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On the Common Nature and Unified Mechanism of Gravitational and Nuclear Interactions

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Abstract
Based on the classical approach, it is shown that gravitational and nuclear interactions have a common nature and a single mechanism. The gravitational field is represented as a set of a limited number of lines of force emanating from a physical body and extending into the distance, similar to the Faraday lines of force for the electric field of a point charge. The consideration is based on P. Dirac's ideas about the limitation of the number of Faraday lines of force and the finiteness of the size of microparticles, expressed by him for the further development of physical theories, as well as the formulated philosophical principle of limitation: physically existing objects are limited by their size, their properties and their capabilities. Based on this formulation, it is accepted that the gravitational interaction of the object is possible only with a limited number of other objects, but not with all in the Universe. The results are obtained and conclusions are made on the basis of taking into account both the finiteness of the size of the mass–forming interaction elements – nucleons and systems consisting of them - atomic nuclei, and the limited number of force lines of the physical field. A proposal has been made that the channels of gravitational interaction for the exchange of gravitons should be the lines of force of their own field of physical objects. The work was carried out within the framework of the classical approach, taking into account the structure of matter discovered by E. Rutherford.
Keywords: Lesage theory, gravity, mass defect, gravitational shielding, gravity mechanism, mass, physical field structure.

1. Introduction

The question of creating unifying theories in the description of fundamental physical interactions is one of the main tasks of physical theory. This issue has a century-old history, but experts have not received final results. At the present stage, attempts to build a unified field theory are made in accordance with the epistemological evolutionary scheme of the birth and transformation of the corresponding elementary particles since the big bang. The fundamental particle in this scheme is considered to be the Higgs particle [1-2]. Experimental detection of particles whose physical characteristics correspond to the theoretically predicted ones is considered to be a confirmation of the theory put forward. At the moment, there are dozens of theories [3-8] proposed as such, but they do not have an experimental evidence base. The Standard Model obtained on the basis of gauge theory [9-10] and superstring theory [11] are popular today. The theory proposed in 1967 by S. Weinberg, Sh. Glashow and

A. Salam is considered to be an established theory in the unification of weak and electromagnetic interactions. [12-14].

The difficulty in creating a unified field theory is considered to be that modern physical representations are built on qualitatively different bases: quantum physics is built on the basis of probable approaches, whereas the modern theory of gravity of GR [15] is built on geometric principles. The peculiarity of modern theories is that they are in the zone of great abstraction and are based mainly on postulates. Modern approaches suffer in terms of clarity and are not always able to meet the principle of causality.

Meanwhile, there are other fundamental questions of the theory that have also been waiting for their unambiguous and final solution for centuries. This is the question of the mechanism of gravity and gravitational shielding, the question of the ether, the question of the nature of the force of inertia. These issues either do not have a satisfactory solution at all, or their solutions are not unambiguously recognized by specialists.

At present, the hope of some scientists about the possibility of further development of classical ideas in solving fundamental issues has not been lost. One example of this is the collection of scientific papers on the topic of gravity published in 2002 under the title "Pushing Gravity" [16]. By returning a look at the possibilities of classical representations for solving fundamental questions of physical theory, one can also consider the ideas of P. Dirac [17].

2. Method and results

The research method in this work is a consideration and analysis of factors that can serve to justify the fact that gravitational and nuclear interactions have a common mechanism. The lack of consideration of the classical theory of gravity, taking into account the peculiarities of the structure of matter according to the model of E. Rutherford [18], can also be attributed to such factors. Consider these factors.

2.1. Mass as a general argument of gravitational and nuclear interactions.

As is known, in the description of both gravitational and nuclear interactions, the main argument is the mass of interacting elements, which is included as an argument in the expressions of the law of universal gravitation and the definition of the mass of the atomic nucleus:

$$F = G\frac{m_1 m_2}{r^2} \tag{2}$$

$$M = N_p m_p + N_n m_n - \Delta m \tag{3}$$

In these expressions, m_1 and m_2 are the masses of the first and second bodies, r is the distance between them, G is the universal gravitational constant, N_p and N_n are the number of

protons and neutrons in the atomic nucleus, m_p and m_n are the masses of the proton and neutron, respectively, Δm is the mass defect.

