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QUANTUM PARTICLE OF MATTER (CHARGE) AS A FUNDAMENTAL SOURCE OF GRAVITY AND MASS OF MATTER IN NATURE

В. Куев, В. Хрома. **Квантова частинка речовини (заряда) як фундаментальне джерело гравітації та маси матерії в природі.** До одних із найбільш інтригуючих проблем сучасної фізики належить пошук частинок за межами Стандартної моделі та створення квантової теорії гравітації. Цим проблемам, а саме проблемі квантового опису гравітації приділяється найпильніша увага. Важливість застосування Стандартної моделі для опису трьох видів силових фізичних взаємодій за участю елементарних частинок не викликає сумнівів. Ці частинки є активними учасниками фізичних процесів електромагнетизму, сильних та слабких взаємодій. Однак, як і раніше, залишається відкритим питання про значення і роль гравітації у природі. Більше того, не ясно, як гравітація взаємодіє з матерією будь-якої маси і в чому полягає суть цих відмінностей. Також немає відповіді на питання про значення в природі фактору дискретності та можливості реального квантування гравітації. Крім того, невідомо чи існує в навколишньому світі квант гравітаційної енергії – гравітон і яка його фактична енергія. Щоб пояснити значення гравітації в космічних масштабах, була застосована Загальна теорія відносності (ЗТВ) А. Ейнштейна, де описується викривлення простору навколо зірок і планет. Однак ця теорія стосується лише взаємодії великих мас матерії і не відноситься до квантових об'єктів у вигляді атомів і елементарних частинок. Що ж до об'єктивного застосування у науковій літературі інших відомих теорій гравітації, включаючи її квантові форми, то всі вони використовують математичний апарат, де відсутній критерій квантової дискретності – постійна Планка. Явна незавершеність досліджень у галузі розробки та створення об'єктивної теорії гравітації та її квантових форм потребує практичного використання існуючого апарату квантової механіки для реалізації цього наукового спрямування. З урахуванням такого погляду необхідно розглянути можливість застосування термодинамічного характеру руху гравітації в природі, де потрібно порушити питання існування та прояву у природі квантової форми гравітаційної енергії, джерелом якої може виявитись квантова частинка речовини (заряду) поза рамками Стандартної моделі. Завдяки унікальному збігу фізичних властивостей квантових частинок речовини (заряду) та фізичних принципів, закладених у роботу будь-якого колайдера, з'являється можливість використання Великого адронного колайдера для вивчення властивостей квантових частинок речовини (заряду) як джерела гравітації у природі.

Ключові слова: гравітація, квантова частинка речовини (заряду), енергія і постійна Планка, рівняння Шредінгера, невизначеність Гейзенберга, гравітон, осцилятор гравітації речовини (заряду), хвиля де Бройля, закони гравітації, конвергуючий ефект гравітаційних полів, Стандартна модель, колайдер

V. Kuiev, V. Hroma. **A quantum particle of matter (charge) as a fundamental source of gravity and mass of matter in nature.** One of the most intriguing problems of modern physics is the search of particles beyond the Standard Model and the creation of quantum theory of gravity. To these problems, namely to the problem of quantum description of gravitation the closest attention is paid. The importance of applying the Standard Model to describe three types of force physical interactions involving elementary particles is beyond doubt. These particles are active participants of physical processes of electromagnetism, strong and weak interactions. However, there is still an open question about the meaning and role in nature of gravitation. Moreover, it is not clear how gravity interacts with matter of any mass and what is the essence of these differences. Also, there is no answer to the question about the meaning in the nature of the discreteness factor and the possibility of real quantisation of gravitation. Besides, it is unknown whether in the surrounding world there exists a quantum of gravitational energy – graviton and what is its actual energy. To explain the significance of gravity on cosmic scales, the General Theory of Relativity of A. Einstein was applied, which describes the curvature of space around stars and planets. However, this theory affects only the interaction of large masses of matter and does not apply to quantum objects in the form of atoms and elementary particles. As for the objective application in the scientific literature of other known theories of gravity, including its quantum forms, they all use a mathematical apparatus where the criterion of quantum discreteness – Planck's constant – is missing. The apparent incompleteness of research in the field of development and creation of an objective theory of gravitation and its quantum forms requires practical application of the existing apparatus of quantum mechanics for realisation of this scientific direction. Taking into account such a view, it is necessary to consider the possibility of applying the thermodynamic nature of the movement of gravity in nature, where it is necessary to raise the issue of the existence and manifestation of the quantum form of gravitational energy in nature, the source of which may be a quantum particle of matter (charge) outside the Standard Model. Due to the unique coincidence of physical properties of quantum particles of matter (charge) and physical principles inherent in the operation of any collider, it is possible to use the Large Hadron Collider to study the properties of quantum particles of matter (charge) as a source of gravity in nature.

Keywords: gravity, quantum particle of matter (charge), energy and Planck's constant, Schrödinger equation, Heisenberg uncertainty, graviton, oscillator of gravity of matter (charge), de Broglie wave, laws of gravity, converging effect of gravitational fields, standard model, collider

Introduction

Within the framework of the theory of gravity, any physical influence in nature is usually considered as a fundamental interaction between material objects with mass.

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Analysis of literary data and problem statement

This nature of the action of gravity, for example, in classical mechanics is explained using Newton's law of universal gravitation. However, a deeper understanding of the theory of gravity can be gained through the application of Einstein's General Theory of Relativity (GTR), where the gravitational effect is achieved by the curvature of the surrounding space around massive stars and planets. At the same time, both theories do not answer the question about the quantum nature of gravity itself, since they cannot characterize quantum objects that are described by quantum mechanics. These objects include elementary particles, atoms and molecules, as well as material bodies with an insignificant amount of their own mass. To create a theory of gravity at the quantum level, it is necessary to use the mathematical apparatus of quantum mechanics and apply the Schrödinger equation. Thanks to this condition, it seems possible to formulate and describe the real conditions and nature of quantum objects in the form of sources of gravitational radiation. Since the search and selection of quantum objects is also important for the development of a quantum theory of gravity, it should be implemented when constructing it.

As for other currently known theories of gravity, including their quantum versions set out in the scientific literature, all of them can only formally be classified as quantum theories, since they do not allow us to describe natural phenomena in the strict language of quantum mechanics using Planck's constant as a physical criterion of quantum discreteness in nature. In addition, the objects of quantization chosen and used in these theories often do not have quantum properties.

The purpose and objectives of research

The purpose of this work is to conduct a scientific and theoretical analysis of the mechanism of existence and action of gravity in nature and to create on this basis an objective theory of quantum gravity outside the framework of the Standard Model, where there is no information about gravity.

Among the research tasks that are important for the implementation of the goal include scientific and theoretical analysis and the search for a possible quantization object, with the help of which it will be possible to achieve the goal set in the work. In this case, it will be necessary to establish the nature and properties of this object and use them to actually construct a fundamental theory of gravity, which can objectively describe the world around us. In addition, knowledge of the principles and provisions of the theory itself, as well as the mechanism of action of gravity, will need to be used to establish physical laws and laws of motion of gravitational energy in nature and the manifestation of gravity at the level of micro and macro scales of the Universe.

