Week #5 – Polarization and Birefringence

Reminder, still practice good optics alignment and Laser Safety practices! You can use photos instead of diagrams/or drawings in your lab report where ever it is appropriate and where they can be properly labeled/understood.

Note, sometimes the HeNe lasers tend to polarization sweep over time (rotate in polarization, the laser light has some polarization to it). The best way to avoid this is to allow the laser to warm up for 30-60 minutes before you start lab. How can you tell if a laser is still polarization sweeping? Simple, place one polarizer between the laser and the photodetector and look for a significant change in optical power measured vs. time.

■ *1. Polarization of Light* **–** Goal: validate the Law of Malus
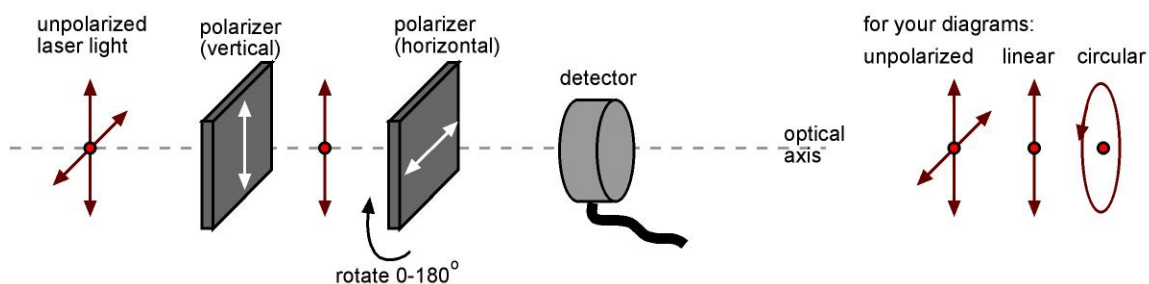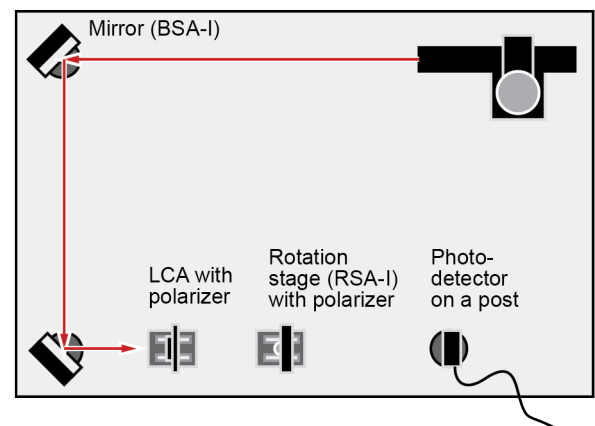
Procedure:

(1) Setup your experiment as shown at right. There are film polarizers (thin, square) and disk polarizers (thicker, round), use the disk polarizers.

(2) The photo-detector simply mounts to a post and post holder using the smaller-size screws. You may need to darken the lights in the room and also put black tape with a hole over it in front of the photodiode (power meter) to reduce non-laser light from effecting your measurements. You can also make a black tube out of black paper and put that over the front to absorb/block non-laser light.

(3) Rotate the second polarizer from 0 to 180° using 10° increments and record the irradiance (W/m^2) at each angle. The detector is 1 cm^2 in area. If you want your data collection to start close to 0° then look for the notches in the polarizers and make them both face up to begin with (aligned, 0°). You might tape the polarizer to the RSA, or use the retaining ring for the RSA (image shown at right) and the post holder plug for the RSA (shine laser through screw hole) to hold it inside the RSA.

(4) Plot these results and also plot a theoretical plot of the Law of Malus. You may need to insert a phase constant into the the Law of Malus to adjust the plots into alignment. Also, in your lab reports, you should have diagrams like that shown below… (they don't need to be fancy angled/3D, just representative).

■ *2. Birefringence of Materials* **–** Goal – explore birefringent materials and demonstrate the basic effect used in a pixel inside a liquid crystal display.

Procedure:

(1) Use a similar optical setup that you used for Part 1, however you will add more components. You will be rotating these components, some of them manually/crudely because you only have one rotation stage.

(2) First setup the polarizers again such that they are crossed (minimum transmission), record the irradiance on the detector.

