Gravity cells as a necessary link in string theory. Energy and frequency of vibrations of gravitational strings. Obtaining a formula for determining the gravitational constant and a formula for determining the mass of an electron. The coincidence of the results obtained with the experimental data.

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Article

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Abstract.

In this study, a new concept is introduced - gravitational cells. The body of a black hole consists of a huge number of such cells. This hypothesis from particle physics has been organically built into string theory. As a result, using the formula for the Schwarzschild radius and the Coulomb formula, a formula was obtained to determine the gravitational constant in the region of black holes and its value was determined. The value of the usual gravitational constant has been confirmed. Also, a new physical constant was obtained - the mass of the gravitational cell of a black hole.

The introduction of the hypothesis of gravitational cells into string theory allowed us to apply Planck's formula to gravitational interaction. As a result, the formula for the quantum of the gravitational field was obtained and the frequency of vibrations of gravitational strings was calculated. Based on this, a formula was obtained to determine the mass of an electron. The electron mass calculated by the new formula coincided with the known experimental value. In this work, it was also proved that the vibration frequency of gravitational strings is directly proportional to the ratio of the mass of an electron and a proton inside the gravitational cell (and inside the atom). The formula for the dependence of the gravitational constant on the magnitude of the electron mass was obtained and confirming calculations were made.

Keywords. Gravitational cell, gravitational constant formula, electron mass formula, gravitational string, gravitational field quantum, gravitational string vibration frequency formula.

Introduction.

The main goal of this study is to embed the physics of elementary particles (in the form of a hypothesis about gravitational cells) into string theory and to obtain, on this basis, specific results that can be compared with experimental data. Therefore, in the introductory part, it is better to highlight the issues and problems of modern physics for the main directions of this article. Let's start with the gravitational constant.

In physics, there have been several attempts to propose scientifically substantiated formulas for calculating the gravitational constant. All the formulas presented by the authors are quite complex, and they necessarily contain additional (often artificial) coefficients and indicators, without which these formulas do not work.

String theory is a branch of theoretical physics that studies the dynamics of the interaction of objects not as point particles, but as one-dimensional extended objects, the so-called quantum strings. String theory combines the ideas of quantum mechanics and the theory of relativity. The theory that arose to describe hadronic physics, but did not quite fit for this, turned out to be a kind of experiment in a vacuum. The main problem of string theory is expressed in a huge

variety of possible solutions, the so-called "landscape problem". This significant circumstance, according to such famous scientists as Lee Smolin and David Gross, takes string theory out of the framework of scientific theory. In this paper, I will try to prove that the introduction of particle physics in the form of gravitational cells into string theory is quite concrete results.

Methods.

The study begins with the Coulomb formula. Let's write this formula for the case of interaction of two opposite elementary charges:

$$f = k \cdot \frac{q_0 \cdot q_0}{r^2} \quad \text{or} \quad f = k \cdot \frac{q_0^2}{r^2} \quad (1-1)$$

Where f is the force of attraction of two elementary charges.

where q_0 is an elementary charge, $1,60217733 \cdot 10^{-19}$ C.

k is the coefficient of proportionality, $k = \frac{1}{4\pi\epsilon_0\epsilon}$. Where $\frac{1}{4\pi\epsilon_0}$ is a constant equal to $9 \cdot 10^9 \frac{\text{kg m}^3}{\text{C}^2 \text{s}^2}$, and ϵ is the relative dielectric constant of the medium.

r is the distance between charges, m.

The value of the proportionality coefficient k depends on the medium.

Maximum value $k = 9 \cdot 10^9 \frac{\text{kg m}^3}{\text{C}^2 \text{s}^2}$ in vacuum (where $\epsilon = 1$), for alcohol $k = 2,6 \cdot 10^8$ (where $\epsilon = 35$), for water $k = 1,1 \cdot 10^8$ (where $\epsilon = 80$), for copolymers $k \geq 10^4$ (where $\epsilon \leq 105$), etc. Theoretically, k can approach its minimum value equal to 1. But $k < 1$ cannot be in any medium, because then the fractionality of elementary charges is allowed. Practical confirmation of this lies in the fact that

science does not know substances where $\varepsilon > 9 \cdot 10^9$. The maximum value of ε is recorded for metal nanoisland structures, $10^7 - 10^8$, where $k \geq 90$.

