(PO2-1) Young`s Interference, Double Slit

Aim of experiment

Determination of the wavelength of a laser beam.

Apparatus

Laser Light Source– Optical Bench – White Screen – Plate with Double Slits.

Theory of experiment

When identical waves from two sources, or from a single source, overlap at a point in space, the combined wave intensity at that point can be greater or less than the intensity of either of the two waves. We call this effect *interference*. The interference can be either constructive, *figure 1-b,* when the net intensity is greater than the individual intensities, or destructive, *figure 1-c*, when the net intensity is less than the individual intensities. Whatever the interference is constructive or destructive depends on the relative phase of the two waves.

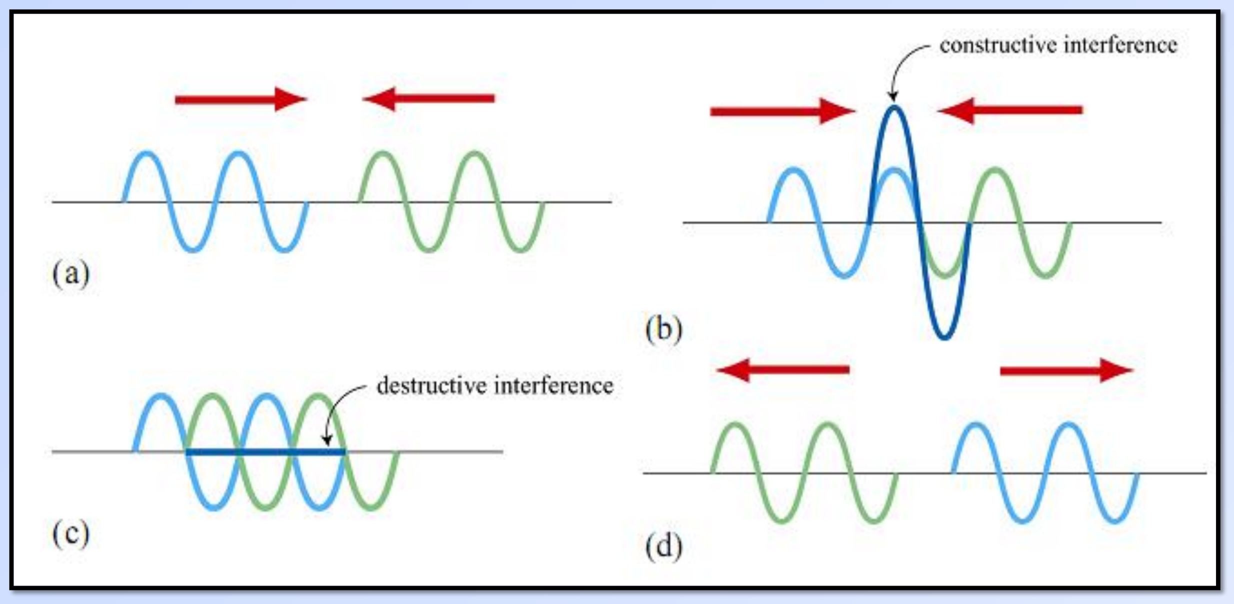

Figure 1. (a) Superposition of waves (b) Constructive interference, and (c) Destructive interference

Although any number of waves can in principle interfere, we consider here the interference of only two waves. We assume that the sources of the waves each emit at only a single wavelength.

We also assume, for the time being, that the phase relationship between the two waves doesn't change with time. Such waves are said to be *coherent*. When coherent waves interfere, the intensity of the combined wave at any point in space does not change with time.

Figure 1 shows a barrier into which two narrow parallel silts have been cut. A train of plane waves, such as might be obtained from laser source, is incident on the slits. Portions of each incident wave front pass through the slits, and so the slits can be considered as two sources of coherent light waves. To analyze the interference pattern, we consider waves from each slit that combine at an arbitrary point P on the viewing screen, *figure 1*. The point P is at distances of r_1 and r_2 from the narrow slits S_1 and S_2, respectively. The line S_1b is drawn so that the lines PS_1 and Pb have equal lengths. If slit spacing, d, is much smaller than the distance L between the slits and screen, S_1b is then almost perpendicular to both r_1 and r_2.

