I worked under Dr. Alistair Rowe and Dr. Yves Lasailly at École Polytechnique in the Physique de la Matière Condensée laboratory. The goal of the internship was to determine the optimal optical set-up for measuring small angle polarization rotations in magneto-optical samples. The motivation for this work includes research into the spin characteristics of indirect band gap semiconductors such as silicon and determination of the thickness of chiral thin films. In both cases the rotations are proportional to the desired characteristic. These applications require access to measurements of extremely small rotations on the order of magnitude of nanoradians.

Three methods of polarization rotation measurements were proposed and their signal to noise ratios compared to determine the optimal set-up. The first method used an optical bridge with a polarizing beam splitter (PBS), with a given extinction ratio of 1,000:1, which determined the difference of intensities between two detectors. The theory of the bridge can be determined using Jones' matrices. It is found that the difference in intensity can be calculated as; $\Delta I = 4I_0 \sin\theta_F$. Where θ_F is the polarization rotation and if θ_F is small enough the difference in intensity becomes; $\Delta I = 4I_0\theta_F$. Therefore the rotation can be extrapolated directly from the difference of intensities and the initial intensity of the incident light. The second method was an optical bridge using a Wollaston beam splitter, which splits unpolarized light into beams at 10° to the optical axis with a given extinction ratio of 100,000:1. The rotation angle is determined in a similar fashion to the PBS system described above. The two set-ups were compared and it was found that the Wollaston beam splitter was able to measure rotations around twice as small as those measured on the polarizing beam splitter bridge. After this determination the third measurement test was introduced, this involved using the phase generated carrier technique. A photoelastic modulator was used to oscillate the polarization rotation between two values associated with the first and second harmonics of the modulator. Jones' matrices were used to determine the first harmonic and second harmonic intensities of the light, which are given as; $I_{1\omega} = J_1(P)\cos 2\theta_F$ and $I_{2\omega} = J_2(P)\sin 2\theta_F$ respectively. Where $J_1(P),\ and\ J_2(P)$ are Bessel functions at a certain phase (P). The ratio of these intensities when $\theta_F \quad \theta_F$is sufficiently small yields; $\theta_F = \dfrac{I_{2\omega}J_1}{2I_\omega J_2}$. $\theta_F = \dfrac{I_{2\omega}}{J_1 2I_\omega J_2}$Therefore the rotation can be determined by the intensities and Bessel functions at a certain phase. During the research it was proposed that the bridge was not necessary to determine the rotation in the magneto-optical sample and instead a single detector could be used.

Ultimately it was determined that using a bridge even when not necessitated by the set-up yields measurements of smaller angled polarization rotations due to the ability to work in lower noise than a single detector. It was also found that phase generated carrier technique did not yield measurements of smaller polarization rotation angles than the bridge set-up used initially as was expected. This is most likely due to alignment issues of the optical set-up. However, further experiments are expected to elucidate the results.