Now let's move on to the gravitational interaction of such physical objects as black holes. (The result obtained here will then make it possible to pass to the gravitational interaction of ordinary bodies).

So, we have two black holes of mass M and M_1 , located at a distance r from each other. The body of a black hole consists of many superdense cells with mass m_0 and charge q_g , numerically equal to the value of two elementary charges q_0 , that is, $q_g = 2q_0$. Such a cell (let's call it a gravitational cell), in a black hole, is a tightly compressed pair of elementary particles: an electron and a proton. In this case, the mass of such a cell will be less than the total mass of a free proton and a free electron by Δm due to the release of energy during compression, where $\Delta m = E/c^2$. The gravitational cells of one black hole M are connected by ultramicroscopic strings with the gravitational cells of another black hole M_1 . As a result, a common gravitational field E is created in space, through which the interaction between black holes takes place along the gravitational strings. The field strength of the gravitational cell g_0 in the black hole region M is determined by the following formula:

$$g_0 = \frac{k_0 q_{g1} \cdot k_0 q_{g2}}{r^2} \quad \text{or} \quad g_0 = k_0^2 \frac{4q_0^2}{r^2} \quad (1-2)$$

where g_0 is the value of the gravitational field of one gravitational cell of a black hole, m/s^2 .

k_0 – proportionality coefficient, $k_0 = 1 \frac{\text{m}^{3/2}}{\text{C s}}$,

q_0 – elementary charge $1,60217733 \cdot 10^{-19}$ C.

q_{g1} and q_{g2} are the charges of the gravitational cells of black holes, $q_g = 2q_0 = 3,20435466 \cdot 10^{-19}$ C.

r – distance between cells, m.

Thus, the gravitational field around the gravitational cell at a distance $r = 1$ m will be $g_0 = \frac{k^2 4q_0^2}{r^2} = 1,026789 \cdot 10^{-37} \text{ m/s}^2$ (1-3)

Formula (1-2) is similar to Formula (1-1). But if in the Coulomb formula the coefficient of proportionality in vacuum is $k = 9 \cdot 10^9$, then in the formula (1-2) $k_0 = 1$. The reason for such a large discrepancy in the coefficients is that the substance of the black hole is so strongly compressed that almost all lines of force of elementary charges are closed inside gravitational cells. **And only an extremely small part of the lines of force go out from the cell, creating a gravitational field in the outer space.** As a result of this circumstance, the coefficient of proportionality of elementary charges outside the gravitational cell decreases to its minimum threshold, that is, **exactly to 1**. At the same time, the main electric field, with the coefficient of proportionality $k = 9 \cdot 10^9$, remains closed between elementary charges inside the gravitational cells and therefore does not manifest itself in any way.

Now let's consider the interaction of two black holes M and M_1 . The body of a black hole with mass M consists of a huge number of gravitational cells with

mass m_0 . Therefore, the total number of such cells will be: $n = \frac{M}{m_0}$. These gravitational cells form a common gravitational field in space, equal to $E = g_0 \cdot n$. Thus, the gravitational field E around a black hole M when it interacts at a distance r with another black hole will be:

$$E = \frac{k_0^2 4q_0^2}{r^2} \frac{M}{m_0} \quad \text{or} \quad E = \frac{k_0^2 4q_0^2}{m_0} \frac{M}{r^2} \quad (1-4)$$

The expression $\frac{k_0^2 4q_0^2}{m_0}$ is the value of the gravitational constant G_0 for the case of interaction of two black holes. (Further, for better perception, the coefficient $k_0 = 1$ will not be displayed in the formulas). As a result, for $k_0 = 1$, formula (1-4) will take the following form:

$$E = G_0 \frac{M}{r^2}, \quad \text{where} \quad G_0 = \frac{4q_0^2}{m_0} \quad (1-5)$$

