Physics 250 Lab #1

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Abstract

This lab tests the nuclear magnetic resonance of substances, to determine the magnetic moment of particles resulting from the spin of the particle, used to find the gyromagnetic ratio of a proton.

1 Introduction

Protons as point charges are fermions, such that they have a half-integer spin with intrinsic angular momentum of $\pm\frac{\hbar}{2}$, producing a magnetic moment due to the rotating charge, as well as due to the intrinsic spin. The magnetic moment produced by the rotation of the charge is $\mu = \pi r^2 \frac{e}{T} = \frac{Le}{2M}$. The magnitude of the spin magnetic moment similarly is $\mu_s = g\frac{Le}{2M} = \pm g\frac{e}{2M}\hbar 4\pi$, multiplied by the magnitude of the external magnetic field to get the energy level difference. As a result, the resonance static magnetic field are those producing an energy difference equal to the oscillating magnetic field frequency times h ($E_s = hf_{oscillation}$). At this point, the energy of the oscillation is enough to excite the energy state caused by the spin, allowing the gyromagnetic ratio to be measured.

2 Apparatus

3 Measurements/Data

4 Analysis

The average of the rising distances and falling distances combined with the times are used to calculate the average rising and falling velocity for each drop. The radius can be calculated the equation, $r = 9.66 * 10^{-5}\sqrt{v_f}$. Using the equation $q\frac{V}{d} = K\sqrt{v_f}(v_f + v_r)(1 + \frac{8.23*10^{-8}}{r})^{-\frac{3}{2}}$ as a correction to Stoke's Law, which states that $q\frac{V}{d} = K\sqrt{v_f}(v_f + v_r)$, the charge of the droplets can be calculated as a result.

Metric	Drop 1	Drop 2	Drop 3	Drop 4
Rising Time 1 (s)	1.83	3.33	5.33	1.39
Rising Time 2 (s)	1.89	3.28	5.64	1.26
Rising Time 3 (s)	1.94	3.56	5.3	1.37
Falling Time 1 (s)	13.88	9.68	12.15	11.24
Falling Time 2 (s)	15.43	9.85	12.76	13.77
Falling Time 3 (s)	19.28	8.02	13.29	12.96
Average Rising Distance (m)	0.00032	0.00032	0.00032	0.00032
Average Falling Distance (m)	0.00032	0.00032	0.00032	0.00032

Table 1: Measured Data

Metric	Drop 1	Drop 2	Drop 3	Drop 4
Average Rising Velocity (m/s)	0.000169611	5.90043E-05	9.43953E-05	0.000238806
Average Falling Velocity (m/s)	1.97572E-05	3.48457E-05	2.51309E-05	2.52831E-05
Radius (m)	4.29378E-07	5.70232E-07	4.84263E-07	4.85727E-07
Integer Multiple of e	2	2	1	3
Charge (C)	3.44745E-19	3.32058E-19	1.77581E-19	5.59455E-19
Calculated Value of e (C)	1.72373E-19	1.66029E-19	1.77581E-19	1.86485E-19

Table 2: Calculated Data

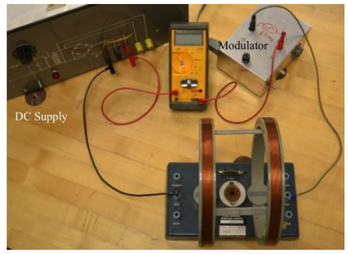


Figure 1: This is the photo of the setup of the Helmholtz coil to measure the static field produced by the coil with respect to current.

5 Conclusions

1. For nuclear magnetic resonance to occur, there must be a nonzero total atomic spin, found in Hydrogen due to the unfilled valence electron shell, causing an electron total spin of one half. Since Helium has a filled valence shell, such that there is a total spin of 0, there is no NMR, while for deuterium, it is still able to occur, due to the spin of the nucleus being integral, the spin of the electrons being half-integral. This is extended to being true that any fermion is able to have NMR. The nucleus is zero spin for those with equal numbers of protons and neutrons, such that He4, Ne20, Ar36, Be8, Mg24, and Ca40 are unable. All others should be able to experience NMR, due to having nonzero spins.

