

Topics: Interference

Related Reading:

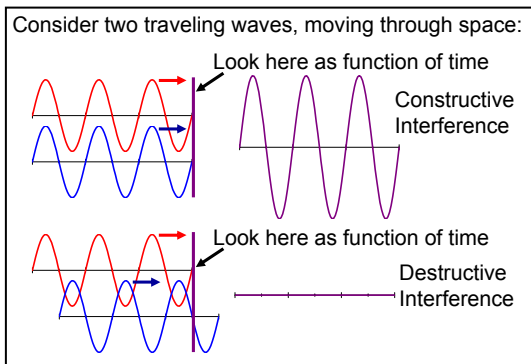
Course Notes (Liao et al.): Chapter 14
 Serway & Jewett: Chapter 37-38
 Giancoli: Chapter 32

Experiments: 13: Interference

Topic Introduction

Today we will investigate the subject of interference, both theoretically and experimentally. We not only have a fun lab – you get to play with a laser, shining it through slits and bouncing it off of CDs – but one that is also very useful in solidifying your conceptual picture of interference. Make sure that you pay attention to this latter aspect as this material will be covered on the final.

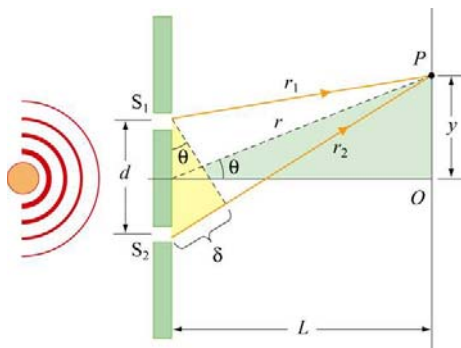
The General Picture



The picture at left forms the basis of all the phenomena we will observe today. Two different waves (red & blue) arrive at a single position in space (at the screen). If they are in phase then they add constructively and you see a bright spot. If they are out of phase then they add destructively and you see nothing (dark spot). In today’s experiments the relative phase between the incoming waves changes as a function of lateral position on the screen.

The key to creating interference is creating phase shift between two waves that are then brought together at a single position. A common way to do that is to add extra path length to one of the waves relative to the other. We will look at a variety of systems in which that happens.

Two Slit Interference



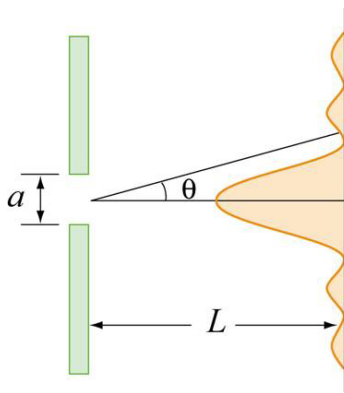
The first phenomenon we consider is two slit interference. Light from the laser hits two very narrow slits, which then act like in-phase point sources of light. In traveling from the slits to the screen, however, the light from the two slits travel different distances. In the picture at left the light from the bottom slit travels further than the light from the top slit. This extra path length introduces a phase shift between the two waves and leads to a position dependent interference pattern on the screen.

Here the extra path length is $\delta = d \sin(\theta)$, leading to a phase shift ϕ given by $\frac{\delta}{\lambda} = \frac{\phi}{2\pi}$.

Realizing that phase shifts that are multiples of 2π give us constructive interference while odd multiples of π lead to destructive interference leads to the following conditions:

Maxima: $d \sin(\theta) = m\lambda$; Minima: $d \sin(\theta) = (m \pm \frac{1}{2}) \lambda$

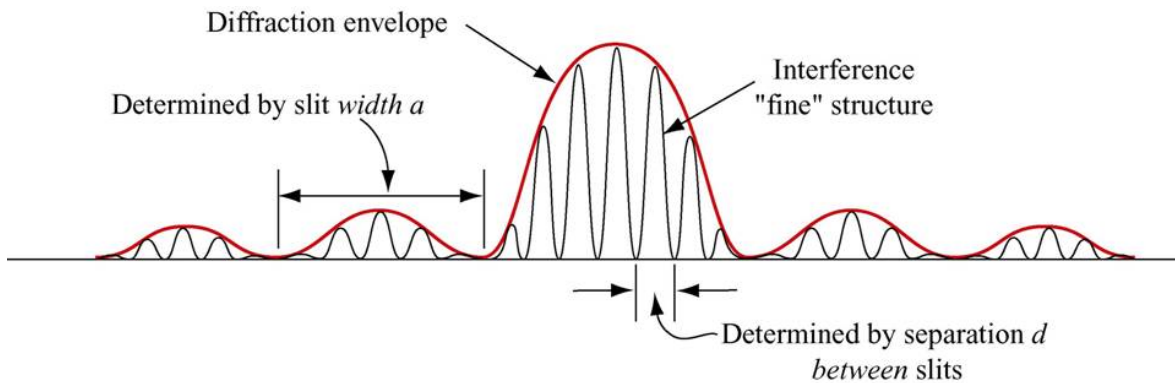
Diffraction



The next kind of interference we consider is light going through a single slit, interfering with itself. This is called diffraction, and arises from the finite width of the slit (a in the picture at left). The resultant effect is not nearly as easy to derive as that from two-slit interference (which, as you can see from above, is straight-forward). The result for the angular locations of the minima is $a \sin(\theta) = m\lambda$.

Putting it Together

If you have two wide slits, that is, slits that exhibit both diffraction and interference, the pattern observed on a distant screen is as follows:



Here the amplitude modulation (the red envelope) is set by the diffraction (the width of the slits), while the “individual wiggles” are due to the interference between the light coming from the two different slits. You know that this must be the case because d must be larger than a , and hence the minima locations, which go like $1/d$, are closer together for the two slit pattern than for the single slit pattern.

Important Equations

Interference Conditions $\frac{\Delta L}{\lambda} = \frac{\phi}{2\pi} = \begin{cases} m \text{ constructive} \\ m + \frac{1}{2} \text{ destructive} \end{cases}$

Two Slit **Maxima:** $d \sin(\theta) = m\lambda$

Single Slit (Diffraction) **Minima:** $a \sin(\theta) = m\lambda$

Experiment 13: Interference

Preparation: Read lab write-up.

The lab investigates the phenomena discussed above.