Faraday Rotation by Lock-In Methods

A workshop mentored by David Van Baak, for TeachSpin, Inc.
at BFY II, College Park, July 2015

What can we do (in under 40 minutes) with this apparatus?

We start with tools – a working Faraday-rotation demonstration – and we need more sensitivity
We note first an electronic (rather than geometric) way to detect Faraday rotation
We then use an alternating (rather than constant) current in the solenoid, to give an ac signal
We measure that signal first by using an oscilloscope, and next by using a lock-in amplifier

1. Faraday rotation's significance, and its apparatus requirements:
   how to get the light, the linear polarization, the sample, and the static magnetic field required

2. Faraday rotation demonstrated, using dc field and geometric detection:
   how to use the 'extinction method' to detect rotation of the plane of polarization

3. Faraday rotation, using dc field and electronic detection
   why it pays to rotate the analyzer to 45°-off-extinction in these circumstances

4. Faraday rotation using ac field and oscilloscope measurement:
   why it pays to use an ac field, and what ac-coupling can do for you

5. Faraday rotation using ac field and measurement by lock-in amplification:
   the tool wonderfully suited to quantifying an ac signal of known amplitude and phase

6. Connecting Faraday rotation's Verdet constant with more fundamental properties:
   The Verdet constant V defined via $\Delta\theta = V\,B\,L$, and the Becquerel prediction that
   $$V = \frac{-e}{2mc} \cdot \lambda \frac{dn}{d\lambda}\ .$$

7. Sources for $n(\lambda)$ information for optical glasses, and for liquid samples:
   look-up tables, fitted to Cauchy and Sellmeier models