Determining Krypton Concentration is Xenon

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Abstract

The ultimate goal of this experiment is to determine a more efficient way of determining the concentration of kyrpton in a given xenon sample using an RGA.This is a subproject from a main experiment Xenon 100 which is in the search of Dark matter. If we are able to create an effiecient way of determining the concentration of krypton which is in xenon we would be able to use this to improve the Xenon 100 experiment. However, before we can begin conducting the experiment of determining the krypton concentraion, we must do pre-lab work involving the creation of a calibration graph.This calibration graph will allow us to relate the pressure and the krypton concentration ,based on their linear relationship. But before this is done, the rate at which xenon flows through the system, must be able to produce consistent pressure results ,limiting error. Once the efficient flow is determined, we will be able to runt he experiment with controls and create a calibration graph or pressure versus time. Pressure and concentration are linearly related and we wish to determine the value of the constant which relates these two things. This is determined by the slope of the calibration graph.

1 Introduction

Dark matter was first postulated by Fran Zwicky in 1933, after determining that the mass of the Coma cluster of galaxies was greater than what he expected .Hence the theory there was "missing mass" . Further evidence was discovered when Zwicky observed that their relative velocities between galaxy clusters millions of light years away, was too great to only be the affect of the gravitational attraction of visible matter. this again yielded a "invisible matter". Another discovery was mane by Vera Rubin in 1950. She determined that orbital velocities of objects on the outskirts of the galaxy was about the same as bodies near the center of the galaxy. This contradicts Newton's law which states that the further an object gets from the center the slower its orbital velocity is. Therefore to account for this contradiction, Rubin continued on Zwicky's theories of missing matter. experiment

Figure 1: Path A is what was the expected result based on Newton's laws and visible matter.Path B is the experimental results, which show that there is indeed mass missing to have a result where the velocity doesnt decrease the further you get from the center of the orbit.

Many contributions are continually made to the theory of dark matter, and today it is widely accepted that about 74 of the universe is dark energy, 22 is dark matter, and about 4 is visible matter which we actually see.

Properties:The theory of dark matter has been one which has been readily accepted, and many people are trying to find dark matter. However the question is how come we are not able to see or easily detect this matter, and what is it ?. This is where theorizing comes into play. There are many theories as to what dark matter properties should be . One theory which Xenon 100 is based off of, is the existence WIMPS. WIMPS are weakly interacting massive particles,the existence of these particles is hypothetical, however one which is a main candidate for cold dark matter .The characteristic that these particles would be weakly interacting is due to the fact interaction with visible matter and cannot be observed through electromagnetic observation. They may in fact only interact with graviational and weak forces., making them difficult to detect. Another characteristic these WIMPS are said to have is being massive; on the order of GEV's .This mass is still unknown, however this is what is hypothetically expected.According the the theory of cold dark matter, this would explain as to why the particles are in fact not relativistic. Where

$$mg = kv_f \tag{1}$$

Figure 2: This is a graph which shows the limitations and the results of what various dark matter experiements have found. Xenon100 is the blue line which eliminated essentially the cross sectional area and mass above that line. What is being tested is the parameters below the line at about 10E-44 cm^2 cross sectional area. The area which is shaded in the gray is the theoretical values to what the mass and cross sectional area os WIMPS are.

E is the electric intensity,q is the charge carried by the drop,m is the mass of the drop, and a is the acceleration of gravity,k is the coefficient of friction and v_f is the velocity of fall The equation of the forces is given by:

$$Eq = mg + kv_f \tag{2}$$

Using the definition of k from equation and solving for q, equation 2 becomes:

$$q = \frac{mg(v_f + v_r)}{Ev_f} \tag{3}$$

We want to eliminate the m from equation 3, using

$$m = \frac{4}{3}\pi a^3 \rho \tag{4}$$

Where ρ is the density of the oil and a is the radius of the droplet.
In order to calculate a, used Stoke's Law:

$$a = \sqrt{\frac{9nv_f}{2g\rho}} \tag{5}$$

Where the n is the coefficient of viscosity, however the viscosity must be multiplied by a correction factor. The equation for a becomes:

$$a = \sqrt{(\frac{b}{2p})^2 + \frac{9nv_f}{2g\rho}} - \frac{b}{2p} \tag{6}$$

Where b is a constant, p is the atmospheric pressure, and a is the radius of the drop. Making all the appropriate substitutions the equation for the charge becomes:

$$q = 6\pi \sqrt{\frac{9n^3}{2g\rho(1 + \frac{b}{pa})^3}} (v_f + v_r)\sqrt{v_f} \tag{7}$$

2 Experiment

Equipment:

atomizer

non-voltatile oil

plate charging switch

Power supply adapter

Pasco Millikan Apparatus

Figure 3: Apparatus

Procedure:

In the start of the experiment the alignments of the set-up must be adjusted. The camera which is looking into the eyepiece needs to line up so we can see the grid placed on the other side of the parallel plates.This grid is used to analyze the velocity of the oil droplet. Once everything is aligned, ionize the oil droplets with the atomizer, and turn of the lights in the room. At first oil droplets fall and reach terminal velocity.Than a voltage between 300-500v is applied to the two parallel plates, creating and electric field.When the voltage is just right it balances out the force of gravity of the drop, and the drops are suspended in the air. The electrons are observed on a television. . An electron chosen to observe, where the rising and falling of the electrons can be controlled.Once the electron is chosen , the velocity of the drop is measured using the time of accent/decent and the distance traveled(5cm).Than using the plate switch,change the direction of the electron in the electric field. thus measuring the rise of the same drop. Repeat this step about 10 times, and for numerous droplets.Than using the plate potential,oil density,viscosity of air, and the barometric pressure to find the charge of the electron.