Materials and methods of research

When developing the concept of gravitational interaction, the existence in nature of a quantum particle of matter (charge) was established, which will make it possible to use it as a real quantum object to create a quantum theory of gravity. The analysis showed that this particle is a fundamental source of gravity and mass of matter in nature. Description of physical processes using a quantum particle of matter (charge) allows us to express the value of the mechanical variable mass m in the form of a discrete quantum quantity and associate it with the action of gravity, which objectively affects any material bodies in nature that have mass.

At the quantum level, any form of physical matter will always have not only the discrete nature of the energy used in it, but must also have a general nature, determined by the magnitude of the gravitational energy inherent in it. The action of gravity in nature is always determined by the need to constantly fulfill the law of conservation of energy at the level of quantum particles of matter (charge). The unique coincidence of the physical properties of quantum particles of matter (charge) and the physical principles inherent in the operation of the Large Hadron Collider (LHC) opens up a practical opportunity for determining and studying the properties of these particles outside the framework of the Standard Model.

Research results

A scientific and theoretical analysis of the problem of the existence and action of gravity in nature has been carried out. It is shown that the real manifestation of gravity in nature is always thermodynamic in nature and is caused by the need for a response of matter to a force action or transfer of matter (charge) in the composition of quantum particles of matter (charge). It has been established that at the quantum level, any movement of matter or the action of a force on it is always accompanied by the oppositely directed emission of gravitons. The reciprocal nature of the influence of gravity in nature is always due to the need to constantly fulfill the law of conservation of energy at the level of

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quantum particles of matter (charge), which is constantly violated by the existence of material objects and bodies in the surrounding world. It has been established that the action of gravity in nature is the determining condition for the existence of matter in the surrounding world. The unique coincidence of the physical properties of quantum particles of matter (charge) and the physical principles inherent in the operation of the LHC is substantiated. Thanks to this condition, it becomes possible to study the properties of such particles outside the framework of the Standard Model with the subsequent possibility of theoretically constructing a physical model of the world order based on the quantum theory of gravity, which will include electromagnetic strong and weak interactions. We used knowledge of the defining principles and provisions of the theory of gravity, as well as a description of the mechanism of action of gravity itself in the surrounding world, to subsequently establish physical laws and laws of motion of gravitational energy in nature and describe gravity at the level of micro and macro scales of the Universe.

Some of the most important points and characteristic features of the manifestation of gravity in nature were considered. In this regard, it was necessary to dwell on them in more detail.

To explain the influence and role of gravity in nature, the *GTR of A. Einstein* is usually used [1], which describes the curvature of space around stars and planets and does not affect quantum objects and elementary particles.

As for the application of other known theories of gravity, which use the idea of quanta, they are usually limited to a description of the action of gravity in nature, in which there is no criterion of quantum discreteness – *Planck's constant*.

Thus, there is a clear incompleteness of research in the field of development and creation of an objective theory of gravity, including the participation of its quantum forms, which requires the practical application of the existing apparatus of quantum mechanics in the implementation of this scientific direction.

Taking into account this point of view, a scientific and theoretical analysis of the physical principles necessary to search and describe possible sources of gravity in nature, which should be formed on the objective nature of the action of gravitational energy in the surrounding world, was carried out with the aim of subsequently creating a theory of gravity with the participation of its quantum forms.

As the initial stage of this search, the idea of the thermodynamic nature of the movement of any energy in nature was used [2], thanks to which it became possible to substantiate the thermodynamic nature of the movement of gravitational energy, which began to be based on the mechanism of constant action of gravity, aimed at eliminating violations of the law of conservation of energy in nature on level of quantum particles of matter (charge), in the form of exchange ml; (mlq) – mass of substance (charge).

Since the introduced quantum particle of matter (charge) has a variable mass depending on the speed of its movement, this condition makes it possible to describe the mass, charge and properties of matter using a quantum particle and Planck's constant, through which a direct connection between gravity and three types of physical forces is established and realized interactions – electromagnetic, strong and weak.

Description of physical processes using a quantum particle of matter (charge) allows us to express the value of the mechanical variable mass - m in the form of a discrete quantum quantity and associate it with the action of gravity, which objectively affects any material bodies in nature that have mass.

At the same time, any physical influence of gravity on the mass of any material object usually occurs in the form of the effect of gravity on a multicomponent system consisting of atoms and molecules, which, as is known, are quantum particles and have quantum properties.

In this regard, if gravity can influence any collection of quantum particles in the composition of any body, then it will also influence an individual quantum particle in this composition.

Therefore, following this logic, we can believe that gravity, acting on an individual particle as a real quantum object, will also have quantum properties and should have its own quantum of energy – the graviton.

Thus, elucidating the role of gravity in nature using the analysis performed shows the correctness of the choice made in favor of the quantum nature of gravity, as a universal way of describing any physical processes and phenomena in the Universe.

Now we will directly consider some characteristic features and conditions for the manifestation of a quantum particle of matter (charge) in nature.

In order for any material object to have quantum properties, it must, in fact, have physical mass (energy) and be described by the Schrödinger equation within the framework of quantum mechanics, which includes Planck's constant.

Therefore, it was initially established that the introduced quantum particle of matter (charge) also obeys these conditions and is a quantum statistical object, the speed of which cannot exceed the speed of light according to *A. Einstein's general relativity* [1]. At the same time, the mass of such a particle should increase with increasing speed of movement, theoretically reaching its maximum value, equivalent according to the condition to the *Planck* energy.

Another necessary criterion for the existence and manifestation of a quantum particle of matter (charge) in nature should be recognized as the thermodynamic nature of the movement of its constituent atoms and molecules in two counter directions through any conventionally selected particle interface drawn perpendicular to the direction of movement.

This nature of the movement of atoms and molecules within a quantum particle of matter (charge) is ensured by their actual movement in the forward and reverse directions. In this case, the number of particles transferred in the forward direction is and is accepted equal to their maximum value in the composition of a quantum particle of matter (charge), which is always equivalent to the Planck energy, while their number transferred in the reverse direction will be determined and increases with increasing speed of movement quantum particle in space (matter), theoretically reaching its maximum value, which corresponds to movement in the forward direction.

Due to the existing nature of the movement of atoms and molecules in the composition of a quantum particle of matter (charge), there will always be no equivalence between the transfer of matter (charge) in the composition of this particle in two opposite directions, which only when the speed of light is theoretically reached can reach equal quantities. In this case, the total energy of particles moving in the opposite direction will approach the Planck energy.

A striking example confirming the violation of the equivalence of substance transfer in two counter directions is an experiment on spontaneous mixing of aqueous solutions, colored in any color, and uncolored, separated by a partition. In this case, after removing the dividing partition, the color of the solution will spread in the forward direction faster than in the reverse direction and therefore, in a short period of time, the color will be irreversibly and evenly distributed throughout the entire volume of the solution and will remain in this state for an indefinitely long time, thereby indicating that irreversible nature of past changes.

As a specific example of the existence of a natural analogue of an introduced quantum particle of a substance (charge), we can serve as an electrochemical parameter - exchange current [3], used in theoretical and experimental electrochemistry in order to determine its value, which is used to determine the intensity of electrochemical reactions occurring in electrochemical systems in direct and the opposite direction.

