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Experimental Proposal to Determine the Gravitational Effect of Electrostatic Field Energy

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Abstract

All charged particles possess electrostatic field energy. The gravitational acceleration generated by this energy form has been theoretically predicated but to date it has not been experimentally confirmed. We show how a hollow electrical insulator with electrons inside the hollow space can be employed in a torsion balance instrument to measure this effect.

Keywords

General Relativity, Electrostatic Field Energy, Torsion Balance Instrument

1. Introduction

There are three interrelated principles of equivalence [1]. Galileo's principle of equivalence maintains that all bodies fall with the same acceleration. That is, the acceleration of gravity does not depend upon the physical properties of the falling body. Newton's principle of equivalence states that inertial mass equals gravitational mass. Einstein's principle of equivalence states that no experiment can distinguish between an accelerated coordinate system and gravitational acceleration.

In 1905 Einstein demonstrated that not only mass, but also energy possesses inertia [2]. In 1911, he realized that not just mass but also energy gravitates [3]. This realization raises the fundamental question: How do the different forms of energy gravitate?

All charged particles posses electrostatic field energy. We showed that general relativity leads to the result that this form of energy gravitates repulsively [4]. Specifically, we found that the gravitational repulsion associated with the electrostatic field energy of charged particles depends upon both the charge and mass of the gravitating charged particles. This circumstance means that charged particles violate the principles of equivalence.

Recently, we demonstrated that the electric field energy in atoms leads to the conclusion that the atoms of each element experience a different gravitational acceleration than the atoms of all other elements [5]. Since bulk matter consists of atoms, it follows that a bulk body made of an element will experience a different gravitational acceleration than another bulk body made of a different element. Consequently, the principles of equivalence are not valid. In [6], we applied the basic equations in [4] and [5] to demonstrate that ball lightning may be a manifestation of the gravitational effect of electrostatic field energy.

The above results are based on the equations of General Relativity. However, the gravitational effect of electrostatic field energy has to date not be experimentally confirmed. An attempt to measure the gravitational acceleration of electrons was carried out by [7]. They found that the electrons do not fall at all in their apparatus, a result that they attributed to a gravity induced electric field in their apparatus. Following this first attempt [8] pointed out the many experimental problems in determining the gravitational acceleration of charged particles. [9] suggested many of the experimental problems could be avoided, if the experiment was carried out in outer space. [10] proposed that the gravitational forces due to electrostatic and magnetic fields in General Relativity are much stronger than those we calculated. They suggested the use of a freely hanging capacitor to test them. None of these previous publications suggested our approach, the employment of a torsion balance instrument, to determine the effect of electrostatic field energy on gravitational acceleration.

2. Torsion Balance Instrument

One of the most accurate experiments to test the possible violation of the principles of equivalence is described in [11]. Using a continuously rotating torsion balance instrument they were able to determine the differential acceleration in any direction between beryllium and titanium down 8.8×10^{-15} m/s^2.

We suggest employing a similar experimental set up to determine the gravitational effect of electrostatic field energy. In contrast to [11] our experiment does not need to rotate since we are interested only in the gravitational acceleration caused by Earth. Specifically, we suggest employing two equally constructed test bodies. Each test body will consist of an electrical conducting hollow body, which contains a hollow electrical insulator inside the hollow space. By equally constructed we mean the bodies will be made out of the same material, possess the same mass and have the same shape. It is manifest that these two test bodies will experience the exact same gravitational acceleration.

The next step is to pump electrons into the hollow space of the insulator of one of the test bodies. According to Galileo's principle of equivalence, which maintains that gravitational acceleration is independent of the physical properties of falling bodies, these two test bodies will still experience the exact same gravitational acceleration. In contrast, General Relativity predicts that due to the gravitational effect of electrostatic field energy of the electrons in the hollow space of the insulator, the test bodies will indeed not experience the same gravitational acceleration. Specifically, the test body that contains the electrons in the hollow space of the insulator will experience a smaller gravitational acceleration because electrostatic field energy gravitates repulsively.

