Unaccounted Energy Aspects of the Gravifrequency and Electromagnetic Interactions. With the Addition

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Yevhen A. Lunin is now independent researcher.

I have no conflicts of interests to disclose.

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Abstract

The electric charge definition is formulated. The refined formula of the electric charge non-invariance is given. The electric charge momentum conservation law was obtained. The concept of "the charged particle spin" is clarified. The angular momentum conservation law for electric charge was obtained. The frequency moment definition (the magnetic moment analog) is formulated in gravidynamics. The formula for the kinetic energy of the translational motion of an electric charge was constructed. Steiner's theorem for electrodynamics was formulated. The rotational motion dynamics equation was constructed for electric charge. The formula for the kinetic energy of the rotational motion of an electric charge was constructed. A Planck formula analog for the magnetic field was obtained. Formula for the interval *s* between two events was constructed in the electric charge space. Another kind of uncertainty ratio was obtained. The value of the gravifrequency interaction constant was calculated $\alpha_g = \frac{m^2 G}{\hbar c} = 17{,}49 \cdot 10^{-46}$. A Reynolds number analog for electromagnetism was obtained. The experiments results on finding the Reynolds number in electrodynamics are given.

Keywords: The angular momentum of electric charge, The rotational motion dynamics equation for electric charge, A Planck formula for the magnetic field, Reynolds number in electrodynamics.

At the very beginning of the discussion, we will try to define the electric charge. Electric charge is a body acceleration measure when only an electric field is applied to the body (it's assumed that the body consists only of an electric charge, that's it hasn't mass).

To unambiguous interpret of the terms used in this work, first of all, the author considers it necessary to make some remarks about terminology. Just as in the electric charges interaction field there are electric, magnetic and electromagnetic fields, in the masses interaction field there are gravitational, frequency (the author suggests using this term) and gravifrequency (again, the author suggests using this term) fields. The term "gravitational field" is used in the conventional sense (field with a strength $\boldsymbol{a}$, which is the acceleration). The frequency field is the field of the angular velocity $\boldsymbol{\omega}$. Given the physical nature of angular velocity and frequency, the term "angular velocity field" may be replaced with the term "frequency field" for brevity. And the gravifrequency field is the same set of gravitational and frequency fields as the electromagnetic field is the set of electric and magnetic fields. Thus, it would be more accurate to speak of a gravifrequency field equations system but not of the gravitational field equations system, and not of gravitational waves, but of gravifrequency waves.

After Maxwell's electrodynamics united in one theoretical scheme the phenomena of electricity, magnetism and optics on the electromagnetic field concept basis, it was hoped that the field concept should be the foundation of a future unified theory of the physical world (Vizgin, 1985).

Einstein attempted to construct a unified field theory in which gravitational and electromagnetic fields are interpreted only as components or manifestations of the same unified field (Isaacson, 2007).

The author believes that there is some set of similar formulas (but not identical) that allows you to describe the phenomena of electrodynamics and gravidynamics. Subsequently, it will probably be possible to add hydrodynamics, thermodynamics, and other sections of physics. But the same structure of these formulas (and the symbols included in them) will imply completely different physical quantities, characteristic of one or another section of physics. This paper shows the formulas commonality of electrodynamics and gravidynamics.

According to Okun L. B. the simplest variants realizing the idea of grand unification assume that there are no new fundamental forces up to colossal energies of the order of 10^{15} GeV (Okun, 1981).

This work considers the frequency interaction, which is a new fundamental interaction.

Formulation of the problem

The purpose of this work is to generalize and specify some concepts of electrodynamics and gravidynamics, as well as to present the results of experiments to determine of the Reynolds number in electrodynamics.