In order for the value of the exchange current, related to the interface surface area of 1 cm^2, to essentially correspond to the definition of a quantum particle of a substance (charge), the concept of reversibility of electrochemical reactions is used, which directly characterizes the number of particles or their total charge per unit time, for example, electrons participating in electrochemical reactions in the forward and reverse directions, where the magnitude of the exchange current between the forward and reverse directions of electron movement is established.

Next, we will dwell on the important moments of the emergence and manifestation of gravitational energy in nature.

The transfer of matter in any direction at any speed is always characterized by the magnitude of the impulse – P, which is determined by the product of the mass of the substance – m and the speed of its movement – V. Analytically, this condition is written as the expression:

$$P = m \times V . \quad (1)$$

In this regard, with an increase in the speed of movement, the magnitude of the momentum of this mass of matter during movement will also increase, which will contribute to an increase in the energy of the matter transferred in the opposite direction as part of quantum particles of matter (charge).

On the other hand, the movement of any mass of matter, and for solids, the transfer of momentum is always the movement of a multicomponent system consisting of atoms and molecules. In this case,

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when a substance is transferred through a conditionally selected interface drawn perpendicular to the direction of movement of this mass, an unequivalent transfer of substance will occur between the direction of movement and the opposite direction, which, due to the irreversibility of the ongoing processes, will be accompanied by a violation of the equality of the transferred mass in the composition of quantum particles substances (charge) consisting of the same atoms and molecules, that is, a violation of the law of conservation of energy [4].

But since in nature the law of conservation of energy is never violated, such a violation must be compensated by the emergence of additional energy, the action of which will be directed opposite to the direction of movement.

For this reason, to compensate for the missing energy associated with mass transfer, there must be a similar energy, which, by the nature of its action, can only be gravitational.

This energy will be emitted by quantum particles of matter (charge) in the composition of any material objects and bodies in the form of gravitons moving opposite to the movement of these bodies, which will actually ensure the fulfillment of the law of conservation of energy, and will also form their own mass in these bodies.

Thus, the effect of gravity will be volumetric on the entire mass of matter of bodies and will be directed opposite to the movement of matter, as a manifestation of its mass.

This interpretation of the action of gravity is directly supported by *Newton's* first law of mechanics [5], according to which it is stated that there is no fundamental difference between the uniform rectilinear motion of a body and its state of rest, since, in the first case, the uniform rectilinear motion of any body will be accompanied by unequal transfer substances in the composition of quantum particles of matter (charge) between the direction of movement and the opposite direction, which will cause a corresponding action of gravity in the direction opposite to the movement of the body in the form of its mass.

In the second case, when the body is at rest, i.e. There is no expressed direction of movement; conventionally selected interfaces, theoretically drawn perpendicular to any chosen direction of movement passing through a stationary body, will characterize the state of rest.

In this case, the conditional movement of a body simultaneously in all theoretically possible directions should be considered only as a simultaneous transfer of matter in the composition of quantum particles of matter (charge) between the forward and reverse directions of movement along all their objectively possible variants of movement. Such a theoretically described movement of matter of a body, consisting of quantum particles of matter (charge), in all possible directions at once will be nothing more than a condition for the body to be at rest, which will be characterized by unequivalent transfer of matter between the forward and reverse directions of movements in all directions.

To compensate for the missing mass arising as a result of the violation of the equivalence of matter transfer in two opposite directions, additional energy will act in the form of emitted gravitons, which will be constantly directed opposite to all theoretically possible options for movement, i.e. directed towards the physical center of mass of a given body. Thanks to this fact, any body at rest will have a rest mass and will be able to attract other bodies to itself.

Thus, the action of gravity is an objectively necessary condition for the existence of physical bodies in nature, which indicates the importance of gravitational energy in the occurrence of any physical processes involving any mass of matter, which, in turn, is ensured by the participation of matter at the level of atoms and molecules in the composition quantum particles of matter (charge). The latter, as shown above, are quantum objects and are described by quantum mechanics.

In this regard, the participation of quantum systems consisting of atoms and molecules in the composition of various substances of any physical bodies, the movement of which is described by Newtonian mechanics, indicates the existence in nature of a physical object capable of connecting and describing any processes and phenomena in nature at the quantum level, which always due to the need to ensure compliance with the law of conservation of energy.

Such an object, in its essence, was established as the above-mentioned quantum particle of matter (charge) in the form of exchange m_{l}; (m_{lq}) – the mass of a substance (charge), with the help of which it becomes possible to describe any physical processes and phenomena in nature using quantum mechanics.

Now let's directly consider the properties of the introduced quantum particle of matter (charge).

First, let's form an idea of the quantum particle of matter (charge) itself.

So, the introduced quantum particle of matter (charge) in the form of exchange m_l ; (m_{lq}) – mass of matter (charge) is a quantum statistical object consisting of 1.301×10^{19} gravitational oscillators of matter (charge), the total energy of which, according to the mass of the particle, is equivalent to the *Planck* energy (1/137 of the Planck energy – for the charge). In this case, all gravity oscillators that are part of a quantum particle of matter (charge) move or oscillate in forward and reverse directions through a conditionally selected interface of 1 sm^2, selected for convenient quantitative calculations at the atomic or molecular level.

A physical object was taken as a gravitation oscillator, consisting of two elementary particles, atoms or molecules moving in parallel towards each other or oscillating in antiphase (for solids), which perform collective group motion as part of a quantum particle of matter (charge).

At the same time, any gravity oscillator can perform both reversible and irreversible oscillations. If a reversible oscillation occurs, i.e. the masses transferred by particles in the forward and reverse directions are equal, then the emission of a graviton does not occur and the gravity oscillator does not manifest itself in any way in the real world. If the vibration is irreversible, then the transfer of mass of the substance in the opposite direction is partially or completely absent, which violates the law of conservation of energy. To compensate for it, the gravity oscillator emits a graviton, the energy of which is equivalent to the difference in mass (energy) transferred between the forward and reverse directions of motion.

A graviton emitted in the opposite direction always moves opposite to the movement of a physical body, which, thanks to this condition, ensures that any body necessarily acquires its own mass.

Since the gravity oscillator participates in group motion as part of a quantum particle of matter (charge), the mass effect it creates is summed up with similar mass effects of other gravity oscillators within the entire quantum particle. At the same time, the effect from an individual quantum particle of matter (charge) is summed up with the effects of other quantum particles of matter (charge) in the composition of a given body. Thus, any body in nature becomes a material object with physical mass.

The rest mass of the proton, as the main carrier of mass in nature, in the form of a material form of matter, was adopted as the theoretical value of the mass of the gravitation oscillator.

In turn, the charge of the electron was taken as the charge gravity oscillator.

A quantitative relationship was established between the mass of a quantum particle of matter – m_l and the mass of a quantum particle of charge – m_{lq}, which is expressed in the form of relation (2), where the fine structure constant – α is used:

$$\alpha = 1/137 = m_{lq}/m_l \, . \tag{2}$$

The identical value of the Fine Structure Constant $\alpha = 1/137$, obtained using calculations and described in the scientific literature [6], indicates that in nature there is no fundamental difference between the material and charge forms of matter in the form of quantum particles of matter (charge), but only the difference is quantitative, inherent in its value, which will be directly determined due to the established value of the Fine Structure Constant $\alpha = 1/137$.