2.1. Basic Equations

According to Einstein energy gravitates, so both the electrostatic field energy as well as the gravitational field energy associated with charged particles must gravitate. Their effect on the gravitational acceleration experienced by charged particles, g_E, is given by Equation (7) in [4]:

$$g_E = \frac{\left(1 - \frac{e^2}{c^2 m r} - \frac{Gm}{c^2 r} - \frac{GM}{c^2} - \frac{3\dot{r}^2}{2c^2}\right) g_N}{1 + \frac{3GM}{c^2 r} + \frac{3\dot{r}^2}{2c^2}} \quad (1)$$

G is the gravitational constant, e the charge of the particle, c is the speed of light, m the mass of the particle experiencing gravitational acceleration, $M \gg m$, r is the distance to the center of M and and $\dot{r}$ is the radial velocity of m, which we set equal to zero because we are only interested in the gravitational effect of electrostatic field energy.

According to the above equation for an electron of mass, m_e, on the surface of the earth, the effect of its electrostatic field energy on the gravitational acceleration is:

$$g_e = -\frac{e^2}{m_e c^2 r} g_N = -4.4 \times 10^{-22} g_N = -\eta g_N \quad (2)$$

which is the classical electron radius divided by the radius of the earth, r, multiplied by $g_N = -\frac{GM}{r^2}$, the Newtonian acceleration of gravity. $e = 1.6 \times 10^{-19}$ is the charge of an electron. It is important to note that $g_e > 0$ because $g_N < 0$, which means that electrostatic field energy gravitates repulsively. For convenience we define: $\eta = 4.4 \times 10^{-22}$.

If an electrically charged body of mass, m, contains n electrons, it follows from the above equations that the contribution of the electrostatic field energy, g_E, to the gravitational acceleration is:

$$g_E = \frac{n^2}{m} g_e \quad (3)$$

Our task is the determine how many electrons in the hollow space of the insulator are required for the gravitational effect of electrostatic field energy to be detectable in a torsion balance instrument. To accomplish this task we employ Equation (3).

g_E in Equation (3) is the contribution of the electrostatic field energy to the gravitational acceleration of the test body that contains electrons in the hollow space of the insulator. n is the number of electrons in the hollow space. m is the mass of this test body (mass of conducting outer shell, m_{cs} + mass of insulator shell, m_{is} + mass of electrons added, n). m is in units of electron mass. So we must convert m_{cs} and m_{is} in kilograms to electron mass units by dividing them by the electron mass in kilograms, $m_e = 9.1\times10^{-31}$.

$$m = \frac{m_{cs} + m_{is}}{m_e} + n \tag{4}$$

The test body, which does not contain additional electrons, experiences the Newtonian gravitational acceleration, g_N . The torsion balance instrument measures the difference in gravitational acceleration between these two test bodies. This difference is g_E . There is however a limit to the precision, δ , any experiment can achieve. By δ we mean the smallest difference in the gravitational acceleration between the two test bodies that can be detected. Clearly, $g_E \geq \delta$.

2.2. Test Bodies

For simplicity of calculation we assume both conductors and insulators are perfect spherical shells of uniform density, located in a vacuum meaning we do not have to worry about breakdown in air. In this section we calculate the range of radii and masses of the test bodies that will allow us to detect the gravitational effect of electrostatic field energy in a torsion balance instrument as a function of the number of electrons, n , in the hollow space of the insulator. As depicted in Figure 1 our test bodies have four sections: (1) hollow space inside the insulator shell (2) insulator shell (3) gap between the insulator shell and the conducting shell (4) conducting outer shell. We discuss the physical properties of each section separately.

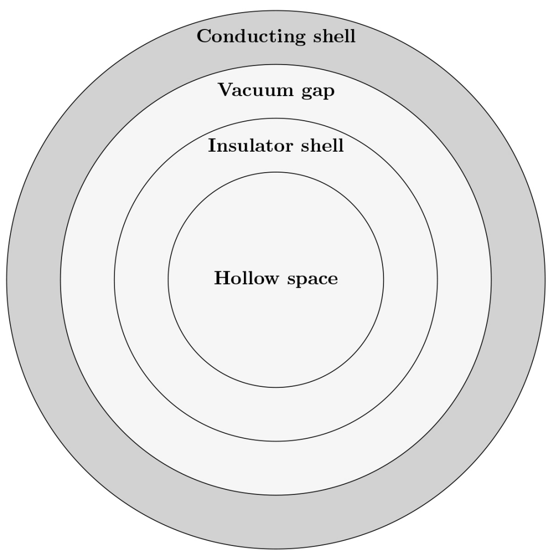

Figure 1. Test body configuration.

