Modern Interferometry

Objectives: To understand the principles of interferometry; Learn how to set up and align optical elements; Apply various interferometer configurations to perform precision measurements.

Suggested Reading: The lab writeup from TeachSpin in the binder is quite thorough. You will have time to complete 4 to 5 of the experiments described in the manual. It is a good idea decides which experiments you will do and plan ahead accordingly.

REQUIRED READING: Melissinos & Napolitano Chapter 4.

Apparatus:

1. Modern interferometry system from TeachSpin.
2. Two-channel digital oscilloscope.

The teach spin kit includes a large number of individual components that can be assembled several interferometers that can be used to perform a wide variety of measurements, some of which are listed in the manual. The components are arranged in labeled cardboard boxes under the bench. Return each component in its proper box when it is no longer needed.

Avoiding damage:

- Please read the description of laser safety in Appendix B of the TeachSpin writeup.
- Make sure to avoid touching the surfaces of any optical elements (e.g., mirrors, lenses, beamsplitters), as described in the TeachSpin writeup.
- Remember that other students will run the experiments after you finished.Please make sure to **return all components to their respective boxes**.

Procedure

1. **Introduction.** For an introduction to interferometry start with Section 0 of the manual. To supplement this material do a literature search and read about interference, and various interferometer configurations.

2. **Michaelson interferometer.** To gain hands-on familiarity with the apparatus read through Section 1 and 2 of the manual to learn about alignment techniques and build your first Michaelson interferometer.

- **Measurement of the wavelength of the HeNe laser (section 9)**
  a. Use this interferometer to find the zero fringe contrast distance for the the diode laser and for the HeNe laser.
  b. Use this interferometer to measure the wavelength of the HeNe laser.
- **Measuring Index of Refraction**
  a. Use this Michelson interferometer to measure the index of refraction of air (section 11)
  b. Measure the pressure dependence of the index of refraction of air (you will need to set up the gas handling system described in appendix S; use the hand-pump to reduce the pressure).
  c. Measure the index of refraction of a transparent slab.

3. **Michaelson quadrature interferometer.** Using the instructions in section 3 build and test a Michaelson quadrature interferometer.

- **Experimental Thickness Measurement.** Read section 10 to learn how to use the Michaelson quadrature interferometer to measure the thickness of samples. Measure one of the Teachspin invar samples, a piece of paper, stainless steel sheet.
- **Detecting thermal expansion**. Read section 12 to learn how to use the Michaelson quadrature interferometer to measure the thermal expansion. Use the provided materials (Copper, Aluminum, steel, Invar, Alumina) and the heater wire provided as described in the manual.
- **Detecting magnetostriction**. Read section 13 to learn how to use the Michaelson quadrature interferometer to measure magnetorestriction.

4. **Sagnac interferometer.** Using the instructions in section 5 build and test a Sagnac interferometer. You will also need to read section 4 on polarization and section 6 on relativity.

- **Index of refraction of air.** Repeat 2a using the Sagnac interferometer. Comment on advantages and disadvantages of this configuration.
- **The electro-optic effect.** a Read section 15 to learn how to use the Sagnac interferometer to measure the electro-optic effect.

5. **Mach-Zender interferometer.** Using the instructions in section 7 build and test a Mach-Zender interferometer. You will also need to read section 4 on polarization and section 8 on quantum mechanics.
   - **Index of refraction of air.** Repeat 2a using the Mach-Zender interferometer. Comment on advantages and disadvantages of the three interferometers for this measurement.