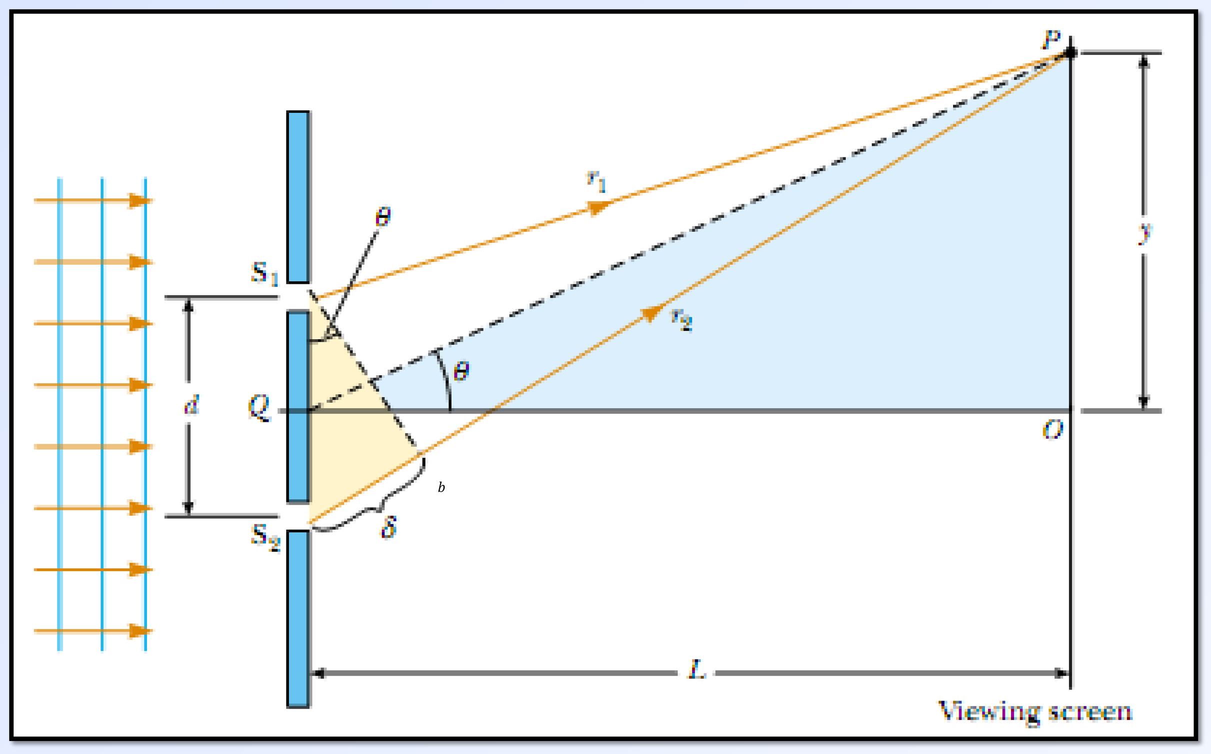

Figure 2. Geometric constructions for describing Young's double-slit experiment (not to scale).

This means that angle S_2S_1b is almost equal to angle PQO, both angles being marked θ in the figure; equivalently, the lines r_1 and r_2 may be taken as nearly parallel. From *figure 2*

$$S_2P^2=L^2 + (y - d/2)^2$$
$$S_1P^2=L^2 + (y + d/2)^2$$

By subtracting

$$(S_2P - S_1P) = yd / L$$

Since $(S_2P - S_1P) = S_1b$, the path difference, which equals $n\lambda$, in case of bright fringe. Therefore $n\lambda = yd / L$

