Gravitational cells and gravitational strings as a necessary part of the gravitational field. Obtaining new physical formulas and indicators: the formula for the gravitational constant, the formula for the mass of the hydrogen atom, the formula for the vibrational velocity of a gravitational string, the minimum distance of action of gravitational forces etc.

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Gravitational cells and gravitational strings as a necessary part of the gravitational field. Obtaining new physical formulas and indicators: the formula for the gravitational constant, the formula for the mass of the hydrogen atom, the formula for the vibrational velocity of a gravitational string, the minimum distance of action of gravitational forces etc.

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Abstract.

This study introduces scientific concepts such as gravitational cells and gravitational strings. This innovation made it possible to move from general ideas about the gravitational interaction of bodies in space to a more detailed understanding of this physical process and to obtain significant scientific results. These results include: obtaining the formula for the gravitational constant, obtaining the formula for the gravitational quantum, obtaining the formula for the electron mass, obtaining the formula for the mass of the hydrogen atom, obtaining the formula for the vibrational velocity of the gravitational string, obtaining the value of the minimum distance of gravitational interaction, obtaining a new physical formula for the speed of a body in a gravitational field, obtaining the formula for the limit of action of gravitational forces. The calculations made according to the new formulas completely coincided with the experimental data.

In this work, Planck's constant was successfully applied to the gravitational interaction (with its help, the minimum distance of the gravitational interaction was determined, the mass of the hydrogen atom was calculated with an accuracy of 10^{-7} , etc.).

A distinctive feature of this study is the fact that most of the new formulas contain only fundamental physical constants.

Keywords. Black hole, gravitational cell, gravitational string, gravitational quantum, gravitational constant formula, the proportion between the mass of the electron and the proton, electron mass formula, hydrogen atom mass formula,

elementary charge, Schwarzschild radius formula, gravitational cell mass, the gravitational field, gravitational constant, vibrational velocity of a gravitational string, the formula for the vibrational velocity of a gravitational string, the minimum distance of action of gravitational forces, Casimir force, electromagnetic string, the vibrational speed of an electromagnetic string, a new relativistic formula for velocity in a gravitational field, the limit of gravitational forces.

Introduction.

In this research, physical concepts such as gravitational cells and gravitational strings were built into the concept of the gravitational field. This made it possible to move from general ideas about the gravitational interaction of bodies in space to a more detailed understanding of this physical process and to obtain real scientific results confirmed by observations.

Methods.

The gravitational field of any body cannot be considered separately without taking into account the interaction of this body with another body in space. In this case, the magnitude of the gravitational field depends not only on the amount of matter (mass), but also on the structure of the interacting bodies. This structure includes gravitational cells. These cells have a charge equal to two elementary charges $2q$ and a mass m . Each gravitational cell m forms around itself in space a set of point gravitational fields g_n , the intensity of which depends on the distance r_n to this point, that is, $g_n = \frac{2q}{r_n^2}$. These numerous point fields are up to a certain point latent potential fields and can manifest themselves only upon contact with the

gravitational cells of other bodies. Therefore, when another body of mass M_1 (also consisting of a plurality of gravitational cells with a charge of $2q$) hits this area of space, a real gravitational field now appears at the point of contact of two cells:

$g = \frac{k \cdot 2q \cdot k \cdot 2q}{r^2} = \frac{k^2 4q^2}{r^2}$. As a result, the field g imparts the acceleration $g = \frac{k^2 4q^2}{r^2}$ to the gravitational cell of the body M_1 . Due to the fact that the body M_1 consists of a huge number of such cells with a charge of $2q$, and the dimensions of the body are much less than the distance r between M and M_1 , then the whole body M_1 will experience an acceleration in this area of space equal to the magnitude of the acceleration of one gravitational cell, that is, $g = \frac{k^2 4q^2}{r^2}$. (This situation can be compared with the same accelerated motion of many absolutely identical charged particles in an electric field of a large electric charge).

