Fresnel's biprism and mirrors

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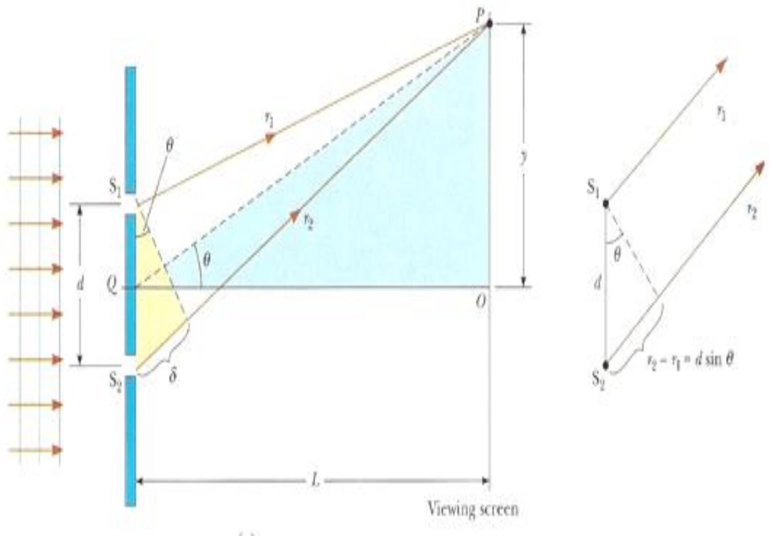
Back ground

Interference of light waves:

Interference in light waves occurs whenever two or more waves overlap at a given point . an interference pattern is observed if
1)The sources are coherent (they must maintain a constant phase with respect to each other) .
2)The sources have identical wave lengths.

Young's double slit experiment:



In Young's double slit experiment, two slits S_1 and S_2 separated by a distance d are illuminated by a single-wavelength light source .An interference pattern consisting of bright and dark fringes is observed on a viewing screen .The interference pattern is produced because the wave from the lower slit must travel further more than a wave from the upper slit by a distance $d \sin\theta$ .This distance is called the path difference δ.
The value of δ determine whether the two waves are in phase or out of phase when they arrive at an arbitrary point P .
If δ is either *zero* or some *integer* multiple of λ,then the two waves are in phase at that point and constructive interference results .Therefore the condition for bright fringes or **constructive interference** at point P is:
$\delta = d \sin\theta_{bright} = m\lambda \qquad (m = 0, = 1,2,3, \ldots, -1, -2, -3, \ldots)$
When δ is an *odd* multiple of $\lambda/2$,the two waves arriving at point P are 180^o out of phase and give rise to destructive interference .Therefore ,the condition for dark fringes, or **destructive interference**, at point P is

$$\delta = d \sin\theta_{dark} = \left(m + \frac{1}{2}\right)\lambda$$

The number m is called the **order number** of the fringe .

Fresnel's Mirrors

EQUIPMENT NEEDED

–Fresnel's biprism.

–He-Ne laser

–Screen.

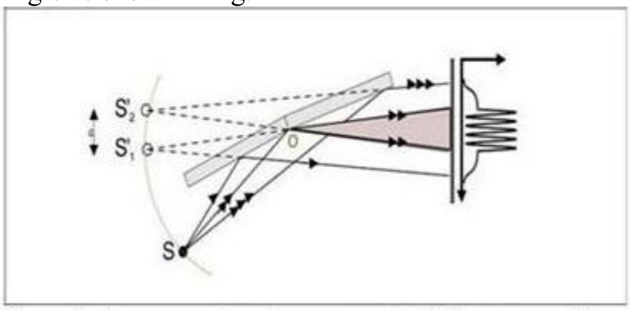
–Magnifying lenses

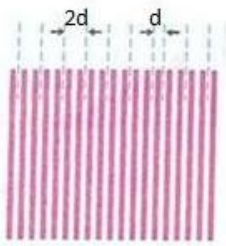
PURPOSE

Measuring the wave length of the He-Ne laser

THEORY

Fresnel Mirrors is an arrangement for obtaining two coherent sources by using the phenomenon of reflection . This gets around the problem that two separate light sources do not produce observable interference phenomena on account of their incoherence. It consists of two plane mirrors inclined to each other at a very small angle as shown in fig. 1





When light propagating from one point light source S (parallel laser beam with lens connected upstream) illuminates the mirrors surface. One portion of the light is reflected from the first mirror and another portion of the light is reflected from the second mirror. After reflection the light appears to diverge from S_1' and S_2' ,which are virtual images of S. Thus they behave as two coherent sources, placed at a distance a from each other. where S_1' and S_2' and S lie on a circle with point O as a center.