In intuitive perception, the presence of the dependence of the above values on the mass, as the main argument, suggests the existence of a fundamental connection between these two types of physical interaction.

2.2. Consideration of the structure of the substance.

The basis of the classical approach in terms of gravitational interaction is the Fatio-Lesage theory [19], according to which the gravitational interaction is due to the difference in the pressure of ether particles exerted on physical objects from opposite sides. In this representation, the defining parameter is the size of the interaction elements in terms of their cross-sectional area. Prior to the establishment of the features of the structure of matter by Rutherford, gravity was considered exclusively for macroscopic bodies, the structure of which was represented as a continuous medium. The structure of matter on Rutherford's part was established during the formation of the foundations of new physics, when researchers were imbued with the spirit of new physics, inspired by its capabilities, linking the realization of all expectations in the construction of the theory only with it. The new physical paradigm did not stimulate us to engage in the previous concepts, which significantly limited the scope of the search for solutions and the study of fundamental issues on the platforms of classical physics. Thus, the classical concepts of gravity that existed at that time were not considered, taking into account only the established structure of matter.

As you know, the peculiarity of Rutherford's discovery regarding the mutual shielding of elements is that the shielding elements turned out to be nucleons and systems consisting of them – atomic nuclei, which are quite small in size compared to the size of an atom. Their ratio is 10^{-4}. This indicates a high degree of transparency of the atoms of ordinary substances relative to the passage of the smallest particles through them. Additional results would be obtained by considering Lesage's theory taking into account the structure of matter. However, this was not done.

2.3. P. Dirac's ideas concerning the further development of physical theory.

P. Dirac expressed his opinions on the importance of taking into account the size of microparticles and the introduction of restrictions on the properties of physical systems and objects in his review article [18].

Dirac’s ideas are as follows:

- return to the analogue of the classical ether;

- setting a limit on the number of Faraday lines of force;

- consideration of an electron as a sphere of finite size.

Dirac's ideas are attributes of classical physics and their implementation is possible within its framework. It is possible to give arguments in the proposal of these ideas.

The breakthrough in the crisis of physical representation at the beginning of the 20th century is associated with the introduction of discreteness in the properties of matter. In the future, taking into account these properties, although it provided a big breakthrough in the description of physical phenomena, however, it cannot be said that the whole nature of the manifestation of this property was revealed. Discreteness in new representations works on the basis of acceptance of postulates and principles. The analytical form of Balmer's formula was obtained by N. Bohr on the basis of the postulates.

Two of Dirac's three ideas relate to the question of limitation, which affects the philosophical categories of finiteness and infinity. The establishment of limitation on the number of Faraday lines of force is a transition in the physical representation from infinity to finiteness, from continuity to discreteness. Consideration of elementary particles (electron) as a sphere of finite size, it is necessary to take into account the size of the interaction elements in physical theory instead of the fact that elementary particles are considered as material points in the framework of modern concepts. Such an approach can be justified only in particular cases, being a distortion of reality in the general case. Dirac's ideas point to the need to take into account particle sizes, which makes it possible to link physical interaction with the phenomenon of mutual shielding of elements.

