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.

$$\partial\theta = V_c * \partial B * L_{sample} \tag{1}$$

II. INTRODUCTION

The Faraday Effect is a magneto-optical phenomenon in which light of a single wavelength, traveling through a medium of a certain refractive index subject to a magnetic field, experiences a shift in the plane of polarization. This has to do with the fact that light has a right-hand circularly polarized component and a left-hand circularly polarized component. If it is sent through a medium considered to be birefringent (having a different refractive index for light in different polarization orientations), the relative phase angle between the two components will have changed and the overall plane of polarization will have rotated.

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, $I(\phi)$=$I_0 * \cos^2(\phi)$, where I is the intensity of measured light through a polarization filter of angle ϕ with respect to the maximal polarization angle (which would transmit light of intensity I_0. Similarly, for voltage output, $V(\phi)$=$V_0 * \cos^2(\phi)$. 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: $V(\phi)$=$V_0 * \cos^2(\phi + \theta)$.

One way to calculate V_c is to measure the phase shift, θ for multiple magnetic fields: collecting data for $V(\phi)$ for a full 0-360 degree range of ϕ 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 $\frac{\partial\theta}{\partial B} = \frac{\partial\theta}{\partial V} * \frac{\partial V}{\partial B}$

III. PROCEDURE

IV. RESULTS

V. ANALYSIS

VI. DISCUSSION

VII. CONCLUSION

VIII. REFERENCES