Now let's move on to the basic formulas. A body of mass M consists of a huge number of n gravitational cells of mass m , where $n = \frac{M}{m}$. These cells together form a common gravitational field $E = g \cdot n$. As a result of all of the above, the formula for the gravitational field of a body with mass M when it interacts with another mass M_1 looks like this:

$$E = g \cdot n = k_{conv} \cdot \frac{e}{r^2} \cdot \frac{M}{m} \quad (1-1)$$

where E is the gravitational field of the body M , m/s².

g is the value of the field of one gravitational cell of the body M , m/s².

n is the number of gravity cells in the mass M .

e is the energy of the gravitational string. The field interaction of two gravitational cells in space can be considered as an extended force string. The energy of such a gravitational string is equal to $e = k^2 4q^2 J$. Where k is the coefficient of energy output from the charges of the gravitational cell (or the coefficient of proportionality), J/Cl.

m is the mass of the gravitational cell of the body M , kg.

q is the value of elementary charges, where $q = 1,60217733 \cdot 10^{-19}$ Cl.

$k_{conv.}$ – unit conversion factor, where $k_{conv.} = 1$ m/kg (This coefficient is entered into the formula so that the units of measurement are not violated).

(Note that if in the formula (1-1) the expression $\frac{e}{m}$ is denoted as G , then taking into account the fact that $k_{conv.} = 1$ m/kg, we obtain the classical formula of the gravitational field: $E = G \frac{M}{r^2}$).

To clearly understand the physics of the process, it is necessary first to consider the case of the gravitational interaction of two superdense masses, called black holes. So, we have two superdense masses M_0 and M_{01} , located at a distance r from each other. These two masses are a homogeneous substance, consisting of many superdense cells with mass m_0 and a charge equal to the value of two elementary charges - $2q$. Such gravitational cells were formed after an extremely dense compression of matter, as a result of which molecules and atoms turned into identical gravitational cells, consisting of two opposite charges. (The mass of such a cell should be less than the total mass of a free proton and a free electron by Δm due to the release of energy during the compression of matter, where $\Delta m =$

E/c^2). The formula of the gravitational field E of a superdense body with mass M_0 in its interaction with another superdense body M_{01} looks like formula (1-1):

$$E = k_{conv.} \frac{e_0}{r^2} \frac{M_0}{m_0} \quad (1-2)$$

e_0 is the energy of the gravitational string between two cells, $e_0 = k_0^2 4q^2 = 1,026789 \cdot 10^{-37}$ J. Where k_0 is the coefficient of energy output from the charges of the gravitational cell (or proportionality factor), where $k_0 = 1$, J/C. m_0 is the mass of the gravitational cell, kg.

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

In the superdense state of matter, the coefficient of energy output from the charges of the gravitational cell is $k_0 = 1$. (For comparison: at interaction of electric charges in vacuum $K = 9 \cdot 10^9$). The reason for such a large discrepancy is that the matter of the black hole is so strongly compressed that almost all the force lines of elementary charges are closed inside the gravitational cells. And only an extremely small part of the lines of force goes outside, creating a gravitational field in the outer space. Due to this circumstance, the coefficient k_0 outside the gravitational cell decreases to its minimum threshold, i.e. exactly to 1. In this case, the main field, with the coefficient of proportionality $K = 9 \cdot 10^9$, remains closed between the elementary charges inside the gravitational cell and therefore does not manifest itself in any way.

In formula (1-2) $\frac{e_0}{m_0}$ shows the value of the gravitational constant, where $G_0 = \frac{e_0}{m_0}$.

Therefore, if we accept the condition that the gravitational constant in the region of the black hole G_0 is equal to the classical value $G = 6,6743 \cdot 10^{-11}$, then we get:

$$m_0 = \frac{e_0}{G_0} = \frac{1,026789 \cdot 10^{-37}}{6,6743 \cdot 10^{-11}} = 1,538422 \cdot 10^{-27} \text{ kg} \quad (1-3)$$

But such a result m_0 cannot be considered final, because the gravitational constant G_0 under extreme conditions of a black hole may have a different value.

Therefore, for the sake of purity of the study, the obtained value $m_0 =$

$1,538422 \cdot 10^{-27}$ kg should be checked through another formula associated with the concept of "black hole". Such a test formula is the Schwarzschild radius formula.