Therefore, it became obvious that at the quantum level, any form of physical matter will always have not only the discrete nature of its energy, but must also have a general nature, determined by the magnitude of the gravitational energy inherent in it, the action of which in nature is always determined by the need for constant fulfillment of the law of conservation of energy on level of quantum particles of matter (charge).

The movement of matter (charge) in the composition of any quantum particle of matter (charge) in the forward and reverse directions allows us to describe such a process in the form of wave motion, in the form of a standing wave. At the same time, it was shown that the movement of a quantum particle of matter (charge) obeys the *Schrödinger equation*, and the particle itself is a quantum object.

Let us now consider some features of the behavior of a quantum particle of matter (charge) within the framework of the *Schrödinger equation*.

Since during the movement of matter (charge) in the composition of a quantum particle of matter (charge), there are no qualitative differences between the material and charge forms of matter, but only quantitative ones take place, which are expressed through the Fine Structure Constant – $\alpha = 1/137$, then all subsequent calculations in within the framework of the *Schrödinger equation*, we will carry out this study using a specific example of the movement of a material form of matter.

In this regard, let us consider the expression of the quantum Schrödinger equation for the case of motion of a quantum particle of matter (charge) in the form of matter.

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Let us present the final form of the standing wave equation in complex form for the wave function of a quantum particle of matter in the form of exchange m_l – mass of matter:

$$Y = \cos(m_l \times k \times C/h) \times \exp[(i \times N_{Al} \times k_1 \times v_{dbl}) \times t/h], \quad (3)$$

where $m_l = 2.176 \times 10^{-8}$ kg – the mass of a quantum particle of matter;

$k_2 = 1.616 \times 10^{-35}$ m – the size of compactification of a substance into a superdense state of vacuum;

$N_{Al} = 1.301 \times 10^{19}$ – the number of gravity oscillators in the composition of a quantum particle of matter;

$k_1 = 5.093 \times 10^{-53}$ J·s – quantum of action of gravitational radiation of matter;

$h = 6.626 \times 10^{-34}$ J·s – Planck's constant;

$C = 3 \times 10^8$ m/s – speed of light;

v_{dbl} – frequency of the de Broglie wave of a quantum particle of matter.

Let us now consider the physical essence of the movement of a quantum particle of matter contained in equation (3):

At

$$\cos(m_l \times k_2 \times C/h) = 1 , \quad (4)$$

there will be antinodes.

At

$$\cos(m_l \times k_2 \times C/h) = 0 , \quad (5)$$

there will be standing wave nodes.

To satisfy conditions (4), it is necessary that $m_l \times k_2 \times C/h = n\pi$ – these will be antinodes. To satisfy conditions (5), it is necessary that $m_l \times k_2 \times C/h = (2n+1) \times \pi/2$ – these will be the nodes.

Let's rewrite the above expressions regarding the value – k_2.

Antinodes:

$$k_2 = (h/m_l \times C) \times n\pi, \quad (6)$$

nodes:

$$k_2 = (h/m_l \times C) \times (2n+1) \times \pi/2. \quad (7)$$

Let us analyze expressions (6) and (7).

If $m_l \to 0$, then, according to these expressions, the value $k_2 \to \infty$ is infinity, i.e. the energy of gravitons emitted from matter is quantized in space in the range from zero to ∞ – infinity, or, in other words, is not quantized at all, but is infinitely distributed in space. This state of matter is characterized by completely irreversible processes. It is the distribution of the absorbed energy of gravitons at any distance from zero to ∞ – infinity that provides the nonlocal mechanism of action of gravitational energy, to describe which one can use, for example, the *Bohm* model [7].

If $m_l \to \infty$ is infinity, then according to (6) and (7) the value $k_2 \to 0$, i.e. the energy of gravitons emitted from matter is quantized, and the quantization size – k_2 formally tends to zero, to infinitesimal sizes. In fact, when $m_l = 2.176 \times 10^{-8}$ kg the constant – k_2 has a finite value, always equal to the size of the compactification of any quantum particle of matter into a vacuum – $k_2 = 1.616 \times 10^{-35}$ m.

Let us rewrite expressions (6) and (7), replacing the ratio $h/m_l \times C$ with the de *Broglie* wavelength – $L_{dbl\ st}$:

$$k_2 = L_{dblst} \times n\pi, \quad k_2 = L_{dblst} \times (2n+1) \times \pi/2,$$

where the de *Broglie wavelength is* L_{dblst} obeys the same laws as the quantity – k_2, since in the limit they characterize the same thing – the size of compactification of a substance into a superdense state of vacuum.

Since the propagation of the de *Broglie* wave of any exchange m_l – mass of a quantum particle of matter is the movement of gravitons emitted from its mass, we express the frequency of gravitons emitted from the exchange m_l – mass of matter of gravitons – v_g through the energy of *the de Broglie* wave of the exchange m_l – mass of a quantum particle of matter:

$$\text{Because } E_g = h \times v_g = N_{Al} \times k_1 \times v_{dbl}, \text{ then } v_g = E_g/h = N_{Al} \times k_1 \times v_{dbl}/h.$$

Let us rewrite this expression, which is also included in the exponent of formula (3), relative to v_{dbl} – the propagation frequency of the *de Broglie* wave exchange m_l – the mass of a quantum particle of matter:

$$v_{dbl} = v_g \times (h/k_1)/N_{Al} = v_g \times 1.301 \times 10^{19}/N_{Al}. \quad (8)$$

As can be seen from formula (8), the propagation frequency of the de Broglie wave – v_{dbl} of the exchange m_l – mass of a quantum particle of matter is determined by the frequency of graviton radiation – v_g, divided by the number of gravity oscillators – N_{Al}, constituting the value of the exchange m_l – mass of a quantum particle of matter. Based on this condition, for the case of completely reversible processes, when the value of N_{Al} is equal to the maximum value of $N_{Al} = 1.301 \times 10^{19}$, i.e. the relation holds:

$$h = k_1 \times N_{Al}, \quad (9)$$

the established frequency of propagation of the *de Broglie* wave – v_{dbl} becomes equal to the frequency of emission of gravitons (in this case, in fact, the last one, possessing the energy of one proton) – v_g from this exchange m_l – mass of a quantum particle of matter, i.e. $v_{dbl} = v_g$.

For completely irreversible processes, the frequency of the *de Broglie* wave is maximum and equal to $v_{dbl} = v_g \times 1.301 \times 10^{19}$, i.e. 1.301×10^{19} times greater than the frequency of gravitons emitted from the exchange m_l – mass of a quantum particle of matter. For the case of partially reversible (irreversible) processes, as the degree of reversibility increases, the frequency – v_{dbl} decreases due to a decrease in the ratio $h/k_1 \times N_{al}$, which is due to the tendency of the value $N_{Al} \rightarrow 1.301 \times 10^{19}$ and in the limit reaches the value $v_{dbl} = v_g$. Thus, for the case of completely irreversible processes, when $N_{Al} = 1$, the frequency – v_{dbl} of propagation of the de Broglie wave of the exchange m_l – mass of a quantum particle of matter is equal to $v_{dbl} = v_g \times 1.301 \times 10^{19}$ s^{-1}, which in comparison with its the value for the case of completely reversible processes increases by 1.301×10^{19} orders of magnitude and becomes equal:

$$v_{dbl} = v_g \times 1.301 \times 10^{19}\ s^{-1}. \quad (10)$$

As for the energy of an individual graviton emitted by one gravitational oscillator of the exchange m_l – mass of a quantum particle of matter, it is always determined by the product of the frequency of the emitted graviton – v_g by the quantum of action of gravitational radiation of the substance – $k_1 = 5.093 \times 10^{-53}$ J·s, i.e.:

$$U_g = k_1 \times \nu_g. \quad (11)$$

Since there is relation (8) between the frequency of emitted gravitons – v_g and the propagation frequency of the *de Broglie* wave – v_{dbl} of the exchange m_l – mass of a quantum particle of matter, we will rewrite it relative to the value – v_g:

$$v_g = v_{dbl} \times (k_1 \times N_{A1}/h)\ . \quad (12)$$

As can be seen from formula (12), the frequency of radiation from the exchange m_l – mass of matter of gravitons – v_g is equal to the frequency of propagation of the *de Broglie* wave – v_{dbl}, multiplied by the ratio $k_1 \times N_{Al}/h$ and for the case of completely reversible processes, when $N_{Al} = 1.301 \times 10^{19}$, i.e. the condition $h = k_1 \times N_{Al}$ (9) is satisfied, the frequency of graviton radiation from the exchange m_l – mass of a quantum particle of matter is maximum and equal to $v_g = v_{dbl}$, i.e. coincides with the frequency of the de Broglie wave of the exchange m_l - mass of a quantum particle of matter – v_{dbl}.

When completely irreversible processes occur, the frequency of emitted gravitons will be set using the following expression:

$$v_g = v_{dbl}/1.301 \times 10^{19}\ s^{-1}. \quad (13)$$

Thus, the analysis of the wave function of the exchange m_l – mass of a quantum particle of matter showed that the values of the wave function take on an infinite series of discrete values, which are determined both by discrete values of the amplitude of oscillations of the exchange m_l – mass of a quantum particle of matter, and by discrete values of frequencies emitted by graviton gravity oscillators. Thanks to this fact, it is possible to quantitatively determine the degree of reversibility of processes occurring in matter, by the magnitude of which it will be possible to unambiguously judge the conditions for the existence of matter in the space-time of our *Universe***.**

The discrete nature of the emission of gravitons from matter and their subsequent absorption by the *Higgs* field of vacuum indicate the irreversibility of the processes occurring in the space of the *Universe* and contribute to the fulfillment of the laws of the gravitational convergent field, with which

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the quantum of action of gravitational radiation of matter – k_1 is always closely related (see formulas (17), (18), (19)). Thanks to this condition, the constant existence of any substance in the surrounding space is ensured.

It should be noted that similar laws govern the wave motion of quantum charge particles in the form of exchange m_{lq} – charge masses. In this case, there are only quantitative differences, which are expressed through the value of the fine structure constant – $\alpha = 1/137$ (see formulas (14), (15), (16)), which indicates the gravitational mechanism of processes occurring in nature.

The following ratios of quantities were established:

$$k_1 \times 1/137 = k_3, \tag{14}$$

$$k_2 \times 1/137 = k_4, \tag{15}$$

$$m_l \times 1/137 = m_{lq}. \tag{16}$$

From the obtained formulas (14), (15), (16) it follows that both matter and the electric charge of quantum particles of matter (charge) are of gravitational origin, which is a prerequisite for the existence of matter in nature and ensures its transition to a superdense state of vacuum. At the same time, a specific connection is established between the compactification parameters of matter and charge, which is determined by the value of the fine structure constant – α, where it quantitatively connects in equation (14) the quantum of action of gravitational radiation – k_1 with the quantum of action of the gravitational form of charge – k_3, in equation (15) the size of compactification in a vacuum of matter – k_2 with the size of compactification in a vacuum of charge – k_4, in equation (16), the value of the exchange m_l – mass of the substance with the value of the exchange m_{lq} – charge mass.

The presence of a quantum of action of gravity of a charge – k_3, the size of compactification into a vacuum of a charge – k_4 and the value of the exchange mass m_{lq} – of a charge, by analogy with matter, indicates the gravitational nature of the processes of compactification into a vacuum of matter and charge and makes it possible to quantify and compare these processes.

Thus, the value of the quantum of action of gravity of the substance – $k_1 = 5.093 \times 10^{-53}$ Js, according to equation (14), allows us to calculate the value of the quantum of action of gravity of the charge – k_3, which after the calculation amounted to $k_3 = 3.718 \times 10^{-55}$ Js. Similarly, using equations (15) and (16), the size of charge compactification in the superdense state of vacuum was established $k_4 = 1.177 \times 10^{-37}$ m and the value of the exchange mass m_{lq} – charge mass $m_{lq} = 1.586 \times 10^{-10}$ kg.

Thus, the analysis showed that the movement of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – the masses of matter (charge) and gravitational oscillators in their composition have a wave nature of movement and obey the *Schrödinger* equation.

The presence of discrete properties and the establishment of a quantum mechanism for the movement of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – the masses of matter (charge) and gravitational oscillators in their composition, contributed to the determination of the characteristic features of the movement of quantum particles in nature, which are due to the discrete (quantum) nature of the manifestation of gravitational energy in the surrounding world.

Let us present and describe the established new laws and characteristic patterns of the movement of gravitational energy in nature, and also consider the previously unknown properties of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) masses of matter (charge) and gravitons emitted by them.

According to the described First dynamic law of the gravitational convergent field, the product of the mass emitted from a quantum particle of matter (charge) in the form of exchange m_l; (m_{lq}) – the mass of matter (charge) of the graviton for the distance it covers before being absorbed by the *Higgs* field, is a constant value and equal to the first constant of the gravitational convergent field – G_U:

$$G_U = m_g \times \Delta X = 2.703 \times 10^{-62} = \text{const, kg·m}, \tag{17}$$

where m_g – the mass of a graviton emitted from a quantum particle of matter (charge) in the form of exchange m_l;

(m_{lq}) – mass of substance (charge);

ΔX –the distance covered by the graviton before being absorbed by the *Higgs* field.

From equation (17) it follows that with an increase in the mass of the gravitational quantum, the distance covered by the graviton before being absorbed by the *Higgs* field decreases, and vice versa, with a decrease in the graviton mass, the distance for graviton localization by the *Higgs* field increases.

Another interpretation of this law is that: the product of the energy of the substance (charge) emitted from a quantum particle in the form of exchange m_l; (m_{lq}) – the mass of matter (charge) of the graviton over the distance it covers before being absorbed by the *Higgs* field is also a constant value and equal to the second constant of the gravitational convergent field – J_U:

$$J_U = U^*_g \times \Delta X = 2.433 \times 10^{-45} = \text{const, J·m,} \quad (18)$$

where U^*_g – the energy of a graviton emitted from a quantum particle of matter (charge) in the form of exchange m_l;

(m_{lq}) – mass of substance (charge);

ΔX – the distance covered by the graviton before being absorbed by the *Higgs* field.

Thus, with an increase in the energy of the gravitational quantum, the distance covered by the graviton before being absorbed by the Higgs field decreases, and vice versa, with a decrease in the graviton energy, the distance for localization of the graviton by the Higgs field increases.

