Gravitational-magnetic-electric interaction in controlling relative permittivity and permeability

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Abstract: Appling the controlling relative permittivity and permeability in the equations for the gravitational-magnetic-electric field interaction, a very large variation of the gravitational acceleration of the Earth by electric/magnetic field could be arrived at. This conclusion may be supported by some of the experiments for the gravitational effect of superconductivity.

Key words: Gravitational-electric/magnetic interaction; Controlling permittivity and permeability; Superconductivity

The possible relation of gravity to electricity was first tested by Michael Faraday[1]in 1985 as the theory for the electromagnetic field was being developed. In recent, it was reported that the gravitational effect of electric/ magnetic field was observed.[2 -13] But, the effect is very little which is difficult to be observed. And, for different hypotheses and different experimental design, the observed results are different. Therefore, the effect is disputed experimentally and theoretically.[14-19] Here, we present that, the gravitational effect of superconductivity[2-5] could be understood and explained with the equations for the gravitational-electric-magnetic interaction.[21] Further, we theoretically demonstrate that a very large effect that the gravitational acceleration of the Earth varied by the controlling permittivity and permeability could be arrived at.

The gravitational acceleration of the Earth varied by a strong electric/magnetic field can be easily understood from Figure 1. In a volume above the surface of the Earth, a body is gravitated by a gravitational acceleration g. g is related with the gravitational energy in this volume. As the volume is filled with photons, the energy of the photons is varied by the gravitational redshift. From the law of conservation of energy, it is easy to known that the energy of the gravitational field in the volume is correspondently varied by the light.

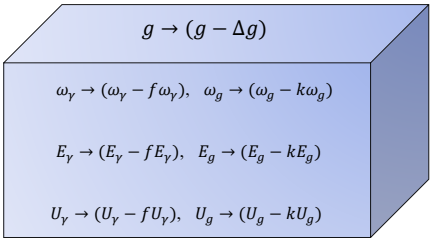

Figure 1. The variations of both electric/magnetic field and gravitational field in a volume. ω_γ and ω_g are the frequency of the photon and graviton, E_γ and E_g are the total energy of the electric/magnetic field and the gravitational field in the volume, f is the gravitational redshift parameter and k is the shift parameter of the frequency of the graviton by the electric/magnetic field (now, k has not been know.). U_γ is the energy density of electromagnetic field, for the electric and magnetic field, there is $U_e = \frac{\varepsilon_0 E^2}{2}$ or $U_m = \frac{B^2}{2\mu_0}$; for the gravitational field there is $U_g = \frac{g^2}{2G}$, where B is the magnetic flux density, E is the electric field intensity, g is the gravitational acceleration of the Earth; G, μ_0 and ε_0 are gravitational, magnetic and electric constant.

This conclusion is based on the well-known experiments: The gravitational redshift/blueshift, the bending of light by gravity and Shapiro time delay. In Pound–Rebka experiment [22,23], for gravitational redshift, the frequency of a photon is varied by gravity for that this photon can absorb a unit energy of the gravitational field. Therefore, as an electric/magnetic field is filled in a volume, both the gravitational field and electric/magnetic field in the volume are varied by each other in three aspects: 1) The frequencies of the photons are varied by gravitational redshift and the frequencies of the gravitons are varied by that a unit of energy is absorbed by the photons. 2) The total energy with the energy density of electric/ magnetic field and that of the gravitational field are varied by the variations of the frequencies of the photons and that of gravitons. 3) The two variations should make the gravitational acceleration g in the volume varied.

From the law of conservation of energy, we know, in this volume, the variation of the total energy of the electric/magnetic field is equal to that of the gravitational field. Therefore, there is

$$\begin{cases} k\frac{g^2}{2G} = f\frac{B^2}{2\mu_0} \\ k\frac{g^2}{2G} = f\frac{\varepsilon_0 E^2}{2} \end{cases} \tag{1}$$

From Equation (1), writing $\sqrt{k}g = \Delta g$, we have:

$$\begin{cases} \Delta g = \sqrt{fG/\mu_0}B \\ \Delta g = \sqrt{fG\varepsilon_0}E \end{cases} \tag{2}$$

From Figure 1, the experimental design to test Eq.(2) is clear. That the gravitational acceleration g in the volume is varied with Δg just means that the gravitational force of the Earth on a body with the mass M inside the volume is varied with $\mathrm{F} = \mathrm{M}\Delta g$. Correspondently, the weight of the body shall be varied:

$$\Delta M = M\frac{\Delta g}{g} \tag{3}$$

Therefore, this design is simple. Setting a body in a strong electric/magnetic field, as the variation of the weight of the body is measured, Eq.(2) shall is confirmed. Therefore, this experiment can be designed as shown in Figure 2.