2.2.1. Hollow Space

Inserting Equation (2) into Equation (3) we obtain:

$$g_E = -\eta \frac{n^2}{m} g_N \quad (5)$$

Because $\eta = 4.4\times 10^{-22}$ is a very small number it is clear from the above equation that n must be large in order for g_E to be detectable. Consequently, we need to maximize the number of electrons in this space to insure the detectability of the gravitational acceleration caused by the electrostatic field energy of the electrons.

The pertinent quantities of the hollow space are: n, number of electrons in this hollow space and R, radius of the hollow space, which is also the inner radius of the insulator. The maximum number of electrons is limited by the electric field at the inner surface of the insulator shell, which must not exceed the dielectric breakdown, $E_{\max}$, of the insulator shell. From the theory of electrostatics the maximum allowable electric field, E, at the surface of the insulator is:

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{R^2} = \frac{\mu n}{R^2} = E_{\max} \quad (6)$$

where the charge, Q, is: $Q = ne$ and $\mu = \frac{e}{4\pi\epsilon_0}$.

n is the primary factor in determining the effect of the gravitational acceleration, g_E, caused by the electrostatic field energy of the electrons in the hollow space of the insulator. So we rearrange the above equation to obtain an expression for n.

$$n = \frac{1}{\mu} R^2 E_{\max} \quad (7)$$

2.2.2. Insulator Shell

As the previous section makes clear the number of electrons in the hollow space is large. Consequently, there will be strong electric fields at the boundary of the hollow space. We therefore suggest that the space that contains the electron gas be bounded by an insulator. If there is no insulator then field emission, discharge, electronic tunneling into the conductor or even runaway charge loss could occur. An insulator avoids these possibilities.

Equation (7) shows that $n \propto E_{\max}$. We need n to be large. Therefore, we require that the dielectric strength, $E_{\max}$, be as large as possible. Among the common insulators with the highest dielectric strengths (Teflon, quartz, fused silica, diamond) quartz has the highest value: $E_{\max} = 10^9\ \text{V/m}$. So baring other considerations, we suggest employing quartz in our proposed experiment to determine the gravitational effect of electrostatic field energy.

We need to compute the properties of the insulator shell (mass, radius and volume) as a function of the number of electrons in the hollow space it encloses. The mass of the insulator shell is determined by the density, $\rho_q = 2650\ \text{kg/m}^3$, inner radius and width of the shell. The inner radius is the radius of the hollow space enclosed by the insulator, *R*, which we now denote as R_q because we have determined that the insulator should be made out of quartz. It depends upon the number of electrons in the hollow space. Rearranging Equation (7) gives of an equation for R_q.

$$R_q = \sqrt{\frac{\mu n}{E_{\max}}} \quad (8)$$

The expressions for the volume and mass of the insulator depend upon the width of the insulator. What should the width of the insulator, ΔR_q, be? At the outer edge of the insulator is a gap. Therefore, the electric field at the outer edge, $R_q + \Delta R_q$, of the insulator should be below the vacuum breakdown, E_{vac}. Gauss's Law states:

$$E_{\text{vac}} = \frac{\mu n}{\left(R_q + \Delta R_q\right)^2} \quad (9)$$

Solving this equation for ΔR_q yields:

$$\Delta R_q = \sqrt{\frac{\mu n}{E_{\text{vac}}}} - R_q \quad (10)$$

Inserting R_q from Equation (8) into the above equation yields $\Delta R_q = 0$. This result means that ΔR_q is small. Experience shows that it can be just a few millimeters.

