PH522 SK1

Objective: To study the properties of two-mirror optical resonators.

Equipment: 1) Commercial HeNe laser.

2) A 30-cm lens for shaping the laser beam. (Placing the lens 160 cm from the laser output will produce a smaller beam waist about 35 cm beyond the lens)

3) Two 1" diameter dielectric mirrors. Both have a radius-of-curvature of 60 cm and are mounted in high quality adjustable mounts. Do not touch the surfaces of these mirrors, as that could damage them beyond repair.

4) 5 cm lens for expanding the beam.

Procedure:

Part I. (Stability)

1) Using the two steering mirrors, steer the laser beam through the middle of the back side of the flat mirror. Although the flat mirror is highly reflective, some light will be transmitted. Position the curved mirror at a distance that you expect will form a stable optical cavity. By adjusting the curved mirror orientation, you should be able to "capture" the beam as it bounces back and forth between the mirrors. When you achieve this, you should see an ellipse on the surface of each mirror (and on a card mounted beyond the curved mirror). With care, you should be able to maintain this ellipse pattern as you slowly vary the mirror separation by sliding the curved mirror away from the flat mirror.

2) Determine the maximum separation between the mirrors that still allows you to capture the beam. Note your conclusion in your lab notebook, and compare with the theoretical prediction of the limit of stability for your cavity

Part II. (Reentrant Patterns)

1) As you varied the mirror separation in Part I, you may have noticed that for certain separations, the ellipse pattern degenerates into a sequence of dots on the mirror surface. These are "reentrant patterns", where the beam retraces its path after completing a certain number of round-trips through the unit cell. For this part of the lab, deliberately adjust the mirror spacing to achieve such a pattern. Sketch the dot pattern you see on the surface of the mirror or on the card and measure the mirror separation at which it occurs.

2) From the measured mirror separation at which the reentrant pattern occurs, calculate the angle

$$\theta = \cos^{-1}\left(1 - \frac{2d}{R}\right)$$

that describes the variation of spot position with number of round-trips, and confirm that it satisfies the condition

$$m\theta = n(2\pi), \quad with\ n \langle \frac{m}{2} .$$

Part III (Transmitted light)

1) Choose any mirror separation that is not confocal (d=R/2), and capture the beam into an ellipse pattern. A small mirror separation works best for this part of the lab. Then by carefully adjusting the two mirrors and the input steering, collapse the ellipse into a single spot. When you achieve this, you may notice that the intensity of the beam inside the resonator seems to fluctuate, as judged by the intensity of the visible spot on the mirror. Why do you think this behavior exists? Gently tap one of the cavity mirror mounts and observe the transmitted intensity. It may help to expand the transmitted beam with a lens.

2) Describe your observations of the transmitted beam as you adjust the mode-matching slightly and gently push on one cavity mirror. Account for these observations using your knowledge of the resonance frequencies of resonators.