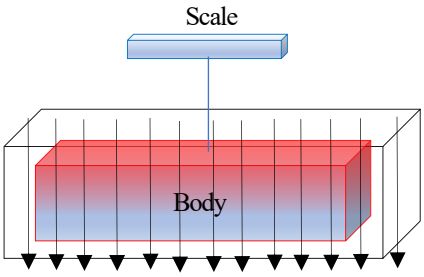

Figure 2. **The design to test the variation of the weight of the body in strong electric/magnetic field.** The red body is inside a strong electric/magnetic field. The weight of the body can be measured with the scale.

From the Figure 2 we found, for different materials, the relative permittivity ε_r and the relative permeability μ_r are different which determines that the energy density of the electric/magnetic field is different. Therefore, Eq.(1) can be rewritten as

$$\begin{cases} k\frac{g^2}{2G} = f\frac{B^2}{2\mu_r\mu_0} \\ k\frac{g^2}{2G} = f\frac{\varepsilon_r\varepsilon_0E^2}{2} \end{cases} \tag{4}$$

Correspondently, Eq.(3) can be rewritten as

$$\begin{cases} \Delta g = \sqrt{fG/\mu_r\mu_0}B \\ \Delta g = \sqrt{fG\varepsilon_r\varepsilon_0}E \end{cases} \tag{5}$$

Eq.(4) shows that as $\varepsilon_r \to \infty$, there is $\Delta g = \sqrt{fG\varepsilon_r\varepsilon_0}E \to \infty$, and as $\mu_r \to 0$, there is $\Delta g = \sqrt{fG/\mu_r\mu_0}B \to \infty$. We know, now, the material with $\varepsilon_r \to \infty$ and $\mu_r \to 0$ not only were studied theoretically, but applied in many areas.[24-30] The variation of the gravitational acceleration by the relative permittivity ε_r and the relative permeability μ_r can be expressed in Figure 3. Therefore, making use of the materials, we could make a very large variation of the gravitational acceleration of the Earth in a small volume. It means that a way to use the gravity should be possible.

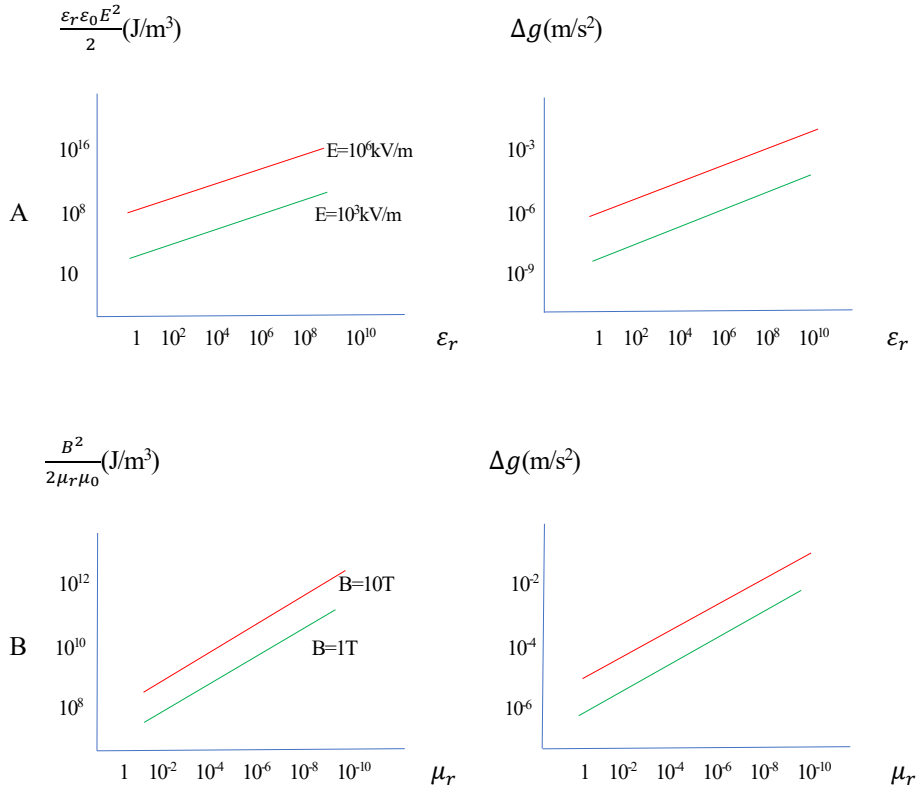

Figure 3. The variation of the relative permittivity and permeability and the variation of gravitational acceleration. A. The variation of energy density of electric field by ε_r and the variation of the gravitational acceleration by ε_r. **B.** The variation of energy density of electric field by μ_r and the variation of the gravitational acceleration by μ_r.