The waves diverging from S_1' and S_2' overlap and interference fringes are produced in the overlapping region on the screen . the fringes are parallel lines of equal thickness.

The condition for constructive interference is the same obtained from young's double slit experiment where the path difference between the two rays is

$$\Delta = a\ \sin\theta_{bright} = m\lambda \qquad (m = 0, = 1,2,3, \dots, -1, -2, -3, \dots)$$

In this experiment, the light source S is the same as the focal point of the lens used to broaden the laser beam. To determine the wavelength λ of the He-Ne laser light used in this experiment, we must first find the separation of the interference bands d. And the distance measured from the sources to the screen L .Where,

$$\lambda = a\frac{d}{L}$$

Then, the two virtual light sources S_1' and S_2' are imaged on the observation screen using a second lens, and the distance A of the projected images is measured. As the geometrical dimensions of the setup are known, we can use these data to determine the distance a between the virtual light sources.

PROCEDURE

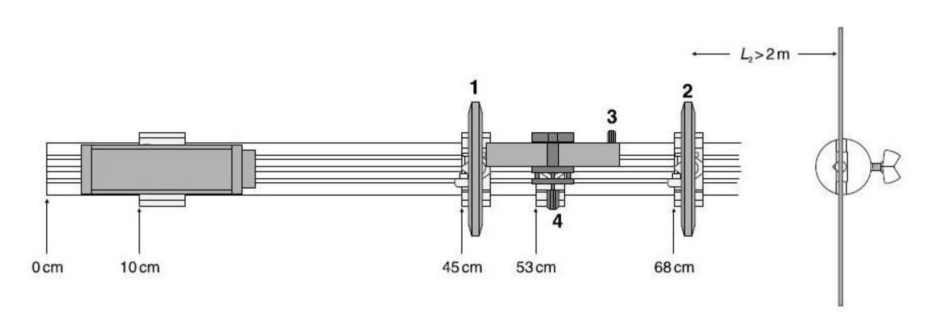
Setup

Note:

Diffraction of the laser light at the outside edge of the Fresnel's mirror can cause unwanted diffraction patterns on the observation screen, which can easily be confused with the desired interference pattern. One way to recognize them is that their position does not depend on the angle of the mirror sections to each other.

Before each measurement, change the angle of the mirror sections to each other using the knurled screw (3) and check whether the distance between the interference lines changes.

Fig. 2 shows the experiment setup. The positions of the left edge of the optics riders are given in cm.



To save time you may move to step 7 unless you are instructed by TA.

1) Attach the optics riders at the given positions on the optical bench and set up the translucent screen on the saddle base at least 2 m from the optical axis.

2) Adjust the laser and the 5 mm lens (1) on the optics riders so that the center of the broadened laser beam runs parallel to the optical bench. You may need to trace the beam path with a piece of paper.

3) Set up the 200 mm lens (2) so that the translucent screen is illuminated.

4) When mounting the Fresnel's mirror, make sure that the broadened laser beam falls on the separating edges of the two half-mirrors. Incline the mirror only very slightly, so that the laser beam just grazes the mirror and the reflected light travels virtually in parallel to the optical bench. Use the vertical adjustment with respect to the optical axis via knurled screw (4) and make sure that the reflected light falls on the center of lens (2).
5)Adjust lens (2) until both virtual light sources are sharply imaged on the translucent screen (move the rider on the optical bench if necessary).
Laser light which bypasses the Fresnel's mirror produces a third light spot on the screen to the left of the two projected images. This does not affect the experiment in any way.
6)Using knurled screw (3), set the distance A between the two projected images to about 5 mm when the screen is positioned approx. 2 m away.

a) Interference of the two virtual light sources:
7) Remove lens (2) from the optics rider.
8) Using the vernier calipers, measure the separation between 7 maxima.
9) Calculate d the separation of the interference bands
10)Repeat this 3 times and take the average.

b) Projecting the virtual light sources:
11) Insert lens (2) and readjust it as necessary to obtain a sharply focused image of the virtual light sources.
12)Measure the distance A between the two virtual sources with the vernier calipers and write this value down.
13) Read the distance L_0 between lens (2) and lens (1) from the scale of the optical bench and write this value down.
14) Using the steel tape measure, measure the distance L_2 between the projected image and lens (2), and write down this value.

