:

$$\Delta x = \frac{L\lambda}{a}$$

where L is the distance from the slit to the viewing screen, λ is the wavelength of the light and a is the width of the slit; and

- b. the intensity of the light in the diffraction pattern as a function of the angle θ is given by the expression:

$$I_{\theta} = I_{\max} \left[\frac{\sin \beta}{\beta} \right]^2$$

___ where $\beta = (\pi a \sin \theta) / \lambda$.

2. For interference and diffraction from a double slit:

$$x = \frac{n\lambda L}{d}$$

where n is the number of the maxima, λ is the wavelength of the light, L is the distance from the slit to the viewing screen and d is the slit spacing; and

- b. the intensity of the light in the interference and diffraction pattern as a function of the angle θ is given by the expression:

$$I_{\theta} = I_{\max} \cos^2 \theta$$

where $\theta = (\lambda d \sin \theta) / \lambda$.

Procedure

Equipment: The following is a brief description of the function of the various pieces of equipment you will use in this lab.

Diode laser: This laser produces linearly polarized monochromatic light with a wavelength of 670 nanometers (6700 Å). The beam shape is rectangular (1 x 3 mm) polarized with the electric field vector perpendicular to the long axis of the beam. As mounted, the polarization is in the horizontal direction.

CAUTION: **Laser light can damage your eyes. *Never* look directly into the laser beam. Always keep your eyes on a different level than the beam.**

Slit plate: The slit plate is a glass plate coated with a black opaque substance. A series of single, double and multiple slit patterns with various slit spacings and widths have been etched in the coating on the plate. The slit spacings and widths are given in an attachment at the end of this document. The light from the laser will be passed through these slits to produce various interference and diffraction patterns. [Note: There is a slit plate holder into which this plate is placed. It consists of a vertical aluminum plate with a quarter inch slot cut into it mounted on a brass bar.]

Mirrors: These are plane mirrors mounted in a frame which allow the direction of the surface of the mirror to be adjusted. Two of these mirrors will be used to direct the path of the laser light to the plotting surface of an x-y recorder.

X-Y recorder #1: Used to provide a surface for the light from the laser to fall on and to provide a mechanism to sweep the light detecting apparatus through the interference and diffraction patterns created by the slits and polarizers.

Photoresistor: This is mounted on the movable arm of the x-y recorder #1 and is used to detect the intensity of the light which falls on the x-y recorder's plotting surface after having passed through the slits in the slit plate and whatever other polarizing materials are called for in the lab writeup. The voltage generated in the photoresistor by the received light will move the pen on the x-y recorder vertically.

Ramp generator: This produces a linearly increasing voltage which is used to drive the plotting arm of the x-y recorder (and hence the photoresistor) at a constant speed along the x axis of the plotting surface. The sweep speed and sweep width are adjustable.

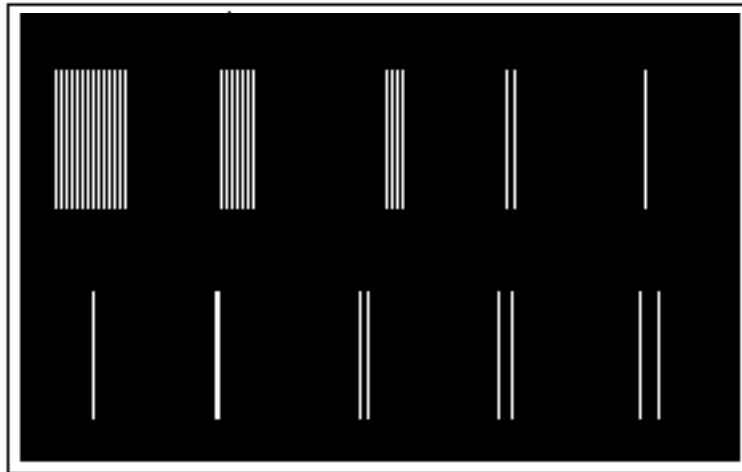
X-Y recorder #2: Used to enlarge the physical size of the plot of the light pattern received at x-y recorder #1. The actual plots will be made on this recorder.