The equations for the volume and mass of the quartz insulator are:

$$V_q = \frac{4}{3}\pi\left(\left(R_q + \Delta R_q\right)^3 - R_q^3\right) = 4\pi\left(\frac{1}{3}\Delta R_q^3 + \sqrt{\frac{\mu n}{E_{\max}}}\Delta R_q^2 + \frac{\mu n}{E_{\max}}\Delta R_q\right) \quad (11)$$

$$m_q = \rho_q V_q = 4\pi\rho_q\left(\frac{1}{3}\Delta R_q^3 + \sqrt{\frac{\mu n}{E_{\max}}}\Delta R_q^2 + \frac{\mu n}{E_{\max}}\Delta R_q\right) \quad (12)$$

2.3. Gap

We suggest the presence of a vacuum gap between the insulator and the conducting shell for the following reasons. Even though the insulator is not charged, the charges in the electron gas create an electric field that would extend through the insulator to the conductor interface, if there were no gap. At that interface, field intensification can still occur due to: field focusing, local surface imperfections and permittivity boundary effects. The existence of the gap will allow the conducting shell to induce exactly the right charge on its inner surface to cancel the electric field from the electrons in the hollow space of the insulator. Consequently, the outer surface will remain field-free, which is the primary reason for having a conducting shell. We now turn to answering the question: What is an appropriate gap width?

The width of the gap, g_w, must be large enough to prevent dielectric breakdown of the vacuum. Specifically, the gap between the quartz shell and the conductor shell must be large enough to avoid field emission, corona discharge, or tunneling effects. We can estimate the minimum gap width, g_w, by employing the equation:

$$g_w = \sqrt{\frac{\mu n}{E_{\text{Al}}}} - \sqrt{\frac{\mu n}{E_{\text{vac}}}} \tag{13}$$

where E_{Al} is breakdown threshold of aluminum. In the next section we discuss the reason we suggest aluminum.

2.4. Conducting Shell

In order to eliminate the prodigious electric fields, $E \approx 10^9\ \text{V/m}$, outside the insulator, which would not allow the high precision required, we suggest encompassing the insulator and gap in a conducting shell. Remembering that $g_E \propto m^{-1}$, it is important to choose material for the conducting shell so that m is as small as possible. We therefore suggest aluminum, which has the lowest density $\rho_{Al} = 2700\ \text{kg/m}^3$, among the common conductors. We now turn to the questions: What should the width, volume and mass of the aluminum shell be?

The aluminum shell has two radii that are needed to compute the volume and mass of the aluminum shell. They are: R_{Ali} and R_{Alo}, which are the inner and outer radius respectively. We have:

$$R_{\text{Ali}} = R_q + \Delta R_q + g_w = \sqrt{\frac{\mu n}{E_{\max}}} + \sqrt{\frac{\mu n}{E_{\text{Al}}}} - \sqrt{\frac{\mu n}{E_{\text{vac}}}} + \Delta R_q \tag{14}$$

For quartz: $E_{\max} = 10^9\ \text{V/m}$ and $E_{\text{vac}} = 10^9\ \text{V/m}$. So the above equation reduces to:

$$R_{\text{Ali}} = \sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q \tag{15}$$

for the outer radius of the aluminum shell:

$$R_{\text{Alo}} = R_{\text{Ali}} + \Delta R_{\text{Al}} = \sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q + \Delta R_{\text{Al}} \tag{16}$$

where ΔR_{Al} is the thickness of the aluminum shell. Like the thickness of the insulator ΔR_{Al} is just a few millimeters.

The mass is obtained from the volume, V_{Al}, and density, ρ_{Al}. That is:

$$V_{\text{Al}} = \frac{4}{3}\pi\left(R_{\text{Alo}}^3 - R_{\text{Ali}}^3\right) = \frac{4}{3}\pi\left(\left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q + \Delta R_{\text{Al}}\right)^3 - \left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q\right)^3\right) \tag{17}$$

$$m_{\text{Al}} = \rho_{\text{Al}} V_{\text{Al}} = \frac{4\pi\rho_{\text{Al}}}{3}\left(\left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q + \Delta R_{\text{Al}}\right)^3 - \left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q\right)^3\right) \tag{18}$$

2.5. Determination of the Properties of the Test Bodies

We recall that $g_E \geq \delta$. g_E is the gravitational acceleration generated by the electrostatic field energies of the electrons located in the hollow space of the quartz insulator. The precision, δ, is the smallest difference in the gravitational acceleration between the two test bodies that can be detected.