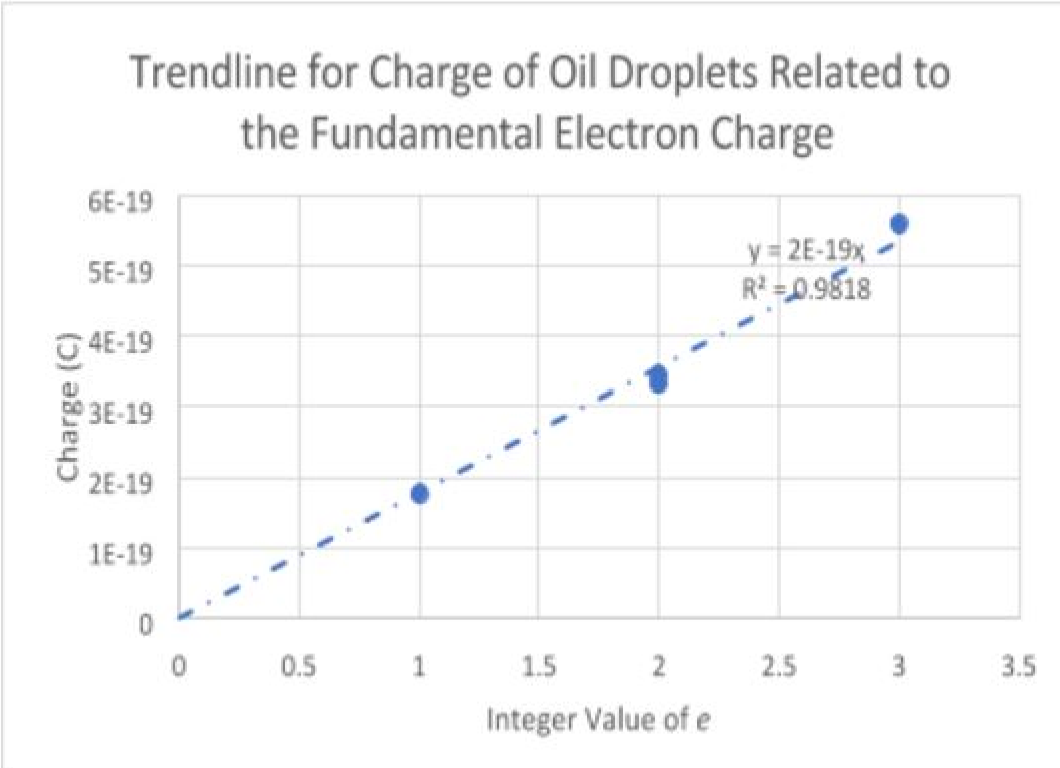
2. It is found by the value of the measurements that g is 0.0349, rather than the expected 1 such that spin doesnt affect the magnetic moment the same amount as classical orbital electron angular momentum. Protons are expected to have a higher value, such that it implies that they are creating magnetic moments by a different mechanism than electrons, or in a different manner. The significance of the value being a non-whole number is due to the fine-structure refinements.

3. By the formula for B_h, it is found that the magnetic field at 5 A is 5.15E-4 T, such that the frequency is 14.44 MHz, such that it is a radio wave.

4. Since the oscillator is required to move the magnetic field over the resonance strength, rather than having to precisely hit the strength, if there was not an oscillator, it would have to be precisely hit by manually varying the signal, which would be vastly harder.

5. The MRI machine is used by finding the resonance of the magnetic field, such that as water is moved within the machine, or some other desired material with a different resonance, the energy is suddenly drastically lost at that particular point, giving the locations of the desired material.

6. The Helmholtz coil arrangement produced a magnetic field either parallel or antiparallel from that of the Earth, such that it had to be taken from both, to determine the effect of a change in the magnetic field of $2B_e$. An additional Helmholtz coil exactly cancelling out that of the Earth could be used instead, or electromagnetic shielding to block the field



of the Earth.

7. For each frequency, the time-base is viewed as a sinusoidal curve, based on the direction of electron flow within the wires shifting, causing the electrons to hit different portions of the oscilloscope detector as the force acting on them is distinct.

8. Protons do have an electric dipole, while electrons do not, due to the former being able to be broken up into the composite particles, while a dipole would imply the electron was made up of composite particles. This is not true for a magnetic dipole, due to the lack of existence of magnetic monopoles.