Split linear polarizing plate: This is a plate approximately two inches square made of two pieces of linear polarizer joined together. With the joint between the two pieces oriented vertically, the polarizing axis of the left half is oriented so that the light that passes through it is polarized at a 45° angle to the left and the polarizing axis of the right half is oriented so that the light that passes through it is polarized at a 45° angle to the right. The net effect is that light emerging from the different halves have their planes of polarization perpendicular to each other and, therefore, can not interfere with each other.

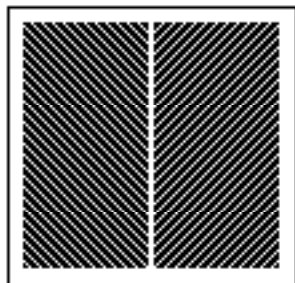
Split circularly polarizing plate: This is a plate approximately two inches square made of two pieces of circular polarizer joined together. With the joint between the two pieces oriented vertically, the fast axis of the left half is oriented so that the light that passes through it is left circularly polarized and the fast axis of the right half is oriented so that the light that passes through it is right circularly polarized. The net effect is that light emerging from the different halves are circularly polarized in opposite directions and can not interfere with each other.

Linear polarizing sheet: This is a sheet of linear polarizer mounted in a circular cardboard frame. The outside of the cardboard frame is ruled off into degrees which will allow the axis of polarization to be oriented at any angle desired to the light passing through it.

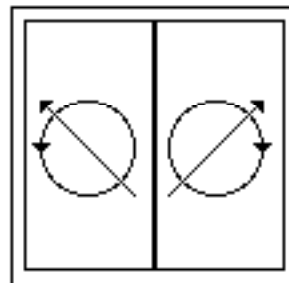
Optics Components



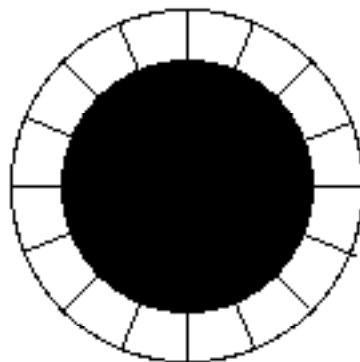
Slit Plate



Split Linearly Polarizing
Plate
(with axis of polarization shown)



Split Circularly Polarizing
Plate
(with fast axis shown)



Circular Linear Polarizing
Sheet

I. Initial Setup. In all of the following procedures, please handle all optical components by their edges.

A. Alignment of the Optical System. The objective of this procedure is to align the laser beam - mirror system so that the light from the laser travels straight down the length of the front two optical tracks, reflects off of the first mirror at a 45° angle to the second mirror, reflects off the second mirror at a 45° angle and travels straight down the rear two optical tracks in the opposite direction and strikes the plotting surface of x-y recorder #1.

1. Mount the diode laser at the far left of the left hand front optical tracks. Mount one of the mirrors at the far right of the right hand front optical tracks. Mount the second mirror at the far right of the right hand rear optical track. Lock these components in place by tightening the locking thumbscrew on the bases of the optical track mounts. Remove everything else from the optical benches. Position x-y recorder #1 so that the middle of the plotting surface aligns with the long axis of the two rear optical tracks. Remove all other mounts from the optical tracks.
2. Turn the mirror on the front track until the plane of the mirror is perpendicular to the long axis of the optical track. Turn on the diode laser and turn its holder until the light from the laser travels straight down both tracks to the first mirror. Adjust the height of the mirror so the laser beam strikes it near its midpoint.
3. Turn the mirror on the rear optical track so that the plane of its mirror is parallel to the long axis of the optical track. Turn the first mirror 45° so that light reflecting from it falls on the surface of the second mirror. Adjust the height of the second mirror so the light strikes it near its midpoint.
4. Turn the second mirror 45° so that the light reflecting from it travels straight down the rear two optical tracks and strikes the middle of the horizontal length of the plotting surface of x-y recorder #1. Adjust the tilt of the second mirror until the point of light hitting the recorder is approximately one inch down from the top of the plotting surface.
5. Using the plastic screw on the photoresistor holder, adjust the height of the photoresistor to the same height as the point of light. Turn on the line and servo switches on x-y recorder #1 and use the x-zero control to sweep the photoresistor horizontally across the plotting surface. The receiving surface of the photoresistor should pass through the point of light. If not, adjust the height of the photoresistor until it does. Using the x-zero control on the recorder, move the photoresistor to the right side of the plotting surface. Turn off the line and servo switches on x-y recorder #1.

