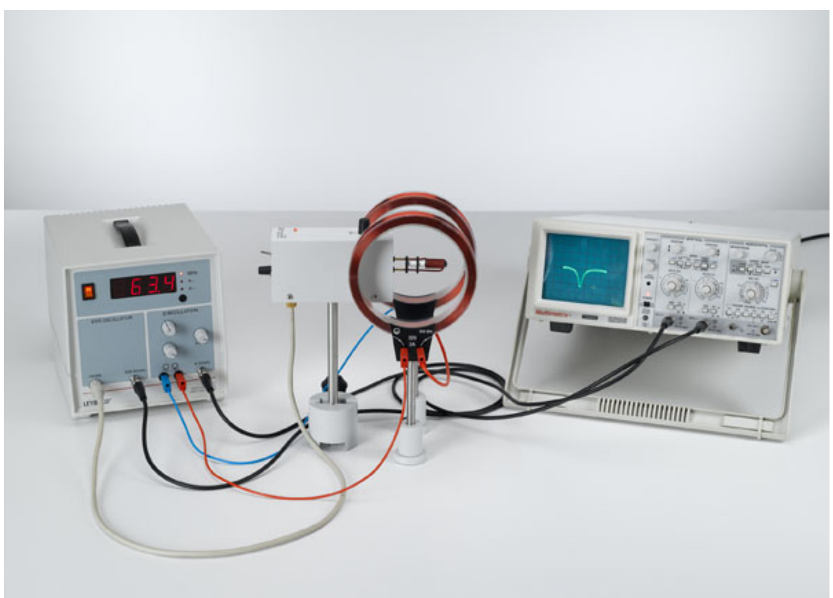
ELECTRON SPIN RESONANCE

CASPAR LANT

Intermediate Experimental Physics II

Section:	001
Date Performed:	March $e^{i\phi}$, 2016
Date Due:	March $\frac{d}{dx}\delta(x)$, 2016
Partner:	Neil Saddler
Professor:	Prof. Andrew Kent
Instructor:	David Mykytyn



Date: May 7, 2016.

The Objective.

1. Theoretical Background/ Abstract

Electron Spin Resonance is a effect that occurs when materials containing unpaired electrons find themselves in the presence of an external magnetic field. Electron spin resonance is similar to the nuclear spin resonance (the subject of another experiment in this course), but instead of relating to the excited spins of atomic nuclei, this type of resonance describes the spin states of excited electrons. Depending on who you ask (and specifically their political allegiances), electron spin resonance was discovered by either a Soviet physicist by the name of Yevgeny Zavoisky, or by the Allied physicist Brebis Bleaney.

Electrons are partially defined by their magnetic moment and spin number, both of which are quantized. The spin number of all electrons, and fermions in general is 1/2. The magnetic moment of an electron is defined by the following:

$$\mu_S = \frac{g_S \mu_B S}{\hbar} \tag{1}$$

Where S is the electron's spin (1/2) and g_s is its g-factor, which is a quantity we hope to arrive at later in this lab (but for now we'll set it equal to 2) μ_s is the Bohr magneton, equal to approximately 9×10^{24} Joules per Tesla. The energy of an electron in the presence of and external magnetic field B_0 depends on the alignment of its spin magnetic moment relative to the direction of B_0. Uncoupled electrons in a material such as DPPH (2,2-diphenyl-1-picrylhydrazyl, shown in figure **??**) have little trouble setting their magnetic moments either parallel or antiparallel to the magnetic field. The energy of such an electron is given by equation 2.

$$E = m_s g_l \mu_B B_0 \tag{2}$$

m_s differs by a sign depending on it's alignment relative to B_0, making the difference in energy between the parallel and the antiparallel state:

$$\Delta E = h\nu = g\mu_B B \tag{3}$$

$$V_s = \frac{h}{\mathrm{e}}\nu - \frac{\phi}{\mathrm{e}} \tag{4}$$

In DPPH it is electron exchange which is important. The full width at half height of the resonance in terms of the magnetic field will be called δB and will be measured.

$$\vec{\mu} \times \vec{B} = \omega_L \times \vec{L} \tag{5}$$

$$\frac{\mu_0 N}{2R}\left(\frac{4}{5}\right)^{\frac{3}{2}}(2I_0) = 2.115(2I_0)mT \tag{6}$$

2. Experimental Procedure

(1) Plug everything in in the manner depicted in the illustration on the cover page and ensure that all measurement devices are powered off.