It follows that $m_0 = \frac{4q_0^2}{G_0}$. It is possible to determine the value m_0 if we admit the possibility of equality $G_0 = G = 6,6743 \cdot 10^{-11}$. In this case, we get $m_0 = \frac{4q_0^2}{6,6743 \cdot 10^{-11}} = 1,53842 \cdot 10^{-27}$ kg. But such a calculation of the value m_0 cannot be considered correct, because the value of the gravitational constant G_0 in the region of the black hole may have a different value, that is, $G_0 \neq G$. Therefore, in order to correctly determine the value of m_0 and also the value of G_0 , it is necessary to turn to the formula for the Schwarzschild gravitational radius:

$$R = \frac{2G_0}{c^2} \cdot M \quad (1-6)$$

where R is the gravitational radius of a black hole, G_0 is the gravitational constant in the field of a black hole, M is the mass of a black hole, and c is the speed of light.

In this formula, of particular interest is the expression $\frac{2G_0}{c^2}$, which is measured in " m / kg ", and denotes the specific length of the gravitational radius of a black hole. (In what follows, we denote $\frac{2G_0}{c^2}$ as γ). And now a very important point. **In space compressed to a point around a black hole, such a category as space does not exist.** Therefore, in the Schwarzschild radius, all physical quantities merge into one quantity - mass, where the initial dimensional unit is the mass of the gravitational cell m_0 . As a result of this circumstance, in the gravitational radius of the black hole, the numerical equality must be observed: $\gamma = m_0$. Taking into account that $\gamma = \frac{2G_0}{c^2}$, and $m_0 = \frac{4q_0^2}{G_0}$, we get the following equation: $\frac{2G_0}{c^2} = \frac{4q_0^2}{G_0}$. Let's solve it and as a result we get:

$$G_0 = \sqrt{2} q_0 c = 6,7927 \cdot 10^{-11} \frac{m^3}{s^2 kg} \quad (1-7)$$

$$m_0 = \frac{\sqrt{8} q_0}{c} = 1,511593 \cdot 10^{-27} kg \quad (1-8)$$

As you can see, G_0 differs from $G = 6,6743 \cdot 10^{-11}$ by 1,7%. In this case, the value of G_0 is related to the mass of the gravitational cell m_0 by the following beautiful formula: $G_0 = \frac{m_0 c^2}{2}$ (1-9).

Now consider the gravitational interaction of an ordinary (that is, not superdense) body $\mathbf{M}$ with another body $\mathbf{M}_1$. The formula of the gravitational field around a body of mass $\mathbf{M}$ in this case will look like this:

$$\mathbf{E} = \frac{k^2 4q_0^2}{r^2} \frac{\mathbf{M}}{m} = \frac{k^2 4q_0^2}{m} \frac{\mathbf{M}}{r^2} \quad \text{or} \quad \mathbf{E} = \mathbf{G} \frac{\mathbf{M}}{r^2} \quad (1-10)$$

Where $\mathbf{k}$ is the proportionality coefficient of the charge of the gravitational cell of

an ordinary body, where $\mathbf{k} = 1,038931 \frac{\text{m}^{3/2}}{\text{C s}}$, $\mathbf{k}^2 = 1,079\,378 \frac{\text{m}^3}{\text{C}^2 \text{s}^2}$

$\mathbf{m}$ is the mass of the gravitational cell, where $\mathbf{m} = 1,660539 \cdot 10^{-27} \text{ kg}$

$\mathbf{G}$ - gravitational constant, where $\mathbf{G} = 6,6743 \cdot 10^{-11} \frac{\text{m}^3}{\text{s}^2 \text{ kg}}$

The gravitational field around the gravitational cell at a distance of $\mathbf{r} = 1 \text{ m}$ will be $\mathbf{g} = k_0^2 4q_0^2 = 1,108293 \cdot 10^{-37} \text{ m/s}^2$ (1-11)

