Physics Department
Kuwait University
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EXP. SIX
Course 127

Interference

Objective

- To produced an interference pattern using a laser beam.
- To determine the wavelength of a laser source.

Theory

Let two parallel, coherent rays of monochromatic light, be incident normally on an obstacle with two narrow slits. And let the space between them to be comparable to the wavelength of the incident beams. The two slits, acts as two coherent sources, and an interference pattern is observed on a screen (Fig. 1).

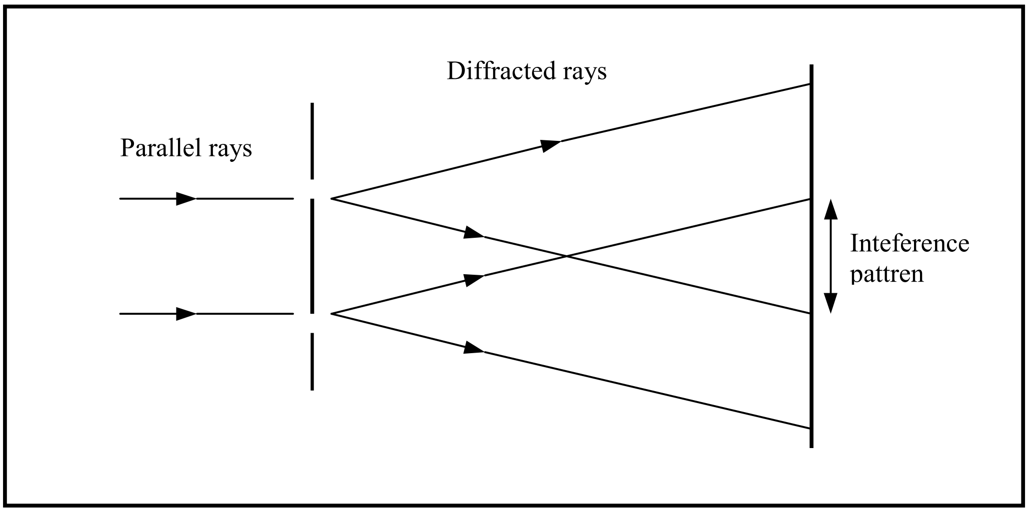

Figure 1: Interference

The interference pattern is a series of successive bright and dark fringes. The bright fringes are produced where the rays interfere constructively, and the dark ones are produced where they interfere destructively. To analyze the conditions for obtaining the bright fringes, lets examine two single rays diverging from slits *A* and *B* as shown in Fig. 2.

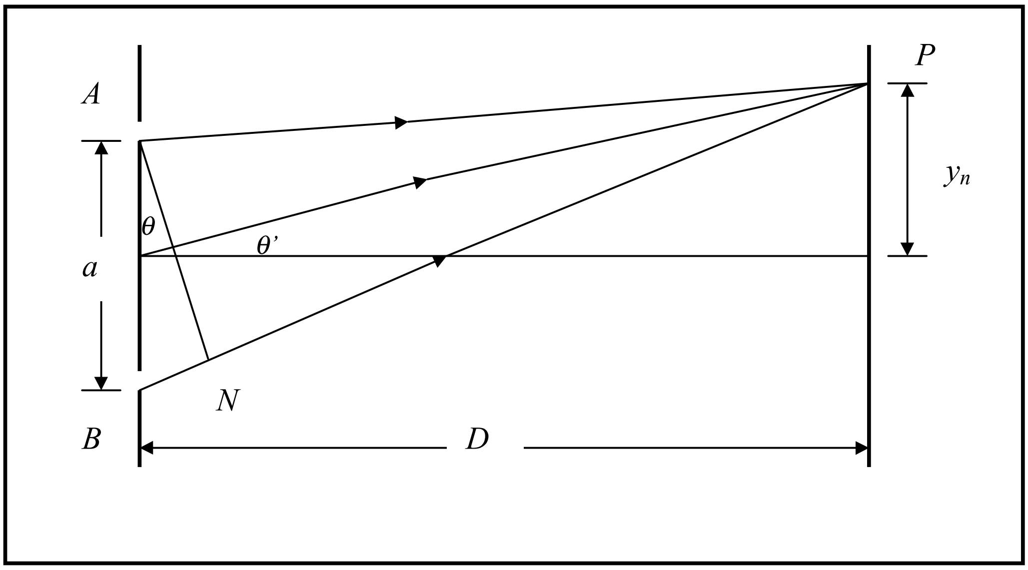

Figure 2: Single interference pattern

Suppose that *p* is the position of the n^{th} bright fringe, and let *PA=PN*. The condition to obtain a bright fringe at point *p* is that the path difference *BN* between *BP* and *AP* is

$$BN = BP\text{-}AP = n\lambda, \qquad n = 0, 1, 2, 3, \ldots \qquad (1)$$

where λ is the wavelength of the monochromatic light beam.