Results

- the momentum conservation law and the angular momentum conservation law are formulated for electric charge;
- the concept of "the charged particle spin" is clarified;
- Steiner's theorem for electrodynamics was formulated;
- the Planck formula analog was obtained for the magnetic field;
- formula for the interval s between two events was constructed in the electric charge space;
- the rotational motion dynamics equation was constructed for electric charge;
- the value of the gravifrequency interaction constant was obtained (the fraction analog $\frac{1}{137}$);
- the Reynolds number analog values were experimentally obtained in the current range from 20 mA to 500 mA.

Discussion

Electric Charge, Electric Charge Non-invariance, Charged Particle Spin, Frequency Moment

The Lagrange function L for the electric charge e in the electromagnetic field can be written in the form (Panofsky & Phillips, 1963).

$$L = -mc^2\sqrt{1-\frac{v^2}{c^2}} + e(\boldsymbol{A}\cdot\boldsymbol{v}) - e\phi \tag{1}$$

Let's transform the Lagrange function for the electric charge space.

By the concept of "electric charge space" the author understands everything that exists or happens without the presence of masses. That's all bodies must be of zero mass and processes or phenomena must occur with bodies having zero mass. And in the calculations it's necessary to take into account only the electric charge of considered bodies.

Since in gravifrequency interactions the vector potential $\boldsymbol{A}_g = \boldsymbol{v}$, (Lunin, 2024) and $\boldsymbol{v} = \boldsymbol{a}\cdot t$, then in electric charge space

$$\boldsymbol{A}_e = \boldsymbol{E}\cdot t,$$

where $\boldsymbol{E}$ is electric field strength.

And when the vector potential $\boldsymbol{A}_e$ is multiplied by the electric charge e, the formula for the electric charge momentum $\boldsymbol{p}_e$ is formed.

$$\boldsymbol{p}_e = e\,\boldsymbol{A}_e$$

It should be noted that $\boldsymbol{p}_e$ is not a part of the fictitious momentum $\boldsymbol{P}$, as indicated in the work (Chubykalo et al., 2020), but of the real one. There is no fiction here. The electric charge momentum $\boldsymbol{p}_e$ is a part of the generalised momentum $\boldsymbol{P}$, which is equal to the sum of the mechanical momentum (mv) and of the electric charge momentum ($\boldsymbol{p}_e$). And hence, there is no forgery or falsification here.

In work (Chubykalo et al., 2019) it is stated: Newton's law of world gravitation has not yet had an electromagnetic explanation. It should be noted that it and cannot receive an electromagnetic explanation. Our knowledge of mass and electric charge (as well as mass and electric charge themselves) go parallel streets. The kind of laws on one street coincide with the kind of laws on the other street. But the basis on each street is different, on one street it is mass and on the other street it is electric charge. Therefore it is incorrect to explain any effects of gravitation (not only the Newton's law of world gravitation with the help of electric charge). How can a tomato salad have a cucumber explanation?

Of course, the relationship between mass and electric charge can always be found, and in different aspects. But it’s impossible to explain mass through electric charge and vice versa. Gravifrequency phenomena are explained by the presence and motion of masses, and electromagnetic phenomena are explained by the presence and motion of electric charges.

For the electric charge space (given that $E = \lambda e$ (Lunin, 2006) and $c^2 \leftrightarrow \lambda$ (Lunin, 2022)) the Lagrange function will be in the form

$$L_e = -e\lambda\sqrt{1-\frac{\boldsymbol{E}t\boldsymbol{v}}{\lambda}} + e(\boldsymbol{A}_e \cdot \boldsymbol{v}) - e\phi_e \tag{2}$$

where λ is constant, $\lambda \approx 10^6$ V (Lunin, 2006);

ϕ_e is electric field potential.

