

EE 413  
LAB 5 FABRY PEROT INTERFEROMETER

**PURPOSE:**

To demonstrate multiple-beam interference and interferometers, and the concept of a Fabry Perot cavity.

**REFERENCES:**

- (1) E. Hecht, *Optics*, Addison-Wesley, Section 9.6 (1987)
- (2) A. Nussbaum and R. A. Phillips, *Contemporary Optics of Scientists and Engineers*, Sections 7-1 to 7-4, Prentice Hall, (1976)
- (3) F. L. Pedrotti, S. J., and L. S. Pedrotti, *Introduction to Optics*, Section 11-6, Second Ed., Prentice Hall, (1993)

**PROCEDURE:**

- (1) Measure the reflectance  $R$  and transmittance  $T$  of the partially transparent mirrors used to form the Fabry-Perot cavity. Based on the measured reflectance, calculate the cavity finesse. [The coefficient of finesse  $F$  and finesse  $\mathcal{F}$  of a Fabry-Perot cavity are  $F=4R/(1-R)^2$  and  $\mathcal{F}=(\pi\sqrt{F})/2$ , respectively. See (9.69) and (9.70) of Hecht].
- (2) Assemble the setup shown in Figure 1. If available, mirrors based on wedged substrates should be used to minimize multiple reflection by various glass surfaces and reflection back to the laser. All components of the Fabry-Perot cavity, i.e., the mirrors and mounting hardware inside the dash-lined box, should be held firmly as one piece to reduce relative motion between these components. (However, be careful with the small set screws. Don't crush the dielectric coated mirrors with the set screws). The whole setup should be as compact as possible. Therefore, keep the mirror separation as small as practical. If a coherent light source with a "reasonable" coherent length is used as the light source, a separation  $d$  of 1~3 cm would be a convenient choice for this experiment. The two mirror surfaces (shown as heavy lines in Figure 1) should be parallel and the laser beam should incident normal to the mirror surface. See Section 7-4 of Nussbaum and Phillips for the procedure for aligning the mirrors. If needed, a second lens may be used to expand the beam further. The deformation of the fringe patterns is most likely due to the dust on or defects of the lenses and mirrors.

(3) If the light used is monochromatic, one set of fringes is produced. If the interferometer finesse is sufficiently high, which requires very careful, almost perfect, alignments, the different modes of the laser, corresponding to different frequencies, produce various interference patterns, all superimposed. Look for these superimposed fringes at the observation screen.

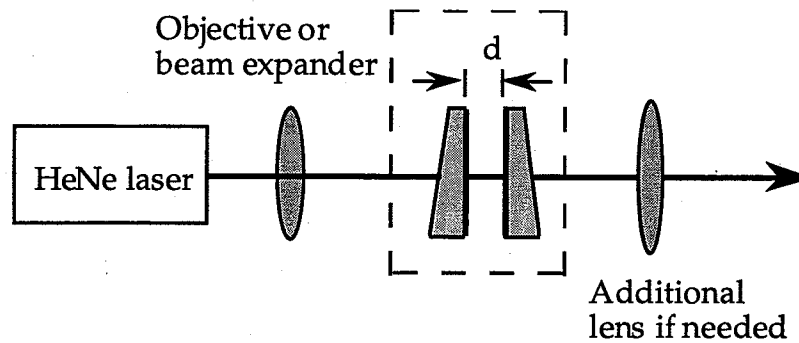


Figure 1. Setup for Fabry-Perot Interferometer

(4) The Fabry-Perot interferometer may be used to measure the refractive index of a glass slide. Use the same technique used with the Lab 4. Place a glass slide of known thickness on a rotation stage and place it in the cavity between the two mirrors.

(5) Position the slide perpendicular to the beam. Record the reading of the wheel position at this point. This will be referenced as the  $0^\circ$  mark. Measure the angular displacement which produces a few (5 or 6) fringe shifts.

(6) Use the equations developed in Appendix of Lab 4 to calculate the refractive index,  $n$ , and compute the average value of  $n$ . If the slide is thick (1 mm or thicker), plot  $(T/\lambda)\phi^2$  vs. number of fringes for the data taken in step (5), and determine the refractive index of the glass slide from the slope of the curve. Suggest a method to determine  $n$  if the slide is thin (0.1 mm or less). Try it to see if your method works.

(7) Use a power meter or a photodiode to monitor intensity of the center fringe. Monitor light intensity as the glass slide is rotated slowly. Make a plot of *transmission vs. rotation angle*.

(8) Upon the completion of the measurements indicated in steps (1) to (7), increase the mirror separation, re-align the mirrors, and then observe the effect of mirror separation on the shape and stability of the fringes.

### QUESTIONS:

- (1) Use the estimated refractive index (step (6)) to convert the *transmission vs. rotation angle* curve to a *transmission vs. optical path length change* plot (in radians). On the new plot, identify the *free spectral range*, *half width* and *fineness* of the cavity. Determine these quantities from the plot and compare the results with the values expected from the mirror separation and reflectance.
- (2) What effect does moving the mirrors farther apart have on the fringe patterns and stability?
- (3) What is the advantage(s) of using a multiple-beam interferometer instead of an amplitude-splitting interferometer?