$$R = \frac{2G_0}{c^2} \cdot M \quad (1-4)$$

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

In this formula, the expression $\frac{2G_0}{c^2}$ is of particular interest. This expression is equal to $\frac{R}{M}$, measured in "m / kg" and is a specific indicator of "length" and "mass". When multiplying $\frac{2G_0}{c^2}$ by the mass of the body M , the gravitational radius of the black hole is determined. But in the one-dimensional space of a black hole, such a physical quantity as length does not exist, therefore the $\frac{R}{M}$ index in "m / kg" should be perceived as the minimum structural unit of the black hole substance,

that is, the mass of the gravitational cell $\mathbf{m_0}$. It follows that $\mathbf{m_0} = \frac{2G_0}{c^2}$. Taking into account the fact that according to f. (1-5) $\mathbf{m_0} = \frac{e_0}{G_0}$, we get the following equation:

$$\frac{2G_0}{c^2} = \frac{e_0}{G_0}.$$

Let's solve this equation and get:

$$G_0 = \sqrt{2} q c = 6,7927 \cdot 10^{-11} \quad (1-5)$$

$$\mathbf{m_0} = \frac{\sqrt{8} q}{c} = 1,511593 \cdot 10^{-27} \text{ kg} \quad (1-6)$$

As you can see, the mass of the gravitational cell of the black hole is $\mathbf{m_0} = 1,511593 \cdot 10^{-27}$ kg, and not $,538422 \cdot 10^{-27}$ kg, as calculated above. But at the same time, these very close results, which were obtained in different ways, indicate the correctness of the hypothesis of gravitational cells. When choosing between two values of $\mathbf{m_0}$, it will be more correct to dwell on the value obtained using the Schwarzschild formula, that is, $\mathbf{m_0} = 1,511593 \cdot 10^{-27}$ kg. (This will be confirmed by calculations in this article when determining the mass of a hydrogen atom).

The discrepancy between $G_0 = 6,7927 \cdot 10^{-11}$ and $G = 6,6743 \cdot 10^{-11}$ is only 1,7%. This slight difference is due to structural changes in superdense gravity cells.

Now let us consider the gravitational interaction of an "ordinary" body of mass $\mathbf{M}$ with another "ordinary" mass $\mathbf{M_1}$. The formula of the gravitational field $\mathbf{E}$ of the body $\mathbf{M}$ according to the basic formula (1-2) looks like this:

$$\mathbf{E} = k_{conv.} \frac{e}{r^2} \frac{M}{m} \quad (1-7)$$

e is the energy of the gravitational string between the cells, $e = k^2 4q^2 = 1,108293 \cdot 10^{-37}$ J. Where k is the coefficient of energy output from the charges of the gravitational cell (or the coefficient of proportionality), where $k = 1,038931$ J/C.

m – mass of the "ordinary" gravitational cell, where $m = 1,660539 \cdot 10^{-27}$ kg.

$k_{conv.}$ – coefficient for converting units of measurement, where $k_{conv.} = 1$ m/kg.

Taking into account the fact that $k_{conv.} = 1$, from formula (1-9) we obtain the classical formula of the gravitational field: : $E = G \frac{M}{r^2}$, where $G = \frac{e}{m} = 6,6743 \cdot 10^{-11}$

Let us now explain the quantities k and m . To do this, imagine that ordinary matter was formed from the superdense matter of a black hole. In this case, each superdense gravitational cell, due to the influx of energy E , will increase its mass m_0 to mass m by the amount Δm (where $\Delta m = E/c^2$). As a result, a plasma is formed from a superdense substance, from which gaseous, liquid and solid substances can then 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 "ordinary" substance can be represented as a huge set of gravitational cells. 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 "ordinary" 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 $2q$, as well as of neutrons, which are also a pair of a proton and an electron with a total charge of $2q$. Thus, the mass of the gravitational cell

m of any substance (plasma, gas, liquid or solid) with a high degree of accuracy will be equal to **1 Da** or $m = 1,660539 \cdot 10^{-27}$ kg.

Under the conditions of the standard density of the substance, $k = 1,038931$, that is, $k > k_0 = 1$. This very small difference between k and k_0 can be explained by the fact that, in contrast to the gravitational cell of a black hole, where elementary charges are absolutely tightly adjacent to each other, in an ordinary cell there is some ultramicroscopic distance between two elementary charges. As a result of this circumstance, slightly more lines of force emerge from the ordinary cell than from the superdense cell, as a result of which $k > k_0$.

The gravitational interaction of an "ordinary" body of mass M and a superdense body of mass M_0 is determined by the total value $e_1 = k k_0 4q^2 = 1,066763 \cdot 10^{-37}$ J and different masses of gravitational cells $m = 1,660539 \cdot 10^{-27}$ kg and $m_0 = 1,511593 \cdot 10^{-27}$ kg.