The refined formula of electric charge non-invariance was applied in formula (2), (Lunin, 2006)

$$e = \frac{e_0}{\sqrt{1-\frac{\boldsymbol{E}t\boldsymbol{v}}{\lambda}}}.$$

Then the action S_e for an electric charge in an electromagnetic field can be written as follows

$$S_e = \int_{t_1}^{t_2} \left(-e\lambda\sqrt{1-\frac{\boldsymbol{E}t\boldsymbol{v}}{\lambda}} + e(\boldsymbol{A}_e\boldsymbol{v}) - e\phi_e\right)dt$$

Similarly, formula (1) can be transformed into a Lagrange function for the mass *m* in the gravifrequency field

$$L_g = -mc^2\sqrt{1-\frac{v^2}{c^2}} + m(\boldsymbol{A}_g \cdot \boldsymbol{v}) - m\phi_g \ ,$$

where ϕ_g is the gravitational field potential.

Then the action S_g for mass *m* in the gravifrequency field can be written as follows

$$S_g = \int_{t_1}^{t_2} \left(-mc^2\sqrt{1-\frac{v^2}{c^2}} + m(\boldsymbol{A}_g \boldsymbol{v}) - m\phi_g\right) dt \ .$$

Formulas (3) and (4) for the action (Landau & Lifshits, 1969) can be converted to formulas (3a) and (4a) for the gravifrequency field

$$S_e = \int_{t_1}^{t_2} -mc^2\sqrt{1-\frac{v^2}{c^2}}\, dt - \int_a^b \frac{e}{c} A_\mu dx^\mu \quad (3)$$

$$S_{e1} = -\Sigma \int mc\, ds - \Sigma \int \frac{e}{c} A_\mu dx^\mu - \frac{1}{16\pi c} \int F_{\mu\nu} F^{\mu\nu} d\Omega \quad (4)$$

$$S_g = \int_{t_1}^{t_2} -mc^2\sqrt{1-\frac{v^2}{c^2}}\, dt - \int_a^b \frac{m}{c} A_\mu dx^\mu \quad (3a)$$

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In formulas (3a) and (4a) the expressions $\boldsymbol{A_\mu}$ and $F_{\mu\nu}$ should be understood as vector potential and tensor of the gravifrequency field.

From formulas (3a) and (4a), following the proof scheme given in (Landau & Lifshits, 1969), one can obtain a gravifrequency field equations system. This was done by the author in (Lunin, 2024). If we want to go to the *pure* space of electric charge, then in formulas (3) and (4) the first terms should be changed and written in this form

$$\int_{t_1}^{t_2} \left(-e\lambda\sqrt{1-\frac{\boldsymbol{E}t\boldsymbol{v}}{\lambda}}\right) dt \quad \text{and} \quad \Sigma \int_{t_1}^{t_2} \left(-e\lambda\sqrt{1-\frac{\boldsymbol{E}t\boldsymbol{v}}{\lambda}}\right) dt$$

Let's write the expression for the electric charge momentum $\boldsymbol{p_e}$ located in a constant electric field with a strength $\boldsymbol{E} = (E_x, 0, 0)$. Notice the body is in the electric charge space.

$$\boldsymbol{p_e} = e\,\boldsymbol{E}\,t,$$

where t is the existence time of the body in the electric field. There is the electric field only.

Then we can write an expression for the force $\frac{d\,\boldsymbol{p_e}}{d\,t} = \boldsymbol{F}_{\mathrm{e}}$,

where $\boldsymbol{F}_{\mathrm{e}} = e\,\boldsymbol{E}$.

In the absence of external forces ($\boldsymbol{F}_{\mathrm{e}} = 0$) we can write

$$\frac{d\,\boldsymbol{p_e}}{d\,t} = 0$$

Consequently it's possible to formulate the electric charge momentum conservation law: the electric charge momentum (located in a system of electric charges) is constant for a closed system.

It should be noted that the electron spin needs to be specified. The electron has mass and electric charge. Each of these quantities is responsible for its part (its contribution) to the total spin. And since both parts are measured in the same units (J·s), they appear as one common spin.

This remark about spin applies to all particles that have mass and electric charge.

