Wave Interference
Physics 247

Introduction: In class we talked about the wave-like nature of light and utility of using an interference pattern in the Michelson-Morley experiment to detect the aether (the invisible medium that would propagate electromagnetic waves, light). In 248 we will employ the two-slit interference apparatus to conduct a single photon (quanta of light) interference experiment. Today we simply want you to more fully appreciate the double-slit interference pattern.

The apparatus consists of a U channel a little over a meter in length with a light-tight removable cover. At one end are two light sources. A laser (with a 633 nm wavelength) is used to produce an intense, nearly classical light wave. There is also a low-intensity light bulb covered by a filter that lets only a narrow range of green light through (not used today). At the other end of the U channel is a light intensity detection system which contains both a photodiode (for detecting the red laser light) and, behind it, a photomultiplier tube (not used today). In between are a series of slits that will be used to produce the interference patterns.

The basic idea of the experiment is that light from the laser first passes through the single slit and then travels to the double slit where it can pass through either one of the two slits. The first slit causes the laser beam to "diverge" (i.e., spread out) and uniformly illuminate the second slit. Each slit of the double slit will individually produce a single-slit diffraction pattern (just like the first slit) but, if light can pass through both slits then you will see an interference pattern analogous to that formed when dropping a stone in a pool of water.

After the two-slit interference pattern is formed this light can fall onto a single, large area photodiode (a light detector). A thin, single slit is placed in front of the detector, thus only allowing light from one part of the pattern to hit the detector. Along the way, the slit blocker can be used to block one or both of the slits if desired, thus changing the two-slit interference pattern into a single-slit diffraction pattern (on none at all).

The plan of today's experiment is this. We will align the red laser to form an optimized double-slit diffraction pattern at the photodiode.
Procedure:
1. Make sure the photodiode is in the proper position. This is achieved by having shutter is the fully down position. The photodiode is built into the shutter. Have the shutter down also protects the sensitive optical components in the detector housing.
2. Remove all optical components (e.g. single and double slits).
3. Locate the laser switch and turn it on. Align the laser beam (there are three adjustment screws) so that it travel center in the channel.
4. Using the magnetic rod or you fingers insert a single slit at the single slit position. You should place the image screen in front of the detector slit (by the photodiode).
5. Remove the image screen and place a second single slit at the "Detector slit" position.
6. Using the micrometer sweep the 2nd single slit horizontal and record the position and the light intensity (voltage at the digital multimeter) with cover on. Plot you result. This is single slit diffraction.
7. Now insert a double slit (of your choice) in the "Double slit" position. Rotate the double slit if necessary to make the interference pattern vertical. Now move the slit blocker to block the individual slits. Note the micrometer readings for both slits blocked, only left slit open, both slits open, and only right slit open. The interference fringes should disappear when either slit is blocked. Do you observe this?
8. Now repeat step 6 with the double slit in place and plot your results.
9. If time permits repeat step 8 with another double slit. Question: If the slits are further apart how does the interference pattern change?

SAFETY NOTE: In the detector housing there is a photomultiplier tube. The photomultiplier is an extremely sensitive detector for light. It must never be exposed to anything other than the filtered light bulb source, and then only with the cover on the apparatus. At the top of the detector module is a shutter. With the cover on and the light sources off, you can open (pull up) and close (push down) the shutter. When the shutter is down, the photodiode is in place and can detect the laser light. It is much less sensitive than the photomultiplier tube and can only be damaged willfully.