2.4. Research on the implementation of Dirac's ideas

In [20], a mass-area equivalence was introduced that combines the kinetic view of Fatio-Lesage with the mathematical formalism of Newton. It is entered in the form

$$m = kS, \qquad (1)$$

where*m* is the mass of the object, *S* is its cross–sectional area, *k* is the mass–area equivalence coefficient. In general, to calculate the cross-sectional area of an object consisting of *N* interaction elements, the formula is proposed:

$$S_{sh} = S_b\left[1-\left(1-\delta\right)^N\right] \qquad (2)$$

The elements of interaction are mass-forming elements - nucleons and systems consisting of them – atomic nuclei. In (2) $\delta = \frac{S_n}{S_a}$ is a mutual shielding parameter, S_n is the cross–sectional area of the nucleon, in the case of close shielding, and/or the cross-sectional area of the atomic nucleus, in the case of far shielding (Fig.1). Close shielding is the mutual shielding of interaction elements when they are at distances, comparable to their size, which is typical for nucleons in the atomic nucleus. Far shielding is the mutual shielding of elements when the distance between the interaction elements is much larger than their size, which is typical for the mutual shielding of atomic nuclei in ordinary matter. S_a is the cross–

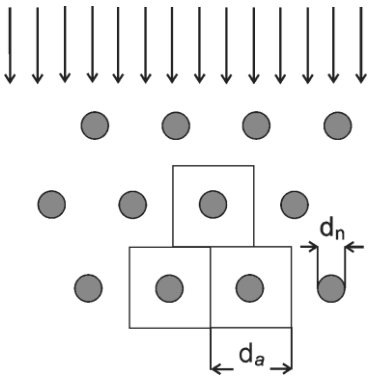

Fig.1. Scheme for calculating the spatial shielding of the interaction

sectional area of the volume of space coming to one interaction element. S_b is the total cross–sectional area of the object.

Mutual spatial shielding of interaction elements, as an interaction mechanism, should lead to a violation of additivity when adding up masses, which follows from the ratio $S < S_1 + S_2$ in the presence of mutual shielding of objects with cross-sectional areas S_1 and S_2. As is known, in the microcosm, a similar picture takes place and is considered as a mass defect phenomenon. In the macrocosm, mutual shielding should manifest itself as gravitational shielding. It is shown in [21-22] that gravitational shielding exists for massive celestial bodies with dimensions comparable to the critical thickness of the shielding $d_c = 1,3 \cdot 10^8$.

Based on the proposed approach, an analytical formula for the binding energy of nucleons in the atomic nucleus was obtained, which satisfactorily describes the experimental data.

Thus, all the factors considered are united by the fact that taking into account the sizes of interacting elements allows us to consider physical interaction as a result of mutual shielding on the path of ether particles within the framework of the classical approach.

3. On the unified mechanism of gravitational and nuclear interactions

Regarding the mechanism of gravitational interaction, there is an idea according to which the interaction occurs through channels of interaction between interacting elements, along which hypothetical particles - gravitons are exchanged. The analogy of the pictures in the description of the electric and gravitational fields, as a function of the central forces, gives grounds for the possibility of using the descriptive base of the electric field for the gravitational field as well. The descriptive base of the electric field is wider than the descriptive base of the gravitational field. For example, the structure of the electric field is described by Faraday lines of force, whereas for the gravitational interaction in the classical approach, such a structure is not considered. The similarity of the mechanisms of these interactions with the fields of central forces allows such a structure to be considered as common to both types of fields. If we generalize Dirac's idea expressed for the structure of the electric field and for the case of the structure of the gravitational field, then the latter can also be depicted as a set of a limited number of gravitational lines of force emanating from the physical body and going into the distance. The establishment of a limit on the number of force lines can be taken as the establishment of a limit on the number of channels of interaction – the transition from continuity to discreteness. This leads to the important conclusion that there are only a limited number of channels of interaction for a given object - a physical body can interact only with a limited number of

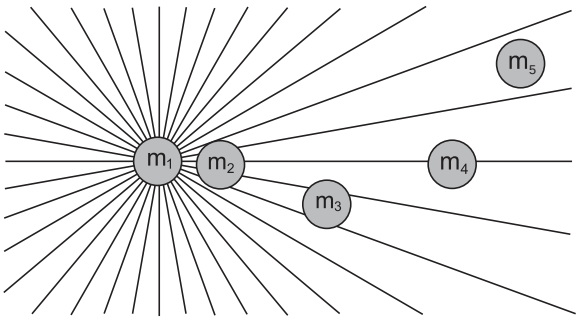

Fig.2. To the scheme of interaction of physical bodies by means of a limited number of force lines.

objects, but not with all in the universe. This gives reason to consider the mechanism of gravitational interaction according to the scheme in Fig. 2.