The same can be said about the orbital momentum (mechanical and electric) of objects that have mass and electric charge. The total momentum will consist of the sum of the mechanical momentum ($m\boldsymbol{v}$) and the electric charge momentum ($e\,\boldsymbol{E}\,t$).

As an example, consider the electron in the first Bohr orbit of the hydrogen. Let's calculate its mechanical and electric momenta. For the electron velocity in the first Bohr orbit there is a tabular value

$\boldsymbol{v} = 21{,}8\cdot10^5$ m/s (this is computed trivially).

$$m\boldsymbol{v} = 19{,}84\cdot10^{-25} \text{ kg m/s}$$

To calculate the electric momentum, we must first find the electric field strength of the hydrogen atom nucleus in the first Bohr orbit. There is a tabular value for the Bohr radius $a_0 = 0{,}53\cdot10^{-10}$m.

$$\boldsymbol{E} = e/(4\pi\varepsilon_0 a_0^2)$$

$$\boldsymbol{E} = 51\cdot10^{10} \text{ V/m}$$

$$\boldsymbol{p}_e = e\,\boldsymbol{E}\,t$$

There is a tabular value for $t = 0{,}15\cdot10^{-15}$ s

$$\boldsymbol{p}_e = 122{,}4\cdot10^{-25} \text{ kg m/s}$$

It turns out that the electrical part of the momentum is 6 times greater than the mechanical part of the momentum. Although it would be more logical to expect this ratio to be not 6, but 10^{42} (as well as α/α_g, look **Interactions Comparison** p. 16).

By analogy with mechanics let's write the expression for the point electric charge e angular momentum $\boldsymbol{L}_e$ (in the electric charge space) relatively to the point O as a vector product

$$\boldsymbol{L}_e = [\boldsymbol{r} \times \boldsymbol{p}_e],$$

where $\boldsymbol{r}$ is the radius-vector from point O to the point charge e.

$$\boldsymbol{L}_e = e\,[\boldsymbol{r} \times \boldsymbol{E}]\,t$$

$$\frac{d\boldsymbol{L}_e}{dt} = [\boldsymbol{r} \times \boldsymbol{F}_e]$$

$$\frac{d\boldsymbol{L}_e}{dt} = \boldsymbol{M}_e,$$

And we got the expression for the forces moment $\boldsymbol{M}_e$ relatively to the same point O.

Consequently it's possible to formulate the angular momentum conservation law for electric charge: the electric charge angular momentum $\boldsymbol{L_e}$ is constant for a closed system (that's $\boldsymbol{M}_e = 0$).

Let's find a physical quantity that is the magnetic moment analog $\boldsymbol{p_m}$.

Let's write down the formula for the magnetic moment $\boldsymbol{p_m}$

$$\boldsymbol{p_m} = IS\boldsymbol{n},$$

where I is electric current; S is the contour area;

$\boldsymbol{n}$ is unit vector of the normal to the area S.

By analogy with the electric charge space, let's call the next expression the frequency moment $\boldsymbol{p_\omega}$

$$\boldsymbol{p_\omega} = I_{mas}\ S\ \boldsymbol{n},$$

where I_{mas} is mass current flowing along the circuit;

S is the area covered by this contour.

The mass current I_{mas} should be understood as the consumption Q_{mas} of mass m, that's the mass m change per unit time t

$$I_{mas} = Q_{mas} = \Delta m/\Delta t$$

Kinetic Energy and Steiner Theorem for Electric Charge

By analogy with mechanics we can write an expression for the kinetic energy E_k of an electric charge e

$E_{ke} = e\cdot\boldsymbol{E}\cdot t\cdot\boldsymbol{v}/2$ (understanding that $\boldsymbol{E}\cdot t$ is an analog of $\boldsymbol{a}\cdot t = \boldsymbol{v}$)

We can write a general expression for the kinetic energy $E_k = \boldsymbol{pv}/2$