First, we calculate the g_E required for the gravitational effect of the electrostatic field energy of the electrons in the hollow space of the quartz insulator to be detectable. It is a function of the number of electrons, n, that are in this hollow space. To accomplish this task we insert Equation (4) into Equation (3), whereby $m_{is} = m_q$ and $m_{cs} = m_{\text{Al}}$ because we have determined that the insulator should be quartz and the conductor aluminum.

$$g_E = -\frac{\eta n^2}{\frac{m_q + m_{\text{Al}}}{m_e} + n} g_N \tag{19}$$

Insertion of expressions for m_q from Equation (12) and for m_{Al} from Equation (18) into the above equation gives us an explicit connection between the gravitational acceleration, g_E, caused by the electrostatic field energies of the hollow space electrons and n, the number of electrons in the hollow space. The calculated g_E is also the precision, δ, required for the gravitational effect of the electrostatic field energies of n electrons to be detectable.

$$g_E = -\frac{\eta n^2}{\frac{4\pi\rho_q\left(\frac{1}{3}\Delta R_q^3 + \sqrt{\frac{\mu n}{E_{\max}}}\Delta R_q^2 + \frac{\mu n}{E_{\max}}\Delta R_q\right) + \frac{4\pi\rho_{\text{Al}}}{3}\left(\left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q + \Delta R_{\text{Al}}\right)^3 - \left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q\right)^3\right)}{m_e} + n} g_N \tag{20}$$

Figure 2 is a plot of $\text{Log}_{10}(g_E)$ or $\text{Log}_{10}(\delta)$ vs. $\text{Log}_{10}(n)$ calculated from the above equation, where g_E and δ are in m/s^2. In order to construct it, we assumed that $\Delta R_{\text{Al}} = \Delta R_q = 0.005\ \text{m}$.

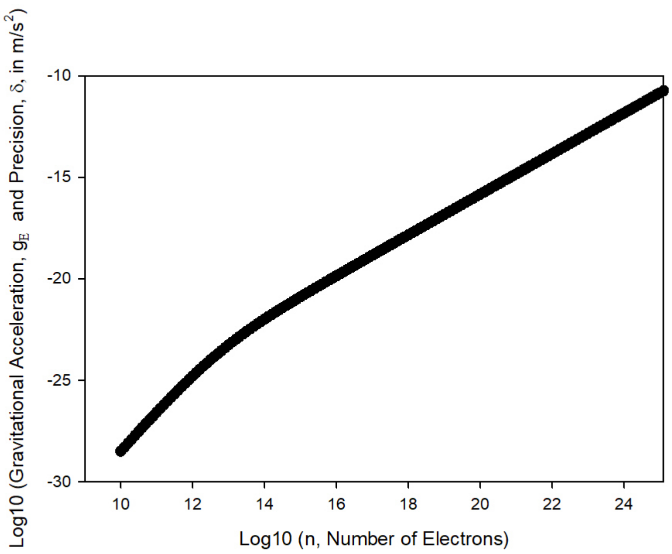

Figure 2. Gravitational acceleration and precision.

Figure 3 shows the mass, $\text{Log}_{10}(m_q)$, in kilograms of the quartz shell (Equation (12)) as a function of $\text{Log}_{10}(n)$.

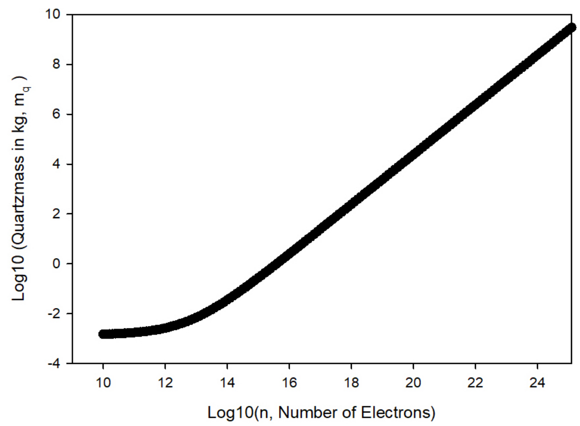

Figure 3. Quartz shell mass.