Let the gravitational field of an element with mass m_1 contain elements of interaction with masses m_2, m_3, m_4 and m_5 at different distances from it. The lines of force emanating from the m1 element, depending on the distance, intersect the other elements in different ways: the m_2 element is bickered many times, the m_3 element intersects twice, the m_4 element intersects once, the m_5 element does not intersect at all. The density of force lines per unit area varies according to the law $\frac{1}{r^2}$. Such a representation of the field structure presupposes distinguishing points and zones around a physical element: points where force lines and zones free of force lines pass, and, accordingly, the presence of two types of mutual state of elements – the presence of interaction between them and its absence. It is natural to assume that the interaction takes place with another element in the case when there is an intersection of force lines with it. The greater the number of intersecting lines with the second element, the stronger the interaction with it. The closer the second element is, the greater the number of intersections, the stronger the interaction.

As noted above, in gravitational interaction, the elements of interaction are nucleons and systems consisting of them – atomic nuclei. If in the short-range interaction we can talk about several lines of force crossing the second element (nucleon), then in the long-range interaction there can be only one interception on several elements of another system. The picture of the interaction can be presented according to the diagram in Fig.3, where two possible variants of the interaction of the element L with the system M are presented, in which the elements are connected by strong bonds with each other. In option a), the interaction of element L with system M occurs through a single channel, but strong in intensity (shown in bold lines in the figure). In option b), the interaction of element L with elements of system M occurs through a variety of channels, but weak in intensity (non-greasy lines). The first variant is a discrete variant of interaction with a finite number of force lines, in other words, channels of interaction. The second option is a continuous option, according to which one element of interaction can interact with all elements of interaction of other systems and the Universe as a whole. Since the interaction takes place by the exchange of material particles, one element cannot interact

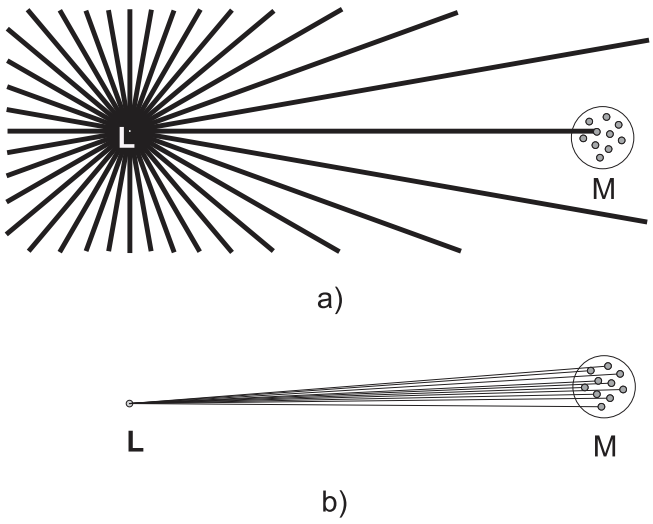

Fig.3. To two possible variants of gravitational interaction: a) - a discrete variant of interaction; b) - a continuous variant of interaction.

with all elements by exchanging particles for simple reasons. Therefore, the mechanism of interaction according to the first - discrete variant is real. The picture of both options can be imagined in our minds, but according to the logic of reality, they differ: option a) meets the principle of finiteness, discreteness; option b) does not meet these requirements.