Now let's explain the magnitude of $\mathbf{k}$ and $\mathbf{m}$. Let's start with $\mathbf{m} = 1,660539 \cdot 10^{-27} \text{ kg}$. To do this, imagine that two bodies of mass $\mathbf{M}$ and $\mathbf{M}_1$ were formed from two black holes $\mathbf{M}'$ and $\mathbf{M}'_1$. In this case, each gravitational cell of the black hole, due to the arrival of energy $\mathbf{E}$, increases its mass $\mathbf{m}_0$ to mass $\mathbf{m}$ by the amount $\Delta \mathbf{m}$ (where $\Delta \mathbf{m} = \mathbf{E}/c^2$). As a result, a plasma is formed from the superdense matter of a black hole, from which gaseous, liquid and solid substances can be formed. All four states of matter are neutral, that is, they have a total electric charge equal to zero. As a result of this circumstance, any substance can be represented as a huge set of gravitational cells. These cells consist of a proton and an electron with a total charge of $2 q_0$, as well as of neutrons, which are also a pair of a proton and an electron with a total charge of $2 q_0$. Thus, the mass of the

gravitational cell ***m*** of any non-superdense substance (plasma, gas, liquid and solid) with high accuracy will be equal to **1 Da** (this is 1/12 of the mass of an atom of the isotope of carbon-12) or **$1,660539 \cdot 10^{-27}$ kg**. This implies that:

$$k = \sqrt{\frac{G m}{4q_0^2}} = \sqrt{\frac{6,6743 \cdot 10^{-11} m}{4q_0^2}} = \mathbf{1,038931} \quad (1-12)$$

Thus, **$k > k_0$** . This can be explained by the fact that, in contrast to the gravitational cell of a black hole, where everything is tightly compressed, in an ordinary cell there is an ultramicroscopic distance between elementary charges. As a result of this circumstance, more lines of force come out of an ordinary cell and go out, creating a **7,9%** stronger gravitational field in outer space. But due to the fact that the mass of an ordinary gravitational cell ***m*** is more than the mass of the gravitational cell of a black hole **m_0** by **9.9%**, then 1 kg of ordinary matter has a smaller number of gravitational cells than 1 kg of black hole matter. As a result of this circumstance, it turns out that **$G < G_0$** , even though **$k > k_0$** . For clarity, we will show this in a mathematical form:

$$G = \frac{k^2 4q_0^2}{m} = \frac{1,079\,378 \cdot 4q_0^2}{1,660539 \cdot 10^{-27}} < G_0 = \frac{k_0^2 4q_0^2}{m_0} = \frac{4q_0^2}{1,511593 \cdot 10^{-27}}$$

Next, consider the gravitational interaction of a black hole with mass **M_0** and an ordinary body with mass **M** at a distance ***r*** between them.

1. The gravitational field ***E*** around a black hole with mass **M_0** will be:

$$E = \frac{k_0 k 4q_0^2}{r^2} \frac{M_0}{m_0} = \frac{k_0 k 4q_0^2}{m_0} \frac{M_0}{r^2} \quad (1-13) \quad \text{or} \quad E = G_1 \frac{M_0}{r^2}$$

where $k_0 = 1$, $k = 1,038931$, $m_0 = 1,511593 \cdot 10^{-27}$ kg. Hence the gravitational constant is equal to:

$$G_1 = \frac{k_0 k 4q_0^2}{m_0} = \frac{1,038931 \cdot 4q_0^2}{1,511593 \cdot 10^{-27}} = 7,0572 \cdot 10^{-11} \frac{\text{m}^3}{\text{s}^2 \text{kg}}$$

The gravitational field E around a black hole of mass M will be:

$$E = \frac{k_0 k 4q_0^2}{r^2} \frac{M}{m} = \frac{k_0 k 4q_0^2}{m} \frac{M}{r^2} \quad (1-14) \quad \text{or} \quad E = G_2 \frac{M}{r^2}$$

where $k_0 = 1$, $k = 1,038931$, $m = 1,660539 \cdot 10^{-27}$ kg. Hence the gravitational constant is equal to:

$$G_2 = \frac{k_0 k 4q_0^2}{m} = \frac{1,038931 \cdot 4q_0^2}{1,660539 \cdot 10^{-27}} = 6,4242 \cdot 10^{-11} \frac{\text{m}^3}{\text{s}^2 \text{kg}}$$

Now we apply the gravity cells hypothesis to string theory. Consider first the gravitational interaction between black holes, and then move on to the gravitational interaction between ordinary masses.