If the body has both mass and electric charge, the total kinetic energy will be as follows

$$E_k = E_{kg} + E_{ke} = \boldsymbol{p}_g\boldsymbol{v}/2 + \boldsymbol{p}_e\boldsymbol{v}/2 = m\boldsymbol{vv}/2 + e\boldsymbol{E}t\boldsymbol{v}/2 = (m\boldsymbol{v} + e\boldsymbol{E}t)\boldsymbol{v}/2 = \boldsymbol{pv}/2$$

And not only mass, but also the electric charge of the body (particle) is responsible for the amount of energy in the body (particle). And when calculation the total energy E_{tot} of a body (particle) it will be necessary to take into account the formula (Lunin, 2006)

$$E = e\lambda$$

By analogy with mechanics we define the electric charge e inertia moment I_e relatively to a given axis as the value equal to the product of the electric charge e and the distance $\boldsymbol{r}$ square to the considered axis

$$I_e = e\, r^2$$

It's possible to formulate the Steiner theorem analog (for electric charge). The electric charge e inertia moment I_e relatively to an arbitrary axis is equal to its moment I_c of inertia relatively to a parallel axis passing through the electric charge center C added with the product of the electric charge e and the distance $\boldsymbol{a}$ square between the axes

$$I_e = I_c + e\, a^2$$

In mechanics

$$\boldsymbol{L} = I\, \boldsymbol{\omega},$$

where $\boldsymbol{L}$ is the angular momentum;

I is the inertia moment;

$\boldsymbol{\omega}$ is the angular velocity.

Passing to the electric charge space, we replace $\boldsymbol{\omega}$ by the magnetic induction $\boldsymbol{B}/2$ (Lunin, 2024).

By analogy we can write

$$\boldsymbol{L_e} = I_e\, \boldsymbol{B}/2$$

where $\boldsymbol{L_e}$ is the angular momentum of the electric charge.

It's possible to construct the rotational motion dynamics equation of electric charge e relatively to a fixed axis.

In mechanics (Hajkin, 1947)

$$\boldsymbol{M} = I \frac{d\boldsymbol{\omega}}{dt} ,$$

where $\boldsymbol{M}$ is the force moment.

Passing to the electric charge space, we can write the rotational motion dynamics equation of electric charge

$$\boldsymbol{M}_e = \frac{1}{2} I_e \frac{d\boldsymbol{B}}{dt} ,$$

where $\boldsymbol{M}_e = [\boldsymbol{r} \times \boldsymbol{F}_e] = [\boldsymbol{r} \times (e\,\boldsymbol{E} + e\,\boldsymbol{v}\,\boldsymbol{B})]$

It's possible to construct a formula for the kinetic energy of the rotational motion in the electric charge space. As it's known, the kinetic energy E_k of the rotational motion in mechanics is calculated by the formula

$$E_k = I\,\omega^2/2$$

By analogy let's write down the formula for the kinetic energy E_{ke} of the rotational motion in electric charge space. In the last formula we replace $\boldsymbol{\omega}$ by $\boldsymbol{B}/2$ (but only for one $\boldsymbol{\omega}$). Then

$$E_{ke} = I_e\,\boldsymbol{\omega} \cdot \boldsymbol{B}\,/4$$

Planck Formula, Interval, Uncertainty Ratio

In the electric charge space it's possible to construct the Planck formula analog, in which the magnetic induction $\boldsymbol{B}$ will participate together with some constant. Let's write down the Planck formula

$$E = \hbar\,\boldsymbol{\omega}$$

Let's replace $\boldsymbol{\omega}$ with the magnetic induction $\boldsymbol{B}$. In this case, it will be necessary to replace and ħ with some other constant

$$E = \text{const} \cdot \boldsymbol{B}/2$$

From this it can be seen that if ħ represents a certain value of the angular momentum in the Planck formula, then the constant represents a certain (constant) minimum value of the magnetic moment in the last formula. Let's denote it by $\boldsymbol{p}_{\mathrm{m}0}$. It's highly likely that it will be the nuclear magneton.