For small angle θ the intensity distribution due to interference at double slit is given by;

$$I \approx I_{max} \cos^2\left(\frac{\pi d}{\lambda L} y\right)$$

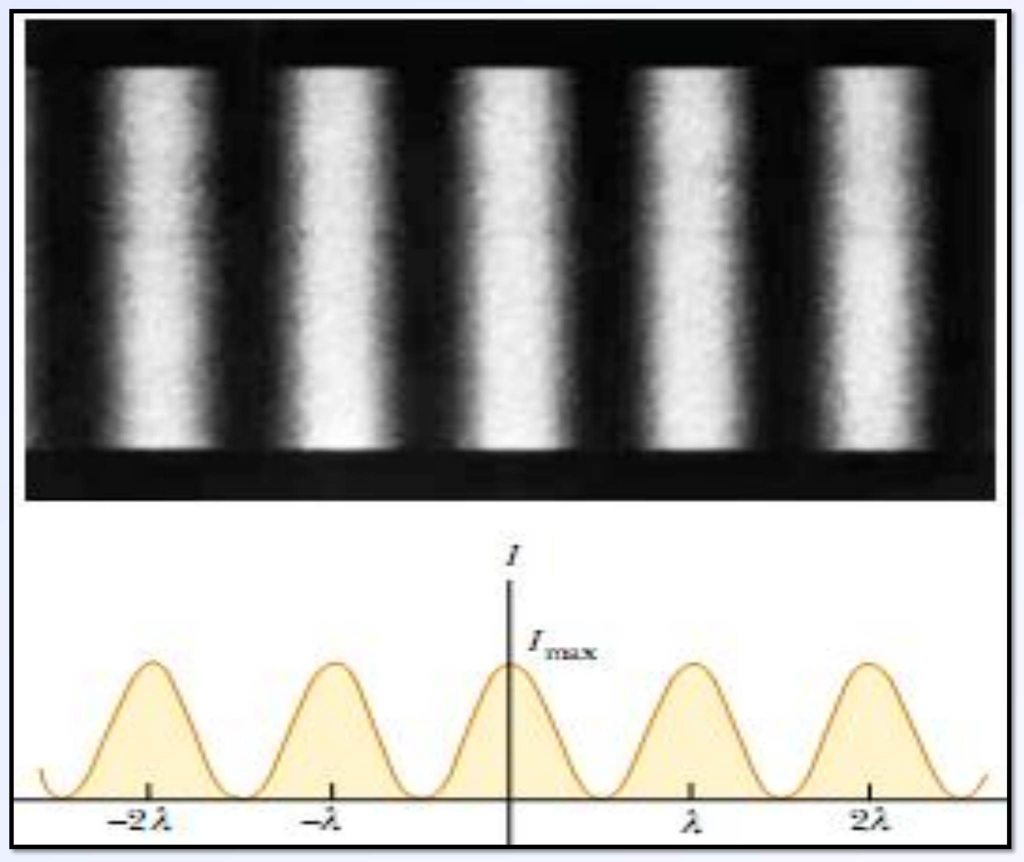

Figure 2 . Light intensity as a function of $d\ sin\theta$ for a double slit interference pattern when L>>d

The spacing between fringes β is given by:

$$\beta=y/n=\lambda L/d$$

So the space between fringes depends on

1. The distance L between the screen and two slits.
2. Wavelength of light used.
3. The distance between the two slits.

So, if the relation between the fringe width, say for 1st order constructive interference, and the distance between the slit and screen, L, one obtains a straight line of slope=λ /d, from which λ is calculated.

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Procedure

1. Turn on the source of laser beam.
2. Put the plate which has the double slit in front of laser source at distance equal about *5 cm*.
3. Put the screen behind the slit at distance $L=80$ cm.
4. Find the width β of the 1st order bright fringe
5. Repeat the above steps by varying the distance between slits and screen in steps of *10cm* until *120 cm*, and record the fringe width, β, in each case.
6. Repeat steps 4-5 for same distances two extra times and tabulate the results
7. Draw a graph between the L on x-axis and fringe width β on y-axis, a straight line is obtained from which the wavelength is given according to the relation λ = *slope x d.*

Results

Order =

d= *cm*

L (cm)					
β_1 *(cm)*					
β_2*(cm)*					
β_3*(cm)*					
β_{av} *(cm)*					

λ= cm

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