Hence, we obtain the following formulas for the gravitational field:

The gravitational field of an "ordinary" body M :

$$E = k_{conv} \cdot \frac{e_1}{r^2} \frac{M}{m} \text{ or } E = G \frac{M}{r^2}, \text{ where } G = 6,4242 \cdot 10^{-11}$$

The gravitational field of a superdense body M_0 :

$$E = k_{conv} \cdot \frac{e_1}{r^2} \frac{M_0}{m_0} \text{ or } E = G \frac{M_0}{r^2}, \text{ where } G = 7,0572 \cdot 10^{-11}$$

It should be noted that these G s are of secondary importance in this study, because they do not reflect the physical essence of the gravity process.

The inclusion of gravitational cells and gravitational strings in the concept of the gravitational field allowed other significant results to be obtained. Such results are obtaining a new formula and calculating the mass of a hydrogen atom using it (complete coincidence with the experimental mass of a hydrogen atom was obtained), as well as obtaining a formula and calculating the mass of an electron inside a substance.

Under the conditions of a black hole, when matter is maximally compressed, the gravitational field between two superdense gravitational cells contracts so much that it turns into a point gravitational quantum. In this situation, the gravitational field formula no longer works and Planck's formula works instead:

$$e_0 = h \gamma \quad (1-8)$$

where e_0 is the energy of the gravitational quantum of the black hole, $e_0 = 1,026789 \cdot 10^{-37}$ J.

h is Planck's constant, $6,62607 \cdot 10^{-34}$ J · s.

γ - frequency, where $= \frac{e_0}{h} = 1,549620 \cdot 10^{-4} \text{ s}^{-1}$ (γ is constant and does not depend on the SI or CGSE measurement system).

The γ frequency is related to the proportion between the energy-mass of negative and positive charges in the gravitational quantum:

$$\gamma = \frac{1}{4} \frac{2 e_{-e}}{2 e_{+p}} = \frac{1}{4} \frac{e_{-e}}{e_{+p}} \quad (1-9)$$

e_{-e} is the value of the energy of the negative charge inside the cell, J.

e_{+p} - the value of the energy of the positive charge inside the cell, J.

Hence, for $\gamma = \frac{e_0}{h}$, we obtain the formula:

$$\frac{e_{-e}}{e_{+p}} = \frac{4 e_0}{h} \quad (1-10)$$

The definition of “energy-mass of negative and positive charge” was introduced because electrons and protons are not independent particles inside gravitational cells and gravitational quanta. The fraction **1/4** is explained by the fact that four charges are involved in the formation of a gravitational quantum, while only one charge in the form of an electron participates in the formation of an electromagnetic quantum. (The correctness of formulas (1-8) and (1-9) will be confirmed below by the coincidence of calculations by these formulas with experimental data

Based on f. (1-8), (1-9) and taking into account that the total energy of the gravitational cell is $m_0 c^2 = e_{+p} + e_{-e}$, we obtain the formula for the energy of a negative charge inside a superdense cell:

$$e_{-e} = \frac{4e_0 m_0 c^2}{h+4e_0} \quad (1-11)$$

Taking into account that $m_0 = \frac{\sqrt{8} q}{c}$ and $e_0 = 4 q^2$, we obtain the value e_{-e} through the formula with three fundamental constants:

$$e_{-e} = \frac{32\sqrt{2} q^3 c}{(h+16q^2)} = 8,415740 \cdot 10^{-14} \text{ kg} \quad (1-12)$$

As you can see, e_{-e} almost coincided with the energy of a free electron, where $e = 8,187110 \cdot 10^{-14}$ J. The discrepancy is **2,7%**. (It should be noted that there should not be a complete coincidence here, because the negative charge inside the gravitational cell and the free electron are different physical quantities).

The energy value of the positive charge in the cell will be: $e_{+p} = m_0 c^2 - e_{-e} = 1,511593 \cdot 10^{-27} \cdot c^2 - 8,415740 \cdot 10^{-14} = 13,577104 \cdot 10^{-11} \text{ J}$.

