Pre-Lab 10

1. A laser beam is vertically, linearly polarized. For a particular application horizontal, linear polarization is needed. Two different students come up with different plans as to how to accomplish this.

   Student A: Use two linear polarizers in the beam path. The first is oriented 45° with respect to vertical linear polarization and the second is oriented 90° with respect to vertical linear polarization. The output beam will then have horizontal linear polarization.

   Student B: Use a half-wave plate at 22.5° (using the same definition of 0° we used in lab 9). Then use a linear polarizer that is oriented 90° with respect to vertical linear polarization. The output beam will then have horizontal linear polarization.

   Which plan or plans would work? Explain.

   Which plan is most efficient in regard to light power with the correct polarization? Explain.

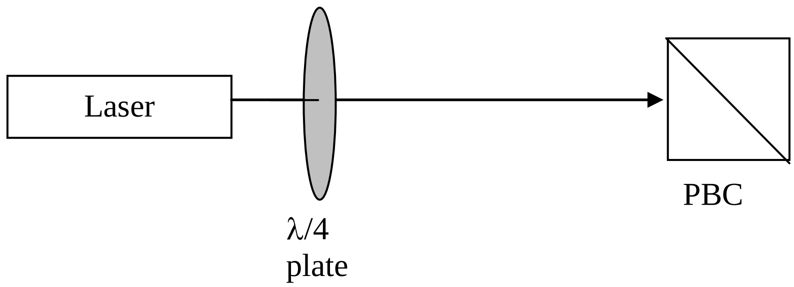
Lab 10

This laboratory is to help you to understand different forms of polarization. The exploration starts with a ¼ wave plate and compares these results with that from a light bulb.

Section 1

Introduction to the quarter wave plate.

Attach a quarter-wave plate (λ/4 – plate) to a plate rotator. Set up the equipment as shown below.



Rotate the λ/4 – plate and describe what happens to the transmitted and reflected beams of light through the PBC as you turn the λ/4 – plate. As you rotate the quarter-wave plate what happens to the transmitted and reflected beams?

1) Which angles virtually eliminate the reflected/transmitted light through the cube?

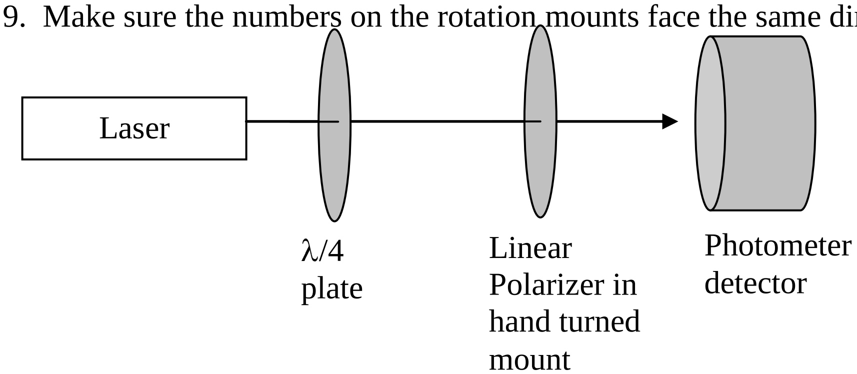
2) For only the angles you found in the previous question, what is the polarization of the light after the quarter-wave plate?

3) For these quarter-wave plate angles, how did the polarization of the light change from before the quarter-wave plate to after the plate?

Section 2

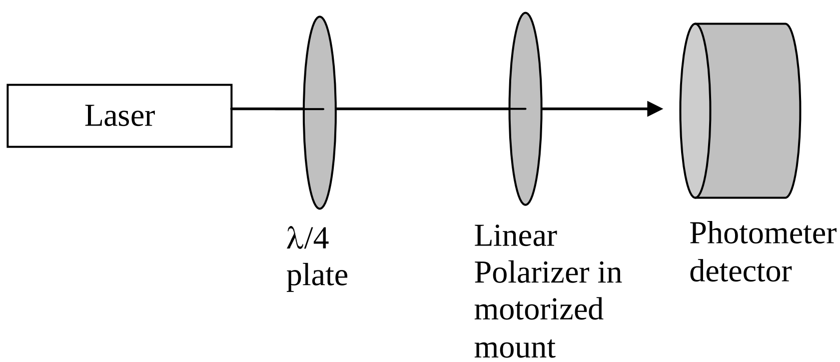
Quantitative measurements using the quarter-wave plate.