Then

$$E = \boldsymbol{p}_{\mathrm{m}0} \cdot \boldsymbol{B}$$

This is the Planck formula analog.

There is a formula for the interval s between two events (Trofimova, 2006)

$$s^2 = c^2\, t^2 - x^2 - y^2 - z^2$$

Let's construct this formula analog in the electric charge space. c^2 will be replaced by λ. In the expression t^2 we pass to angular velocity ($t = 2\pi/\omega$). And we will do it only for one time, and leave the second time t unchanged.

In the right-hand side of the equation, the first term will look like this $\lambda\, t\, 2\pi / \omega$.

And now we replace ω by $B/2$. And we get the final formula for the interval s_e between two events in the electric charge space

$$s_e^2 = \lambda\, t\, (4\pi/B) - x^2 - y^2 - z^2$$

De Broglie wavelength $\lambda_B = \mathrm{h}/\boldsymbol{p}$ (Trofimova, 2006). In the electric charge space it will look as follows

$$\lambda_{Be} = \mathrm{h}/(e\boldsymbol{E}t)$$

$$\lambda_{Be}/(2\pi) = \hbar/(e\boldsymbol{E}t)$$

$$1/\boldsymbol{k}_e = \hbar/(e\boldsymbol{E}t)$$

$$e\boldsymbol{E}t = \hbar\, \boldsymbol{k}_e$$

$$\boldsymbol{p}_e = \hbar\, \boldsymbol{k}_e$$

Let's write the uncertainty ratio (Trofimova, 2006)

$$\Delta E \cdot \Delta t \geq \hbar$$

Considering that (Lunin, 2006)

$$E = e\,\lambda\,,$$

we can write

$$\Delta(e\,\lambda\,) \cdot \Delta t \;\geq\; \hbar$$

$$\Delta e \cdot \Delta t \;\geq\; \hbar/\lambda$$

The shorter the some state existence time or the time allotted for its observation, the less definitively it’s possible to speak about the electric charge of this state.

Let's think about the uncertainty ratio from a different point of view. Based on the three conservation laws (angular momentum, energy and momentum), we can formulate three postulates.

a) Postulate 1: there is a minimum value of angular momentum (it turned out to be equal to ħ).

This immediately follows the Heisenberg uncertainty ratio.

$$\boldsymbol{r} \times \boldsymbol{p} \;\geq\; \hbar$$

Or in a more familiar form

$$\Delta r\,\Delta p \geq \hbar \qquad (5)$$

We obtained the known uncertainty ratio, but only did it in a simpler way (by introducing postulate 1). Of course, you need to understand that $\boldsymbol{p}_g$ and $\boldsymbol{p}_e$ are calculated using different formulas (see above).

b) Postulate 2: there is a minimum value of energy.

Let’s denote E_{min} - the minimum energy value.

If ħ is a constant value, then there is a minimum value ω_{min}

$$E \geq \hbar\,\omega_{min}$$

$$E/\omega_{min} \;\geq\; \hbar$$

Or in a more familiar form

$$\Delta E \, \Delta t \geq \hbar \qquad (6)$$

The last expression can be obtained without the second postulate.

If $p = E/c$, then we can divide and multiply the left-hand side of expression (5) by c and obtain the expression (6).

c) Postulate 3: there is a minimum value of momentum.

$$p \geq p_{min}$$

If $p = E/c$, then

$$p \geq E_{min}/c$$

$$p \geq \hbar \, \omega_{min}/c$$

$$p/\omega_{min} \geq \hbar/c$$

$$\Delta p \, \Delta t \geq \hbar/c \qquad (7)$$

The last expression can be obtained without the third postulate. We can divide expression (6) by c (or divide expression (5) by c) and obtain the expression (7).

Note that it's not necessary to formulate all three postulates to obn expressions (5) - (7). It's enough to formulate any of the three postulates and hence all three expressions (5) - (7) are obtained.

