Experiment 4: Interference & Polarization

You may do the three parts in any order. If you see that the Part 3 apparatus is free, drop what you're doing, take care of that, and then get out of the next group's way.

Part 1. Single Slit Diffraction.

CAUTION: THE LASER CAN DAMAGE YOUR EYES IF IT ENTERS THEM. Its intensity is similar to looking at the sun.

You will check whether the equation for single slit interference is obeyed as light passes between the jaws of a dial caliper. You do this by shining a laser through the slit and measuring the interference pattern on the wall beyond.

The dial on the caliper reads in thousandths of an inch. Set it for 5. $(.005 \text{ inch} = 127 \text{ }\mu\text{m}.)$ The instructor has a feeler gauge which makes this easier. Mount the caliper in a clamp on a ring stand. You might need to put a folded paper towel in the clamp for it to hold the caliper tightly.

The wall should be one to two meters from one side of the caliper and the laser should be a foot or two from the other. Adjust the height so the beam hits the jaws near their tips where they are thin. A vertical strip of light reflects off the caliper. To have the caliper normal to the beam, this strip of light should go



across the laser's aperture. Put a piece of scrap paper on the wall under the diffraction pattern. Mark the center and as many dark areas as you can reliably see. Don't guess at less distinct ones. Measure across the pattern and divide by 2 to get y, the distance from the center to the farthest minimum. Also record m, the order number, for this minimum.

Calculate θ from y and the distance from the slit to the screen, x. (Not from $m\lambda = a \sin\theta$, the thing you're trying to verify.) Calculate a sin θ . Calculate $m\lambda$. For the laser light, $\lambda = 632.8$ nm. Assume 10% uncertainty in a sin θ and negligible uncertainty in $m\lambda$.

As your conclusion, state whether a sin θ agrees with m λ .

Part 2. Polarization.

You will verify Brewster's law.

Your apparatus is a laser and a plastic semicircle with protractors attached. To tell when the plastic reflects only horizontally polarized light, you will shine light on it which is polarized vertically. This will make the reflected beam disappear when you turn the plastic to the angle for complete polarization. To polarize the incoming light, you will use a polarizing disk, which only transmits light whose E vector is vibrating in one particular direction called its transmission axis.

Attach the semicircle to a ring stand with a clamp. Leave the clamp loose enough to turn the

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semicircle to different angles, but tight enough that it will stay when you let go.

Align the laser with the protractor: For a coarse adjustment, move the clamp up or down the pole until the beam hits by the mark at the center of the protractor. Then, for a fine adjustment, adjust the screws under the laser to tilt it until the law of reflection works. (If the incoming beam is on the 45° mark, the reflected beam should be on the 45° mark. To observe these, you can move the ring stand toward or away from you to make the beam hit the numbers on the protractor. Do not change its distance from the laser, or it may affect the aim of the beam.)

Turn the plastic so that the beam is reflected down onto some paper on the counter. Mount the polarizer in a clamp on another ring stand, or someone could hold it. Place it in the beam between the laser and the plastic semicircle. Rotate the polarizer until you find the position which makes the spot on the counter the faintest. This might be easiest if you darken the room.

Rotate the semicircle until the spot on the screen vanishes, indicating that the reflected beam is completely polarized. Record the angle of reflection, estimating a reasonable uncertainty. Remember to subtract the reading from 90° to get the angle from a normal.

The refractive index of this plastic is about 1.50. (You will measure this yourself in a later experiment.) Use this to calculate the angle at which you would expect complete polarization. In your conclusion, compare the measured and calculated values.

Part three. Michelson Interferometer.

Be careful not to bump the laser or interferometer - it takes time to get them realigned.

You will use an interferometer to measure a neon laser's wavelength. The beam hits a beam splitter; a partially silvered mirror which reflects part of it toward a stationary mirror, and transmits part toward a movable mirror. Both beams are reflected back to the splitter, which sends part of each to the viewing screen. Interference between these beams forms bright and dark fringes there. (Different path differences to different points on the screen cause different kinds of



interference.) If the movable mirror moves half a wavelength, the round trip distance for that beam changes by a whole wavelength, moving the pattern on the screen over by one fringe. Counting how many fringes the pattern moves tells you how many half-wavelengths the mirror moves. The knob you turn to move the mirror tells you the same distance in μ m, giving you how many μ m in a wave.

(This sensitivity to just a fraction of a wavelength makes an interferometer one of the most sensitive distance measuring devices known. It is also the apparatus used for the Michelson-Morley experiment, which helped lay the foundations of Special Relativity.)

(You will not notice the movable mirror moving when you turn the dial, because it goes so slowly.)

PROCEDURE: Each division on the micrometer dial means the mirror moved 1 μ m. Get it right on 0 to start with, then turn the dial until 25 fringes have gone by some reference point on the screen. Record the final dial reading, estimating to the nearest 1/10 of a division.

Pick up where you left off, and count another 25 fringes. If you don't get about the same difference, something is wrong. Do another 25, then another, for a total of 100 fringes. Your final reading is the only one you will actually use.

As explained above, every time one fringe goes by, it means the mirror moved by $1/2 \lambda$. So, if 100 fringes went by, the mirror moved 50 λ . So, the number of micrometers you measured equals 50 λ . Solve for λ .

Determine an uncertainty in your wavelength by assuming the number of μm you measured might be off by half a division. (A more patient person could make the percent uncertainty as small as they wanted by just counting more fringes.)

As usual, your discussion should include a brief explanation of how the interferometer works. For your conclusion, comment on how well your value compares to 632.8 nm, the accepted value for this type of laser.

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<u>Part 1.</u>			
y =	dist. to screen =		
m =			
Calculate θ :			
$a \sin \theta = $	$m\lambda =$		
<u>Part 2.</u>			
Measured $\theta =$			
Calculate θ :			

<u>Part 3.</u>

Trial	Initial	Final	Calculate λ :
<u>#1</u>			
#2			
<u>#3</u>			
<u>#4</u>			