To confirm the conclusions obtained using the First dynamic law of the gravitational converging field of the *Universe*, the parameters of this field were calculated and compared for the entire range of changes in the masses of matter and the speeds of its movement possible in nature. The calculation was carried out in the mass range from the known rest mass of the electron $m_e = 9.109 \times 10^{-31}$ kg to the theoretical mass of matter $M = 10^{60}$ kg, which is 10^7 times greater than the mass of the visible part of the *Universe* ($M_{un} = 10^{53}$ kg). The range of speeds of movement of matter (charge) was in the range from the minimum possible speed of movement of matter (charge) in the space of the *Universe* $V = 1.18 \times 10^{-37}$ m/s, which is equivalent to the size of charge compactification into a superdense state of vacuum, divided by time – second, up to the theoretical value of the maximum speed of movement of matter (charge) in space, equal to the speed of light – 3×10^8 m/s.

The obtained calculation results confirmed the invariance of the constants G_U and J_U over the entire range of changes in the mass of matter (charge) and the speed of its movement possible in nature, which indicates the objectivity of the conclusions made using the First Dynamic Law of the Converging Gravitational Field.

It should be noted that according to our calculations, if the mass of the *Universe* is theoretically increased, for example, by one *Google* time, then all the described constants will retain their values unchanged over the entire range of speeds possible in nature, which means that the presented theory will be correct and gives the correct idea about the *Universe*.

Along with the First dynamic law of the gravitational converging field, the Second dynamic law of the gravitational converging field was established, according to which the product of the gravitational inductance of the physical vacuum – L_U and the frequency of the *de Broglie* wave of the charge quantum – v_{dbq} (quantum of matter – v_{db}/α), where $\alpha = 1/137$) is a constant value and equal to the third constant of the gravitational convergent field – R_U, called the resistance constant of the gravitational convergent field:

$$R_U = L_U \times v_{dbq} = 1.763 \times 10^{35} = \text{const, Ohm,} \quad (19)$$

where v_{dbq}; (v_{db}/α) – frequency of the de Broglie wave of the charge quantum (quantum of matter) in s^{-1};

L_U – gravitational inductance of physical vacuum *in Henry*.

When calculating the value of the gravitational inductance of vacuum – L_U, we used the idea of the movement of charge quanta in a vacuum, which, in fact, is a current, which we accepted as the movement of a charge per unit time, causing the appearance of a magnetic field in a vacuum.

To confirm the conclusions obtained using the Second Dynamic Law of the gravitational converging field of the Universe, the parameters of this field were also calculated and compared over the entire range of changes in the masses of matter and the speeds of its movement possible in nature. Calculations were carried out over a range of speeds and in a range of masses similar to those in the calculation of the First Dynamic Law of the Converging Gravitational Field.

The obtained calculation results confirmed the invariance of the constant – R_U over the entire range of changes in the mass of matter (charge) and the speed of its movement possible in nature, which indicates the objectivity of the conclusions made through the analysis of the second dynamic law of the gravitational convergent field.

The characteristic participation of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – the mass of matter (charge) in thermodynamic processes is always closely related to the

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degree of reversibility of the processes occurring with their participation, due to which the thermodynamic nature of graviton radiation from matter is always ensured:

$$h > k_1 \times N_{Al};\ \ h > m_l \times k_2 C; \tag{20}$$

$$h > (k_3/\alpha) \times N_{Al};\ \ \ h > (m_{lq}/\alpha) \times (k_4/\alpha) \times C. \tag{21}$$

In this regard, the quantities included in the four inequalities (20) and (21) determine the limiting (boundary) conditions for the existence of matter in the form of a substance (charge), and are also a condition for the implementation of the quantum transition of exchange m_l; (m_{lq}) – mass of substance (charge) in a superdense state of vacuum. If the product of these quantities is less than *Planck's constant – h,* the matter of the Universe will exist in the form of a substance (charge) in which thermodynamic processes occur and gravitons are emitted; if it is equal to or greater, the matter will go into a superdense state of vacuum with entire elements of exchange m_l; (m_{lq}) – mass of substance (charge).

Inequalities (20) and (21) characterize *the Basic Quantum Thermodynamic Law* and make it possible to quantitatively determine the conditions for the existence of matter in the form of a substance (charge), as well as to evaluate the reversibility of the processes occurring in it, by which one can judge the thermodynamic state of bodies and their quantitative parameters movements.

Quantum thermodynamic law (20) and (21) evaluates the energy conditions for the existence of matter in the form of matter (charge), when matter is in the region $m_l \times k_2 \times C$ – energies of matter and region $(m_{lq}/\alpha) \times (k_4/\alpha) \times C$ – charge energies in the Universe.

Taking into account an actually new approach to the problem of the existence of matter in the *Universe*, when the mechanism of existence of any substance (charge) is realized through the emission of gravitons from its mass of matter (charge), which are then absorbed by the *Higgs* field, a *new Universal law of gravitational interaction of the converging field* was established and described (22). Thanks to this condition, the real existence and localization of any substance (charge) in any state and place in the space of the *Universe* from elementary particles to galaxies is ensured, which allows us to describe the gravitational field as a unitronic converging field of the *Universe*.

According to the Universal law of gravitational interaction of the converging field introduced by us, the product of the first constant of the gravitational converging field – G_U by the squared frequency of the *de Broglie* wave of the quantum of mass of matter – v_{db}^2 (charge quantum – $(v_{dbq} \times \alpha)^2$, where $\alpha = 1/137$) is described with using the expression

$$F_U = G_U \times v_{db}^2, \tag{22}$$

where F_U – fundamental quantum gravitational force;

G_U – the first constant of the gravitational convergent field;

v_{db}^2; $(v_{dbq} \times \alpha)^2$ – square of the *de Broglie* wave frequency of the mass quantum of matter (charge quantum).

Equation (22) is a gravitational quantum analogue of *Newton's* well-known classical second law [5] strength:

$$F_b = m \times b_g,$$

where F_b – the fundamental gravitational force expressed by Newton's second law;

b_g – acceleration of the gravitational field;

m – mass of substance.

In order to compare the values of F_U and F_b with each other, their values were calculated for the entire range of motion of matter (charge) possible in nature from the speed $V = 1.18 \times 10^{-37}$ m/s to the speed of light $C = 3 \times 10^8$ m/s.

The calculations showed that the values of F_U and F_b over the entire possible range of motion of matter (charge) have the same values, and only when the range of relativistic velocities was reached did the values of F_U begin to deviate (decrease) from the F_b values. In this case, the maximum difference in this deviation was achieved under the condition of movement at the speed of light.

Let us present the calculated and described values of these quantities for the speed of light:

– $F_b = 1.212 \times 10^{44}$ N and $F_U = 9.310 \times 10^{24}$ N and divide them into each other;

– $F_b / F_U = 1.212 \times 10^{44} / 9.310 \times 10^{24} = 1.301 \times 10^{19}$.

Based on the result of their division, it was established that, provided that the speed of light is achieved, the fundamental gravitational force – F_b exceeds the fundamental quantum gravitational force – F by 1.301×10^{19} times.

This difference between the force – F_b and the force – F_U reflects the connection between the force – F_b and the mass defect, which, in turn, at relativistic speeds is due to the transition (quantum jump) of quantum particles of matter (charge) in the form of exchange m_l – masses of matter (charge) into the superdense state of Vacuum Planckeons. Since the number 1.301×10^{19} simultaneously represents the number of gravitational oscillators of the exchangeable m_l – mass of matter (charge), such a difference between the force – F_b and the force – F_U clearly indicates a quantum transition into vacuum when the speed of light is reached for entire elements of the exchangeable m_l – mass of matter (charge) , containing 1.301×10^{19} gravity oscillators.

