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PROPOSED ELECTRON FREE-FALL EXPERIMENT TO VERIFY COULOMB ELECTRIC GRAVITY

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ABSTRACT. The prediction of current standard gravity theories is that all material bodies, whether neutral macroscopic bodies, charged particles or ions, fall at the same rate in a homogeneous gravitational field. This is referred to as the Universality of Free Fall, UFF or the weak equivalence principle. There is agreement to this with Newtonian gravitation or the General Relativity theory. But this prediction has been verified only for neutral macroscopic bodies. It has never been experimentally verified for charged particles such as the electron. The reason is that the gravitational force is extremely weak as compared to that of the electrical interaction, an order difference of about 10^{-37}. It is therefore near impossible to shield electrons from extraneous electrical influences in any free fall experiment for the electrons. The original design outline here was proposed for the free fall of a bunch of trapped electrons to verify Coulomb electric gravity. As the predicted free fall for the electron is 8996m/s^2 and not the usual 9.8m/s^2, it was thought there was a huge margin of error to work with to distinguish between the two values. It was finally realized that the proposed design cannot work. The mutual repulsion between the electrons is far too strong as compared to the weight of the electron under the earth's gravity. The design may be feasible if it could be adapted to monitor the free fall of a single electron instead of a bunch of electrons.

1. INTRODUCTION

The prediction of current gravitational physics is that all material body fall at the same rate under a homogeneous gravitational field. Both Newtonian gravitation and General Relativity agree in this respect. It applies to neutral macroscopic body as well as to charged particles and ions. This prediction is referred to as the *'universality of free fall', UFF*. UFF has been verified to a high degree of precision for neutral macroscopic body. But UFF for charged particles has never been verified; thus, in this case, it is only a theoretical prediction and not an experimentally proven fact.

Key words and phrases. Coulomb electric gravity, weak equivalenc principle, electron free fall, gravity.

Legend has it that Galileo Galilei verified that a small lead ball and a larger one fall at the same rate by dropping them from the Leaning Tower of Pisa. Such experiments could easily be done as the only significant force acting on such neutral bodies is the earth's gravity. Though the physics world would love to perform such true free fall experiments for charged particles, e.g. the electron, it is unlikely anyone could conduct such an experiment in the foreseeable future. The reason is that the electrical force between electrons with electrons or protons are 10^{37} times stronger than the gravitational attraction. So attempts to shield an electron from unwanted electrical influences are near impossible. This is the reason no experiment has ever been done to measure the free fall acceleration of the electron due to the earth's surface gravity. Theory predicts that it should also fall at the rate of 9.8 m/s^2 as with other neutral bodies.

Textbook electromagnetism shows that the electric field inside any closed hollow conductor is zero (assuming that the region enclosed by the conductor contains no charges). So we may imagine that we may be able to shield the free fall of a single electron from unwanted electrical influences by enclosing the experiment within a metal vacuum enclosure; the electron's fall would then only be determined by the earth's gravity. But because all matter are composed of positively charged nuclei and negatively charged orbital electrons, subtle and mostly unknown electrical fields may always be present near matter, even for a nominally neutral body as a metal piece.

The most notable free fall experiment involving the electron is the one done by F. C. Witteborn and M. Fairbank (1967) - the Witteborn-Fairbank experiment (1967) [2]. It was a highly complex experiment that propels electrons emitted from a cathode at the bottom of a copper vacuum drift tube (91 cm x internal diameter 5 cm) upwards where the electrons would be detected by a detector. The experimenter was not trying to determine if the electron's free fall acceleration was also 9.8 m/s^2 as predicted by theory. They have theoretical prediction that the conductor metal of the drift tube would produce a electric gradient along the tube that would offset the gravitational force acting on free falling electrons. Their experiment confirmed such gravity-induced electric field along the metal drift tube that offset almost exactly the earth's gravitational field on the electrons. Their. experimental result showed that the electrons fall at the rate of 0.09 g instead of the usual 1 g - almost zero!

The gravity-induced electric field in the drift tube could be easily explained as a *'hydrostatic'* effect. The vertical drift tube has a cloud of free electron within the conducting metal and they are subject to the force of their own weight. This causes a *'sagging effect'*; the electron density of the free electrons increases with depth similar to hydrostatic pressure. This would mean there is a gradual electric gradient change along the length of the drift tube. The 'sagging-effect' would just balance the effect of the weight of the electrons. So the Witteborn-Fairbank experiment cannot determine if the gravitational mass is the same as the inertial mass for electrons. To date, no experiment could confirm the UFF for the electron - a variation of the weak equivalence principle for electrons.