Figure 4 shows the mass, $\text{Log}_{10}(m_{\text{Al}})$, in kilograms of the aluminum shell (Equation (18)) as a function of $\text{Log}_{10}(n)$.

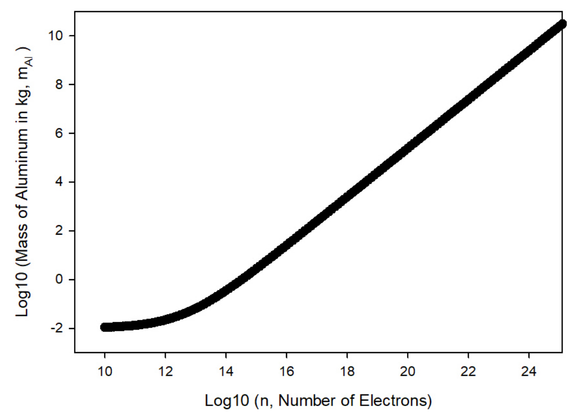

Figure 4. Mass of aluminum shell.

Figure 5 depicts the inner radius, $\text{Log}_{10}(R_q)$, in meters of the quartz shell in meters (Equation (8)) as a function of $\text{Log}_{10}(n)$. R_q is also the radius of the hollow space that contains the electron gas.

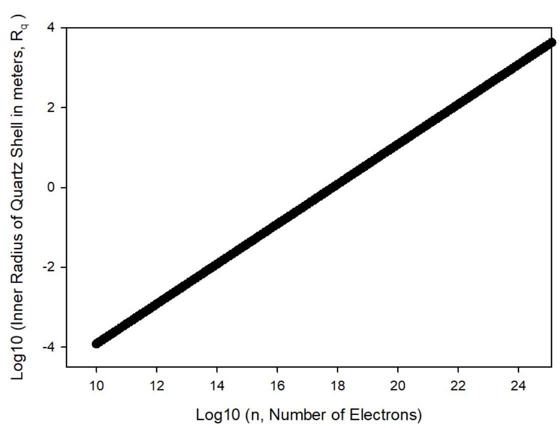

Figure 5. Inner radius of quartz shell.

Figure 6 shows the outer radius, $\text{Log}_{10}(R_{\text{Alo}})$, in meters of the aluminum shell (Equation (16)) as a function of $\text{Log}_{10}(n)$.

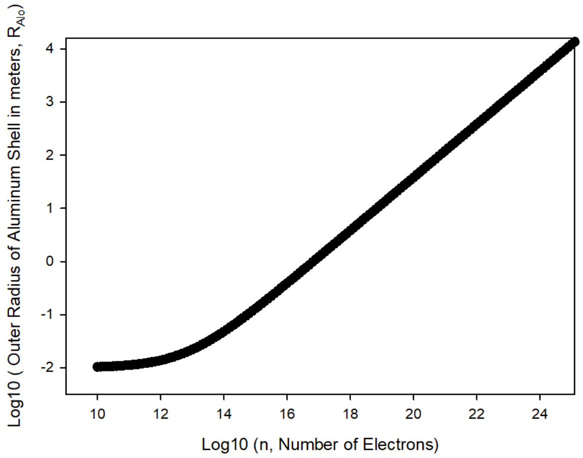

Figure 6. Outer radius of aluminum shell.

Finally, Figure 7 depicts the width of the gap, g_w, in meters (Equation (13)) as a function of $\text{Log}_{10}(n)$.

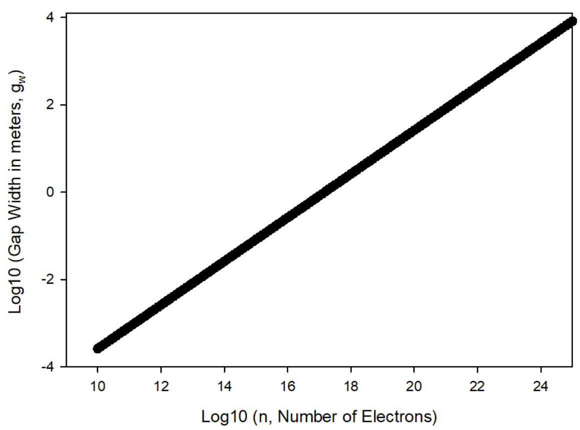

Figure 7. Gap width.

