Measurement of Faraday Rotation and Calculation of the Verdet Constant for a Glass? Rod

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Abstract

We aim to calculate the Verdet constant relating the change in magnetic field through a medium sample to the change in polarization angle of light traveling through the medium. A **wavelength?** laser was sent through a solenoid containing a **glass?** rod and an adjustable polarizer and received by a photodiode. A lock-in amplifier was used on the voltage output of the photodiode to reduce background noise. The phase offset was found by performing a non-linear least squares regression on the output voltage (V) versus polarizer angle (θ) data for four B fields. The Verdet constant for the sample was calculated from phase differences due to changes in the magnetic fields and found to be 20.1 $\frac{1}{mT*m}$ ERROR.

I. AIMS

a. To demonstrate the Faraday effect of the rotation of the plane of polarization of light as it travels through magnetic fields of different magnitudes.

b. To calculate the Verdet constant relating the change in magnetic field to the change in polarization angle.

$$\Delta\phi = V_c\Delta B L_{sample} \tag{1}$$

II. INTRODUCTION

The Faraday Effect is a magneto-optical phenomenon in which light of a single wavelength, traveling through certain materials subject to a magnetic field, experiences a shift in the plane of polarization. These materials, called birefringent, have different refractive indices for the right and left circular polarizations of light. This changes the relative phase angle between the two polarizations as the light travels through, thus rotating the overall polarization plane.

As shown in Equation 1, the Verdet Constant (V_c) relates the change in magnetic field of a medium to the change in polarization angle of the traveling light. V_c is specific to any medium. There are two ways in which we can calculate V_c. By Malus's Law, $I(\theta)=I_0*\cos^2(\theta)$, where I is the intensity of measured light through a polarization filter of angle θ with respect to the maximal polarization angle. Similarly, for voltage output, $V(\theta)=V_0 * \cos^2(\theta)$. Once we add into this set-up a magnetic field through which the light can travel, we will observe the voltage output equation to have a phase shift, θ: $V(\theta)=V_0 * \cos^2(\theta + \phi)$.

One way to calculate V_c is to measure the phase shift, ϕ for multiple magnetic fields: collecting data for $V(\theta)$ for a full 0-360 degree range of θ and comparing data for different magnetic fields to a base data set of the same set up, where there is no magnetic field. θ can be plotted against B- they should have a linear relationship- and by finding the slope of that linear fit, $\frac{\partial\theta}{\partial B}$ will be found and thus V_c by Equation 1.

Another way to find V_c is to notice that $\frac{\partial\theta}{\partial B} = \frac{\partial\theta}{\partial V} * \frac{\partial V}{\partial B}$