(2) Carefully plug the largest RF coil into the RF unit.

(3) space the solenoids by a distance of 6.8cm.

(4) Place the sample into the coil and place it in the center of the volume formed by each solenoid.

(5) Make sure that U_0 is set to zero, and U_{mod} is set to the second scale marking.

(6) Turn on all devices. The oscilloscope should be set for two channel operation with channel one triggering.

(7) Set the frequency adjuster on the RF unit to 15 MHz. The Amplitude should be at its maximum.

(8) Now, increase the DC coil voltage U_0 until resonances are seen on the oscilloscope's phosphor screen. This will take the form of a nice, symmetric "v"-curve, similar to the Gaussian function $-e^{-x^2/a}$

(9) Note the current

3. Graphs and Tables

Table 1. Voltage vs. Deflection

f (MHz)	I_0 (A)	$2I_0$ (A)	B(mT)
30.7	0.644	1.288	2.724
35.0	0.731	1.462	3.092
40.0	0.880	1.760	3.722
45.0	0.993	1.986	4.200
50.0	1.112	2.224	4.704
55.0	1.205	2.410	5.097
60.0	1.317	2.634	5.571
65.0	1.442	2.884	6.100
70.0	1.534	3.068	6.489
75.0	1.595	3.190	6.747
80.0	1.692	3.384	7.157
85.0	1.765	3.530	7.466
90.0	1.917	3.834	8.109
95.0	2.035	4.070	8.608
100.0	2.067	4.134	8.743
105.0	2.221	4.442	9.395
110.0	2.293	4.586	9.699
100.0	2.412	4.824	10.203

The topmost plot corresponds to a filter of slit width 577 nm, the middle plot 546 nm, and the last plot a wavelength of 435 nm.

4. Questions

(1) *The manufacturer designed this experiment with the coils connected in parallel. A series connection would be better. Why?*

(2) *The p-p modulation current $\delta(2I_0)$ for the half-width δB is obtained from Where does the divisor 10 come from?*

(3) *In the method given for measuring δB, the scope controls are not used in a calibrated mode. Why is this OK?*

(4) *Why is the multimeter set for DC amperes for measuring g and for AC amperes for measuring the line width?*