2.6. Feasibility

In this section we derive what the precision, δ, must at least be in order to detect the effect of the gravitational acceleration caused by electrostatic field energy. We also derive the number of electrons, n, in the electron gas and the properties of the quartz and aluminum bodies (mass and radius) that are required in order to insure that the proposed experiment is feasible.

First, we explore, if our test bodies could fit in the [11] experiment, which is currently operating. This experiment achieves: $\delta = 8.8\times10^{-15}\ \text{m/s}^2$ or $\text{Log}_{10}(\delta) = -14.1$. Remembering that $g_E \geq \delta$ it follows that $g_E = \delta$ is the minimum value g_E must have in order for the gravitational acceleration caused by electrostatic field energy to be detectable. Because all physical properties of our test bodies are a function of n, the next step is to solve Equation (20) for n in order to derive the physical characteristics of our test bodies. However, it is a transcendental equation and is therefore, not algebraically solvable. From Figure 2 or more directly from Equation (20) we see that $g_E = \delta = 8.8\times10^{-15}$ corresponds to: $n = 10^{21.7} = 5\times10^{21}$ electrons. Starting with this value we employ our equations to derive the other properties of the system.

$R_q = 84.9\text{ m}$ (Equation (8)), $m_q = 1.2\times10^{6}\text{ kg}$ (Equation (12)), $m_{\text{Al}} = 1.2\times10^{7}\text{ kg}$ (Equation (18)), $R_{\text{Alo}} = 268.5\text{ m}$ (Equation (16)). Clearly, such high values means the current experiment can not determine the gravitational acceleration due to the electrostatic field energies of electrons in the hollow space of such a test body. These values also tell us, what is required to detect the effect if the precision is $\delta = 8.8\times10^{-15}$.

It appears that the experiment is only feasible, if it is possible to decrease by orders of magnitude the value of δ, which is the smallest difference in the gravitational acceleration between the two test bodies that can be detected. In order to see about what the precision must be for laboratory masses, we assume $m = 20\text{ g}$ in Equation (3). The expression for m is:

$$m = m_q + m_{\text{Al}} + nm_e \tag{21}$$

Inserting Equations (12) and (18) into the above equation leads to m in kilograms:

$$\begin{aligned} m = {} & 4\pi\rho_q\left(\frac{1}{3}\Delta R_q^3 + \sqrt{\frac{\mu n}{E_{\max}}}\Delta R_q^2 + \frac{\mu n}{E_{\max}}\Delta R_q\right) \\ & + \frac{4\pi\rho_{\text{Al}}}{3}\left(\left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q + \Delta R_{\text{Al}}\right)^3 - \left(\sqrt{\frac{\mu n}{E_{\text{Al}}}} + \Delta R_q\right)^3\right) + nm_e \end{aligned} \tag{22}$$

The numerical solution for $m = 20\text{ g}$ is: $n = 4.8\times10^{11}$. This value of n leads to:

$R_q = 0.84\text{ mm}$ (Equation (8)), $m_q = 2.2\text{ g}$ (Equation (12)), $m_{\text{Al}} = 17.8\text{ g}$ (Equation (18)), $R_{\text{Alo}} = 12.6\text{ m}$ (Equation (16)). Finally, we calculate the crucial quantity, g_E by inserting the value for $n = 4.8\times10^{11}$ in Equation (20). We obtain: $g_E = 4.6\times10^{-26}$. So the precision must be no larger than $\delta = g_E = 4.6\times10^{-26}$ to detect the effect of the gravitational acceleration caused by the electrostatic field energy of electron gas containing $n = 4.8\times10^{11}$ electrons.

This value of $\delta = g_E = 4.6\times10^{-26}$ may not be achievable. In order to detect this effect with a δ value larger than this value one must increase all of the physical quantities associated with the test bodies. Specifically, **Figure 2** shows that if we increase the value of g_E and correspondingly δ then the values of all the properties of the test bodies must increase too as **Figures 3-6** make graphically clear. We conclude it may not be possible to perform this experiment with laboratory size test bodies.

