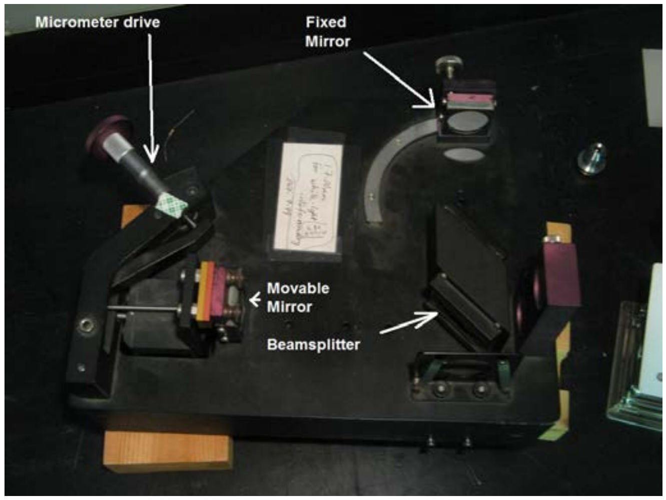
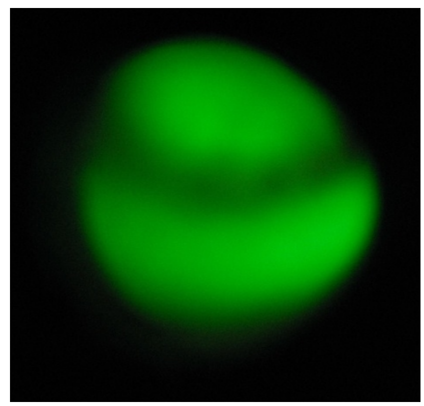
THE MICHELSON INTERFEROMETER

BACKGROUND RESEARCH
Read about the Michelson-Morley experiment. Find an equation that relates the [classically] predicted phase shift to the parameters of the interferometer. A good place to start to look for this information would be your textbook and other textbooks. I will expect you to do this step in the future before the week's lab.



EXPERIMENT #1: GREEN- AND WHITE-LIGHT MICHELSON INTERFERENCE PATTERNS

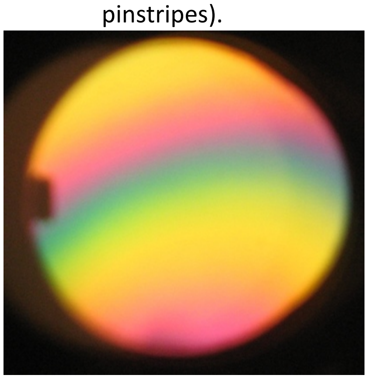
STEP 1: ALIGN THE TWO MICHELSON INTERFEROMETER IMAGES



- Mount a green laser as the source, with a lens in front that disperses the narrow laser beam.
- Adjust the two set screws on the back of the one mirror (the one that has two set screws on it) to align the reflections coming from the two separate mirrors. When they are close to exact alignment, you will start to see "pinstripes" in the green field of view. Adjust the set screws very gently and slowly!
- Adjust the set screws until these stripes become wider. Keep going, alternating set screws as needed. If you're lucky you may be able to turn these stripes into the center of a bull's eye pattern (with the concentric circles getting closer as you move away from the center. Adjust the stripe/circles as best as you can to get the center of the bull's eye.
- Sketch and describe what you see in your lab notebook.

STEP 2: CHANGING THE PATH LENGTH

- You should be able to get constructive interference (which will show up as a bright spot in the middle of the bull's eye center) if the two path lengths in the interferometer are either equal, or differ by an integer number of HALF-wavelengths. Adjust the single set screw on the other mirror to move that mirror straight in or out. Describe in your lab notebook what happens to your interference pattern – both at its center and away from the center (the pinstripes).



STEP 3: APPROACHING THE WHITE-LIGHT INTERFERENCE PATTERN

- If the path lengths are much different, the center of the bull's eye will shrink: the center dot in the bullseye will get smaller.
- Dial this second mirror forward and backward and verify that at the extremes this pattern does shrink.
- Now dial the adjustable mirror until the vernier along its side reads about 16.15mm. (Make sure that your partner and you measure the same value on the micrometer scale.) The path lengths should now be close to equal.
- Replace the green light source with a white light bulb. Shield your eyes from the lightbulb's direct light so that you can still see the bull's eye clearly.
- SLOWLY adjust the knob (on the mirror with just one knob) in search of

something interesting. It is probably somewhere between 16.00mm and 16.30mm. When something interesting happens to the white screen, slow down even further and describe in your notebook what happens if you continue in that direction. Repeat this for the bull's eye center and for some "pinstripes" not too far away from the center.

- Sketch the pattern near this magical location in your notebooks and describe it thoroughly, assigning names to the colors you see ("ecru", "eggplant", etc.). Record what the mirror's knob's vernier records for the middle of this magical zone. What happens at *that* location to the colors? Explain why this makes sense.
- Do you see spectral ("rainbow") colors? Explain why this makes sense.
- Dial in the bullseye center again and replace the white light source with the green helium lamp. Describe what you see and describe what differences, if any, there are between this bulls eye pattern and the one when the path lengths aren't quite equal.
- Explain why the two should behave differently.

EXPERIMENT #2: WAVELENGTH MEASUREMENT WITH THE MICHELSON INTERFEROMETER

- Mount the green laser. Make sure the interferometer is set up to display interference fringes. You can use either the central bullseye or a set of moderately wide fringe stripes.
- Dial the movable mirror to a round number, like 16.00mm, on its vernier (Record this value in your notebook). Keeping your eye glued on the location of one of the fringes (or the bullseye) and resting your chin on the lab table or on your hand on top of the lab table (so that your head doesn't move), slowly turn the set screw until 100 fringes glide by (or the bullseye goes from bright to dark to bright again 100 times). Record the final mirror position in your notebook. This distance represents the length of 100 half wavelengths. Sort of.
- You will notice that the vernier screw does not directly drive the mirror holder, but is levered. Verify that the vernier only moves the mirror 4mm when it has been dialed 20mm. Use this fact to properly calibrate the calculation you did above for the length of 100 half wavelengths (which equals *how many* full wavelengths?). Calculate and record the wavelength of the green laser light. Compare to its expected value.
- Repeat the data taking (the length of 100 half wavelengths) several times, and have your partner do the same. Compare to the results from other lab partners in the class. What is the class's best value and its uncertainty? This uncertainty is very important for comparing your values to the accepted value.

EXPERIMENT #3: THE MICHELSON-MORLEY EXPERIMENT

- The Earth's motion in space is the vector sum of its daily rotational motion, its annual revolution around the Sun, the Sun's motion relative to its neighbors, and the Solar System's revolution around the center of the Milky Way galaxy. Find values for all these speeds.
- Compare these numbers. What is the maximum and the minimum of the length of the vector sum of these velocities?
- Your instructor will show you a rotating Michelson interferometer. A fringe shift of "1" would represent a bright bull's eye turning dark and then bright again. Record the number of fringe shifts as it is rotated through 180°. Do NOT write zero. If it appears to be zero, estimate an upper bound. Measure any appropriate parameters for this interferometer.
- Using an equation for the fringe shift as a function of the speed of motion, calculate the upper bound for the slowest velocity that this interferometer is capable of detecting.
- Your instructor will show you a larger intererometer down the hall that can be configured as a Michelson interferometer. Measure any appropriate parameters for it and redo this calculation.
- Interpret your data. Should either of these interferometers be able to detect Earth's motion in space if the minimum detectable fringe shift is 0.25? Should either of them be able to detect the Earth's daily rotation?