2. Proposed Free Fall Experiment For The Electron

The Witteborn-Fairbank experiment of 1967 was only a pseudo free fall experiment as weak electric fields were used to modulate the gravitational force; a superconducting solenoid was needed to guide the electrons to travel along the axis of the drift tube. The design outline of the proposed experiment in this paper is a true free fall experiment for electrons where the electrons fall only under their own weight. Until today, not only has such an experiment not ever been attempted, no physicist has ever come up with any idea for a design for such an experiment. There is a reason for this. The physicists have been preoccupied with attempts to identify all possible extraneous influences; but there is never an end to such infinitesimal electrical influences as long as the electrons live in our earthly environment. Because of this, the prospect is extremely remote that anyone could ever verify if the weak equivalence principle applies also to the electron.

Though the proposed experiment here is rather simple and straightforward, there is a unique feature in the design of this experiment. It admits of the so called *'extraneous influences'* and could work coexisting with them in the experiment. The most important aspect of this design is that a true electron free fall experiment is feasible. To verify the weak equivalence principle for the electron is an experiment of fundamental importance. By the standard of today's experiment, the funding expected for such an experiment is modest - to say the least. Most good universities could easily get the funding needed for such an experiment.

Still, the proposed experiment here do have its drawbacks. It would not be able to produce any conclusive result under the following situations:

(1) weak equivalence is valid for the electron.
(2) weak equivalence is violated; but only a small violation.
(3) weak equivalence is violated; the gravitational mass of the electron is near zero.

To verify the above listed situations requires an experiment that could measure the free fall of the electron with a high degree of accuracy; such experiments require an almost perfect shielding of electrons from extraneous electrical influences. The proposed experiment cannot satisfy the requirements. But the proposed experiment can produce definitive conclusions if there is a clear violation of weak equivalence for the electron where the gravitational mass exceeds the inertial mass by a massive amount. Where there is an almost total acceptance of current gravitational theory - especially the General Relativity of Einstein - it is difficult to envisage any experimental group to even consider such a proposed experiment which may result in a categorical refutation of accepted current gravitational theory.

> *This experiment is only for those who seek truths without reservation.*

Though very few of today's physicists would consider it possible that Einstein's General Relativity theory could ever be overturned unconditionally, the author has to disagree. He has developed a *'Coulomb Electric Gravity'* theory [1] which has predictions that are totally at odds with the gravitational predictions of General Relativity.

Unlike Einstein's General Relativity, the Coulomb electric gravity is a simple straightforward theory that involves no complex mathematics. The basic idea of this electric gravity is that gravitation is simply the very slight excess of the attractive forces between unlike charges over the repulsive forces between like charges. No one should dismiss offhand this theory just because it involves no mathematical complexity. The motivations for an electric gravity theory comes from the pioneers of electromagnetism since the early 19th century. The first to propose this idea was O.F. Mossotti in 1830, a French physics teacher at the University of Buenos Aires [4]. It was said Weber gave serious consideration to the Mossotti hypothesis[5]:

> *In a posthumously published manuscript on the relationship of electricity and gravitation, he discussed the extreme difficulty of experimentally determining whether such a small difference between attractive and repulsive forces exists.*

It is not surprising that early physicists tried to find links between gravity and the Coulomb electrostatic forces as both are inverse-square forces. Faraday attempted experiments to relate gravity and electricity, but was unsuccessful. From his published essay [3]:

> "*The long and constant persuasion that all the forces of nature are mutually dependent, having one common origin, or rather being different manifestations of one fundamental power, has made me often think upon the possibility of establishing, by experiment, a connection*

between gravity and electricity, and so introducing the former into the group, the chain of which, including also magnetism, chemical force and heat, binds so many and such varied exhibitions of force together by common relations. Though the researches I have made with this object in view have produced only negative results, yet I think a short statement of the matter, as it has presented itself to my mind, and of the result of the experiments, which offering at first much to encourage, were only reduced to their true value by most careful searchings after sources of error, may be useful, both as a general statement of the problem, and as awakening the minds of others to its consideration."

