Experiment 9: Retardation and optical activity

The wave plates in the optics laboratory are designed to operate at a wavelength of 633 nm. Their fast axes are marked with two white lines.

1 Quarter-wave plate

A quarter-wave can be used to produce a circularly polarized beam from a linearly polarized beam, and vice versa. The linearly polarized beam has to be at a 45° angle to the fast and slow axes of the wave plate.

Rotate the laser and position a polarizer in the laser beam so as to create a beam that is linearly polarized in the horizontal direction. (To do this, utilize the reflection null at Brewster angle for horizontal polarization.) Mount a large aperture polarizer on a rotation stage to be used for analyzing the polarization, and cross this with the horizontally polarized laser beam.

Mount the quarter-wave plate on a rotation stage and position it between the polarizers. Rotate the quarter-wave plate so that its fast axis is vertical. Determine the polarization state after the wave plate by using the second polarizer. To this end, measure the degree of linear polarization V using the optical power meter.

Rotate the quarter-wave plate so that its fast axis is making a 20° angle with the vertical. Repeat the same measurements. What is the polarization state of the beam?

Rotate the quarter-wave plate so that its fast axis is making a 45° angle with the vertical. Repeat the same measurements. What is the polarization state of the beam?

Obtain a circularly polarized beam. Remove the second polarizer. Position a flat mirror after the wave plate to reflect the beam back through the plate and the linear polarizer almost back into the laser. The reflection at the mirror flips the handedness of the the circularly polarized beam (LHC becomes RHC and vice versa, see problem 6.1-5). **What** should you see after the reflected beam passes back through the retarder and the linear polarizer? What do you observe?

2 Half-wave plate

A half-wave plate can be used to rotate the polarization state of a wave by an arbitrary amount. The rotation angle is twice the angle between the input polarization and one of the axes of the wave plate. In this part, you will verify this for a few angles.

Prepare a horizontally polarized beam with a polarizer and pass it through the half-wave plate. Use a polarizer after the half-wave plate to determine the polarization state. Rotate the half-wave plate and measure the rotation of the output polarization.

3 Optical activity

In this part, you will measure the optical activity exhibited by a solution of sugar molecules in water. Position a polarizer in the laser beam so as to create a beam linearly polarized in the horizontal direction. Fill the glass tank with water and position it on the rotation stage so that the beam propagates through the water. Position a polarizer after the tank to determine the polarization state of the transmitted beam. Dissolve four sugar cubes in the water and determine the polarization state. Add two more sugar cubes and repeat your measurement until the solution is saturated. Calculate the rotary power of the solution and plot it as a function of number of sugar cubes dissolved in the solution.