The gravitational field between black holes M_{01} and M_{02} consists of many ultramicroscopic vibrating strings that connect the gravitational cells of black holes. These gravitational strings in their totality form a gravitational field in space. From the set of energies e of these strings, the total energy of the gravitational field between the bodies is added, that is, $E = \sum e$. The vibration energy of one gravitational string e , which connects two gravitational cells, is a constant value and is numerically equal to g_0 (f.1-3), that is:

$$e = 4 q_0^2 = 1,026789 \cdot 10^{-37} \text{J} \quad (1-15)$$

Essentially, **e** is the energy quantum of the gravitational field. **But a gravitational quantum, unlike an electromagnetic quantum (photon), does not move in space, but vibrates in the form of a long energy string connecting two gravitational cells of two masses.**

The energy source of the string is 4 elementary charges located in two gravitational cells. The cells vibrate with the same frequency **γ** together with the gravitational string, forming a single whole with the string. (It should be noted that the frequency of vibrations of gravitational strings can be considered as the frequency of gravitational waves, because these are two names for one physical process). With a decrease (increase) in the distance **R** between the cells, an increase (decrease) in the frequency **γ** of oscillations of the gravitational string occurs, but the energy of the quantum always remains unchanged: **$e = 1,026789 \cdot 10^{-37} \text{J}$** . (This can be compared with playing on guitar when clamping the neck of the guitar changes the length of the string, after which the frequency of vibration of the string changes). In contrast to the well-known formula for the quantum of the electromagnetic field **$e = h \gamma$** , the formula for the quantum of the gravitational field is as follows:

$$e = h_g \gamma R^2 \quad (1-15) \quad \text{or} \quad \gamma = \frac{e}{h_g R^2} \quad (1-16)$$

e is the energy of the quantum of the gravitational field, **$e = 1,026789 \cdot 10^{-37} \text{J}$** .

h_g is constant for the case of gravitational interaction, where **$h_g = \frac{1}{4} h =$**

$$1,656518 \cdot 10^{-34} \text{ kg} \cdot \text{s}^{-1}$$

γ is the vibration frequency of the gravitational string, **s^{-1}** .

R is the distance between cells (bodies), m.

The change in the value of Planck's constant under conditions of a gravitational field is explained by the following reason. Unlike an electromagnetic quantum, where a quantum (photon) is formed as a result of oscillations of one charged particle (electron), a quantum of the gravitational field is the result of oscillations of 4 charges. In this case, all 4 charges are in a closed system, which increases the specific frequency of oscillations of the gravitational quantum by 4 times in comparison with the electromagnetic quantum. (That is, with the conditional equality of the energy of the gravitational and electromagnetic quanta, the frequency of oscillations of the gravitational quantum will be exactly 4 times greater).

The expression γR^2 is a constant equal to $e/h_g = 3,874067 \text{ m}^2 \cdot \text{s}^{-1}$. Thus, each meter of increase in the distance between bodies (cells) reduces the frequency of vibrations of the gravitational string by R^2 times. As a result, the frequency of vibrations of the string decreases from the maximum frequency γ to an infinitely small value.

$$\gamma_{max} = \frac{e}{h_g} = \frac{1,026789 \cdot 10^{-37}}{1,656518 \cdot 10^{-34}} = 6,198480 \cdot 10^{-4} \text{ s}^{-1} \quad (1-17)$$

As it was already written above, the frequency of vibrations of a string is equal to the frequency of vibrations of gravitational cells. And now an important point. The maximum oscillation frequency γ_{max} of the gravitational cell is exactly equal to the ratio of the electron mass m_e to the proton mass m_p in the cell:

$$\gamma_{max} = \frac{m_e}{m_p} = \frac{m_e}{m_0 - m_e} \quad (1-18)$$

We transform this formula and substitute the values m_0 and γ_{max} into it.