B. Electronic Equipment Control Settings. All electrical equipment should be off at the beginning of this procedure.

1. The slit plate has two rows of slits. One row consists of a single slit and four double slits of varying slit spacings. Place the slit plate into the slit plate holder (the one mounted on the small non-adjustable optical track mount) in such a way that the middle double slit in the row just described is centered in the slit in the slit holder. Mount the slit plate in its holder several inches in front of the diode laser. Lock this mount into position using the locking thumb screw. Adjust the height of the slit plate holder so that the light from the laser falls squarely on the middle two slit pattern. You should now see a two slit interference pattern on the plotting surface of recorder #1.
2. Set the x and y RANGE control knobs to the 100 mV/in settings on x-y recorder #1. Turn on the line and servo switches recorder #1. Using the X-ZERO control, position the receiving surface of the photo resistor in the central maximum of the interference pattern. Using the Y-ZERO control position the pen approximately 1 inch from the bottom of the plotting surface.
3. Set the METER SELECTION switch on the dc power supply to VOLTS. Turn the COURSE and FINE voltage controls full counterclockwise. Turn on the power supply and adjust the COURSE voltage control until pen on the recorder rises to within 2 inches of the photoresistor holder. Turn off the power supply.
4. Using the X-ZERO control position on the recorder, position the receiving surface of the photoresistor so that it is under the 1.5 inch mark on the horizontal ruled scale at the top of the recorder. [Note: do not adjust the height of the photoresistor. You are only adjusting its horizontal position.]
5. Turn the SWEEP TIME control on the ramp generator to its full clockwise position. Turn the SWEEP WIDTH control clockwise until it just clicks on. The photoresistor should start to slowly sweep to the right. Hold down on the PUSH TO START button. The photoresistor should return to the 1.5 inch position. Releasing the PUSH TO START button should again start the sweep to the right. The sweep to the right should stop at approximately the 7 inch mark on the recorder.
6. Press the push to start button on the ramp generator and then release. The photoresistor should move past the left side of the two slit interference pattern and then sweep through the entire pattern and stop. If it does not, make the necessary adjustments to the ramp generator controls.

The remainder of this lab must be done in the dark. Turn off the lights in the room.

7. Turn on the power supply and push the PUSH TO START button on the ramp generator. As the photoresistor sweeps through the interference pattern you should see the pen rise and fall accordingly. If this does not happen, repeat these steps.
8. Make sure the LINE, SERVO, CHART and PEN switches on recorder #2 are in the OFF position. Set the X RANGE to the position between 10 and 100 mV/in. Set the Y RANGE to the 100 mV/in position. Turn the X VERNIER to the full counterclockwise position. Hold down the PUSH TO START button on the ramp generator and turn on the LINE and SERVO switches on recorder #2. While still holding down the PUSH TO START button on the ramp generator, use the X ZERO control to position pen on recorder #2 to the zero mark on the ruler at the top of the recorder. Using the Y-ZERO control, position the height of the pen at approximately the 1 inch mark on the vertical ruler on the pen arm. Release the PUSH TO START button. The pen on both recorders should slowly sweep horizontally and the pen on both recorders should rise and fall as the photoresistor moves through the light and dark portions of the interference patterns. The pen on recorder #2 will stop at approximately the 5 inch horizontal position.

Note: To expand the horizontal range of travel of the pen on recorder #2, simply adjust the X-VERNIER control to the desired range. To expand the vertical range, place the Y-RANGE control in the position between the 10 mV and 100 mV settings and adjust the Y-VERNIER control accordingly. To change the starting position of the pen, use the X and Y ZERO controls while holding down the PUSH TO START button on the ramp generator.

Both the optical and electrical components of the apparatus are now adjusted and you are ready to start to take data.

II. Single and Two Slit Interference.

A. Two Slit Pattern #1. The general procedure for making a plot of an interference or diffraction pattern is as follows:

1. Place the PEN switch on recorder #2 in the UP position and the CHART switch in the RELEASE position. Place a blank sheet of paper on the plotting surface of recorder #2 and place the CHART switch in the HOLD position.
2. Hold down the PUSH TO START button on the ramp generator and use the X and Y

ZERO controls on recorder #2 to position the pen where you want the plot to start.
Place the PEN switch in the DOWN position and release the PUSH TO START button.