Let's just do some simple calculations with Coulomb electric gravity to arrive at the predicted free fall acceleration for the hydrogen atom, the proton and the electron. Newton's second law of : $a = F/m$ applies for acceleration a under a force F for a particle of mass m. We have to note that in Coulomb electric gravity, the neutron within atoms may just be treated as another proton and a nuclear electron in calculating the excess of attraction over repulsion between a body and the earth.

(1) ^{1}H - hydrogen has 1 proton and 1 electron; being neutral, its free fall acceleration is the usual 9.8 m/s^2.
(2) the proton - the gravitational force (now the excess of attraction over repulsion with the protons and electrons of the earth) is half of that of hydrogen; but the mass of the hydrogen atom is almost the same as that for the proton. The free fall acceleration of the proton, therefore, would be 4.9 m/s^2.
(3) the electron - the Coulomb gravitational force on the proton and the electron are the same, but the mass of the electron is 1/1836 of that of the proton. The free fall acceleration of the electron, therefore, would be 1836 x 4.9=8996 m/s^2.

Our proposed experiment is actually an experiment to verify Coulomb electric gravity. What our experiment need is to verify if the free fall acceleration of the electron is the usual 9.8 m/s^2 or the predicted 8996 m/s^2 under Coulomb electric gravity. This offers a huge margin of error allowed for the experiment! It is because of this allowed margin of error that we could almost ignore the extraneous electrical influences that other experimenters are obsessed with. Let's say the compensating gravity-induced electric field of the conducting shielding vessel takes away half the free fall acceleration of the electron, it still would leave us with an acceleration of 4888 m/s^2. This figure would still be far, far different from a 9.8 m/s^2!

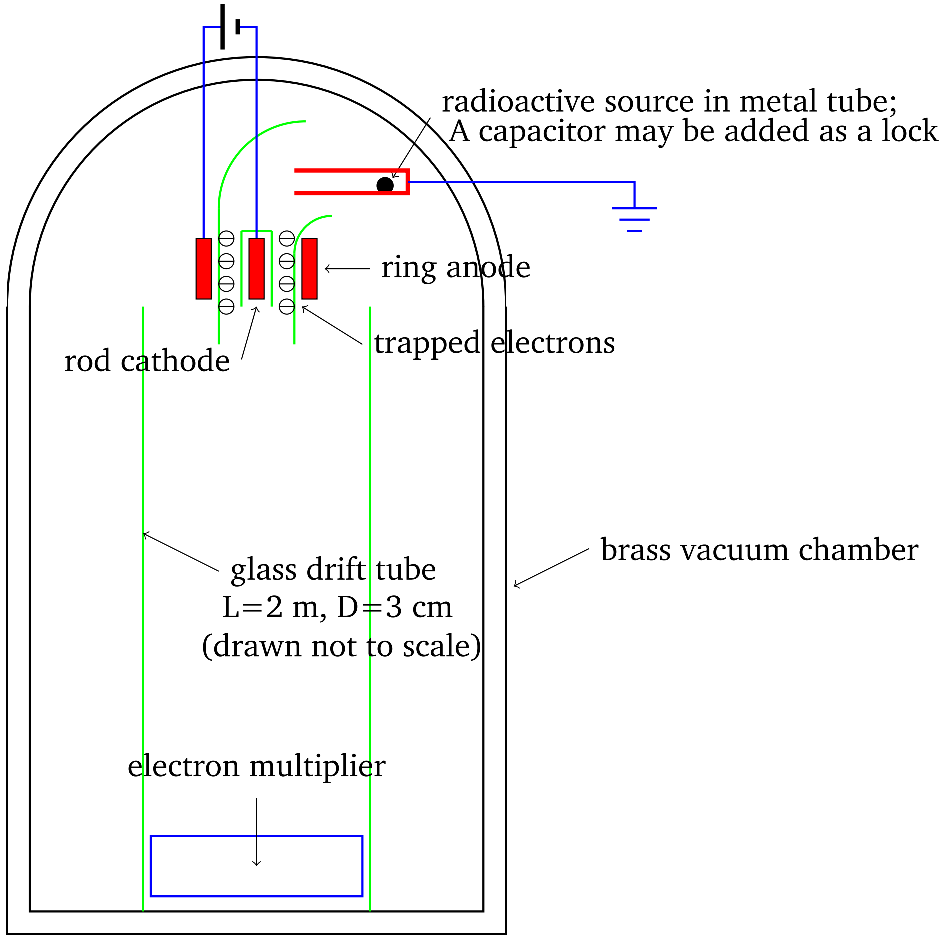

FIGURE 1. Schematic Diagram Of Experimental Setup. Enclosing cylindrical brass vacuum chamber (height=3m,diameter of 2m). The earthed red copper tube contains the radioactive electron source. The green lines are the sides of a glass drift tube (L=2m, D=3cm) to constrain the free-fall of the electrons. The electron-trap capacitor in red with outer ring anode and a rod cathode.