Thus, the Universal law of gravitational interaction of the converging field (22) showed that the product of the first constant of the gravitational converging field – GU by the squared frequency of the *de Broglie* wave of the quantum of mass of matter – ν_{db}^2 (charge quantum – $(\nu_{dbq}\times\alpha)^2$) is a quantum analogue of the second Newton's law and is expressed by the magnitude of the fundamental quantum gravitational force – F_U. In comparison with the given law of force [5], the fundamental quantum gravitational force will not only reflect the fact of the influence of gravity on the implementation of the laws of *Coulomb*, *Newton* (including the law of universal gravitation), *Galileo*, *Ampere*, but will also actually take into account the converging effect of the gravitational field caused by the mechanism localization and real existence of any substance (charge) in the space of the Universe.

The obtained result indicates another very important conclusion, which is that any quantum particle of matter (charge) in the form of exchange m_l; (m_{lq}) – the mass of matter (charge) at speeds comparable to the speed of light due to a mass defect will lose its mass (charge), passing into its main superdense state of vacuum, where its energy will become equal to the minimum energy of the quantum due to Planck's constant – h . These are the conditions that are observed in nature during the movement of cosmic objects - quasars, when their high speed of movement, comparable to the speed of light, and large masses of matter (charge), will contribute to the transition of entire elements of quantum particles of matter (charge) in their composition into vacuum, which must be accompanied by the emission of great energy, which occurs precisely under such conditions.

According to the theory of magnetism [8], the classical magnetic field – W is described using the expression:

$$W = L\times I^2/2 ,$$

where the design parameters include inductance - L and current - I.

On the other hand, if as magnetic energy – W_U we use the value of the gravitational field energy, which is always equivalent to the energy of *the de Broglie* wave of one gravity oscillator – U^*_{dbl}, or the total energy of gravitons emitted from one exchange m_l – mass of matter (charge) – Ug, absorbed by the superdense state of vacuum, then, thanks to the calculations carried out, complete equivalence was established between the classical magnetic energy – W and the magnetic energy – W_U, expressed using the above discrete quantities: U^*_{dbl} and U_g,

Taking this fact into account, the possibility of practical use of discrete characteristics of gravitational fields for calculating various magnetic fields became obvious, which, in fact, was confirmed in the case of calculating vacuum magnetic fields, which were used to establish and calculate the Second dynamic law of the gravitational converging vacuum field (19), described and stated in the article above.

Thus, the calculations showed that the energy of the gravitational field is always identical to the energy of the magnetic field, which, in fact, is evidenced by their complete equivalence with each other, which allows you to use any result obtained for any calculations where you need to compare magnetic and gravitational fields with each other with a friend.

Along with comparing the values of magnetic and gravitational energy, a comparison was made of the discrete values of the total energy of the *de Broglie* wave of the sum of the exchangeable m_l – masses of matter – $E_{mdbl} = U_{db\times}n$, included in the substance of any physical body, mass – m, where U_{dbl} is the wave energy de Broglie one exchangeable m_l – mass of substance; n is the number of exchanged m_l – masses of the substance in the composition of a given body, and the magnitude of the mechanical energy of movement of this body – $E = m\times V^2$, where m is the body mass in kg; V is the speed of movement of a body in space, m/s, over the entire range of movement speeds possible in nature from the minimum speed $V = 1.18\times10^{-37}$ m/s to the speed of light $C = 3\times10^8$ m/s.

Using the calculations carried out, it was established that, at any speed of movement of a particular body in the given speed range, there is always complete equality of the calculated values of the total energy of the de *Broglie* wave and the energy of the mechanical movement of this body:

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$$E_{\text{mdbl}} = U_{\text{dbl}} \times n = E = m \times V^2.$$

In addition, thanks to the calculations made, it was shown that both the total energy of the *de Broglie* wave and the mechanical energy of motion of anybody always characterize its total energy inherent in the mass of the substance of a given body at any specific speed of movement in the speed range $V < C$, and not only in the case of theoretical motion of this body at the speed of light, when the classical *Einstein formula* $E = m \times C^2$ is used to determine the energy.

As for the movement in nature of an individual electron, its movement cannot be considered an elementary current if the movement of the electron is described outside the composition of a quantum charge particle, since in this case the electron, like any other elementary particle, will not manifest itself in the form of a really existing charge, where they act as a separate gravity oscillator participating in the formation of an elementary current.

For this reason, any elementary current in nature must represent the movement of an elementary charge carrier, for example an electron, as a gravity oscillator, which must emit gravitons and participate in collective motion together with other gravity oscillators as part of quantum charge particles. In this case, the strength of the electric current will be determined as the ratio of the magnitude of the charge of quantum charge particles – in Coulombs to a unit of time – a second.

It is known that the wave motion of matter in nature is described as probabilistic and is characterized using *Heisenberg* uncertainty [6], where *Planck's* constant – h is used as a criterion for this probability.

It was found that when describing the movement in nature of quantum particles of matter (charge) in the form of exchange m_{l}; (m_{lq}) – mass of matter (charge), when irreversible processes occur and gravitons are emitted by matter, the constant – h cannot be used as the main criterion, since the number of gravity oscillators emitting gravitons – N_{Al}, as a rule, is less than their theoretical value. For this reason, the conditions of the equation $h = k_1 \times N_{\text{Al}}$ (9) are not met, which affects the accuracy and reliability of calculations using the constant – h.

In this regard, as a criterion for the probability of movement of gravitational energy, instead of the constant – h, it is necessary to use the constant k_1; (k_3/α) is the gravitational quantum of matter (charge), and instead of the well-known *Heisenberg* uncertainty expression, the uncertainty established for gravitational fields should be used.

After such a substitution, the *Heisenberg* uncertainty takes the following form:

$$\Delta X \times \Delta P >= k_1;\ (k_3/\alpha);$$

$$\Delta E \times \Delta t >= k;\ (k_3/\alpha).$$

where ΔX – the distance covered by the graviton before it is absorbed by the vacuum;

ΔP – momentum transferred by the emitted graviton;

ΔE – the graviton energy, equivalent to its theoretical mass;

Δt – the time of movement of the graviton before it is absorbed by the vacuum;

$k_1 = 5.093 \times 10^{-53}$;

($k_3 = 3.718 \times 10^{-55}/\alpha$), J s – quantum of gravity of the substance (charge);

$\alpha = 1/137$ – Fine structure constant.

The established mechanism of wave motion in nature of quantum particles of matter (charge) in the form of exchange m_{l}; (m_{lq}) – mass of matter (charge), is always accompanied by constant discrete emission of gravitons from matter, absorbed by the superdense state of vacuum, which indicates the important role of gravity in physical processes and phenomena. In this regard, the need arose for a more detailed study of the influence of gravitational energy on the nature of the existence of matter in nature and its manifestation of physical or other properties.

To clarify the role of gravity in physical processes, a specific example of the classical experiment of *Hendrik Casemier* was considered [9], where the physical mechanism of manifestation of gravitational energy in nature was directly studied.

