

Lab #3 -- Polarization

The purpose of this lab is to observe interactions between polarization components and polarized light.

Preparation

Review your class notes on polarization. Hecht and Zajac, "Optics", Chapter 8 has a very good explanation of polarization. Also be familiar with Brewster angle.

Here we will use polarization, half wave plate, quarter waveplate, wollaston prism, etc.

Procedure

- 1) Determine the transmission axis of the plastic polarizer using reflections off the table or the floor.
- 2) Use the plastic polarizer to determine the polarization of the HeNe laser labeled "Mode test." Use a scanning Fabry Perot provided by the Lab Instructor to determine the number of modes.
- 3) Look through a plastic polarizer and the red plastic material provided. As you rotate the red material note how the observed intensity changes. Then flip the red material over and look at the transmitted intensity as the red material is rotated.
- 4) Set up the polarizer and analyzer with the HeNe.
 - a) For a crossed polarizer-analyzer combination, observe the output as a quarter-wave or half-wave plate placed between the polarizer and analyzer is rotated.
 - b) For various fixed positions of the quarter-wave and half-wave plates, note the output as the analyzer is rotated.
 - c) Place the "half-wave" plate (piece of scotch tape or cellophane) between the crossed polarizer and analyzer. Observe the color of the transmitted light for incident white light.
- 5) Place a half-wave plate between the laser and the Wollaston prism. Check the polarization of the two beams leaving the Wollaston prism. Observe the relative intensities of the two beams as the half-wave plate is rotated.
- 6) Place a half-wave plate between the laser and the polarization beamsplitter.
 - a) Check the polarization of the two beams leaving the polarization beamsplitter. Observe the relative intensities of the two beams as the half-wave plate is rotated.
 - b) Use a mirror to reflect the beam transmitted through the beamsplitter back to the beamsplitter. Where does the beam go? Place a quarter-wave plate oriented with the crystal axes at 45° to the beamsplitter axes between the mirror and the beamsplitter. Where does the beam go now?
 - c) Repeat b) for the beam initially reflected off the beamsplitter.

- 7) Reflect the polarized laser beam off the two mirrors provided. Use a polarizer to determine the direction of polarization of the laser output.
 - a) Arrange two mirrors of a beam ladder so that after reflecting off both mirrors the light is propagating toward the laser. Check the direction of polarization.
 - b) Arrange the two mirrors so that after reflecting off both mirrors, the light is propagating perpendicular to the initial direction. Measure the direction of polarization and compare with the direction of polarization of the light leaving the laser.
- 8) Place a plane parallel plate (microscope slide) at Brewster's angle with respect to a polarized laser beam. Rotate the polarization of the laser beam and observe what happens. ($\tan \theta_b = n_t/n_i$, where θ_b is Brewster's angle, n_t and n_i are the refractive indices of the media for the transmitted and incident beams.)

Questions

- 1) Explain why you see color in part 4(c).
- 2) Why do the relative intensities of the beams leaving the Wollaston prism change as the half-wave plate is rotated?
- 3) What did you notice about the reflected beam from the beamsplitter when the beamsplitter was at Brewster's angle?
- 4) Each mode of a laser beam is polarized. Use this information to explain your observations in part 2.
- 5) What determines the thickness of a quarter-wave plate?
- 6) As temperature changes, waveplate material expands or contracts. Since a simple waveplate has many orders of phase delay, the change in dimension of the material changes the net phase delay between the crystal axes. How could we combine two waveplates so that this effect is minimized?
- 7) Changes in wavelength can cause changes in the index of refraction of the waveplate material. This will cause a change in the relative phase delay between the crystal axes. How could we combine two waveplates to minimize this effect?