Figure 3 shows, for electric field, $U_e = (\frac{\varepsilon_0 E^2}{2})\varepsilon_r$ is corresponding to $\Delta g = (\sqrt{fG\varepsilon_0}E)\sqrt{\varepsilon_r}$. For magnetic field, $U_m = (\frac{B^2}{2\mu_0})\frac{1}{\mu_r}$ is corresponding to $\Delta g = (\sqrt{f\frac{G}{\mu_0}}B)\sqrt{\frac{1}{\mu_r}}$. It indicates that a lager energy is needed to make the gravitational acceleration varied. In mathematics, there are $U_e = (\frac{\varepsilon_0 E^2}{2})\varepsilon_r \to \infty$, as $\varepsilon_r \to \infty$ and $U_m = (\frac{B^2}{2\mu_0})\frac{1}{\mu_r} \to \infty$, as $\mu_r \to 0$. But, in fact, it is impossible to have a material that its energy density is infinite large. So, it is need to studied that what is the limit of the energy density of a material. After this limit is known, the limit of Δg shall be known.

The design in Figure 2 seems very simple. But, it is very important for arriving at right result. It further clarifies that our conclusion is that the gravitational acceleration of the Earth in a small volume is varied by an electric/ magnetic field. Therefore, the necessary condition to measure the variation of the gravitational acceleration is that the whole body is inside the electric/magnetic field. In this case, from Eq.(3) we know, the gravitational force on the body is not $\mathrm{F} = \mathrm{M}g$. Instead, it is $\mathrm{F} = \mathrm{M}(g - \Delta g)$. So, Figure 2 is helpful to further constraint our work. And, from Figure 2, the condition and device to detect Δg from Eq.(2), (5) or (6) can be known exactly. Therefore, in Supplementary Material 1, we give the detailed device for the experiment and predict the precision possible experimental result.

The gravitational effect of superconductivity was reported[2-8] while it was disputed experimentally and theoretically.[14-20] Now, there has not been an accepted theoretical explanation for it. But, from our work, if Eq.(4) should be valid, for the superconductivity, there is $\mu_r = 0$, a very large Δg should be produced. Therefore, the results in Refs.[2-5] may can be explained with Eq.(5). In Refs.[2-5], because of their theory, their experimental design is different from ours in Figure 2. The tested body is not wholly in a uniform magnetic field which results in that they cannot obtain the largest variation of gravitational effect. And, the position of the tested body relative to the magnetic field is different in different experiment, so the observed effect is different in different experiment.

In Refs.[2,3], the gravitational effect is related with the variation of the magnetic field. And, in Refs.[6, 13], it is related with discharge. We know, as an initial current produced from that a switch is on or off is used to produce an electric/magnetic field, a very large initial electric/magnetic field can be produced. From Eq.(2) or (5) we know, a very large instantaneous gravitational effect could be produced. Discharge is also related with the varying electric/ magnetic field while it is a complicated process. Therefore, Eq.(5) can be rewritten as

$$\begin{cases} \partial g = \sqrt{fG/\mu_r\mu_0}\,\frac{\partial B}{\partial t} \\ \partial g = \sqrt{fG\varepsilon_r\varepsilon_0}\,\frac{\partial E}{\partial t} \end{cases} \tag{6}$$

Different from the Maxwell equation, Eq.(6) only means that, as an electric/magnetic field is varied, the gravitational acceleration is correspondently varied. Now, we know that the gravitational acceleration of the Earth only is a single direction which cannot be affected by the electric/magnetic field. Therefore, in Eq.(6), the relation between the directions of the fields and the variation of the gravitational acceleration has not been known. It only can be known

with further experiment.

ε_r and μ_r are affected by the frequency of the electron in the material.[24] Because the polarized direction of the electron is determined with the direction of the electric/magnetic field, the ∂g should be affected by the direction of the body moving relative to that of the field.