ANALYSIS

1) The point-shaped light source is located in the focal point of the 5-mm lens; thus, $L_1 = L_0 - .5$ ($f = 0.5$ cm.)
2) For the distance L between the light sources and the projection screen, we can say that
   $L = L_1 + L_2$
3) Calculate the distance between the two virtual sources
   $$a = A\frac{L_1}{L_2}$$
4) Calculate the wave length of the used light
   $$\lambda = a\frac{d}{L}$$
5) Calculate the error , where $\lambda_{theo}(HeNe)$=632.8 (nm)

Fresnel's Biprism

EQUIPMENT NEEDED

–Fresnel's biprism.

–He-Ne laser.

–Screen.

–Magnifying lenses

OBJECTIVE

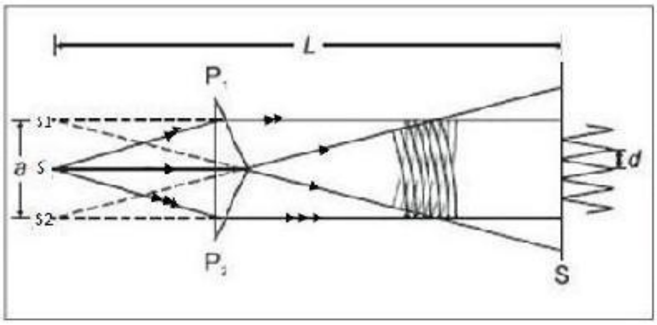
Measuring the wave length of the He-Ne laser.

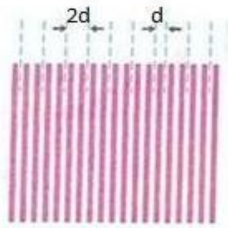
THEORY

Fresnel's biprism consist of two prisms of very small angles joined base to base. In practice , a thin glass plate is taken and one of its faces is ground and polished till a prism is formed with an obtuse angle of about 179° and two side angles of the order 30°.

When light ray is incident on an ordinary prism , the ray is bent through an angle called the angle of deviation .as a result ,the ray emerging out of the prism appear to have emanated from a virtual source S' located a small distance above the real source. A Biprism , in the same way creates two virtual sources S_1 and S_2. These two virtual sources are coherent because they are images of the same source S created by refraction .

When Light is incident on the biprism. Light passing through the lower section is refracted up, while light going into the top section is refracted down, forming a region where the beams interfere. This creates two *virtual sources* S_1 and S_2 , with an apparent separation a.





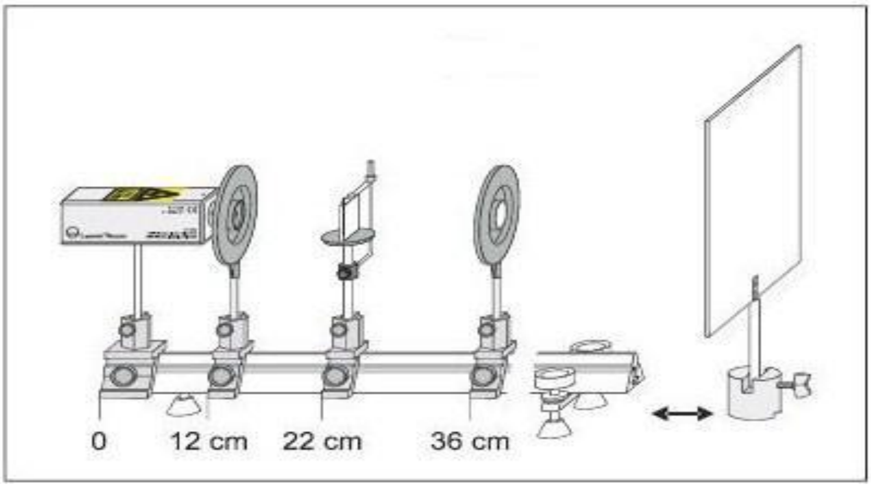
In this experiment, the light source S is the same as the focal point of the lens used to broaden the laser beam. To determine the wavelength λ of the He-Ne laser light used in this experiment, we must first find the separation of the interference bands d. And the distance measured from the sources to the screen L .Where,

$$\lambda = a\frac{d}{L}$$

Then, the two virtual light sources S_1 and S_2 are imaged on the observation screen using a second lens, and the distance A of the projected images is measured. As the geometrical dimensions of the setup are known, we can use these data to determine the distance a between the virtual light sources.

