INTRODUCTION

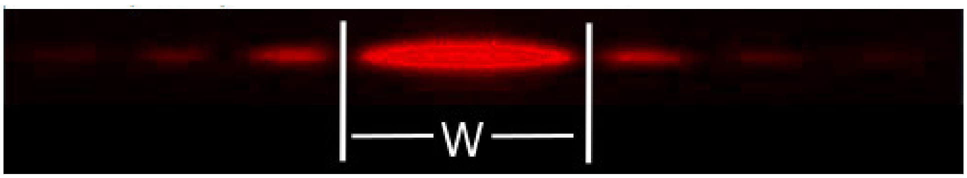
The phenomenon of *diffraction* is a wave effect of light that causes the light to bend when passing a sharp edge. It can be seen if light passes through a very narrow slit. Instead of traveling in straight lines through a narrow slit, light “bends” through the slit and spreads out much wider than the slit and it interferes with itself.

There is a slide with four slits in it of width 0.02, 0.04, 0.08, 0.16 mm. You can see interference if you hold the slide next to your eye and look through it at a small spot of light. Go ahead and try this and record what you see.

Now turn on your laser and place the slide with single slits in the beam and look at the results on a screen. Record below qualitatively what you see when you compare the different width slits.

I. LASER LIGHT THROUGH A SINGLE NARROW SLIT

The goal is to measure the wavelength of different lasers using the diffraction through a slit. You should see a pattern something like the image below. The width of the central spot is *W*. Note that it is measured from the middles of the dark bands on either side of the spot.



The width *W* of the central spot in a far-field diffraction pattern by a single slit is related to the width *b* of the slit, the distance *L* to the screen, and the wavelength λ of the light by

$$\lambda = \frac{2L}{W \cdot b}$$

Use this to measure the wavelength of the red diode laser. Use each of the four slits. You may (should) change the distance to the screen for each slit to give you the best accuracy. Estimate the uncertainty of each parameter. Then calculate relative uncertainty of the wavelength using

$$\frac{\Delta\lambda}{\lambda} = \sqrt{\left(\frac{\Delta W}{W}\right)^2 + \left(\frac{\Delta L}{L}\right)^2 + \left(\frac{\Delta b}{b}\right)^2}$$

Finally calculate the wavelength with uncertainty. You should end up with four measurements of the diode wavelength, each with uncertainty.

Combining Multiple Measurements

If you have multiple measurements of the same quantity, x_i, and each measurement has its own uncertainty, σ_i , then assuming the distribution is Gaussian, the best results is

$\bar{x} = \sigma_{\bar{x}}^2 \sum \frac{x_i}{\sigma_i^2}$ where the uncertainty is $\sigma_{\bar{x}} = \sqrt{\frac{1}{\sum \frac{1}{\sigma_i^2}}}$. Use these formulas to calculate a final result.

II. MEASURE LASER WAVELENGTHS

In this section you will measure the wavelength of other lasers, a Helium-Neon (HeNe) laser, a green diode laser and a violet diode laser. For each one use all four slits and combine your measurement into one best value.

HeNe laser:

Green Diode Laser:

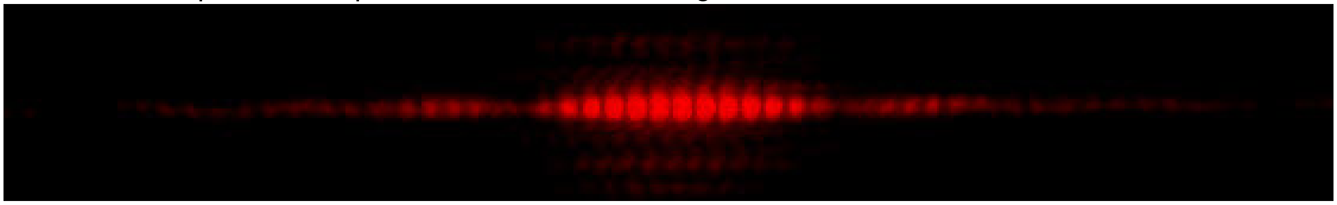
Violet Diode Laser

III. MEASURING A HUMAN HAIR

It may not make much sense, but there is a theorem about waves that claims that a *solid* object on a transparent background makes the same diffraction pattern as a *transparent* hole in an opaque background. An example of this is that a hair makes the same diffraction pattern as a slit. (However the direct laser beam does shine through.) Use this result to measure the diameter of a human hair with uncertainty.

IV. TASK – DIFFRACTION PATTERN OF MULTIPLE SLITS

The diffraction pattern of a pair of slits looks like the figure below.



The diffraction pattern of two slits distance *d* apart is

$$W=\frac{\lambda \cdot L}{d}$$

where *L*is the distance to the screen, *λ* is the wavelength, and *W* is the distance between dark bands. Note that unlike the single slit pattern, all of the bright bands have the same width.

There is a slide with four double slit patterns. The complication is that the diffraction pattern is the pattern of one slit ***multiplied*** by the pattern of a double slit. You will see two patterns superimposed on each other. Your task is to figure out which pattern is due to the width of each slit, and which is because there are two slits.

For just one pattern, you need to measure the distance, including uncertainty, between the slits based on measurements you take. Then compare it to the values on the slide.