3. When the pen has stopped moving, place the PEN switch in the UP position. To remove the paper, place the CHART switch in the RELEASE position.

Using this method make a plot of the two slit pattern currently in the slit holder.

- B. Two Slit Pattern #2. Reposition the slit plate in its holder so that the two slit pattern with the next wider slit spacing is positioned in the beam of the laser. Make a plot of this interference pattern.
- C. Single Slit Pattern. Reposition the slit plate in its holder so that the one single slit in the same row of slits is positioned in the beam of the laser. Make a plot of the resulting single slit diffraction pattern.

III. Linear Polarization.

- A. Reposition the slit plate in its holder so that the original two slit pattern is positioned in the beam of the laser.
- B. Located somewhere on your lab table (not on the optical tracks) is a second slit plate holder which is mounted in a large optical track mount which is adjustable in two directions, vertically and horizontally. Find this large mount and move the two post position adjustment knobs to determine which moves the post. Place the split linear polarizer plate in this second slit plate holder and position the split plate so that the joint between the two polarizer halves is vertical and centered in the slot in the vertical aluminum plate of the slit plate holder. If necessary hold the split plate firmly against the vertical aluminum plate of the slit plate holder with a rubber band.
- C. Place this large mount on the same optical bench track as the diode laser with the horizontal position adjustment knob is facing toward you. Grasp the slit plate holder and physically rotate the slit plate holder until the vertical aluminum plate is perpendicular to the long axis of the optical track and is on the side of the large adjustable optical track mount closest to the diode laser. Slide the large adjustable optical track mount toward the diode laser end of the track until the vertical aluminum plates of the two slit plate holders are approximately $1/4$ " apart. Lock the large adjustable mount into position on the optical track using the locking knob at the base of the mount.
- D. Using the horizontal post position adjustment on the large mount, adjust the horizontal

position of its slit plate holder until light from the laser passes through the slits, through the split polarizer plate and onto the recorder screen. Using the same position adjustment knob, move the split linear polarizer plate away from you (i.e. towards the rear optical tracks) until the light reaching the recorder plotting surface completely disappears. Then move the plate towards you until the two slit interference pattern just returns.

E. Using the horizontal position adjustment on the large mount, move the split linear polarizer plate toward you until the light on the recorder screen again completely disappears. During this movement note that the interference pattern changes from a two slit pattern to a single slit diffraction pattern and back to a two slit interference pattern. Explain why the pattern changes the way it does. (Hint: think about which half of the split polarizer the light from each slit passes through in each of the three areas.)

F. Using the same post position adjustment knob, move the split linear polarizer plate away from you (i.e. towards the rear optical tracks) until the light reaching the recorder plotting surface completely disappears. Then move the plate towards you until the two slit interference pattern just returns. [If possible, make the next three plots on the same sheet of paper. It will make the comparison of the patterns easier.]

1. Make a hard copy plot of this two slit interference pattern.
2. Move the split polarizing plate towards you through the single slit pattern and to the second two slit interference pattern. Make a hard copy plot of this pattern.
3. Move the split polarizing plate away from you and find the position that gives the best single slit pattern. Make a hard copy plot of this pattern.

G. Do not make any changes to the configuration of the system as in F3. The single slit pattern should still be on the recorder plotting surface. Located somewhere on your lab table (not on the optical tracks) is a wooden v-shaped lens holder in a small optical track mount. Place the linear polarizing sheet mounted in the circular cardboard in either of the slots in this lens holder with the 0° line on the outside rim at the top. Place this mount on the same optical bench track as the diode laser anywhere to the right of the split linear polarizing plate. Lock the mount in place on the optical track. Grasp the wooden lens holder and physically rotate it until the linear polarizing sheet mounted in the circular cardboard is perpendicular to the long axis of the optical track. Note that the double slit pattern returns. Slowly rotate the disk through 360° . Note that there is a pure double slit pattern at the 0° and 90° positions and a pure single slit pattern at the $\pm 45^\circ$ positions. Explain.

