# MAGNETO-OPTIC KERR EFFECT IN A MAGNETIZED ELECTRON GUN


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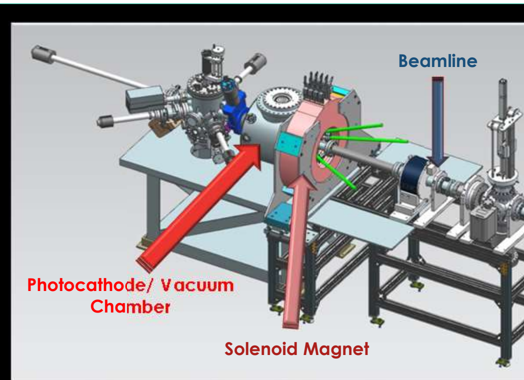
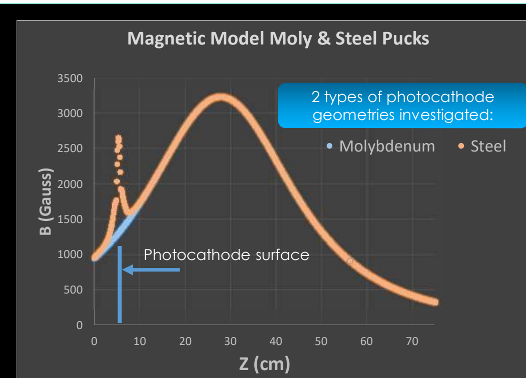
## Electro-Optic Kerr Measurement for a Magnetic Electron Beam Source

**The achievable luminosity of an Electron Ion Collider (EIC) depends upon minimizing the degradation ion beam emittance induced by intra-beam scattering. Electron beam cooling is a method to extract the transverse momenta of the ion beam to a "cooler" beam of electrons. The cooling efficiency is enhanced by using a magnetized electron beam to increase the interaction time with the ions in long solenoid magnet.**

**A magnetized electron beam cooler source is being developed at Jefferson Lab. The magnetized electron beam is generated from an alkali antimonide photocathode immersed in a longitudinal magnetic field. The photocathode is operated at high voltage in a high vacuum chamber and is not accessible. In this work the Magneto-Optic Kerr Effect (MOKE) was demonstrated as a novel in-situ method to measure the magnetic field at the photocathode during normal operation.**




## Modulated Polarization Method

**Ellipticity**

$$\varepsilon_{kerr} = \frac{\sqrt{2}\,V_{1f}}{4J_1\,V_{DC}}$$

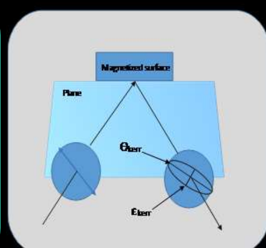
**Rotation**

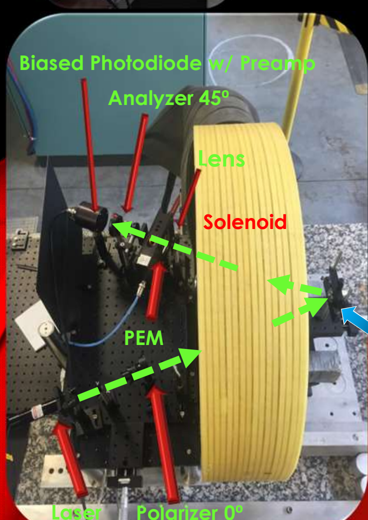
$$\theta_{kerr} = \frac{\sqrt{2}\,V_{2f}}{4J_2\,V_{DC}}$$


### Kerr Effect

Light reflected from a magnetized surface can experience a change in ellipticity, plane of polarization, and intensity. An induced circular birefringence results in rotation of the plane (θ) and change in degree of ellipticity (ε). These changes are linearly related to the magnetization of the sample. By extracting **θ** and **ε** using the equations to the left, we are able to determine the magnetization of the surface of the mock photocathode.

### Kerr Diagram



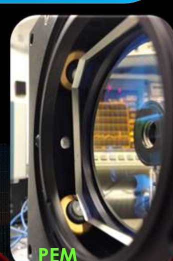




**Step 1:** Laser Polarized at 0°

**Step 2:** Reflected off pure iron foil on puck, results in rotation θ and change in ε

**Step 3:** Photo-Elastic Modulator alters polarization of light by applying stress on silica crystal at resonant frequency (≈42 kHz). Set up propagates the Kerr effect (ε and θ) at harmonics of the PEM frequency

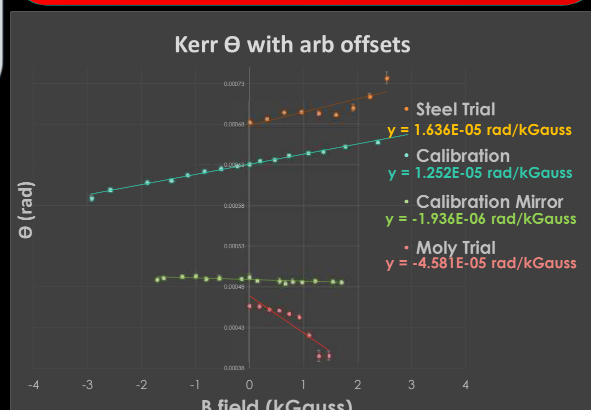
**Step 4:** Light analyzed at 45° and lock-In amplifiers detect the 1f and 2f amplitudes of the analyzed light to extract the Kerr signal.

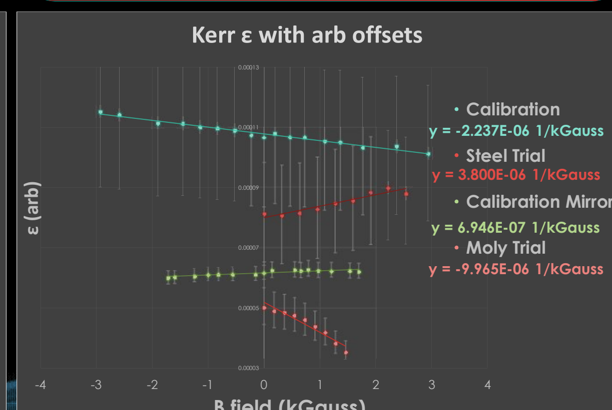




## Results

**Measurements:**
1. Intercepts are negligible, slope is only concern
2. Calibration trials (done with permanent magnets) reported consistent slopes
3. Mirror trials reported relatively flat slopes
4. Steel puck trials with solenoid magnet had 25% difference in slope (θ) from calibration tests
5. Moly trials reported opposite sign slope

**Conclusions:**
1. Magnetic field(up to 500 Gauss) affects equipment
2. Puck stability is incredibly important in order to minimize laser displacement in set up
3. With optimal set up, magnetic field at surface can be determined to a degree of certainty





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