3. THE EXPERIMENTAL SETUP

The schematic diagram for the setup of the experiment is shown in figure (1). All free fall experiments for the electron require a vacuum chamber. A fairly large closed metal conducting chamber is needed for the vacuum as well as for electrical shielding. It is a wide diameter cylinder with a hemispherical top, preferably made of brass; steel may not be a good choice as it is magnetic. The electric field within any closed hollow conductor is zero. As noted above, the conducting side of the cylinder produces a gravity-induced electric field gradient along its height. In the Witteborn-Fairbank experiment, the width of the metal tube was very arrow, only 5 cm, and this induced electric field was dominant along the central axis. In the case of our cylinder, we have a wide diameter, say 2 meter. With this width, the induced electric field along the central axis may be ignored for the purpose of our experiment. The actual drift tube would be a narrow bore glass tube along the central axis.

The electron source would be a radioactive material placed in a small copper tube closed at one end. This tube may need to be earthed as the source emitting electrons may acquire a positive charge if not earthed; this may not be desirable. The electron source may be Barium-133 which emits monoenergetic conversion electrons or other beta-decay nuclides. A small capacitor charged to a small voltage is needed to trap and gather the emitted electrons. The purpose of the trap is to gather a sufficient amount of electrons for every time-of-flight measurement of the electrons fall. The trapped electrons would cling to the side of the glass tube next to the positively charge ring anode. When a sufficiently large bunch of electrons have been gathered, they are propelled off the glass through application of a reverse-biased small voltage. The timing of this reverse voltage times the start of the free fall. Because the bunch of electrons each repulses the others, all of them would detach themselves off the glass and it is unlikely any could stick themselves on the glass tube. All electrons would begin the free fall.

In the electrons fall through the glass drift tube, they may collide a number of times with the tube. This collisions may slow the actual fall a little, but it would be acceptable in the case of our experiment. When an electron hits the electron multiplier below, it generates an electrical signal which indicates its time of arrival. As there are many electrons making the fall simultaneously and because electrons repel each other fairly strongly, not all of them would hit the detector at the same time. The first to hit the detector gives the shortest time of flight with time of arrival t_{min}; the last to hit the detector gives the time of arrival t_{max}. The other electrons' arrival time would be between t_{min} and t_{max}. If the electrons distribution is plotted against the arrival time, there is an arrival time t_{avg} representing the peak of the distribution curve; this is the time with the most number of electrons arriving. If the start of free fall is t_0, then the time of flight is $t = t_{avg} - t_0$. The time t may be taken to indicate the time of flight for a single electron's free fall. If we assume the free fall begins with a velocity of zero, then the acceleration of the electrons free fall would be given by the usual kinematic formula: $g_e = 2L/t^2$ where L is the height of the fall. Conversely, for a fall height of L = 2 m and g_e of 9.8 m/s^2 and 8996 m/s^2, the time of flight t would respectively be 640 ms and 21 ms.

3.1. **Failure - The Electrons Motion Due To Mutual Repulsion.** If we calculate the motion of a single electron with that of another under their mutual repulsion from close proximity to a separation of 2m , the time required is 88μs. Even with the predicted g_e of 8996 m/s^2, the time_of_flight for a fall of L=2m is still 21ms, too large a time interval as compared to 88μs. This shows the electrical repulsion among electrons is too strong for any free fall experiment for a bunch of electrons. The experiment may succeed if there is a way to adapt the setup for monitoring the free fall of a single electron.

4. Conclusion

The design outline was originally meant for an experiment to determine the acceleration of free fall of a bunch of electrons under the earth's gravity. It was found that the concept of the design was flawed as the mutual repulsion between the electrons are too strong as compared to the electron's predicted weight under gravity. But the experiment may succeed to confirm or refute Coulomb electric gravity if the experimental setup could be adapted to test the free fall of a single electron.

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