LAB 4: INTERFEROMETRY, PART 1

LEARNING OBJECTIVES

You will:

- Build a Michelson Interferometer.
- Record how interference fringes respond to changes in the experimental setup.
- Write a formal methods section (and a short results section) that will be peer-reviewed by a classmate.

PRE-LAB QUESTIONS

1. Read this lab handout and watch the pre-lab video introducing the day's activity.
   https://www.youtube.com/watch?v=cVqTX5kwj2s
   (The video is from four years ago, but we are doing much the same experiment! The main difference is that when he refers to "last week" he is referring to your Diffraction experiment before break.)
   a. What did Dr. Brad "forget" to do? (OK, he was just pretending…)
   b. What are the optical components that you will use when setting up your Michelson Interferometer?

2. Read about one example of an interferometer in an experimental setting. (*Not* the Michelson-Morley ether experiment; find something more current.) You are welcome to search with scholar.google.com, webofscience.com, the Astrophysics Data System (primarily astrophysics and astronomy research) or PubMed (biomedical research). It should be a formal article in a scientific journal.
   a. Be prepared to give a two-minute summary of the experiment to someone else in the class, or possibly the whole class. You should be able to draw the schematic of the experiment on a whiteboard and describe what the interference patterns revealed to the researchers.
   b. Provide this sketch and a citation (at least authors, journal name, and year) for your source in your prelab submission.

THE MISSION: BUILD AN INTERFEROMETER

Your job is to build a Michelson interferometer. For now, this is an interesting example of wave interference and how adding two light beams can leave a dark spot. In the next lab, you will use computer code to move a mirror mount and collect data from a photodetector, and show that a single photon interferes with itself (!).

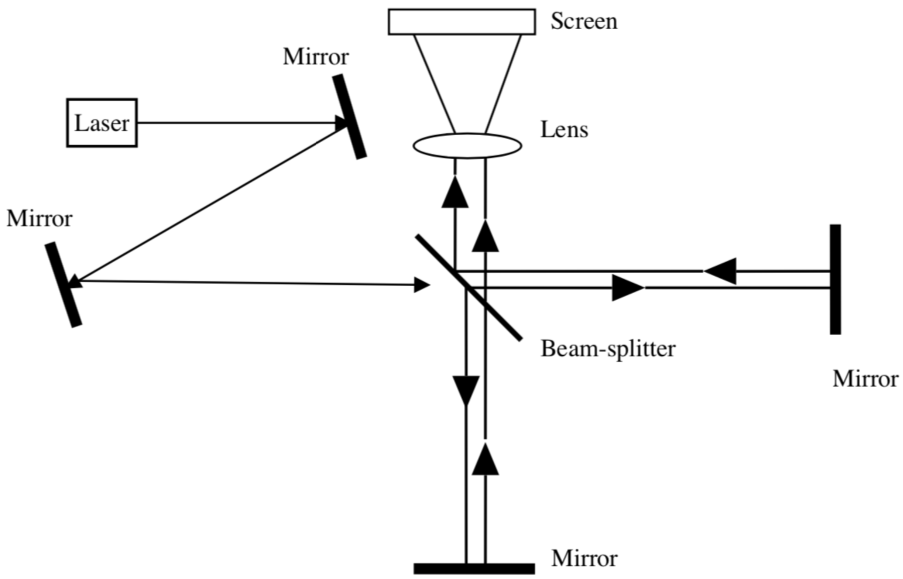

Figure 1 Top-view schematic of Michaelson interferometer with two additional mirrors for steering the beam.

Important notes about optics before you start:

- **CAUTION:** Keep your eyes above the optical plane to avoid a stray beam getting into your eye. These lasers are not very powerful, but they can be harmful to your eyes if you look directly into a beam.
- Take care not to let stray beams endanger students in other groups as well. Keep laser light confined to your set-up, for safety.
- **Do not touch** the surfaces of the optical components. These are front surface mirrors and beam-splitters that can be damaged by fingerprints. If you get a fingerprint on a mirror, tell your instructor so that they can clean the mirror using the proper protocol.
- To avoid frustration, **secure all components to the optical breadboard**. If not screwed down, your optics **will** move when you try to use the mirror mount controls.

The lab professor will discuss optical degrees of freedom and alignment.

Procedure:

A. Set up a Michelson interferometer equivalent to the one shown in Figure 1. You have been provided 4 mirrors, 1 beam splitter, and one lens. There is also a special moveable base – the "DAEDAL base". Use this DAEDAL base to hold the mirror on one of the two paths (also called arms) of the interferometer. We will be able to adjust the path length difference between the two arms with the DAEDAL base next week.

   Hints:
   - Before you get everything aligned, plan out where things will go. You need to leave room for the lens to be attached to the optical breadboard.
   - The 1-inch (short) post is for the mirror that goes in the DAEDAL base, not for the steering mirrors.

- There is a thin piece of glass, called a coverslip, and it is very easy to break. If you break it, then your instructor can help clean up the broken glass.
- Work one mirror at a time following the beam path.
- Keep the "arms" of the interferometer equal length and relatively short (4-8 cm).
- Align components to the rows of holes and keep the height constant using a card.
- Hole-punched card: A good trick for checking your alignment is to punch a hole in an index card, then place the card in the path of the laser so that the incoming beam passes through the hole. Adjust the reflected beam so that it returns through the same hole.

B. In your lab notebook, record differences in the interference pattern when the beams are completely aligned (one on top of the other) and misaligned (beams are side-by-side).

C. To see how sensitive this instrument is, apply light pressure to the optical breadboard and to one or more of the mounts. Observe that it does not take much adjustment to make the optical fringes move. The interferometer is a very sensitive device! That is why interferometers are used to look for extremely weak effects such as gravitational waves.

D. Block one arm of the interferometer and observe what happens to the interference pattern. Repeat for the other arm. Note your observations in your lab notebook.

E. Insert the thin glass cover slip into the beam in one "arm" of the interferometer with the glass perpendicular to the laser beam. Observe changes in the fringe pattern as you gently change the orientation. As you increase the angle θ between the laser light and the normal, the light passes through more glass. Why does that make the fringe pattern move?

F. If it is not yet 3:30 pm and you've done all the other pieces, then you can get started on Part II: controlling the position of the mirror in the DAEDAL base using the LabJack and python. The DAEDAL base has a piezoelectric actuator, which converts electricity into motion, allowing you to apply a voltage to it to move the mirror. You will write a python code to send a voltage into the DAEDAL base, setting its position. If your code changes the voltage, the position will change and you can see the fringe pattern of your interferometer change!

   a. Find DAC0 on the LabJack. Attach the piezoelectric actuator to the voltage output of the LabJack (red wire in DAC0, other wire in GND – use the slotted screwdriver from your supplies).
   b. Then use python to send a voltage to the DAEDAL base:

```
from LDrive import LDrive
s = LDrive()

#Then you can do:
s.DAC0Write(volts)    # Set DAC0 output to 'volts', a number from 0 to 5.0.
```

What do you see when you move the mirror with the translation stage? How does the output change?

G. If it is not yet 3:20 pm and you've done all the other pieces, then there's time for more practice with the optics alignment and to explore how misalignment affects the appearance of the interference fringes. Please adjust the interferometer to make the fringes vertical. Then adjust it to make the fringes horizontal. Then return to the bull's eye pattern. But if it is after 3:20 pm then you are not required to play with the misaligned fringes. (You probably already did!)

IF YOU ARE IN THE TUESDAY LAB, take apart your interferometer and leave your lab station the way you found it.

IF YOU ARE IN THE FRIDAY LAB, leave your interferometer set up, as we need them for the next experiment.