(3) Next, insert a quarter-waveplate disk and rotate it to achieve maximum transmission, record the irradiance, and in your report draw/diagram the case for maximum transmission (fill in the question marks in the diagram below).
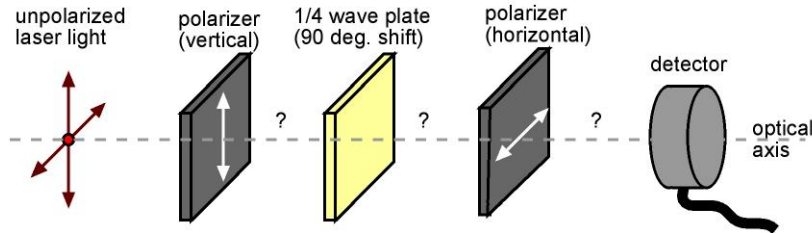

(4) Now, insert a second quarter-waveplate and rotate it to again maximize transmission, record the irradiance, and in your report draw/diagram the case for maximum transmission (fill in the question marks in the diagram below).
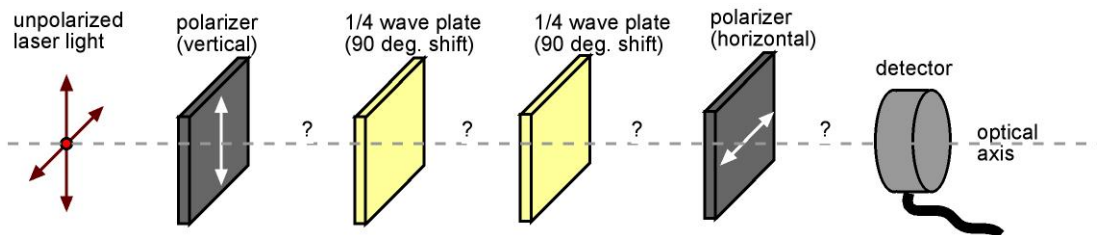
■ **3. Circular Polarizers** – Goal – create a circular polarizer, and figure out what makes it work!

Now, using the simple setups provided below (and your eyes only, no laser), setup the test cases shown below and rotate the components to obtain minimum and maximum reflection.

(1) When properly aligned, only one of these setups will provide a black reflectance appearance (not grey). The one that appears black is a circular polarizer. In your report draw/diagram the case for minimum transmission for each and explain why you get black appearance for only one of the cases.
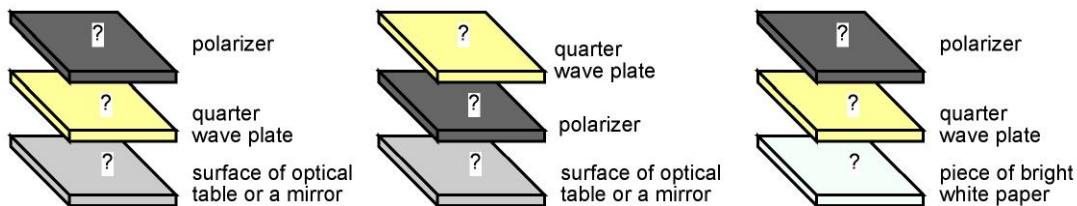
(2) Lastly, find the the circular polarizer film (is in one of the small bins). Try it out on the reflective surface of the optical table, and confirm that it works similar to the circular polarizer you created above. Then place it over the tape holding down the table label and explain why you can't get the same dark black color.

(3) OLED displays are coming out for TVs and smart phones. The problem is that the pixels are shiny like mirrors from their metal electrodes. One way the get the screen to look black when the pixels are off (not like a mirror) is to apply a circular polarizing film to the front of the OLED display. How does this prevent reflected light yet allow light emitted in the pixels to escape? *Note, not all the pixel emitted light gets out, at most about 40% or so….*

■ *4. Brewster's Angle* **–** Starting this week, we will expect you to be more independent and figure out how to setup and do more measurements using your own designs.

Goal: determine Brewsters angle for a simple glass slide.

Procedure: you determine a procedure of your design and validate it experimentally and theoretically. See the lecture notes for information on Brewter's angle. It is recommended that you measure Fresnel reflectance vs. incidence angle for a glass slide and with polarized light. One approach that is more challenging is to move the detector each time to measure *reflected* light as you rotate the glass slide, but if you are smart, there is a much easier way…

■ *5. Setup Dismantle and Storage* **–** Proper care of optical components is just as important to achieving reliable results as is careful experimental setup. Improper handling, setup, dismantling, and storage will detract from your final grade in this course. Unsure about any component? Just ask. The next group should find all parts neatly stored in the optics kit. There is a card with each kit that shows where each component goes.
,
■ *6. Theoretical/Calculation Problem* **-** None this week. This lab is a longer one (lots of parts) so there are no extra theoretical problems. Some nice MATLAB code for polarization optics can be found here:

http://www.optics.arizona.edu/milster/505%20Lecture/Spring%202011/opti_505_lec_Spring_2011.htm