Interactions Comparison

This section provides a comparative analysis of different interaction forces (electric with gravitational, magnetic with frequency, electromagnetic with gravifrequency). As well in this section the formula of the constant characterizing gravifrequency interactions is constructed.

The relation of the electric interaction force to the gravitational interaction force is calculated trivially in a school physics course.

$$\frac{F_{el}}{F_{gr}}=\frac{e^2}{m^2 4\pi\varepsilon_0 G}=4{,}17\cdot 10^{42} \quad (8)$$

where e and m are the electric charge and mass of electron;

ε_0 and G are electric and gravitational constants.

A value of the same order is also given in (Wilczek, 2017).

It should be noted that so far we can speak about the relation only of electric and gravitational forces, but not about the relation of electromagnetic and gravifrequency forces. Although in the future it will turn out that this relation is true for electromagnetic and gravifrequency interaction as well.

Let's try to calculate the relation of magnetic forces to frequency forces. The interaction force between two magnets placed in parallel is calculated by the formula (Pyatin, 1980)

$$F_{mag\ par}=\frac{0{,}75\,\mu_0 p_1 p_2}{\pi r^4} \quad (8a)$$

where p_1 and p_2 are magnetic moments; r is the distance between the magnets.

Let's calculate this force of interaction between two elementary magnets. As elementary magnets, let's take two electrons rotating along different circuits (S_1 and S_2) and with different rotation periods (T_1 and T_2)

$$F_{mag\ par}=\frac{0{,}75\,\mu_0 \frac{e}{T_1} S_1 \frac{e}{T_2} S_2}{\pi r^4}$$

For the electron, as a mass carrier, we can write by analogy the formula for the frequency interaction force

$$F_{\omega\ par}=\frac{0{,}75\,\mu_{0g} p_{\omega 1} p_{\omega 2}}{\pi r^4}$$

$$F_{\omega\ par}=\frac{0{,}75\,\mu_{0g} \frac{m}{T_1} S_1 \frac{m}{T_2} S_2}{\pi r^4}$$

$$\frac{F_{mag\ par}}{F_{\omega\ par}}=\frac{\mu_0 e^2}{\mu_{0g} m^2}$$

$\mu_{0g} = 4\pi G/c^2$ (Lunin, 2024).

Then $\frac{F_{mag\ par}}{F_{\omega\ par}}=\frac{\mu_0 e^2 c^2}{4\pi G m^2}$

$$\frac{F_{mag\ par}}{F_{gr}}=\frac{e^2}{m^2 4\pi\varepsilon_0 G}=4{,}17\cdot 10^{42} \qquad (9)$$

We obtained an expression (9) that coincides completely with expression (8).

And only now we can assert that expression (8) characterises the relation not only of electric interaction to gravitational interaction or magnetic interaction to frequency interaction; expression (8) characterises the relation of electromagnetic interaction to gravifrequency interaction.

There is another way to compare electromagnetic and gravifrequency interactions. There is a fine structure constant (α = 1/137), which characterises the electromagnetic interaction.

$$\alpha=\frac{e^2}{4\pi\varepsilon_0\hbar c} \qquad (10)$$

Let's construct an analog α_g of this constant, which will characterise the gravifrequency interaction.

We make the standard substitutions: $e \rightarrow m$ and $1/4\pi\varepsilon_0 \rightarrow G$ (Lunin, 2022)

$$\alpha_g=\frac{m^2 G}{\hbar c} \qquad (11)$$

Since the electric charge of the electron appears in expression (10), we must put the mass of the electron in expression (11)

$$\alpha_g=17{,}49\cdot 10^{-46}$$

To find out how many times the electromagnetic interaction is stronger than the gravitational interaction, we need to divide α by α_g

$$\frac{\alpha}{\alpha_g}=\frac{e^2}{m^2 4\pi\varepsilon_0 G}=4{,}17\cdot 10^{42}$$

This expression coincides completely with expression (8) and (9). This fact is a good confirmation of formula (11).

