Young’s Double Slit Experiment

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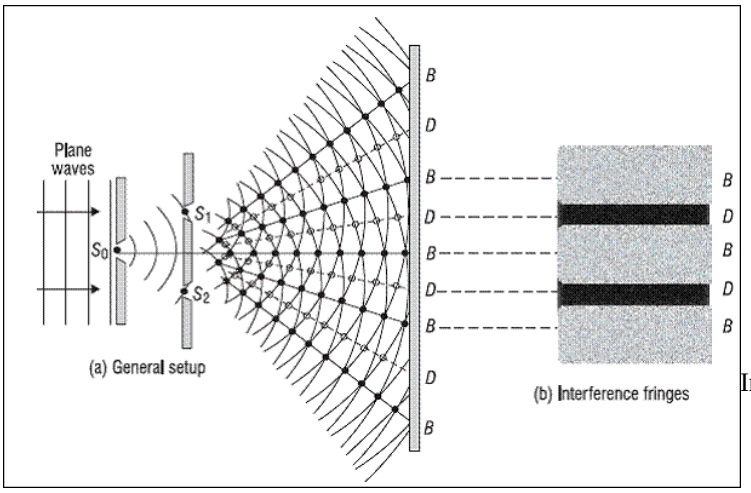
Introduction to Young’s Double Slit Experiment

Experimental arrangement

Thomas Young first demonstrated interference in light waves from two sources in 1801.



In his experiment, light is incident on a screen with a narrow slit. The light waves emerging from this slit arrive at a second screen that contains two narrow, parallel slits, S1 and S2. The narrow slits, S1 and S2, act as sources of waves. The waves emerging from the slits originate from the same wave front and are therefore always in phase.

The resulting pattern on the screen shows where constructive interference occurs (maxima, labeled B) and where destructive interference occurs (minima, labeled D). We have constructive interference if paths differ by any number of full wavelengths and destructive interference if the difference is half of awavelength.

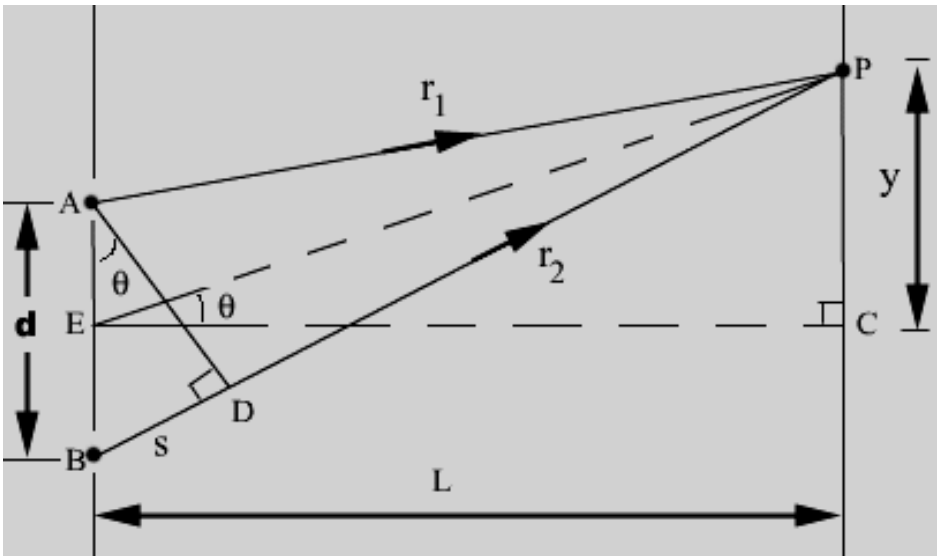
Analysis

Let the wave length of light = ?

The distance between slits A and B = d

The distance between slits and screen = L

Consider a point 'P' on the screen where the light waves coming from slits A and B interfere such that PC=y. The wave coming from A covers a distance AP=r1 and the wave coming from B covers a distance BP=r2 such that PB is greater than PA.



Description of the Analysis

Path difference = BP-AP = BD

S = r2-r1 = BD

In right angled DBAD

Sin? = BD/AB

Or

sin? = s/d

Or

S = dsin? -------(1)

Since the value of 'd' is very small compared to L, q will also be very small. In this circumstance, we can assume that :

Sin? = tan?

From (1)

S = dtan? ---(2)

In right angled DPEC

Tan??= PC/EC = y/L

Putting the value of tanq in eq. (2), w get

S = dy/L

Or

y = SL/d -----(3)

For bright fringe S = m? -----(3)

Therefore, the position of the bright fringe is:

y = m?L/d

For destructiveinterference, the path difference between the two waves is (m+1/2)l ----(3)

Therefore, the position of the dark fringe is:

y = (m+1/2)?L/d

There are two possible results of this experiment

Fringe Spacing

The distance between any two consecutive bright fringes or two consecutive dark fringes is called fringe spacing.

Fringe spacing, or the thickness of a dark fringe or a bright fringe, is equal and is denoted by ?x.

Consider a bright fringe.

y = m?L/d

For a bright fringe m=1

y1 = (1)?L/d

for the next order, the bright fringe m=2

y2 = (2) ?L/d

fringe spacing = y2 - y1

or

?x = (2)?L/d - (1)?L/d

?x =?L/d (2-1)

?x = ?L/d

A similar result can be obtained for a dark fringe.

Particle interpretation:

If light exists as particles, then the intensity of both slits will be the sum of the intensity from the individual slits.

Wave interpretation:

If light exists as waves, then the light waves will have interference under the principle of superposition, and create bands of light (constructive interference) and dark (destructive interference).

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Reference links:

- http://www.homepages.ius.edu/kforinas/W/waves/PathDiff.html
- http://www.en.wikipedia.org/wiki/Wave
- http://en.wikipedia.org/wiki/Coherence_(physics)

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