Ocean Optics Class- Polarization Lab

<u>Station 1: Playing in the lab</u>
Scattering and reflection affect the polarization state of light interacting with matter. Polarization is a relatively new frontier in ocean optics and has been shown to be useful to avoid glare, and help characterize the composition of particulate material in the ocean.

Station 1.1 Polarization due to scattering of a light beam

a. Shine a collimated light source through from the sides of an aquarium. Add a few drops of Maalox and observe the intensity of the beam as function scattering angle (relative to the direction of propagation, see diagram) and azimuth angle. How does the intensity change?
b. Holding a linear polarizer, observe the beam at 90° scattering angle and rotate the polarizer on its axis. Does the intensity change with the axis of your polarizer? Now observe the beam from other scattering angles. How does the relative change in intensity (between the two axes of polarization) vary with scattering angle? Try this with the filter just in front of the light source and in front of your eye.
c. Do the same experiment but with a laser as a source. Observe the beam through the polarizer from a 90° scattering angle as you rotate the laser on its axis (shining in the same direction). Can you explain the observation given the fact the laser is linearly polarized?
d. Now take a radiometer and use a filter in front of the light source, measure the VSF as best as you can at ~10 angles from ~30°-140°. Flip the filter 90° and measure it again. Tonight calculate the degree of linear polarization from these two measurements and describe if it fits your expectations.
    a. DoLP will be calculated via:
        i. measurement with the filter at 0 ° + measurement at 90° = S11 (i.e. VSF)
        ii. measurement at 0° - measurement at 90° = -S12
        iii. DoLP = S12/S11.
        iv. See Bohren and Huffman pg 415 for more information.
    b. You have now measured two elements in the Mueller Matrix!!!

Station 1.2 Reflection from Surfaces
Look at the specular reflection of a collimated unpolarized light from a smooth nonmetallic surface (e.g. plastic, wood, or water). View the surface through a linear polarizer.
a. How does the intensity vary with the direction of the polarizer?
b. What if you use a polarizer in front of the source before it interacts with the surface?
c. How different are the result for a metallic surface?
d. View polarized light as it reflects from a depolarizing surface (white diffuser), is it still polarized at all? Vary the polarization of the input light (parallel and perpendicular to surface).

Station 1.3 The Three Polarizer Mystery
Shine an unpolarized light source through two filter that are perpendicular to each other and observe the light that passes through. Add in a filter in the middle that is 45° to the other filters and observe if any light passes through. Come up with your own hypothesis for why this occurs (quantum or classical is welcome!). Look it up and compare to your hypothesis and share this in the morning discussion.

Station 2: Polarization in the natural light field
Scattering due to molecules and aerosols cause skylight to be partially linearly polarized. Even clouds maintain this polarization to some degree (actually interesting patterns there). Reflection from the water surface also will introduce polarization.

Station 2.1 Skylight
Using your linear polarizer, view the sky with the polarizer at different angles.

a. Where is the skylight most polarized (biggest difference between having the polarizer and not having it)? What is the plane of polarization in different areas of the sky?
b. Take a photo from your phone with the polarizer at multiple angles. Annotate it with what you see and include this in the presentation.
c. Measure the sky polarized radiance again with your phone (ensuring you capture an image across the plane of the sun's zenith). Use a grey card held perpendicular to the ground and rotate a polarizing filter 90 degrees between images. Normalize your images to the grey cards, plot these (pseudo-reflectance) images and compare them.

Station 2.2 Water surface (at the dock)
Find somewhere you can view the water surface (hopefully flat water, but also look in areas of wind ruffled surface to check that out). Look for angles of both the polarizer and your viewing angles which most strongly eliminate the surface reflectance.

Take a photo from your phone with the polarizer. Annotate it with what you see and include this in the presentation.

Take polarized images with your phone using the grey card (held parallel to the ground) of the sea surface (try to take this around 40 degrees off nadir). Use the grey card to normalize this image (this will be Lt/Ed).

Groups that are done early can come back and play with the LISST-Horizon!

Hint:
To use the grey card assume Ed = (pi/plaque_reflectance) * L_plaque where:
- plaque_reflectance = 0.18 (double check on grey card packaging)
- L_plaque = radiance from the section of the image that has the plaque
- Use Ed to normalize the whole image such that: Lt_image / Ed = pseudo_Rrs