Reynolds Number in Electrodynamics

Let's construct the Reynolds number $\check{R}$ in electrodynamics. Reynolds number R is calculated by the formula (Feynman et al., 1977)

$$R=\frac{\rho \boldsymbol{v} D}{\boldsymbol{\eta}}$$

We replace the dynamic viscosity $\boldsymbol{\eta}$ by the magnetic field strength $\boldsymbol{H}$ (Lunin, 2024).

Then $$\check{R}=\frac{\rho e \boldsymbol{v} D}{\boldsymbol{H}}$$

The current I in a conductor with cross-section s can be calculated by the formula (Trofimova, 2006)

$$I=\rho_e \boldsymbol{v} s,$$

where ρ_e = electric charge density;

s = $\pi D^2/4$ (for a circular conductor).

Consequently $\rho_e \boldsymbol{v} = I/s$

Then there is the final expression

$$\check{R}=\frac{\rho e \boldsymbol{v} D}{\boldsymbol{H}}=\frac{I D}{s\boldsymbol{H}}=\frac{4I}{\pi D\boldsymbol{H}}\ .$$

Having obtained this formula we can proceed to the experimental part.

Changing the magnetic field strength $\boldsymbol{H}$, we will receive corresponding values of current I, which will be shown by an ammeter in a conductor circuit. And from these values of the magnetic field strength $\boldsymbol{H}$ and the current I we can calculate the Reynolds number in electrodynamics.

The solenoid was made of the ferromagnetic wire with a length of $l = 1.1$ m and a diameter of D = 0.2 mm. The wire was wound on a plastic tube with a diameter D = 50 mm. The Reynolds number $\check{R}$ values change from $1.27 \cdot 10^{-3}$ to $2.54 \cdot 10^{-3}$ when the current *I* changes from 80 mA to 160 mA with the external magnetic field strength ***H*** = 400 A/m. Measurements were taken at 5 mA intervals. The Reynolds number varied in proportion to the current.

The current *I* change was stably observed at the external magnetic field strength ***H*** change from 400 A/m to 10^3 A/m. The current change was spasmodic, no large and very stable: from 90.2 mA to 90.1 mA (when the external magnetic field strength ***H*** reached the value of 700 A/m). A spasmodic change in resistance occurs approximately at $\check{R} \approx 1.43 \cdot 10^{-3}$. The current changes remained the same when the magnetic field direction changed to the opposite.

The same change in current *I* (by 0.1 mA) is observed at such currents: 80 mA, 100 mA, 130 mA, 150 mA.

The magnetic field strength ***H*** change didn't lead to a current change at such currents: 60 mA, 50 mA or less. Perhaps this is due to the insufficient accuracy of the measuring equipment. The magnetic field strength ***H*** change also didn't lead to a current *I* change at such currents: from 200 mA to 500 mA.

The magnetic field strength ***H*** change did not lead to a current *I* change in experiments with a copper wire with the diameter D = 0.2 mm. The external magnetic field strength ***H*** changed so: from 400 A/m up to 1000 A/m.

The experiment was carried out in the current range (20÷500) mA.

Conclusions

It's desirable to carry out further experiments in this direction with more stable and powerful power sources, with more accurate measuring equipment, with different wire diameters and knowing the magnetic permeability μ of the wire.

Funding

This research received no external funding.

Data availability statement

Data are contained within the article and collected from the references listed in the bibliography.

Acknowledgments

The author is grateful to Tetiana Shashkova, Tatyana Vasina, Vanesa Gonzalez, Oleh Araslanov, Petro Kanivets, Igor Mizin, Kirill Bileckiy and Vladimir Dzjuba for their help. I would like to give special thanks to my grandson Yaroslav Arnaut, with whom we started a series of experiments in 2006 at home.

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