For D >> a, we have *AN* at right angle to *BP*. Therefore,

$$BN = n\lambda \approx a \sin\theta. \qquad (2)$$

Also, for D >> a, we have $\theta \approx \theta'$, therefore,

$$\sin\theta \approx \sin\theta' \qquad (3)$$

and since for small angles, $\sin\theta \approx \tan\theta$, using Eq.(2) one can write

$$n\lambda \approx a \tan\theta = a \frac{y_n}{D}, \qquad (4)$$

or

$$y_n \approx n \frac{\lambda D}{a}, \qquad (5)$$

and for p corresponding to n+1, Eq.(5) is written as

$$y_{n+1} \approx (n+1)\frac{\lambda D}{a}. \tag{6}$$

Now, the separation distance between two successive fringes, Δy, is

$$\Delta y = y_{n+1} - y_n \approx \frac{\lambda D}{a}. \tag{7}$$

Therefore, by changing the screen-slits distance D, and measuring Δy, a plot of Δy versus D results in a straight line where the slope represents $\frac{\lambda}{a}$.

Equipment

- Optical bench.
- Helium Neon laser.
- Double split (a=10μm).
- Graph paper with graph holder.

Procedure

1. Setup the equipment as shown in Fig. 3, and let the zero of the bench to be at the screen side.
2. Adjust the screws such that bench is horizontal.
3. Turn on the laser switch, then open output aperture.
4. Set the distance, D, between the double slit and the screen, to the 1st entry of Table I.
5. Further adjust the settings such that the laser beam falls directly at the center of the double slit in order to get the interference pattern.
6. Measure the distance between any successive bright fringes, Δy, using a ruler (or, to get more accurate results, measure the distance, L, between n number of fringes, then $\Delta y = L/(n-1)$). Record in the table.
7. Complete the table.
8. Plot a graph for Δy versus D, from which determine the slope and calculate λ.

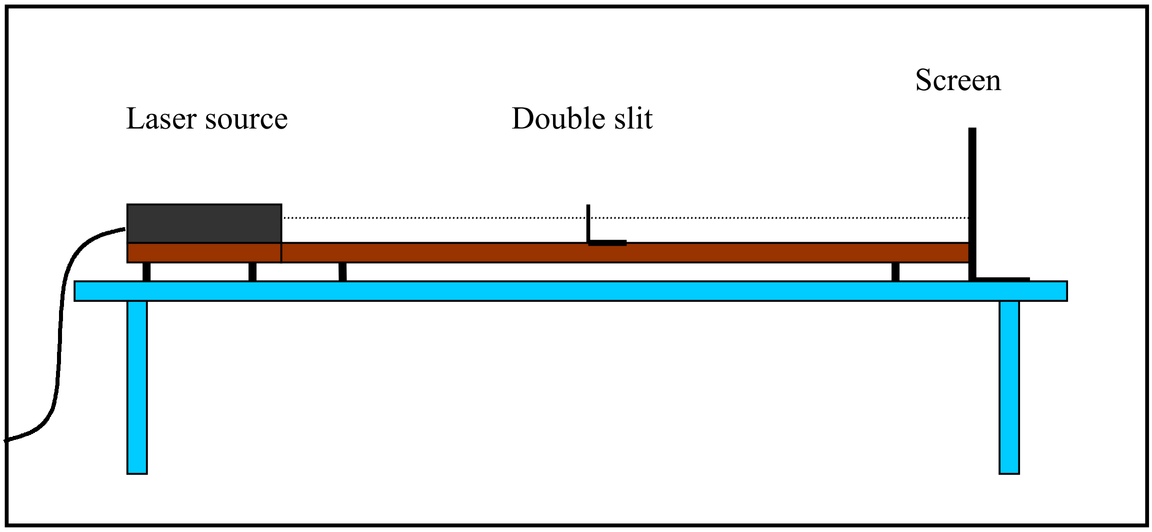

Figure 3: Interference setup

Table I

D(cm)	L(cm)	Δy(cm)	λ(µm)
40			
45			
50			
55			
60			
65			

Questions

1. Define: Interference, coherence, monochromatic light.
2. Explain, briefly, how a laser beam is produced.
3. Why does a 50 W, laser source could have a destructive effect on the eyes, whereas, similar power light bulb doesn't?
4. What is the effect of using a double slit with bigger spacing constant on the result of this experiment?