Physics 202 Lab 7
Interference of Light

May 27, 2013

Equipment

- Meter sticks
- Slit-film demonstrator plates (with white edges)
- Pen lasers
- Holographic diffraction gratings
- Vernier calipers
- 12” rulers

Young’s Experiment

In 1801, Thomas Young demonstrated the interference of light waves in the same manner that you will today, thereby showing that light acts like a wave.

In the following diagram (Figure 1), light emerges from two slits that are separated by a distance d, and an interference pattern is observed on a screen that is a distance D from the slits, where $D \gg d$. An interference pattern appears on the screen, in which the bright fringes are points in which waves from the two slits are constructively interfering, and the dark fringes are points where they are destructively interfering. This is analogous to the interference of sound from two speakers.

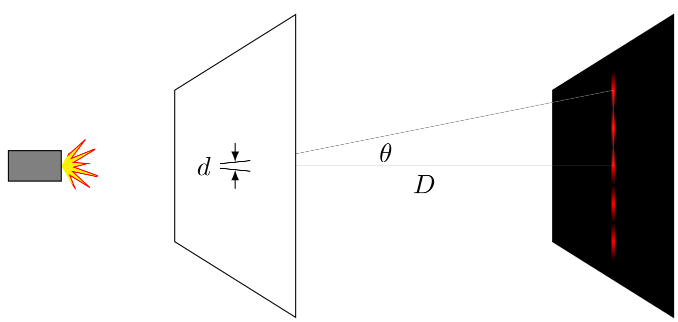

Figure 1: Double Slit Experiment

The angles at which constructive interference occurs (we call these points maxima), can be determined geometrically to be given by this equation:

$$\sin\theta = m(\lambda/d) \qquad m = 0, 1, 2, 3, \ldots$$

Hold the slit plate with the CAL monogram in the upper right hand corner. In the far right-hand column, except for the top element which is a single slit, there are several double slits of various spacings. Look through the various double slits at the clear light bulb on the counter. Comment on the spacing of the interference fringes that you see in relation to the spacing of the slits (d). Explain mathematically why this is so.

Until now, the “screen” we have been using is the retina of our eye. The same interference effects can also be observed on a screen outside of our eye. Using the pen laser (*don’t ever look directly into it*), shine the laser light through the various double slits, and observe the interference patterns on a distant wall. Record your observations with drawings and comments.

The spreading out of light passing through a small aperture or around a sharp edge is called diffraction. This is the phenomenon that made Young's double slit interference possible. Diffraction can also be observed with a single slit. The far left column of the slit plate contains single slits of varying width. Look through each of them at the clear light bulb, and comment on the patterns you observe as the slits get narrower. Which gives a more noticeable diffraction pattern, a wide or narrow slit?

Diffraction Grating

A diffraction grating is an array of a large number of parallel, evenly spaced slits. The interference pattern observed through such a grating is similar to that from a double slit (see diagram from previous part), and the equation describing the positions of the maxima is identical:

$$\sin\theta = m(\lambda/d) \qquad m = 0, 1, 2, 3, \ldots$$

where d is the spacing between the centers of the slits in the grating.

The middle column of the slit plate contains diffraction gratings of various slit spacings. Look through the central diffraction grating at the bulb placed behind two different colored filters. Comment on the spacing of the interference fringes that you see in relation to the wavelength of the light (λ). Explain mathematically why this is so.

Using the holographic diffraction grating slide (please don't touch the surface) and the laser, observe the interference pattern on a wall several feet from the slide. This diffraction grating has 750 slits per mm. What would be its slit spacing, d?

Now, carefully measure the distance between two of the maxima on the wall and the distance from the slide to the wall. Use these two measurements to calculate θ (refer to Figure 1), and then using the above equation, solve for the wavelength, λ, of the laser light. Check with me when you have finished this calculation.

Now that you know the wavelength of the laser light, use this value and a method similar to what you just did, to solve for the slit spacings of two different diffraction gratings on the slit plate.

Poor Man's Single Slit

Use the Vernier calipers to make the smallest slit that you can measure on the calipers. Point the laser beam through the slit. Can you see a diffraction pattern on the wall?

Confirm that the pattern matches the diffraction equation for $m = 1$ (the first fringe from the center).

$$\sin\theta = m(\lambda/W) \qquad m = 1, 2, 3, \ldots$$

where W is the width of the slit.