Lab #5 -- Coherence I

The purpose of this lab is to observe the effects of spatial and temporal coherence on fringe visibility, and obtain a good physical feel for both. We will also observe the temporal coherence of a laser diode and measure the separation of a sodium doublet.

Preparation:

Review the relationships between fringe visibility and spatial and temporal coherence. Understand how the size of a source can affect the fringe visibility. Be familiar with the underlying principles of Young's double slit. See Chapters 9 and 12 of Hecht and Zajac or Hecht. You may also review Steel, Born and Wolf, or Hariharan. Find out the wavelengths for a sodium doublet.

HeNe Laser Source:

1) Illuminate the double slits and the multiple slits with the HeNe laser beam.

2) Determine the slit separation by observing the interference (diffraction) pattern. Note the differences in the patterns.

Sodium Source

1) Place the adjustable slit in front of the sodium source. Look through the double slit back at the source slit and observe the interference fringes. Vary the source slit width and observe the change in visibility.
2) Calculate the minimum slit width that will give zero fringe contrast.
3) For a fixed source slit width, vary the distance between the source slit and the double slit. Observe, and explain the change in visibility.
4) Repeat 1)-3) for the multiple slits.
5) Put a lens after the multiple slits and look at the interference fringes in the plane where the source slit is imaged. Note any differences in the fringe visibility as compared to viewing with your eye.
6) Set up a Michelson interferometer and measure the separation of the sodium doublet.

White Light Source:

1) Place the adjustable slit in front of the white-light source. Observe Young's double slit fringes as both the source slit width and source-slit-to-double-slit distances are changed.

Questions:

1) Can you see more or less Young's double slit fringes in white light than you observed using the white light source in the Michelson interferometer? Explain any differences. (This question will be answered after completion of Lab #6.)

2) What are the effects of non-parallel slits?

3) How would waviness in the slit lines affect the fringes and their visibility?

4) What effects would be observed if the double slits are not parallel to the source slit?

5) Give a physical (not mathematical) explanation for (A) the Van-Cittert Zernike theorem, (B) spatial coherence, and (C) temporal coherence.

6) What would be the result of using multiple slits with the white-light source?

7) What is the temporal bandwidth of the laser diode, based on your observations?

8) Estimate the precision and accuracy of your measurements when using the Michelson interferometer to determine the separation of the sodium doublet.

9) How would the Michelson interferometer observations differ if there were three lines in the sodium lamp?

10) Can our observations from the double-slit experiment be used to determine the separation of the sodium doublet? Why or why not?

11) What is Fourier transform spectroscopy?