ELECTRON SPIN RESONANCE

CASPAR LANT

Intermediate Experimental Physics II

Section:	001
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Partner:	Neil Saddler
Professor:	Prof. Andrew Kent
Instructor:	David Mykytyn

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The Objective of this lab was to observe the famous photoelectric effect first hand, and to experimentally derive the value of Planck's constant, a quantity central to the study of quantum physics.

1. Theoretical Background/ Abstract

Due to quenching, the role of the orbital angular momentum of the paramagnetic electron in a DPPH molecule is very small. To begin with, we assume it is zero, and then will modify our expressions slightly at the end. The electron has a spin angular momentum S whose magnitude is given by S = s(s + 1)h where s = 1 is the spin quantum number. Associated 2 with S is a spin magnetic moment given by = (gsBS)/h , where gs is the g factor for the electrons spin and B is the Bohr magneton. From this relation it is seen that gs, which is dimensionless, is the ratio of the electrons magnetic moment in units of the Bohr magneton to its angular momentum in units of h . We will take gs = 2 although if Q.E.D. corrections are included it is equal to about 2.0023. It is twice gl, the g factor for the orbital motion. In a magnetic field that points in the z direction the spin angular momentum can only have projections onto the z-axis of Sz = h ms, where ms is the magnetic spin quantum number with values of only 1. As a result the spin magnetic moment can only have projections onto 2 the magnetic field of z = gsBms. As the potential energy of a dipole in a magnetic field B is U = B, there are two possible energy levels whose values are 1gsBB. The 2 energy of these levels is plotted as a function of the magnetic field in Fig. 1. The energy difference E between these two levels at a given magnetic field is

$$\Delta E = h\nu = g\mu_B B \tag{1}$$

where ν is the frequency of the radiation necessary to induce a transition and the subscript s has been removed from the g to account for the fact that there are still small effects due to the electrons orbital motion and that we do not expect g to be exactly equal to 2. The value of g is measured in this experiment. In an ESR experiment the line width can supply information about many properties. Contributions to the line width can come from If we take V_S, the stopping potential, to be the kinetic energy of a given photoelectron times its charge, we can produce the following equation:

$$V_s = \frac{h}{\mathrm{e}}\nu - \frac{\phi}{\mathrm{e}} \tag{2}$$

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.

$$\vec{\mu} \times \vec{B} = \omega_L \times \vec{L} \tag{3}$$

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

2. Experimental Procedure

(1) Plug everything in in the manner depicted in the schematic.

(2) Now that I know that you don't read the procedure section, typing them up has become so much more laborious.

(3) Put on your pair of Ali-G glasses and instruct your partner to do the same.

(4) Remember, always don your pair of glasses first if your partner is unable to do so.

(5) Turn on the Ammeter (referred to in the lab manual as a galvenometer) and zero it.

(6) Zero both potentiometers such that the retarded voltage (displayed on the multimeter) is zero volts.

(7) Turn on the UV lamp and place it close to the device's aperture. Wait a minute and note the deflection on the ammeter.

(8) Turn the dial photoelectric effect device to the 577 nm wavelength position.

(9) Record the ammount of deflection by the ammeter for retarding voltages of zero to three volts, at tenth-of-a-volt intervals.

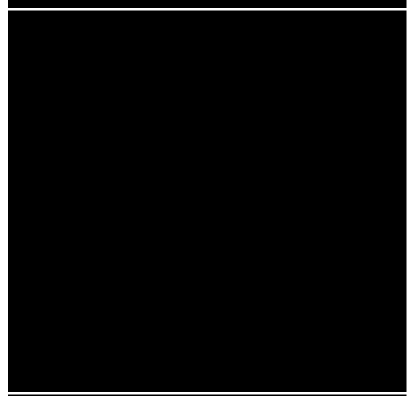
(10) Turn the dial to the next setting and repeat the last 3 steps.

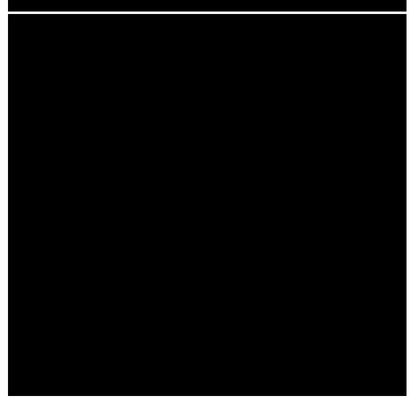
(11) Repeat the last three steps for the remaining two wavelengths.

3. Graphs and Tables

Table 1. Voltage vs. Deflection

f (MHz)	Io (Amp)	2Io (Amp)	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?*

There don't seem to be any questions to answer in this lab report.

[redacted]

FIGURE 1. Finding Planck's Constant
$h = 6.14 \times 10^{-34}\ {}^{\mathrm{m^2 kg}}\!/\!{}_{\mathrm{s}}$

[redacted]

FIGURE 2. Schematic Diagram of the Experimental Setup

[redacted]

(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?*

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