PROCEDURE

Using a rider, mount the He-Ne laser to the optical bench as shown in Fig. 4.



To save time you may move to step 7 unless you are instructed by TA.

1)Set up the screen at a distance of approx. 1.80 m from the laser.

2) Direct the laser towards the screen, connect the plug-in power supply to the laser, and switch the laser on.
3) Place the spherical lens with the focal length f = +5 mm at a distance of approx. 2 cm in front of the laser. (The laser beam is expanded by the lens and should have a beam diameter of approx. 15 cm on the screen.)
4) Put the prism table on the optical bench at a distance of approx. 15 cm from the spherical lens.
5)Fix the biprism using the adjustable spring clamp. (If necessary, readjust the height of the laser and of the spherical lens so that the laser beam passes through the centre of the biprism.)
6) The interference fringes appear vertically in the centre of the translucent screen.

a) Interference of the two virtual light sources:
7)Remove lens (2) from the optics rider.
8) Using the vernier calipers, measure the separation between 7 maxima.
9) Calculate d the separation of the interference bands .
10)Repeat this 3 times and take the average.

b) Projecting the virtual light sources:
11) Insert lens (2) and readjust it as necessary to obtain a sharply focused image of the virtual light sources.
12)Measure the distance A between the two virtual sources with the vernier calipers and write this value down.
13) Using the steel tape measure, measure the distance L_2 between the projected image and lens (2), and write down this value.

ANALYSIS

1) Using the imaging equation
$$L_1 = \frac{L_2 . f}{L_2 - f}$$
2) For the distance L between the light sources and the projection screen, we can say that
$$L = L_1 + L_2$$
3) Calculate the distance between the two virtual sources
$$\mathrm{a} = \mathrm{A}\frac{\mathrm{L}_1}{\mathrm{L}_2}$$
4) Calculate the wave length of the used light
$$\lambda = \mathrm{a}\frac{\mathrm{d}}{\mathrm{L}}$$
5) Calculate the error , where $\lambda_{theo}(HeNe)$=632.8 (nm)

Name: Date:
Computer ID: Group:

LAB 5: Fresnel's Mirrors and Biprism

Results(Fresnel's Mirrors)

1. Remove lens (2) from the optics rider and then measure the separation of the interference bands d ,Repeat this 3 times and take the average.
   $d_1 = \frac{7d}{7} =$ $d_2 =$ $d_3 =$ $d_{avg} =$
2. Insert lens (2) and then measure the distance A between the images of the two virtual sources
   $A =$
3. Measure the distance L_2 between the projected image(screen) and lens (2).
   $L_2 =$
4. Measure the distance L_0 between lens (2) and lens (1)
   $L_0 =$
5. The point-shaped light source is located in the focal point of the 5-mm lens; thus, calculate the distance between the point source and lens 2.
   $L_1 = L_0 - .5 =$
6. Calculate the distance L between the light sources and the projection screen.
   $L = L_1 + L_2 =$
7. Calculate the distance between the two virtual sources
   $a = A\frac{L_1}{L_2} =$
8. Calculate the wave length of the used light
   $\lambda = a\frac{d}{L} =$
9. Calculate the error , where $\lambda_{theo}(HeNe)$=632.8 (nm)
   error=

Results(Fresnel's Biprism)

1. Remove lens (2) from the optics rider and then measure the separation of the interference bands d ,Repeat this 3 times and take the average.
   $d_1 = \frac{7d}{7} =$ $d_2 =$ $d_3 =$ $d_{avg} =$
2. Insert lens (2) and then measure the distance A between the images of the two virtual sources
   $A =$
3. Measure the distance L_2 between the projected image(screen) and lens (2).
   $L_2 =$
4. Using the imaging equation, calculate the distance between the point source and lens 2.
   Note: $f = 20\ cm$
   $L_1 = \frac{L_2 . f}{L_2 - f} =$
5. Calculate the distance L between the light sources and the projection screen.
   $L = L_1 + L_2 =$
6. Calculate the distance between the two virtual sources
   $a = A\frac{L_1}{L_2} =$
7. Calculate the wave length of the used light
   $\lambda = a\frac{d}{L} =$
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