Lab #8: Circular Polarization

Goal:
Explore various aspects of circular polarization

Equipment:
Optical bench with laser, incandescent lamp, polarizers, retarders, and photometer

1 making circular light

1.1 physics
We use a polarizer (PF) to make linear (P) light, and a \(\lambda/4\) plate (QWP) with its fast axis at \(\pm 45^\circ\) with respect to the transmission axis of PF to convert this light to either \(L\) or \(R\) type circular polarized. When this light is reflected from a mirror such that it travels back towards the light source, the QWP-PF combination acts as a circular analyzer. If the light at the mirror is truly circular, the reverse beam does not pass this analyzer.

1.2 setup
Let us agree that we measure orientation angles \(\alpha\) clockwise from the positive y-direction (up), while looking in the direction of the source. Arrange a laser, a polarizer (PF\(_1\)) with \(\alpha_{PF1} = 0\), a \(\lambda/4\) plate (QWP\(_1\)) with \(\alpha_{QWP1} = 0\), and a mirror as shown in the figure.

![Diagram of setup](image)

The reflected light can be seen at the front face of the laser (maybe a little improvised white paper screen helps). Since the PF\(_1\) and the QWP\(_1\) also reflect the beam, one must be careful in identifying the relevant spot by jiggling the mirror a bit.

1.3 experiment
Adjust the angle \(\Delta \alpha = \alpha_{QWP1} - \alpha_{PF1}\) between the transmission axis of the PF\(_1\) and the fast axis of the QWP\(_1\) until the reflected dot intensity is a minimum. Using the degree scales on both, the PF\(_1\) and the QWP\(_1\), determine the value of \(\Delta \alpha\). Is there more than one such angle for which the reflected intensity is a minimum? If yes, what are the values of these angles? Which ones correspond to \(L\) or \(R\) type light?

2 inspection of circular light

2.1 physics
We have made circular light as well as we can. The problem is that the \(\lambda/4\) retarder is matched to green light (560 nm), and works only approximately at other wavelengths. Thus, we expect that our circular polarizer is not perfect, i.e., makes light that is somewhat elliptical.
2.2 setup
Using our circular polarizer (PF₁ + QWP₁) from section 1, replace the laser by the incandescent lamp and add a second polarizer and a light sensor, as shown in the figure below.

![Diagram of setup](image)

2.3 experiment
If we have truly circular light, rotating PF₂ should not affect the transmitted intensity. Measure the variation of intensity as you rotate PF₂ through 360° (what we are really interested in are the angles $\alpha_{PF₂}$ for which the intensity is largest and smallest).

Set the retarder angle to $\alpha_{QWP₁}=20°$. Now you know that you have elliptical light. Again, measure the variation of intensity as you rotate PF₂ through 360°. Graph the results for both measurements.

3 inspection of elliptical light
3.1 physics
Imagine that elliptical light (as it emerges from QWP₁) is passed through another $\lambda/4$ retarder (QWP₂). It can be shown that there is an orientation of QWP₂ for which it transforms the elliptical to linear light. This is the case if the fast axis of the retarder coincides with the major axis of the ellipse.

3.2 setup and experiment
To the setup of sect. 2.2, add a second $\lambda/4$ retarder (QWP₂). Adjust the angle of both, QWP₂ and PF₂, such that the transmitted intensity is as low as it gets. Note these angles: can you consolidate this observation with the result of sect. 2?

4 play with bi-refringent stuff between crossed polarizers…