H. If possible, make the next three plots on the same sheet of paper. It will make the compari-

son of the patterns easier

1. Return the linear polarizing disk to the 0° position. Make a hard copy plot of this pattern.
2. Rotate the linear polarizing disk to the 90° position. Make a hard copy plot of this pattern.
3. Rotate the linear polarizing disk to the either 45° position. Make a hard copy plot of this pattern.

Compare the three plots and explain any similarities and differences you observe. Remove the linear polarizing sheet in the cardboard mount from the beam, but leave the wooden lens holder in place.

IV. Circular Polarization.

- A. Remove the split linear polarizing plate from the second slit plate holder. Place the split circular polarizer plate in this second slit plate holder and position the split plate so that the joint between the two polarizer halves is vertical and centered in the slot in the vertical aluminum plate of the slit plate holder. If necessary hold the split plate firmly against the vertical aluminum plate of the slit plate holder with a rubber band. At this point, the setup should be the same as in Part III with the exception that the split linear polarizer plate has been replaced by the split circular polarizer plate.
- B. Using the horizontal post position adjustment on the large mount, adjust the horizontal position of its slit plate holder until light from the laser passes through the slits, through the split polarizer plate and onto the recorder screen. Using the same position adjustment knob, move the split circular polarizer plate away from you (i.e. towards the rear optical tracks) until the light reaching the recorder plotting surface completely disappears. Then move the plate towards you until the two slit interference pattern just returns.
- C. Using the horizontal position adjustment on the large mount, move the split circular polarizer plate toward you until the light on the recorder screen again completely disappears. During this movement note that the interference pattern changes from a two slit pattern to a single slit diffraction pattern and back to a two slit interference pattern. Explain why the pattern changes the way it does. (Hint: think about which half of the split polarizer the light from each slit passes through in each of the three areas.)
- D. Using the same post position adjustment knob, move the split circular polarizer plate away

from you (i.e. towards the rear optical tracks) until the light reaching the recorder plotting surface completely disappears. Then move the plate towards you until the two slit interference pattern just returns. [If possible, make the next three plots on the same sheet of paper. It will make the comparison of the patterns easier.]

1. Make a hard copy plot of this two slit interference pattern.
 2. Move the split polarizing plate towards you through the single slit pattern and to the second two slit interference pattern. Make a hard copy plot of this pattern.
 3. Move the split polarizing plate away from you and find the position that gives the best single slit pattern. Make a hard copy plot of this pattern.
- E. With the split polarizing plate positioned to give the best single slit pattern, reinsert the linear polarizing sheet mounted in the circular cardboard mount back into one of the slots in the wooden lens holder. Note that the double slit pattern returns. Starting with the 0° mark at the top, slowly rotate the disk through 360° . Note that no matter what the angle of rotation, the pattern is always a double slit pattern. How is this different from what you observed when you did the same thing with the split linear polarizer in place? Also, note that the maxima in the pattern move in one direction when the disk is rotated clockwise and in the opposite direction when the disk is rotated counterclockwise. Explain.
- F. If possible, make the next three plots on the same sheet of paper. It will make the comparison of the patterns easier.
1. Rotate the linear polarizing sheet mounted in the circular cardboard until the 0° line is vertical. Make a hard copy plot of this interference pattern.
 2. Rotate the linear polarizing sheet until the 45° line is vertical. Make a hard copy plot of this pattern.
 3. Rotate the linear polarizing sheet until the 45° line on the opposite side of the 0° line is vertical. Make a hard copy plot of this pattern.

Compare these three plots and explain any similarities and differences that you observe.

This completes the labwork. Please do the following: (1) Turn off the laser and all other electronics equipment. (2) Discard any plots that you do not want and generally clean up the lab bench. (3) Put the cap back on the plotter pen.