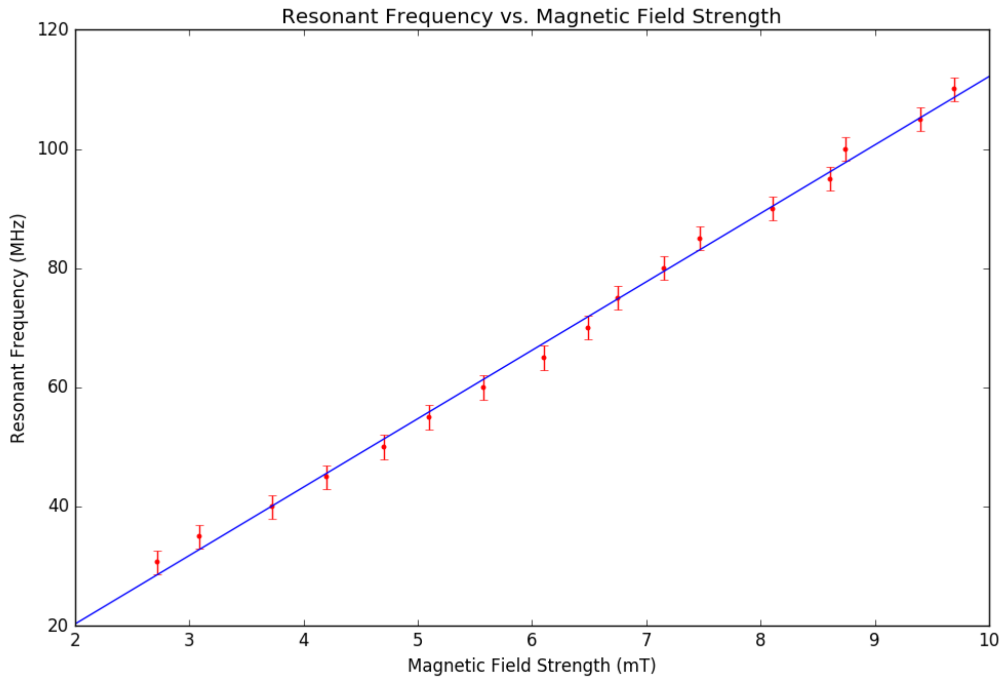


FIGURE 1. Finding g_s

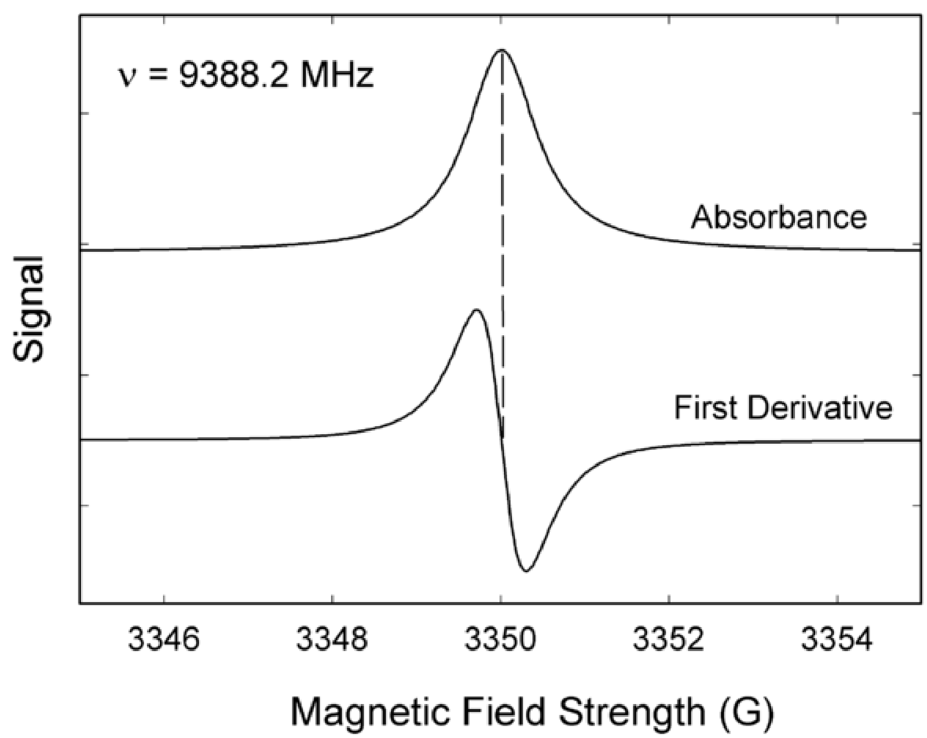
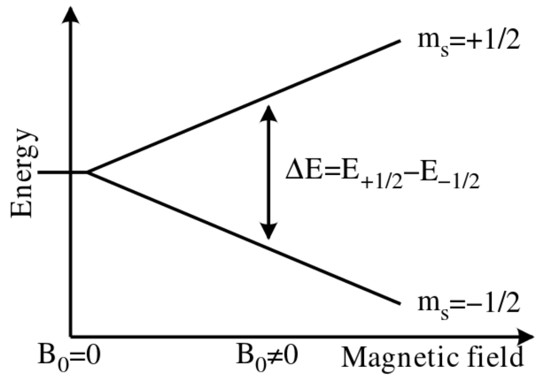


FIGURE 2. Schematic Diagram of the Experimental Setup



The line width is given by I_{rms}, which

(5) *Is there an RF electric field associated with the RF coil? If so, make a sketch of what the fields look like.*

There is no electric field associated with the RF coil, assuming it's been aligned properly.

5. Error Analysis

slope = 11.4794866225