Set up the equipment as shown below using the linear polarizer in the hand turned mount from lab 9. Make sure the numbers on the rotation mounts face the same direction.



Turn the linear polarizer to 90° (based on the definition in Lab 9, section 1). Rotate the quarter-wave plate to minimize the transmitted laser beam power to the detector. We will call this 90°. Rotate the quarter-wave plate 90° clockwise. We will call this 0° and we will keep this definition throughout the rest of the investigation. NOTE: This designation more than likely does not agree with the values on the plate rotator. What is the reading on the quarter-wave plate's rotator at our defined 0°?

Replace the linear polarizer in the hand-turned mount with the linear polarizer in the motorized mount. Make sure the label on the motorized mount faces the same direction as the numbers on the quarter-wave plate's mount. Enter the average phase you found in lab 9 section 2 into the box called "phase offset" (in the ""Polarama 2.1"" program).



With the quarter wave plate at the defined 0°, run the LabView program, “Polarama 2.1”. Record the following…

Amplitude	DC Offset	Phase angle	Eccentricity	Tilt angle

Are your above measurements consistent with your answers to questions 1 – 3 (in section 1, p. 2)? EXPLAIN.

Briefly describe the shape in the polarization plot in the LabView program.

With the quarter wave plate at the defined 35°, run the LabView program, “Polarama 2.1”. Record the following…

Amplitude	DC Offset	Phase angle	Eccentricity	Tilt angle

Briefly describe the shape in the polarization plot in the LabView program.

With the quarter wave plate at the defined 45°, run the LabView program, “Polarama 2.1”. Record the following…

Amplitude	DC Offset	Phase angle	Eccentricity	Tilt angle

Briefly describe the shape in the polarization plot in the LabView program.

With the quarter wave plate at the defined 70°, run the LabView program, “Polarama 2.1”. Record the following…

Amplitude	DC Offset	Phase angle	Eccentricity	Tilt angle

Briefly describe the shape in the polarization plot in the LabView program.

With the quarter wave plate at the defined 90°, run the LabView program, "Polarama 2.1". Record the following…

Amplitude	DC Offset	Phase angle	Eccentricity	Tilt angle

Briefly describe the shape in the polarization plot in the LabView program.

SHOW YOUR RESULTS TO YOUR INSTRUCTOR BEFORE PROCEEDING.

Section 3

The purpose of this section is to give you some insight into what is elliptical polarization and what is unpolarized light.

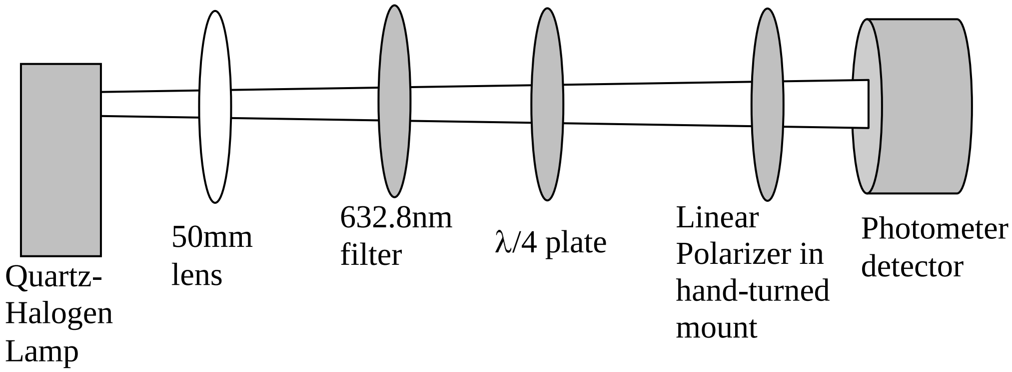
1) What does it mean if the light is said to be "unpolarized"?

2) If the computer reports an eccentricity of zero, does this mean the light is "unpolarized"?

3) What would a linear polarizer do to light that is "unpolarized"?

SHOW YOUR ANSWERS TO YOUR INSTRUCTOR BEFORE PROCEEDING.

Using a quartz-halogen lamp, place a 50.0 mm focal length lens in front of it to produce a collimated beam of light. Then send the collimated beam through a 632.8nm filter, mirror side toward the light source (waveplates are very sensitive to wavelength so that we must limit the wavelength of the source). Then the beam should pass through the quarter-wave plate and then the linear polarizer in the hand-turned mount.