3 Data

Free Fall(s)	Rise time(s)	v_f(cm/s	)v_r(cm/s)
32.4	8.9	0.0015	0.0056
35.1	5.0	0.0014	0.101
28.7	5.2	0.0017	.0096
27.5	8.6	0.0018	0.0058
24.3	7.8	0.0021	0.0064

Table 1: Drop 4

Free Fall(s)	Rise time(s)	v_f(cm/s)	v_r(cm/s)
40.6	4.3	0.0012	0.012
55.7	3.3	0.0009	0.015
37.6	4.3	0.0013	0.012
43.9	7.1	0.0011	0.007
45.7	7.2	0.0011	0.007

Table 2: Drop 5

Free Fall(s)	Rise time(s)	v_f(cm/s)	v_r(cm/s)
47.9	3.9	0.0010	0.013
56.3	6.4	0.0009	0.008
52.1	6.4	.0010	0.008
54.6	14	.0009	0.003
59.3	6.0	.0008	0.008

Table 3: Drop 6

Free Fall(s)	Rise time(s)	v_f(cm/s)	v_r(cm/s)
91.7	3.5	0.0005	0.014
41.4	3.2	0.0012	0.016
83.4	3.2	0.0006	0.016
68.4	3.2	0.0007	0.016
58.5	3.2	0.0009	0.016

Table 4: Drop 7

Free Fall(s)	Rise time(s)	v_f(cm/s)	v_r(cm/s
27.1	7.1	0.0018	0.007
34.7	6.8	0.0014	0.007
38	7.1	0.0013	0.007
38.2	4.5	0.0013	0.011
45.5	6.6	0.0011	0.008

Table 5: Drop8

4   Analysis

The average of the v_f and v_r are found for each drop, to use in the equation for q. Also, the

Average v_f(cm/s)	Averagev_r(cm/s)	σv_f(cm/s)	σv_r(cm/s)
0.0017	0.0075	0.0017	0.002
0.00106	0.0136	0.001	0.0001
0.00093	0.0081	0.0008	0.0009
0.00079	0.0155	0.002	0.00008
0.0014	0.008	0.001	0.0001

Table 6: Average Velocities

radius of each droplet needs to be found to affectively compute the charge of the electron q,using the equation:

$$a = \sqrt{(\frac{b}{2p})^2 + \frac{9nv_f}{2g\rho}} - \frac{b}{2p} \tag{8}$$

Radius(cm)	Uncertainty(cm)
$8.5318x10^{-6}$	$8.702x10^{-6}$
$1.148x10^{-4}$	$1.201x10^{-5}$
$8.8601x10^{-5}$	$9.149x10^{-6}$
$1.227x10^{-4}$	$1.285x10^{-5}$
$8.829x10^{-5}$	$9.042x10^{-6}$

Table 7: Radius

Parameter	Variable	Value
Plate Sep	d	0.762cm
Plate Voltage	V	196V
Resistance	R	1.862MOhms
Temperature	T	27.6°C
Baro Pressure	p	752.4 cm Hg
Air Viscosity	n	$1.87x10^{-4}$ dyne s/cm^2
Constant	b	$6.17x10^{-4}cmHg$
Gravity	g	980 cm/s^2
Oil Density	ρ	0.886g/cm^3

After taking the average of the velocities and using the parameters of the experiment , the charge of the electron can be measured in and outside of the electric field, using

$$q = 6\pi\sqrt{\frac{9n^3}{2g\rho(1+\frac{b}{pa})^3}}(v_f + v_r)\sqrt{v_f} \tag{9}$$

Charge rising(e.s.u)	Uncertainty	Charge(e.s.u)	Charge uncertainty
1.536E-9	2E-9	1.11E-9	1.11E-9
1.929E-9	2E-9	1.42E-9	1.42E-9
1.107E-9	2E-9	1.54E-9	1.54E-9
1.846E-9	2E-9	1.54E-9	1.85E-9
1.42E-9	2E-9	1.93E-9	1.93E-9

Table 8: Radius

Taking the average of the charge values.

$$\frac{(1.11E-9\pm3.14E-10)+(1.42E-9\pm1.15E-10)+1(.54E-9\pm3.10E-10)+(1.85E-9\pm8.29E}{4}$$

$$= 2.05E - 10 e.s.u. \pm 3.4E - 10 \tag{10}$$

Using this value we can now find the percent difference and percent error using the accepted value of 4.80E-10 e.s.u

$$\%Error = \frac{(2.05E - 10) - (4.80E - 10 e.s.u)}{2.05E - 10} \tag{11}$$

=134.1%

$$\%Difference = \frac{(2.05E - 10) - (4.80E - 10 e.s.u)}{4.80E - 10} \tag{12}$$

=57.29%

5 Conclusion

In the Millikan experiment there was a high percent difference and error. This probably is the result of the set up we used was very temperate an we constantly needed to adjust the camera and grid. Most problems during the experiment arose from focusing. The grid with the apparatus used was difficult to get completely in position affecting the distance the oil droplets traveled.Also, observing the electrons on the television was easier than looking through a lense however, it still was very diffiicult to keep track of the drop, and many times the drop would get lost or the drop wouldn't switch directions when the plate switch was switched as a result of losing its charge. There were multiple trials taken,however the other data was worse than this. The many trials, were done over multiple days, affectively changing the temperature and barometer reading slightly, ultimately affecting the charge.One key source of error probably was the result of us taking data when the voltage of the plate is 195 V, when it is supposed to be between 300-500V. When we used the suggested voltage we had more difficulties with the experiment, hence we chose a lower one. This affects the rise and fall of the electrons, the velocites and essentially the entire calculation of the charge.There are many of variables and parameters which play a role in the determination of q, resulting in many more places for error to occur.