The ratio between the energies of elementary charges in a superdense cell is: $\frac{e_{-e}}{e_{+p}} =$

$$\frac{4 e_0}{h} = 6,19848 \cdot 10^{-4}$$

The body of a black hole consists of a huge set of such closely spaced superdense cells. Now let's consider the process of formation of hydrogen atoms from gravitational cells. For this, external energy must enter each cell. As a result of energy entering the cell, the positive charge in the cell $e_{+p} = 13,577 104 \cdot 10^{-11} \text{ J}$ increases exactly by the value $\Delta e_{+p} = 1,455 672 \cdot 10^{-11} \text{ J}$, that is, up to the value of the rest energy of the proton: $e_p = m_p c^2 = 1,6726219 \cdot 10^{-27} \cdot c^2 = 15,032776 \cdot 10^{-11} \text{ J}$. (More than this value, the positive charge in the cell cannot increase!). Thus, the total energy of the gravitational cell increases by Δe_{+p} and becomes equal to:

$$e = e_{-e} + e_p = 8,415740 \cdot 10^{-14} + 15,032776 \cdot 10^{-11} = 15,041191 \cdot 10^{-11} \text{ J}$$

As you can see, the calculated value $e = 15,041191 \cdot 10^{-11} \text{ J}$ almost absolutely coincided with the experimental value of the energy of the hydrogen atom, where $e_h = 1,6735575 \cdot 10^{-27} \cdot c^2 = 15,041185 \cdot 10^{-11} \text{ J}$. The ultramicroscopic discrepancy of $6 \cdot 10^{-17} \text{ J}$ can be safely attributed to the permissible error of calculations. But at the same time, this very small discrepancy may be a consequence of the release of neutrino particles during the formation of a

hydrogen atom (here it is necessary to take into account that $e = 15,041191 \cdot 10^{-11} \text{J} > e_h = 15,041185 \cdot 10^{-11} \text{J}$, and not vice versa). Therefore, taking into account this probability, we write the result obtained by the following formula:

$$e_h = \frac{32\sqrt{2} q^3 c}{(h+16q^2)} + e_p - \sum e_v \quad (1-13)$$

where e_h is the energy of a hydrogen atom, $15,041185 \cdot 10^{-11} \text{J}$.

e_p is the rest energy of a proton, $15,032776 \cdot 10^{-11} \text{J}$.

$\sum e_v$ - total neutrino energy, $\sum e_v = 6 \cdot 10^{-17} \text{J}$.

q, h, c - fundamental physical constants.

(It should be noted that after the formation of a hydrogen atom from a superdense cell, the ratio between the charge energies ($\frac{e-e}{e+p} = 6,19848 \cdot 10^{-4}$)

changes and becomes equal: $\frac{e-e}{e+p} = \frac{4e}{h} = \frac{4 \cdot 1,108293 \cdot 10^{-37}}{h} = 6,6905 \cdot 10^{-4}$)

Taking into account that $E = m c^2$, we get the formula for the mass of a hydrogen atom:

$$m_h = \frac{32\sqrt{2} q^3}{c (h+16q^2)} + m_p - \sum m_v \quad (1-14)$$

where m_h is the mass of a hydrogen atom, $1,6735575 \cdot 10^{-27} \text{ kg}$.

m_p is the mass of the proton, $1,6726219 \cdot 10^{-27} \text{ kg}$.

$\sum m_v$ is the total mass of the neutrino, $\sum m_v = 7 \cdot 10^{-34} \text{ kg}$.

q, h, c - fundamental physical constants.

Considering that the value $\sum m_v$ is negligible in relation to the mass of a hydrogen atom (0,00004%), formula (1-14) can be written as:

$$m_h = \frac{32\sqrt{2} q^3}{c (h+16q^2)} + m_p \quad (1-15)$$

Thus, the calculated mass of the hydrogen atom almost completely coincided with the experimental mass of the hydrogen atom. This result directly confirms the correctness of formulas (1-8), (1-9), as well as the value obtained using the formula for the Schwarzschild radius $m_0 = \frac{\sqrt{8q}}{c} = 1,511593 \cdot 10^{-27}$ kg. The main result of the above proof is that the coincidence of the calculated by the formula and the experimental mass of the hydrogen atom confirms the existence of gravitational cells and strings.

Let's give one more proof of the existence of gravitational cells and strings and at the same time get a practical scientific result. To do this, consider the gravitational interaction of two ordinary masses, from where we select the formula for the interaction of two gravitational cells:

$$E = \frac{e}{d^2} \frac{m}{m} \quad \text{or} \quad E = \frac{e}{d^2} \quad (1-16)$$

where E is the strength of the gravitational string between the cells (gravitational field), m/s^2

e – energy of the gravitational string, $1,108293 \cdot 10^{-37}$ J.

d is the distance between two gravitational cells, m.