As a result, we get the mass of the electron:

$$m_e = \frac{m_0 \gamma_{max}}{1 + \gamma_{max}} = \frac{1,511593 \cdot 10^{-27} \cdot 6,198480 \cdot 10^{-4}}{1 + 6,198480 \cdot 10^{-4}} = 9,363775 \cdot 10^{-31} \text{kg} \quad (1-19)$$

As you can see, the calculated electron mass almost completely coincided with the experimental mass of a free electron: $9,109389 \cdot 10^{-31}$ kg. The reason for the discrepancy by 2,7% is the fact that in the gravitational cell of a black hole there is an insignificant increase in the mass of an electron in comparison with the mass of an electron in a free state. It is important to note here that the electron and proton inside the gravitational cell of a black hole are not independent particles. Therefore, they should be considered inside the cell only as two opposite charges with different masses.

Further, taking into account that, $m_0 = \frac{\sqrt{8} q_0}{c}$, $\gamma_{max} = \frac{e}{h_g}$, $h_g = \frac{1}{4} h$, $e = 4q_0^2$, we obtain the basic formula for the electron mass:

$$m_e = \frac{32 \sqrt{2} q_0^3}{c h (1 + \frac{16 q_0^2}{h})} \quad (1-20)$$

Note that on the right side of the formula there are independent physical constants q_0 , h , c , where the category "mass" is absent.

Based on (1-4) and (1-15), the gravitational constant in the black hole region is

$$G_0 = \frac{e}{m_0}. \text{ Taking into account that } e = h_g \gamma_{max}, \gamma_{max} = \frac{m_e}{m_0 - m_e} \text{ we obtain the}$$

following formula for determining the gravitational constant in the region of the black hole G_0 :

$$G_0 = \frac{h m_e}{4 m_0 (m_0 - m_e)} = 6,7927 \cdot 10^{-11} \quad (1-22)$$

In the case of gravitational interaction between ordinary bodies, the energy of the gravitational string has a different value and is equal to $e = 1,108293 \cdot 10^{-37}$ J (1-11). As a result, we obtain, according to the formula (1-17), the maximum frequency of string vibrations:

$$\gamma_{max} = \frac{e}{h_g} = \frac{1,108293 \cdot 10^{-37}}{1,656518 \cdot 10^{-34}} = 6,69050 \cdot 10^{-4} \text{ s}^{-1} \quad (1-21)$$

Knowing the vibration frequency of gravitational strings and the mass of the "ordinary" gravitational cell $m = 1,660539 \cdot 10^{-27}$ kg, we determine the mass of an electron in an ordinary gravitational cell:

$$m_e = \frac{m \gamma_{max}}{1 + \gamma_{max}} = \frac{1,660539 \cdot 10^{-27} \cdot 6,69050 \cdot 10^{-4}}{1 + 6,69050 \cdot 10^{-4}} = 11,102\,408 \cdot 10^{-31} \text{ kg}$$

As you can see, the mass of an electron in a "ordinary" gravitational cell is 18% than the mass of an electron in a superdense cell. This is explained by the increase in the mass of the gravitational cell by 10% and the related structural changes within the "ordinary" gravitational cell. Thus, the mass of an electron in a superdense gravitational cell is closest to the mass of an electron in a free state: the difference is only 2,7%.

The value of the "usual" gravitational constant G is determined by a formula similar to the formula 1-22:

$$G = \frac{h m_e}{4m (m - m_e)} = 6,6743 \cdot 10^{-11} \quad (1-23)$$

(For better perception in the higher formulas, conversion factors for units of measurement are not specially set, which are equal to 1).

Results and discussion.

In this study, gravitational constants were determined for different cases of gravitational interaction.

1. $G_0 = 6,7927 \cdot 10^{-11}$ (for the case of interaction of two black holes).
2. $G = 6,6743 \cdot 10^{-11}$ (for the case of interaction of two ordinary bodies).
3. $G_1 = 7,0572 \cdot 10^{-11}$ and $G_2 = 6,4242 \cdot 10^{-11}$ (for the case of interaction between a black hole and an ordinary body).