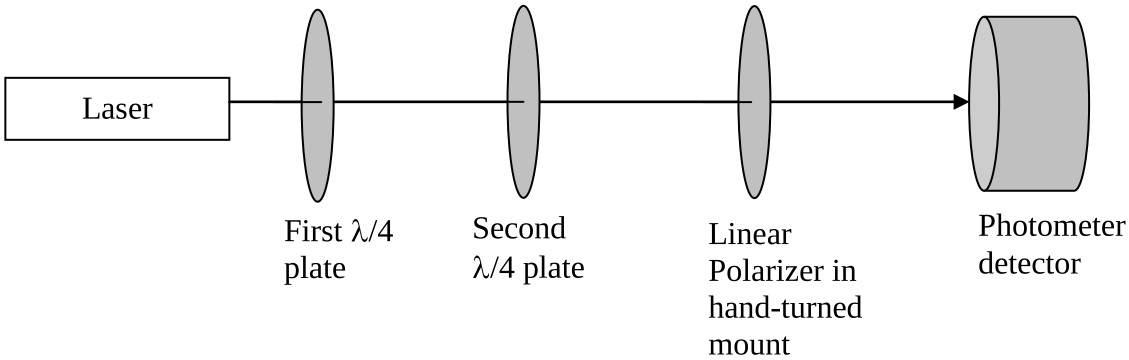
By only rotating the quarter-wave plate and linear polarizer, try to minimize the light reaching the photometer detector. Was there a significant decrease in light power at a particular polarizer angle compared to other angles? Quantify your answer using data.

Remove the quarter-wave plate and the linear polarizer without changing the position of the photometer. What does the photometer meter now read? What is the ratio of the light power reaching the detector with the quarter-wave plate and linear polarizer (minimizing the light) compared to the light power without them?

Is the light from the quartz-halogen lamp “unpolarized”?

How does the quartz-halogen light compare with your expectations of “unpolarized” light?

Connect a second λ/4 – plate to a plate rotator. Attach a piece of tape to this mount (NOT ON THE OPTICS) so that you can distinguish this quarter-wave plate from the first. Set up the equipment as shown below.



Turn the first quarter-wave plate (your original one) back to 45°. You should know the polarization of the light that exits the quarter-wave plate from an exercise in section 3.

By only rotating the SECOND quarter-wave plate and linear polarizer, try to minimize the light reaching the photometer detector. Was there a significant decrease in light power at a particular polarizer angle compared to other angles? Quantify your answer with data.

Remove the second quarter-wave plate and the linear polarizer without changing the position of the photometer. What does the photometer meter now read? What is the ratio of the light power reaching the detector with the second quarter-wave plate and linear polarizer (minimizing the light) compared to the light power without them?

Is the light that exits the first quarter-wave plate "unpolarized"?

How does the light that exits the first quarter-wave plate compare with your expectations of "unpolarized" light?

Based on your measurements for the quartz-halogen light and the laser light exiting a quarter-wave plate rotated to 45°, was the light (for either case) ever linearly polarized before it reached the linear polarizer?

Can a quarter-wave plate turn "unpolarized" light into linearly polarized light?

Circularly polarized light is light where the electric field and magnetic field vectors maintain constant magnitudes but they rotate about the light's propagation direction. This results from a constant phase shift of $\pi/2$ between two orthogonal linear polarizations. It's called circularly polarized because the electric/magnetic field vectors trace a circle over time.

Suppose circularly polarized light passes through a linear polarizer in a motorized mount. The exiting light from the linear polarizer then enters the photometer. What would you expect the LabView program to produce in terms of the photometer vs. angle graph and the polarization plot for circularly polarize light? Explain your reasoning.

What differences (if any) would you expect between "unpolarized" light and circularly polarized light?

DO NOT REMOVE ANY POLARIZER FROM ITS MOUNT. YOU WILL NEED THEM NEXT WEEK.

Task: A Polarization maze

You will have to accomplish the following:

1) The laser beam must first reflect off two mirrors before any other equipment
2) The laser beam must pass through a tube set to the same vertical height as the laser beam.
3) The polarization of the light exiting the tube must be circularly polarized (the eccentricity of the light must be smaller than 0.1)
4) The beam exiting the tube must have 80% or more of the available light power.

When you have measured the polarization and feel you have accomplished this goal, draw a sketch of your experimental set up. Show your data and experimental set up to your instructor before leaving.