Lab Report

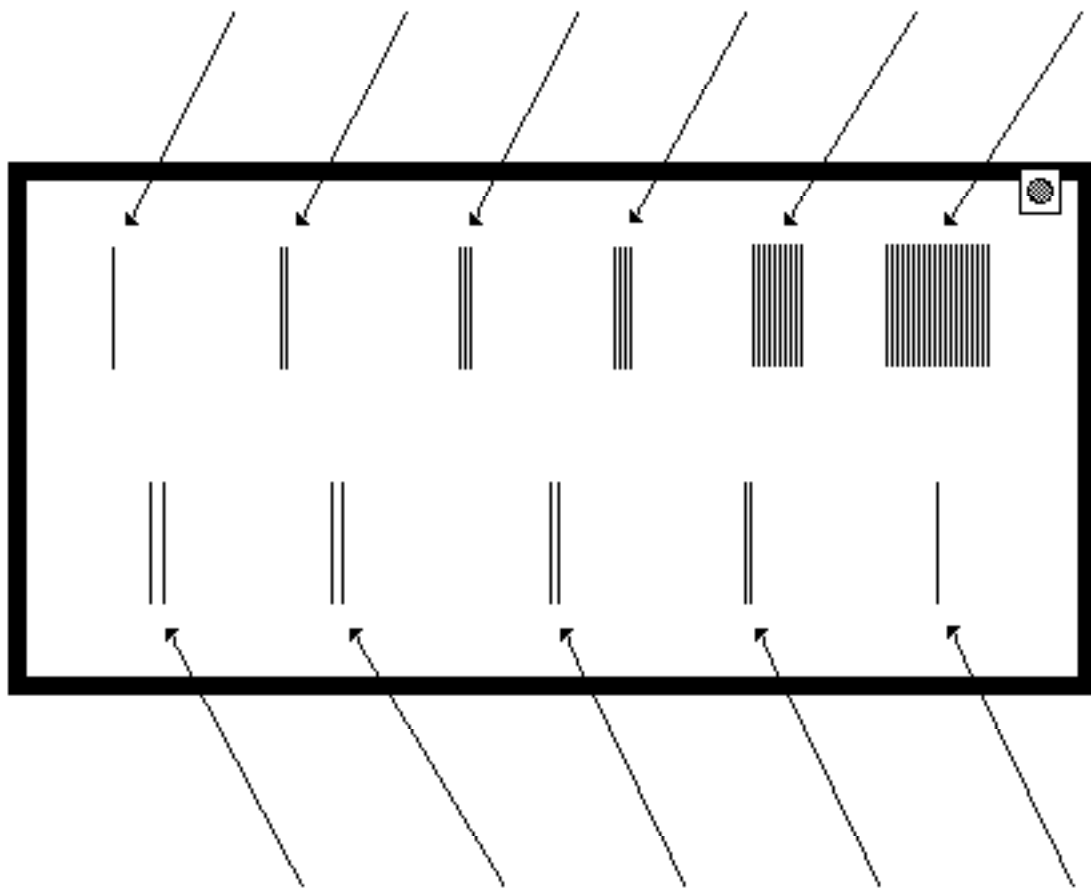
Follow the usual lab notebook format. Your lab report should include the answers to all of the questions asked in the introduction or procedure, all raw and derived data, and an estimate of the magnitude and sources of error in any data recorded. When answering any question or when giving any comparison or explanation, always refer to specific data to support your statements.

Be sure to include the following in your report:

1. copies of the intensity vs x-position plots taken in the lab clearly labeled with all of the pertinent information (slit spacing, slit width, etc.);
2. copies of the corresponding theoretical plots of intensity vs x-position for the six slit patterns which you were asked to record;
3. a comparison between the theoretical plots of intensity vs x-position and the experimental plots of intensity vs x-position for the single slit patterns; in your comparisons comment on the agreement between your experimental plots and the features of the patterns as predicted by equations (3) and (4);
4. a comparison between the theoretical plots of intensity vs x-position and the experimental plots of intensity vs x-position for the two slit patterns; in your comparisons comment on the agreement between your experimental plots and the features of the patterns as predicted by equations (1) and (2);
5. Compare your observations with the Arago-Fresnel Laws of interference of rays of polarized light for both linearly and circularly polarized light.
6. Explain the absence of interference of orthogonally polarized rays of light, considering light as a linearly (circularly) polarized transverse electromagnetic wave.
7. Explain the absence of interference of orthogonally polarized rays of light, considering light as a linearly (circularly) polarized beam of photons.

Slit Plate Dimensions

Slit Width	85	78	60	74	83	60
Slit Spacing	—	133	131	131	130	128
# of Slits	1	2	3	4	10	20



Slit Width	131	123	119	140	149
Slit Spacing	1379	688	343	171	—

All dimensions are in microns (1000 microns = 1 mm).