It is necessary to explain the third case of gravitational interaction, where there are two values of the gravitational constants G_1 and G_2 . The presence of two gravitational constants can raise the question: "Isn't there a violation of Newton's third law?" **There is no violation here, because throughout the study, mass was only a measure of the amount of matter, and nowhere did it act as a gravitational and inertial mass.** This is clearly seen from formulas (1-13) and (1-14), in which the masses M_0 and M show only the number of gravitational cells in the body: $n = \frac{M_0}{m_0}$ and $n = \frac{M}{m}$. Therefore, Newton's third law ($F_1 = -F_2$), where there is inertial mass ($m_1 a_1 = -m_2 a_2$), cannot be applied here.

When discussing the research results, it is necessary to pay attention to the following point. The force of interaction between two elementary charges q_0 inside the gravitational cell is relatively large and is determined by the formula (1-1), where the proportionality coefficient is $k = 9 \cdot 10^9$. But outside the gravitational cell, the proportionality coefficient k decreases sharply and for superdense gravitational cells it becomes equal to 1, for ordinary gravitational cells

– **1,038931**. This circumstance $9 \cdot 10^9$ times weakens the electric field outside the gravitational cell, turning it into a gravitational field.

The scientific result of this study is the determination of the mass of the gravitational cell of a black hole $m_0 = 1,511593 \cdot 10^{-27}$ kg. Gravitational cells with a mass less than m_0 do not exist.

Obtaining the formula and the magnitude of the quantum of the gravitational field $e = 1,026789 \cdot 10^{-37}$ J is a significant result of this study. (This result assumes the existence of a similar electric field quantum, in the form of a string between two elementary charges, with the value $e = 9 \cdot 10^9 q^2 = 2,310275 \cdot 10^{-28}$ J).

Determination of the vibration frequency of gravitational strings also refers to new scientific results. **A special place in this work is occupied by obtaining a formula for determining the mass of an electron. The coincidence of the electron mass calculated by the formula with the experimental mass indicates not only the correctness of the new formula, but also the correctness of the theoretical approach.** Another important result is the derivation of a formula for the dependence of the gravitational constant on the magnitude of the mass of an electron and a gravitational cell.

Conclusions.

An important result of this research is the embedding of the hypothesis of gravitational cells in string theory and the subsequent application of the augmented theory to one of the fundamental interactions - gravitational interaction. This

avoided the so-called landscape problem in string theory. As a result of the application of the hypothesis of gravitational cells and the concept of string theory, a formula for the gravitational constant in the region of black holes was obtained and its value was determined: $G_0 = \sqrt{2} q_0 c = 6,7927 \cdot 10^{-11}$. Also received justification and confirmation of the value of the "ordinary" gravitational constant $G = 6,6743 \cdot 10^{-11}$. In this study, the mass of the gravitational cell of a black hole was determined, where $m_0 = 1,511593 \cdot 10^{-27}$ kg.

Through augmented string theory, it was possible to apply Planck's formula to the gravitational interaction of bodies. As a result, a formula was obtained to determine the quantum of the gravitational field and the frequency of vibrations of gravitational strings was determined. Further, on this theoretical basis, a formula was obtained to determine the mass of an electron. The electron mass calculated by this formula turned out to be equal to the experimental electron mass. A formula was obtained that determines the dependence of the value of the gravitational constant on the mass of an electron, and calculations confirming this formula were made.

Thus, based on the unification of the hypothesis of gravitational cells and string theory, in addition to theoretical achievements, two specific practical results were obtained. This is the electron mass calculated by the new formula and the value of the gravitational constant calculated by the new formula. The results obtained coincided with the experimental data. Double coincidence of the end results on the same theoretical basis (combining string

theory and the hypothesis of gravitational cells) completely eliminates the element of randomness.

Also, based on the results obtained, it can be concluded that in a free state, the proton and the electron do not have gravitational mass. Only when these particles come close together, a gravitational field is formed around them.

A detailed interpretation of the results obtained in this study will be given in the next article. Now at this stage, it is important to consolidate the results obtained.

Declarations

1. **Availability of data and materials.**

All data obtained and analyzed in the course of this study is included in this article.

2. **Competing interests.** Not applicable (there are no competing interests).

3. **Funding.** Not applicable.

4. **Authors' contributions.** Not applicable.

5. **Acknowledgements.** Not applicable.