It need be noted that the relationship between the initial electric/magnetic field and ε_r or μ_r is unknown. The value of the gravitational effect by a varying ε_r or μ_r only can be measured with experiment.

Ivanov[31] obtained the equation $F_g = \sqrt{G\varepsilon_r\varepsilon_0}E$ and $F_g = \sqrt{G\mu_r\mu_0}H$ in 2004. But, it is noted that, Ivanov's equations are different from our Eq.(5) physically and mathematically. In physics, in Ivanov's[31] equations, it is that a gravity is induced or produced from an electric or magnetic field. In our equations, it is that the local gravitational acceleration of the Earth is changed by a magnetic or electric field. In mathematics, in our equation, there is a gravitational redshift factor $f \approx 6.95 \times 10^{-10}$. This factor makes that the possible measurable force in our equations is much less than that in Ivanov's. And, in ou r work, the gravitational field is just varied by the gravitational redshift. So, the $f \approx 6.95 \times 10^{-10}$ is not only a mathematic constant, but expresses a process of physical interaction.

In our work, the graviton-photon interaction is studied.[21] In [21] the equation (12) was presented to unify the gravitational, electric and magnetic constant. Therefore, our work is related with the Grand Unified Theory. But, it is noted that, our work is different from the current Grand Unified Theory. Our work is just an effort trying to explain another aside of the experiment of gravitational redshift.[22,23] Just as a coin has two sides, one side of the experiment showed that the light was redshift by the gravity, which was well studied and understood; while another side could show that, at the same time, the gravity is changed by the light, which has not been noticed before our work.[21] Even if Eqs. (2), (5) and (6) could be experimentally confirmed, it should not mean that this is a resolution of the Grand Unified Theory. It only shows something about an aspect of the graviton-photon interaction. For example, the spin of the graviton is not involved in our work. We think, the best way to detect the graviton is the graviton-photon interaction. Some work was done to understand the quantum gravity through bending of light[32] and gravitational redshift[33]. Our work may be a new possible to understand the quantum gravity.

It is stressed that, the basic conditions to obtain a measurable result is that the electric field is $\mathrm{E} \geq 10^6 kV/m$

and the magnetic field is $B \geq 10T$ as presented in Table 1 and 2 in Ref.[21]. From Eq.(5), as $\varepsilon_r \to \infty$ and $\mu_r \to 0$ are considered, less E and B can be possible as shown in Figure 3.

In the Supplementary Material 2, the experiments[2-5] on superconductivity are reviewed. It is presented that, the experimental results in [2-5] is very roughly accordant with Eq.(5) and Figure 3. These experiments may be the supporter of our work. It should imply that the gravitational effect of superconductivity or electric/magnetic field is possible. Therefore, further experiment to test the gravitational effect of electric/magnetic field is needed.

It is the feature of our work that, the predicted results and the conditions for the possible measurable results are exact, the conclusion in our work can be exactly observed with experiment. And, we have a detailed experimental design in the Supplementary Material 1. Very high precision measured result can be obtained from the experimental design. Therefore, the conclusion can be certainly and clearly assessed. These conclusions can be easily tested: 1) To test Eq.(2) with static electric/magnetic field. In Ref.[21], it was shown that, the variation of the gravitational acceleration varied by a strong magnetic field could be observed. Here, we presented that, $\triangle g = \sqrt{fG\varepsilon_r\varepsilon_0}E$ can be tested with static electric field. As $\varepsilon_r = 34000$ which is the known largest relative electric permittivity, under the condition of $V = 100kV$ and $d = 10^{-2}m$, there should be $\triangle g = 1.18 \times 10^{-6}ms^{-2}$. In current technology, it is easy to be measured. We have a detailed experimental design in the Supplementary Material 1 for measuring it. 2) To test Eqs.(5) and (6) with varying electric/magnetic field and superconductivity. For superconductivity, $\mu_r = 0$. A very large initial magnetic field can be produced from that an initial current is produced by that a switch is on/off. Therefore, a very large instantaneous $\Delta g = \sqrt{fG/\mu_r\mu_0}B$ could be correspondently produced. It is noted that the external magnetic field has an action on the superconductivity. Making the optimized combination of B and μ_r need be studied. 3) To test Eq.(6) with the moving body in the strong electric/magnetic field. 4) To explore the materials with controlling ε_r and μ_r which could produce large gravitational effect of electric/magnetic field. For the materials of $\varepsilon_r \to \infty$, because the external electric/magnetic field has action on ε_r,[24] how to make the combination of E and ε_r optimized need be studied.

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