Faraday Rotation

In 1845, Michael Faraday was searching for experimental evidence that the forces in nature were all interconnected. He made a remarkable discovery by carefully examining the polarization of light as it passed through a transparent material in the presence of a magnetic field. He observed that linearly polarized light propagating through matter parallel to a static magnetic field, experiences a rotation of the plane of polarization. The effect is small, but he was an exceptional experimenter and he unambiguously identified the phenomenon. The rotation of the plane of polarization is still called the "Faraday Rotation".

Faraday rotation has a practical application in optical isolators. An optical isolator is a device that allows light to go through in one direction but severely attenuates reflected light propagating in the opposite direction.Optical isolators have important applications in telecommunications preventing reflected signals on fiber optic cables from producing unwanted signals. Isolators are important when lasers are used because reflected light can cause havoc with the operation of the laser itself.

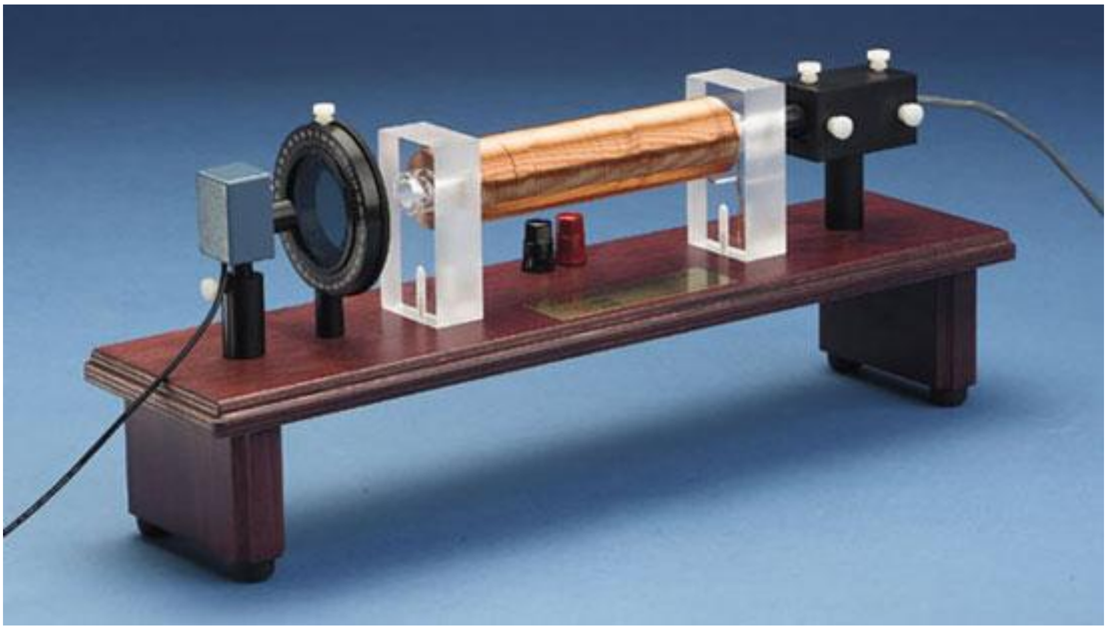

Figure 1 Experimental setup

TeachSpin's Faraday Rotation Apparatus, FR1-A, Includes:

- The Light Source
- The Solenoid (magnetic field source)
- The Analyzer Polaroid
- The Optical Detector

The Light Source

The light source is a red laser pointer operating at a nominal wavelength of approximately 650 nm with a power output of about 3 mw. It requires a voltage regulated supply of 4 volts and 40 mA. TeachSpin's Power Audio Amplifer PAA1-A has a voltage regulated (4V) supply output specifically designed for this laser diode light source.

Although the output is approximately 60% polarized, the laser light is directed through a polarizing filter which increases its polarization to about 95%. Before the sample is installed, four nylon thumb screws on the laser mount are used to aim the laser beam along the central axis of the solenoid.

The entire laser mount is removable so that an experimenter could use other light sources to study the frequency dependence of Faraday rotation. If any other sources are used, however, it is important that the intensity be stable. Small modulations in the frequency will not be as important.

The Solenoid

The solenoid is a 15 cm coil of #18 double insulated wire with DC resistance of 2.6 ohms. The approximate calibration at its center is:

B = (11.1mT/A) I

where I is in amperes and B is in millitesla.

The maximum continuous current through the unit is 3 amperes. For times of the order of 30 seconds, however, 10 amperes can be used without damaging the solenoid or its supports.

The Analyzer Polaroid

The unit is equipped with a rotatable Polaroid film in a calibrated mount. The decal is marked in 5° increments. This limits the accuracy of an angular measurement to about 2°.

The Detector

The detector is simply a photodiode connected in series to one of three resistors; 10K, 3K, 1K. The photodiode is a current source and is a linear photonic detector, as long as the voltage across it is less than about 0.3 volt. Saturation begins to occur when this bias voltage appears across the diode. This makes the detector nonlinear. Varying the load resistor keeps the bias voltage below the 0.3 volt value

Experiment

1- Connect multimeter, solenoid and power supply in series.
2- Connect another multimeter to the photodetector.
3- Start rotating the analyzer, you will notice the change in the multimeter.
4- Find the minimum value by rotating the polarizer.
5- Then start recording the data by rotating by 5 degree-increments.
6- Take the data between 0-180°.
7- Adjust the polarizer so that you read the minimum value again.
8- This time you will apply current through the solenoid. Increase the current value from the power supply.
9- You will take the data between 0 to 5 A by 0.1 A increments. You need to consider the current value read from the multimeter which is connected to the power supply and the solenoid.