We have shown how critically important the precision, δ, is for the success of our experiment. To emphasize this point in **Table 1**, we list the physical properties of the test bodies as a function of δ.

The success of our proposal depends upon over coming practical challenges. (1) dielectric breakdown of the quartz insulator: This can be mitigated with the use of ultra-pure quartz. (2) charge instabilities: This may be mitigated by employing hybrid Penning geometry. (3) vacuum issues: mitigation through cryopumping, ion getters, or a multi-stage vacuum chamber. (4) Emission: This can be mitigated through the use of ultra-polished quartz. Finally, we note the major source of false effects in a torsion balance experiment comes from gravity gradients, which are thoroughly discussed in [12].

Table 1. Test body properties.

$\mathrm{Log}_{10}(\delta)$	$\mathrm{Log}_{10}(n)$	$\mathrm{Log}_{10}(m_q)$	$\mathrm{Log}_{10}(m_{A1})$	$\mathrm{Log}_{10}(R_q)$	$\mathrm{Log}_{10}(R_{A1})$
−14	21.83	6.21	7.22	1.99	2.49
−15	20.83	5.21	6.22	1.49	1.99
−16	19.83	4.21	5.22	0.99	1.49
−17	18.84	3.22	4.23	0.50	1.00
−18	17.84	2.22	3.23	0.00	0.50
−19	16.84	1.23	2.23	−0.50	0.00
−20	15.85	0.25	1.26	−1.00	−0.48
−21	14.89	−0.67	0.34	−1.48	−0.94
−22	13.99	−1.46	−0.46	−1.93	−1.32
−23	13.19	−2.04	−1.07	−2.33	−1.60
−24	12.50	−2.41	−1.46	−2.67	−1.78
−25	11.88	−2.61	−1.70	−2.98	−1.88

3. Conclusions

The general objective of this work is to suggest an experimental set up, which will demonstrate that gravitational repulsion exists. Since Newton published his theory of gravitation in 1687 it is believed that gravity is only an attractive force unlike the electric force, which can be either attractive or repulsive. However, in 1916 first Drude and then Hilbert independently noticed that in Einstein's theory of gravitation, gravity can also act repulsively. The history of this discovery is in [13]. It has been well over a century since this discovery, yet the vast majority of scientists firmly believe that gravity is only an attractive force. The primary reason for this circumstance is that gravitational repulsion has to date not been experimentally confirmed.

The specific objective of this work is to outline an experiment to confirm that electrostatic field energy gravitates repulsively as is predicted by General Relativity. We suggest constructing a torsion balance instrument in which the difference in the gravitational acceleration of two test bodies of same shape, same material and equal mass is measured. Each test body consists of a hollow insulator surrounded by a conducting shell with a gap in between. After confirming that there is no difference in the gravitational acceleration between the two test bodies, the hollow space of one of the test bodies is filled with electrons. Then the difference in the gravitational acceleration between the two bodies is determined. The difference is caused by the gravitational effect of the added electrons.

The equation, which gives the difference in the gravitational acceleration between the two test bodies, is Equation (3). The successful execution of this experiment will determine the left side of this equation, that is g_E, the gravitational acceleration due to electrostatic field energy. But this quantity is equal to the right side of Equation (3), which contains only three quantities. Two of these quantities, n and m are known. Therefore, determining g_E leads to a determination of g_e the gravitational acceleration experienced by a single electron due to its electrostatic field energy.

The history of gravitational waves is similar to gravitational repulsion. In 1916, the discovery year of gravitational repulsion, Einstein predicted the existence of gravitational waves [14]. Like gravitational repulsion there were doubts about their existence. In fact, even Einstein along with Rosen submitted a paper to the Physical Review, in which they argued that gravitational waves do not exist. It was not until 2015 that gravitational waves were detected, almost 100 years after they were first predicted.

The successful carrying out of this experiment will demonstrate that gravity can also act repulsively and dispel the notion that has existed for almost 340 years that gravity is only an attractive force.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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