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

The gravitational string between the cells is not in a static state: it constantly vibrates. Moreover, its vibrational velocity v directly depends on the magnitude of

the strength of the gravitational string (gravitational field) E between the cells and Planck's constant and obeys the following formula:

$$v = \frac{E}{h} \quad (1-17)$$

where v is the vibrational velocity of the gravitational string, m/s.

h is Planck's constant.

Hence, based on the formulas $E = \frac{e}{d^2}$ and $E = h v$, we obtain the following formula:

$$v = k_{conv} \cdot \frac{e}{h d^2} \quad \text{or} \quad v = \frac{e}{h d^2} \quad (1-18)$$

k_{conv} – coefficient for converting units of measurement, where $k_{conv} = 1 \text{ m}^3$.

The vibrational speed of the string v must have an upper limit, which is equal to the speed of propagation of light in vacuum: $v_{max} = c$. Hence it follows that there must be a minimum distance d_{min} at which the formula stops acting:

$$d_{min} = \sqrt{\frac{e}{h c}} = \sqrt{\frac{1,108293 \cdot 10^{-37}}{6,62607 \cdot 10^{-34} \cdot c}} = 0,747 \text{ } \mu\text{m} \quad (1-19)$$

With the termination of the formula (1-20), the gravitational string between the cells "breaks" and turns into a quantum, where another formula $E = h \gamma$ acts. From this moment, the gravitational interaction turns into direct interaction of elementary charges in opposite cells. In this case, the main lines of force of elementary charges (where $K = 9 \cdot 10^9$) which were enclosed inside the gravitational cells, begin to be released. As a result, a new strong interaction arises, called the Casimir force. (We will not dwell on its physical nature, because this is not part of the research task. (We will not dwell on its physical nature, because this

is not part of the research task. It is important to emphasize the coincidence of the point of "break" of the gravitational string $d_{min} = 0,747$ microns and the beginning of the action of the Casimir force). This ultramicroscopic boundary of the transition of the gravitational interaction into another interaction is confirmed by experiments to study the Casimir effect: it is from a distance less than a micrometer between two mirror-polished metal plates that a noticeable manifestation of the Casimir force begins. Taking into account the large orders of the physical quantities used in the formula (1-19) (10^{-37} , 10^{-34} , 10^8), an accidental coincidence of the calculated and experimental results is excluded. It follows from this that the formula (1-19) on the basis of which the result $d_{min} = 0,747$ μm was obtained is correct. Therefore, formulas (1-16), (1-17), (1-18), on the basis of which this formula was obtained, are also correct. This, in turn, confirms the existence of gravitational cells and strings.

It can be assumed that, by analogy with gravitational strings, there are electromagnetic strings between elementary charges. Based on this assumption, we obtain the following formulas:

$$v = \frac{e}{h d^2} = \frac{K q^2}{h d^2}$$

where v is the vibrational speed of the electromagnetic string, m / s.

e - the energy of the electromagnetic string, $2,310275 \cdot 10^{-28}\text{J}$

q is the value of elementary charges, $q = 1,60217733 \cdot 10^{-19}\text{C}$.

K - coefficient of proportionality, $9 \cdot 10^9$.

$$d_{min} = \sqrt{\frac{e}{h c}} = \sqrt{\frac{2,310275 \cdot 10^{-28}}{6,62607 \cdot 10^{-34} \cdot c}} = 3,4 \text{ cm}$$

It turns out that at a distance of $d_{min} = 3,4$ cm, the electromagnetic string between the elementary charges "breaks off". Note that this fact does not cancel the action of the Coulomb forces, because, unlike the gravitational interaction, the lines of force of elementary charges are free in space. As a result, the boundary of the transition of the interaction through the string to the direct interaction between elementary charges is clearly not observed. To fix this probable ultramicroscopic discrepancy, it will be necessary to arrange a multitude of elementary charges on parallel plates, in one plane, at a close distance. And this is practically impossible due to the strong interaction of charges and their inevitable movement.

(For a better perception of information in some of the higher formulas, the coefficients for converting units of measurement k_{conv} . are not specially set, because they are equal to 1).

