NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3210 **POLARIZATION** 10/99 Po

Objective: In this experiment we will investigate linear polarization and circular polarization using linear polarizers, half-wave plates, and quarter-wave plates to manipulate the beam.

Equipment:

Uniphase 1508 HeNe laser ($\lambda = 632.8$ nm, $P_{\text{out}} = 0.5$ mW)
HP 8152A optical power meter
Beam collimator
Visible light linear polarizers (3 ea)
Half-wave plate (1 ea)
Quarter-wave plate (1 ea)
Circular polarizer (marked "CP") (1 ea)
Optical collimator
Optical bench
Adjustable rotary mounts

Preparation: Read the chapter in the notes on Polarization. Do problem 3.3 *before* coming to perform the lab.

CAUTION: While this laser does not produce sufficient power to do eye or skin damage, do *not* stare at the beam.

Procedure:

1. If it is not already on, energize the laser by turning on the power strip on the side of the table. Check that the optical collimator in front of the laser is properly aligned.

2. Turn off the laser by pulling the plug out of the power strip along the side of the table. Measure the background level of optical power. Turn the laser back on by plugging it into the power strip.

3. Using a linear polarizer as an analyzer, check whether the collimator output beam is linearly polarized. Whether it is polarized or not, place a linear polarizer ("polarizer #1") in the beam path (after the collimator). Rotate the polarizer axis to maximize the power transmitted through it.)

4. Align the beam as required to allow the beam to fall on the center of the detector portion of the power meter.

5. Insert a second linear polarizer ("polarizer #2") into the beam.

   Rotate the polarizer #2 in 10-degree increments for a full 360° of rotation. Measure the transmitted power at each location. Normalize your data to its maximum value. Plot it and $I_{\text{out}}/I_{\text{in}} = \cos^2\theta$ vs. rotation angle θ on the same graph. Interpret your results.

6. Adjust the linear polarizer to obtain minimum power out (i.e., cross-polarized). Insert a third linear polarizer ("polarizer #3") between polarizer #1 and polarizer #2. Adjust the rotation of polarizer #3 to obtain maximum power out.

   Verify the results of Prob. 3.3 by changing the rotation of polarizer #3 in 10-degree increments (through a full 360° rotation) and plotting the output power (normalized to the maximum measured value) vs. the rotation angle of polarizer #3.

7. Replace polarizer #3 with a mount holding the half-wave plate. Align the beam into the hole in the rotary mount. Adjust the rotation angle of polarizer #2 to obtain maximum power output.

   Rotate the half-wave plate by 10 degrees. Verify that polarizer #2 must be rotated by 20 degrees to restore a maximum power reading. Repeat for rotations of 20 and 30 degrees.

8. The plate circular polarizing plate (marked "CP") is a sandwich made of a linear polarizer and a quarter-wave plate. The manufacturer has aligned the linear polarizer axis at 45° to the fast axis of the quarter-wave plate (saving us from a tedious alignment). This combination can be used to create circular polarized light from unpolarized light.

   Unpolarized light to circular polarization: Remove polarizers #1 and #3 and the half-waveplate from the bench. Insert the CP polarizer with the label side toward the laser *between the laser and polarizer #2. Rotate polarizer #2 and record the power values at 15° increments. Is the wave circular polarized? Why or why not?*

9. Remove the CP polarizer and reinstall polarizer #1. Rotate the polarizer #2 to detect maximum power. Insert the quarter-wave plate between polarizers #1 and #2. For an arbitrary orientation of the quarter-wave plate, rotate the analyzer and observe a maximum and a minimum of transmission. (You have elliptical polarized light coming out of the quarter-wave plate.)

   Rotate the quarter-wave plate in increments and keep testing the output with the analyzer. Can you obtain linear polarized outputs from the quarter-wave plate? Can you obtain circular polarized output from the quarter-wave plate? (How will you be able to tell?)

10. Optical isolator: An optical isolator keeps reflected light from propagating back along the propagation axis. (Sometimes, this reflected light can upset the operating properties of the laser if it re-enters the laser resonator.) The isolator consists of a linear polarizer and a quarter-wave plate.

    Remove all of the optical components from the optical bench (including the collimator). Insert a mirror between the laser and the detector at the detector end of the bench. Adjust the mirror angle so that you can see the reflected beam on the front of the laser just next to the laser output. Insert a linear polarizer and a quarter-wave plate (with the linear polarizer closest to the laser). Show that when properly aligned you can remove (or minimize) the reflected light.

Report: Submit a written report together with your plotted data. This report is due within one week of completing this experiment.