Background preparation

- Michelson interferometer: Peatross & Ware, Section 8.1.

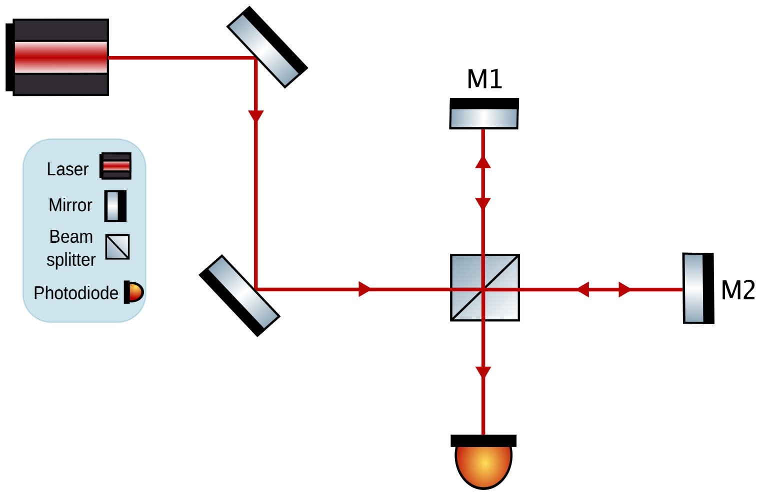

Figure 1: *Schematic of a Michelson interferometer. Light goes through a beam splitter and each beam traverses different paths. The two mirrors reflect the beams back to the beam splitter so they can be combined again. The re-combined beam is detected at the free output port.*

1: Michelson interferometer

a) Build a *Michelson interferometer* according to the diagram shown in Fig. 1. Ensure that the two interfering beams are overlapped properly at the output, and that the beams hit the retro-reflecting mirrors M1 and M2 **at exactly 90 degrees**. Start with M1 and M2 fairly close to the beam splitter (around 10 cm). Align the beams at the output of the interferometer, where the photodiode is positioned.

b) Increase the size of the interference pattern by placing a lens before the interferometer input. When you achieve a good overlap between the enlarged beams, the intensity pattern seen on white paper should show a circular pattern of dark and bright rings. Show the TA or course instructor your intensity pattern.

   Tips: *Make sure all your optics are secured to the breadboard. Test to see if they are stable by pushing on them.* Set up your interferometer in such a way that you have room on the breadboard to create a large path length difference between the arms (see Part c). To create a good interference pattern, you will need to align both the *position and angle* of the two beams at the photodiode. Use the horizontal and vertical alignment knobs on M1 to overlap the beams just past the beam splitter, and use the knobs on M2 to overlap the beams at or past the photodiode position. Overlapping the beams at two positions will guaruntee that the beam positions and angles are aligned at the photodiode.

c) You may find that the interference pattern is sensitive to small vibrations and air currents. Very gently push on one of the mirrors by hand to perturb the interference pattern, and measure the *fringe contrast*[1]

[1]The fringe contrast is defined in terms of the maximum $V_{\max}$ and minimum $V_{\min}$ photodiode voltage as

$$F = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}}.$$

by looking at the change in light intensity measured on the scope. You can select a portion of the interference pattern to be detected by the photodiode by using a diaphragm iris.

d) Set up the interferometer with a different initial value of the path length difference between the arms, d. Using a photodiode and oscilloscope, measure what happens to the fringe contrast at a set of different values of d. Take measurements at a number of different values of d (ideally around 5).

e) How does the interference pattern depend on the difference in polarization between the light in the two arms of the interferometer? Discuss with your group what you expect to happen for various polarization differences. Set up the interferometer to have the path length difference that gave the largest fringe contrast. Add a waveplate in a rotation mount into one arm of the interferometer, see Figure 2. (Which waveplate should you use?) Measure how the fringe contrast depends on the angle of the waveplate's slow axis. Should you add a linear polarizer before (or after) the interferometer to make the effect more extreme?

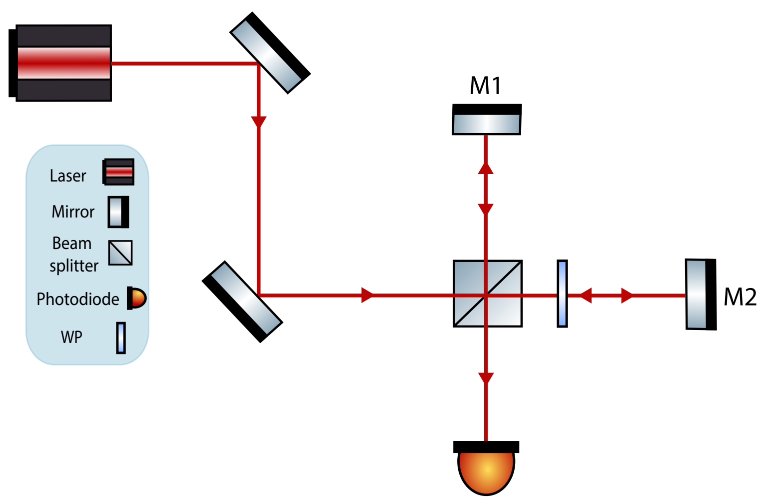

Figure 2: *Schematic of a Michelson interferometer with a waveplate in one arm.*