The theory of gravitational cells makes it possible to apply the formula for the total energy of a moving body to the speed of a body in a gravitational field.

Let's write this famous Einstein formula:

$$E_{full} = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \text{or} \quad E_{full} = \frac{E_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (1-20)$$

where E_{full} is the total energy of the moving body.

E_0 is the energy of a body at rest.

v is the speed of the body.

Let's apply this formula to the motion of a body in a gravitational field:

$$E_{ful} = \frac{E_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (1-21)$$

E_{ful} full is the total energy of a moving body m in the gravitational field of mass M , J.

E_0 is the rest energy of the body m , J.

From f. (1-21) get the formula for the speed of the body m : $v_r = c \sqrt{1 - \frac{E_0^2}{E_{full}^2}}$

(1-22)

where v_r is the speed acquired by the body m in the gravitational field through $r = 1$ m after the start of movement, m/s.

Let's expand the value of E_{full} : $v_r = c \sqrt{1 - \frac{E_0^2}{(E_0 + E_g)^2}}$

where E_g is the potential energy of the gravitational field at a distance R from the mass M at the location of the body m , J.

Let's decompose E_g into constituent physical quantities: $E_g = \frac{GMm}{R}$.

As a result, we obtain the following formula for the speed of a body with mass m in a gravitational field 1 m after the start of motion:

$$v_r = c \sqrt{1 - \frac{m^2 c^4}{\left(m c^2 + \frac{GMm}{R}\right)^2}} \quad (1-24) \quad \text{or} \quad v_r = c \sqrt{1 - \frac{c^4}{\left(c^2 + \frac{GM}{R}\right)^2}} \quad (1-25)$$

Let's expand the formula (1-25):

$$v_r = \sqrt{\frac{c^2 \left(c^2 + \frac{GM}{R}\right)^2 - c^6}{\left(c^2 + \frac{GM}{R}\right)^2}} = \sqrt{\frac{2 c^4 \frac{GM}{R} + c^2 \frac{G^2 M^2}{R^2}}{c^4 + 2 c^2 \frac{GM}{R} + \frac{G^2 M^2}{R^2}}}$$

Taking into account the extremely small value of $c^2 \frac{G^2 M^2}{R^2}$ in comparison with $2 c^4 \frac{GM}{R}$ and also $2 c^2 \frac{GM}{R} + \frac{G^2 M^2}{R^2}$ compared to c^4 (the difference is 10^{27} times), we get a simplified version of formula (1-25):

$$v_r = \sqrt{\frac{2 c^4 \frac{GM}{R}}{c^4}} = \sqrt{\frac{2GM}{R}} \quad (1-26)$$

The result is a classical formula for the speed of a body in a gravitational field. Note that for very large values of the mass, the simplified (classical) formula (1-26) will give inaccurate results. At the same time, the relativistic formula (1-25) will give the exact value of the body's velocity.

The final speed v_n when the body m passes the entire distance R_n is determined by the following formula:

$$v_n = c \sqrt{1 - \frac{c^4}{\left(c^2 + \sum_{R=1}^n \frac{GM}{R}\right)^2}} = c \sqrt{1 - \frac{c^4}{\left(c^2 + GM \sum_{R=1}^n \frac{1}{R}\right)^2}} \quad (1-27)$$

To calculate the speed of movement, when the distances between the bodies are huge $R_n \rightarrow \infty$, it is necessary to use applied formulas. To obtain them, we use the reduced Euler formula $H_n \approx \ln n + \gamma$. Let's apply this formula to the harmonic series $\sum_{R=1}^n \frac{1}{R}$ in the obtained formula. As a result, we get:

$$v_n = c \sqrt{1 - \frac{c^4}{(c^2 + GM(\ln R_n + \gamma))^2}} \quad (1-28)$$

where v_n is the final speed acquired by the body m when passing the distance R_n .

R_n is the distance between M and m .

γ is the Euler constant.

The resulting formulas 1-25, 1-27,1-28 are universal. Unlike the formulas of classical mechanics, these formulas give accurate results when huge masses and distances are involved in the calculations.