According to *Casemir's* ideas, under conditions of a physical vacuum, two uncharged parallel metal plates will be attracted to each other. This effect will arise due to the fact that both plates always experience the force action of virtual vacuum particles, the number of which on the outside of the plates in vacuum is much greater than on the inside, since on the inside of the plates the number of virtual particles is limited by the distance between the plates, and on the outside of such there are no restrictions. For this reason, taking into account *Casemir's* calculations, the energy of attraction be-

tween them should increase according to the law inversely proportional to the fourth power of the distance between the plates.

To test this effect in the laboratory, a number of experiments were carried out. The most accurate of these turned out to be an experiment conducted in 1996 at the Los Alamos National Laboratory by *Stephen Lamoreaux* [9], which, similar to previous experiments, completely confirmed the result predicted by *Casemir's* calculations.

It should be noted that, established by us with the help of quantitative calculations, the *Law of Inverse Cubes* of the gravitational converging field, also indicates a fundamental feature of the gravitational field due to the growth of the energy of the quantum (in our case, the gravitational quantum) when its volumetric geometric dimensions decrease. In this case, the volumetric energy density of the gravitational field changes (increases) according to the law of the fourth power.

Thus, a complete analogy was revealed between the law of changes in the density of gravitational energy of the field and the force action of the physical vacuum on metal plates, which showed that the real source of the force manifestation of vacuum in nature is gravitational energy as the initial and final stage of the implementation of all physical processes and phenomena in nature. At the same time, it should be assumed that fluctuating oscillations in the superdense state of vacuum will be formed precisely with the help of gravitational energy in the form of its discrete portions.

When calculating the energy ranges and speeds of movement in nature of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – mass of matter (charge), quantitative values of the energy and mass of gravitons emitted from matter (charge), as well as the dimensions of compactification of quantum particles of matter (charge) into a superdense state of vacuum were established.

According to calculations, the following minimum values of portions of energy and mass of emitted gravitons were obtained, as well as the dimensions of the superdense state of matter (charge) in vacuum, which were respectively: for matter, graviton energy – $E_g = 6.234\times10^{-73}$ J; graviton mass – $m_g = 6.926\times10^{-90}$ kg, for the charge graviton energy – $E_{gq} = 4.551\times10^{-75}$ J; graviton mass – $m_{gq} = 5.056\times10^{-92}$ kg. In parallel, the calculated dimensions of compactification of quantum particles of matter (charge) into a superdense vacuum state were respectively: for matter – $k_2 = 1.616\times10^{-35}$ m; for charge – $k_4 = 1.18\times10^{-37}$ m.

Thanks to the calculations carried out and the conclusions made with their help, we can believe that gravitons can be the active principle in nature, with the help of which, in fact, the real physical reality surrounding us should be formed. Moreover, any experimental determination, for example, using the *LHC* or similar experimental installations, of the fact of the existence in nature of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – mass of substance (charge), will only confirm the theory stated above.

To experimentally verify the existence in nature of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – mass of substance (charge) a method was developed and a patent application was filed in Ukraine [10], in which, using various physical methods, including the use of *LHC*, an experimental method is proposed for identifying quantum particles of substance (charge) in the form of exchangeable m_l; (m_{lq}) – masses of matter (charge) and their energy parameters in the composition of various physical objects and bodies.

In this regard, if the experimental determination of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – mass of matter (charge), can be carried out using the *LHC* using the proposed method [10], this condition will allow answering a number of questions concerning the world order and the subsequent development of physical science.

The counter-movement of particles, atoms and molecules in the composition of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – mass of matter (charge), in its essence, is an actual analogue of the oncoming motion of elementary particles, nuclei and atoms as part of two colliding beams (bunches) of any collider. Therefore, thanks to this unique coincidence of the physical properties of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – the mass of matter (charge) and the physical principles inherent in the operation of the collider, it becomes possible for the first time in real research practice to use the *LHC* to study the nature and properties of quantum particles of matter (charge) in the form of exchange m_l; (m_{lq}) – masses of matter (charge) and identify their properties outside the framework of the Standard Model.

Since the LHC, at one time designed and put into operation by CERN LHC specialists [11], was brought to the planned maximum power of *14* TeV to continue experimental studies of the nature and

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properties of elementary particles, an excellent opportunity opens up for objective research using quantum particles of matter (charge) in in the form of exchange m_l; (m_{lq}) – the mass of the substance (charge), which will allow, based on the results of the experimental work done, to identify these particles and study their physical properties.

Conclusion

1. The physical essence of a quantum particle of matter (charge) in the form of exchange ml has been established; (m_{lq}**)** – mass of matter (charge) as a fundamental source of gravitational energy and mass of matter in nature.

2. It is shown that at the quantum level, any form of physical matter will always have not only the discrete nature of its energy, but must also have a general nature, determined by the magnitude of the gravitational energy inherent in it.

3. The action of gravity in nature is always due to the need to constantly fulfill the law of conservation of energy at the level of quantum particles of matter (charge).

4. Description of physical processes using a quantum particle of matter (charge) allows us to express the value of the mechanical variable mass *m* in the form of a discrete quantum quantity and associate it with the action of gravity, which objectively affects any bodies in nature that have mass.

5. The presented work touches upon the existence and manifestation in nature of a quantum form of gravitational energy, which, with the help of an introduced quantum particle of matter (charge), allows us to describe any physical processes without the need to invoke the Standard Model, where there is no explanation of the role of gravity in nature.

6. Thanks to the unique coincidence of the physical properties of quantum particles of matter (charge) and the physical principles inherent in the operation of any collider, it becomes possible to use the *LHC* to study the nature and properties of quantum particles of matter (charge) outside the framework of the Standard Model.

7. Five new laws of motion of gravitational energy in nature have been established and described.

8. The action of gravity in nature is an objectively necessary condition for the existence of physical bodies in the surrounding world and indicates the importance of gravitational energy in the course of any physical processes involving any mass of matter.

9. A complete analogy was revealed between the nature of the change in the volumetric density of gravitational energy in nature according to the Law of Inverse Cubes of the gravitational converging field and the force action of physical vacuum on metal plates in the *Casemir* experiment, which confirmed the conclusion that the real source of the force manifestation of vacuum in nature is gravitational energy as the initial and final stage of the implementation of all physical processes and phenomena in nature.

10. The following minimum values of portions of energy and mass of gravitons emitted in nature have been established, which are respectively: for matter, graviton energy:

– $E_g = 6.234\times10^{-73}$ J; graviton mass – $m_g = 6.926\times10^{-90}$ kg, graviton energy for charge;

– $E_{g\,q} = 4.551\times10^{-75}$ J; graviton mass – $m_{gq} = 5.056\times10^{-92}$ kg.

11. In parallel, the calculated dimensions of compactification of quantum particles of matter (charge) into a superdense vacuum state are respectively: for matter – $k_2 = 1.616\times10^{-35}$ m; for charge - $k_4 = 1.18\times10^{-37}$ m.

12. The total energy of the *de Broglie* wave of any body, as well as the mechanical energy of its movement, always characterizes the total energy inherent in the mass of matter of a given body at any specific speed of movement in the speed range $0 < V < C$. and not only during the theoretical movement of this body with speed light according to *Einstein's* formula $E = m\times C^2$.

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