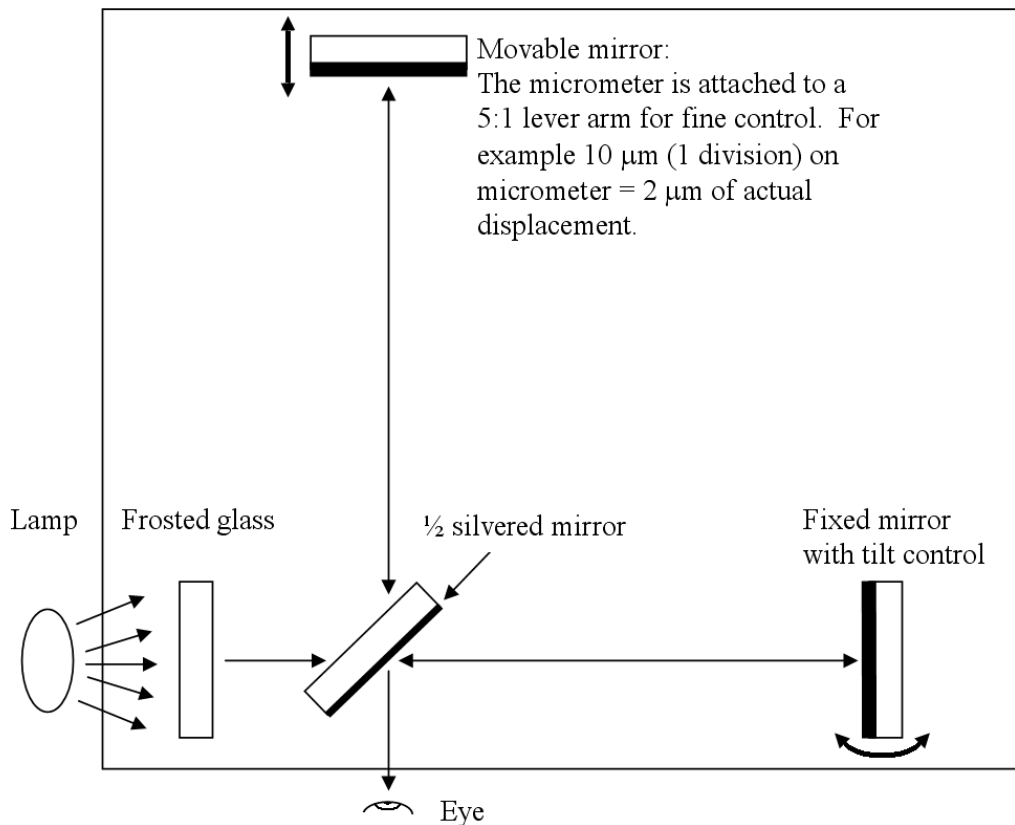


In the last experiment, you observed interference between the reflections from two surfaces. With the Michelson interferometer, you will see exactly the same thing: interfering light rays reflected from two surfaces, in this case two mirrors. As shown below, a single ray of light is split into two beams by a half-silvered mirror. Each beam travels to a different mirror, which directs the reflection again back to the half-silvered mirror. The resulting light that reaches the observer is the recombination of the two beams. In this way, interference fringes can be seen.



For a narrow beam of light, if the two arms of the interferometer have exactly the same length, the optical path difference (OPD) between the two rays will be zero. Hence, if no phase differences are introduced by the reflection process, the two rays will be in-phase and you will see a bright fringe. If you have an extended light source, you will see a pattern of light and dark fringes due to the differences in path length for different angles. If the movable mirror shifts its position, the OPD increases and the fringe pattern is seen to move. For light with a well-defined wavelength, each time the mirror position is shifted by  $\lambda/2$  the OPD increases or decreases by one wavelength. Hence the fringe pattern returns approximately to its original form. If the images of the two mirrors as seen by the observer are perfectly parallel, then a circular pattern results. Otherwise, the pattern will look more like parallel lines.

For section D, involving sodium lamps, you will investigate a beat pattern. This phenomenon is very familiar to those you who have tuned a stringed musical instrument. For two strings tuned to a slightly different frequency, the ear does not hear the pure tone of either string. Instead you hear a tone equal to the average frequency, but the amplitude is pulsing.

Procedure:

- A. Using a Hg lamp ( $\lambda=5461 \text{ \AA}$ —green line) play with the controls of the interferometer and observe straight and circular fringes. As the OPD is varied, circular fringes may appear from or disappear toward the center. If they are appearing, moving outward from the center, then the OPD is increasing. If the fringes are moving toward the center, then the OPD is decreasing. Try to get the OPD close to zero. Near zero, the fringes will be very large and it will be difficult to tell whether they are moving inward or outward.
- B. Now switch to a white light source and carefully search for fringes. You will find that you can only see fringes if the OPD is less than  $3\lambda$ . **Q1** Why does the OPD have to be nearly zero in this case? For the parallel-line pattern, the fringe in the center corresponds to angle where the OPD is exactly zero. **Q2** Does the center fringe appear to be dark or bright? How can you explain this? Record the position of the micrometer of zero OPD for your interferometer.
- C. Return to the Hg lamp to measure the wavelength of the green line. It is recommended that you adjust the appearance of the fringes to minimize eye strain. While slowly moving the mirror, count at least 50 fringes. From the distance the mirror translated, compute the wavelength. As always, make a reasonable estimate of the error.
- D. Now switch to the yellow Na lamps. The yellow line of these lamps is actually two very closely spaced lines at  $5890 \text{ \AA}$  and  $5896 \text{ \AA}$ . Near zero OPD you will observe clear fringes. As the OPD increases, the fringe pattern decreases in contrast and becomes difficult to see. But the contrast eventually will increase again upon further increase of the OPD. You can go through several maxima and minima in this way. What you are actually seeing is the beat pattern between the two sodium lines. By measuring the wavelength and the separation of minima, compute  $\Delta\lambda$  using the formula

$$\frac{\Delta\lambda}{\lambda} = \frac{1}{n},$$

where  $n$  is the number of fringes in one period (minima to minima). This exercise requires more than 100 fringes. To save your sanity, in this case it is recommended to estimate the number of fringes – instead of counting every one.