Gravity cells are a structural unit of mass ***m***. Therefore, with what speed the body *m* moves, then one cell ***m_g*** moves with the same speed. Based on this, we obtain from the above formulas the following formulas based on gravitational cells.

$$v_r = c \sqrt{1 - \frac{m_g^2 c^4}{(m_g c^2 + e_s \frac{M}{R})^2}} \quad (1-29)$$

$$v_n = c \sqrt{1 - \frac{m_g^2 c^4}{(m_g c^2 + e_s M \sum_{R=1}^n \frac{1}{R})^2}} \quad (1-30)$$

$$v_n = c \sqrt{1 - \frac{m_g^2 c^4}{(m_g c^2 + e_s M (\ln R_n + \gamma))^2}} \quad (1-31)$$

where ***e_s*** is the specific energy of the gravitational field, , **$108293 \cdot 10^{-37} \text{ J} \cdot \text{m/kg}$** .

(***e_s*** is numerically equal to the energy of the gravitational string, where ***e*** = **$1,108293 \cdot 10^{-37} \text{ Дж}$** (**ф. 1-7**). Also ***e_s*** = ***G m_g***)

m_g is the mass of the gravitational cell, **$1,660539 \cdot 10^{-27} \text{ kg}$** .

Note that f. (1-29), which is based on energy, better shows the physical nature of the process of motion in a gravitational field than f. (1-25). Therefore f. (1-29) is primary in relation to f. (1-25).

It should be emphasized that the new formula (1-30) establishes the same limit of gravitational forces for all masses.

To verify this, consider the expression in formula (1-30): $e_s M \sum_{R=1}^n \frac{1}{R}$.

This expression is the total energy of the gravitational field of mass M , that is,

$\sum E_g = e_s M \sum_{R=1}^n \frac{1}{R}$. Note that the gravitational field is created by the energy contained in the mass M , equal to $E = Mc^2$. Therefore, the value of $\sum E_g$ in this formula will always be less than the value of $E = Mc^2$, that is, $\sum E_g < Mc^2$. (It is assumed that the difference between these energies should be very significant: $\sum E_g \ll Mc^2$). As an equation, it looks like this:

$$\sum E_g = k Mc^2 \quad (1-33)$$

where k is the reduction factor. (This coefficient can be considered as a conversion coefficient of a very small part of the internal energy of the mass $E = Mc^2$ into the energy of the gravitational field $\sum E_g$).

We open in f. 1-31 expression $\sum E_g$: $eM \sum_{R=1}^n \frac{1}{R} = k Mc^2$

The same result is obtained from f. 1-33: $eM (\ln R_n + \gamma) = k Mc^2$

We reduce the mass M in this equation and get:

$$\ln R_n = \frac{k c^2}{e} - \gamma$$

The result obtained shows that the gravitational field of all bodies has the same action limit $\lim R_n$, which does not depend on the value of the body mass. Beyond this distance R_n , the gravitational forces of a body of any mass stop acting.

Results.

The main results of this research include the introduction of such important components as gravitational cells and gravitational strings into the concept of the gravitational field. This circumstance made it possible to obtain new physical formulas and new physical indicators. This should include the formula for the gravitational constant, the formula for the gravitational quantum, the formula for the mass of an electron, the formula for the mass of the hydrogen atom, the mass of the gravitational cell, the value of the gravitational quantum, the value of the minimum distance of gravitational interaction. In this work, Planck's constant was successfully applied to the concepts of gravitational cells and gravitational strings. As a result, the formula for the minimum distance of gravitational interaction was obtained, the formula for the mass of the hydrogen atom was obtained and calculated with an accuracy of 10^{-7} .

Through the synthesis of the theory of gravitational cells and the formula of the total energy of Einstein, a new physical formula for the speed of a body in a gravitational field was obtained. Based on this relativistic formula, an applied velocity formula was obtained, which can be used for practical calculations of the speed of space bodies in gravitational fields. A formula was obtained for a single limit of the action of gravitational forces.

The results obtained by the new formulas completely coincided with the experimental data.

Conclusion.

In this work, concepts such as gravitational cells and gravitational strings were built into the gravitational field. This made it possible to obtain such scientific results as the formula for the gravitational constant, the formula for the electron mass, the formula for the hydrogen atom, the formula and value of the minimum distance of the gravitational field. A new relativistic formula for the velocity of a body in a gravitational field, a formula for the limit of action of gravitational forces, etc. were obtained. In this work, the concept of a gravitational quantum was introduced and its value was determined. A new physical constant was also obtained - the mass of the gravitational cell of a black hole. All new formulas were confirmed by experimental data.

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.

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5. Acknowledgements. Not applicable.