Lab #6 -- Coherence II

The purpose of this lab is to observe fringes of equal inclination and fringes of equal thickness using Hg and HeNe laser sources, and white light fringes of equal thickness. This lab also will teach you about the relationship between frequency distribution and extent of the source and fringe contrast (spatial and temporal coherence and the van Cittert-Zernicke theorem).

Preparation:

Fringes of equal inclination and fringes of equal thickness are described in Chapter 9 of Hecht (2nd ed.). Coherence is discussed in Chapter 12 of Hecht (2nd ed.). Also see pp. 25-27 of Hariharan.

Definitions:

Fringes of equal thickness:
Equal path length between the mirrors. See tilt fringes. Fringes localized at the intersection of the mirrors.

Fringes of equal inclination:
Unequal path length between the mirrors. See circular fringes. Mirrors must be parallel.

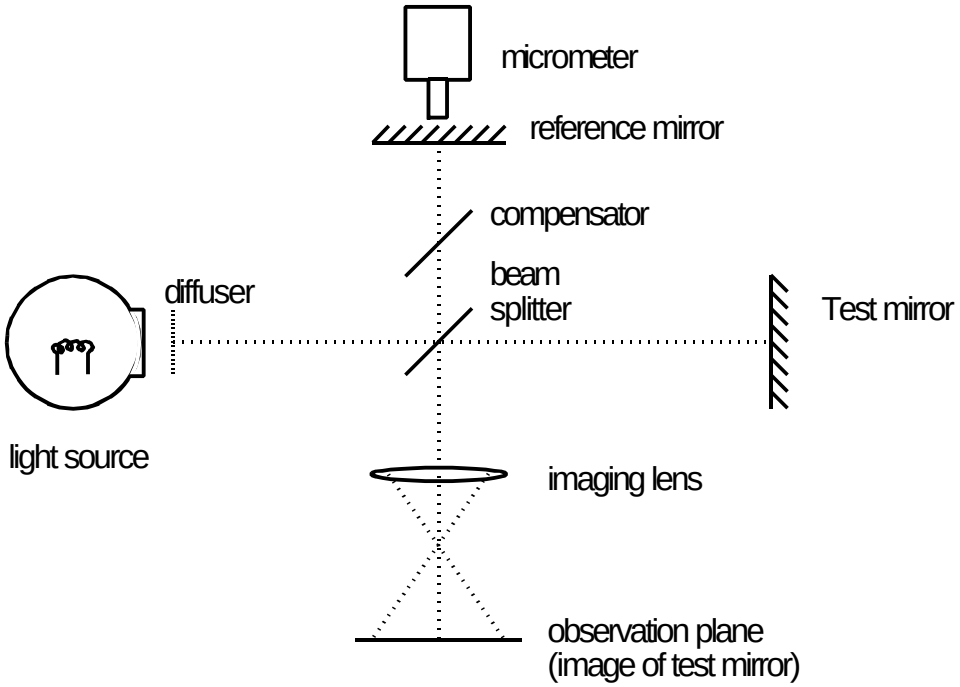
Spatial Coherence:
Related to the spatial extent of the source. Is it a point source, an extended source, or multiple apertures?

Temporal Coherence:
Related to the frequency distribution of the source. Is it a single wavelength, a narrowband source, discreet frequencies, or a continuous band?

van Cittert-Zernicke:
Spatial coherence is related to the Fourier transform of the source geometry. Temporal coherence is related to the Fourier transform of the source frequency distribution.

Narrowband illumination:
A bandpass of certain frequency range.

White light illumination:
A very wide bandpass, usually the entire visible spectrum.



Michelson Interferometer

IMPORTANT!! Before turning on the Hg source, place the ground glass and the green filter in front of the source.

Fringes of Equal Thickness (Hg source) - equal path with mirrors tilted

1) Adjust the mirror position so that the two mirrors are equally distant from the beamsplitter (to within a few millimeters).

2) Place a pin, or other sharp point, between the light source and the beamsplitter. Adjust the tip and tilt of one of the mirrors until a single image of the sharp point is obtained. Fringes should then be present. Translate the movable mirror until straight equally spaced fringes are seen. So see sharp fringes, the eye must be focused on the mirror. Note that if the mirror is translated so that the two paths in the interferometer are unequal, curved fringes are obtained.

3) Using an imaging lens, image the fringes to show that they are localized near the image of the mirrors.

Fringes of Equal Inclination (Hg source) - unequal path with mirrors parallel

4) Adjust the mirror tip and tilt so a single fringe of equal thickness is obtained. Adjust the distance between the beamsplitter and the movable mirror to obtain circular fringes localized at infinity. Unfortunately, as the mirror is translated it tips slightly. It may be necessary to readjust the tip and tilt of the second mirror to keep the images of the two mirrors parallel.

5) Adjust the movable mirror and observe whether the fringes move in or out as the mirror is translated. Note whether the path difference is increasing or decreasing.

White Light Fringes - Equal path, like fringes of equal thickness

6) Translate the mirror until the paths are nearly equal. When going through equal path, the fringes will first curve in one direction, straighten out, and then curve in the opposite direction. Tilt the mirror to obtain 4 or 5 straight equally spaced fringes of equal thickness.

7) Turn off the Hg source, turn on the white light, and remove the green filter. Leave the ground glass in front of the source. Translate the mirror back and forth a small amount (about 2 turns max), but do it slowly so you can catch the white-light fringes as they whiz by.

8) If you miss the fringes the first time, you may have to turn the Hg source back on (with green filter) and find nearly straight fringes again. Don't be discouraged if it takes two or three tries.

9) Once you have white-light fringes, hold the orange narrowband filter in front of the source. Note how many more fringes you can see.

Fringes with HeNe Laser Source

10) Find both circular and straight fringes using a collimated laser followed by a ground glass as the source.

11) Remove the ground glass and again find both kinds of fringes. Use a lens to find the fringes as you did in the first lab. **Do not look straight into the raw laser beam**.

12) Try holding the ground glass in your hand, rather than mounting it on the table. Is there any difference in the fringes?

Laser Diode:

13) Determine the coherence length of a laser diode by using a Twyman-Green interferometer and varying the path length in one arm.

Questions:

(steps 1-5)

1) How do you determine which side of the beamsplitter is coated in Michelson?

2) How do you determine where general fringes (somewhere between equal thickness and equal inclination) will be localized?

3) What determines the number of circular fringes present?

4) Which way do the fringes move?

(steps 6-9)

5) How many white-light fringes can you see?

6) What limits the number of white-light fringes that you see?

7) Can you see fringes of equal inclination in white light? Why or why not?

(steps 10-12)

8) Where are the fringes localized for the HeNe laser source without the ground glass? With the ground glass? Why is there a difference?

9) Do you see any difference between the fringes obtained using an Hg source and fringes obtained using a collimated laser beam and ground glass?

10) Does the ground glass destroy the spatial coherence of the HeNe laser beam? Why or why not?