We can consider the quantitative side of this issue. Suppose that n_0 lines of force come from each element A (Fig. 4). Let system A have N_A and system B have N_B interaction elements. The total number of force lines emanating from system A and B, respectively, $n_A = n_0 N_A$ and $n_B = n_0 N_B$ .Let the lines of force be described by some parameter λ characterizing the power of this type of interaction. Given the limited number of force lines emanating from one interaction element located in system A, it cannot interact with all the interaction elements in system B, but interacts only with those crossed by its force lines. If the average number of force lines originating from each interaction element in system A and reaching system B is n_{AB}, then the total number of force lines originating from system A and reaching system B will be $N_{AB} = N_A n_{AB}$ in which $n_{AB} \leq n_0 N_A$. Similarly, for the total number of force lines originating from system B and reaching system A, there will be $N_{BA} = N_B n_{BA}$, in which $n_{BA} \leq N_B$. The total number of force lines connecting system A to system B will be equal to: $N = n_{AB} N_A + n_{BA} N_B$ .The total force of interaction between systems A and B

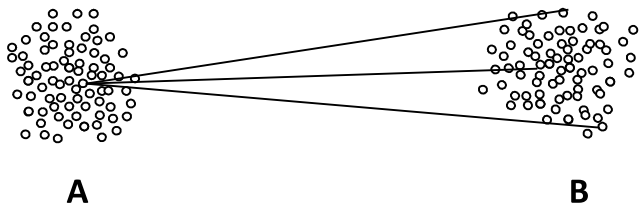

Fig.4. To the limited variant of physical interaction: an element in system A interacts only with a limited number of elements in system B.

$$F = \lambda\left(n_{AB} N_A + n_{BA} N_B\right). \qquad (3)$$

Suppose that the total interaction force of this magnitude is obtained as a result of the interaction of each individual element in system A with each element in system B. Then the total number of force lines connecting all elements of system A with all elements of system B will be equal to $N = N_A N_B$. The total force can be represented as

$$F = \lambda_1 N_A N_B \qquad (4)$$

Equating (3) with (4), we get

$$\lambda\left(n_{AB} N_A + n_{BA} N_B\right) = \lambda_1 N_A N_B$$

Given that $n_{AB} \leq N_A$ and $n_{BA} \leq N_B$, we can estimate the relation

$$\frac{\lambda}{\lambda_1} = \frac{N_A N_B}{n_{AB} N_A + n_{BA} N_B} \qquad (5)$$

This ratio is a large quantity or, in other words, the parameter λ_1, which characterizes the interaction under the assumption that all elements of the interaction interact with all elements of the interaction, is a very small quantity. As a result, in our view we get a weak interaction.

4. Discussion

One can consider the justifications in the identity of the gravitational and nuclear interactions.

The first is the possibility of expressing all the laws regarding gravitational and nuclear interactions in the formulations of mutual shielding of interaction elements.

1) Based on the mass-area equivalence [20], the law of universal gravitation is written in the form:

$$F = G' \frac{S_1 S_2}{r^2}. \qquad (6)$$

In (6) G' is written as $G' = Gk^2$, where G is the universal gravitational constant, k is the mass-area equivalence coefficient.

2) Based on the same equivalence, the expression for the mass of the atomic nucleus is written as:

$$S_{nc} = N_p S_p + N_n S_n - \Delta S, \qquad (7)$$

where N_p and N_n are the number of protons and neutrons in the atomic nucleus, S_p and S_n are the cross–sectional areas of protons and neutrons, ΔS is the area of mutual overlap of nucleons.

3. The formula for the mutual overlap of interaction elements has the form:

$$S_{sh} = S_b \left[1 - (1 - \delta)^N \right] \qquad (8)$$

The interaction force in (6) is proportional to S_1 and S_2 – the interaction areas of the first and second objects. In the representations of mutual shielding, the area of interaction is the area of the shadow that is formed on the screen from parallel rays passing through the elements of a physical object. If there is mutual shielding of the elements of the object, the total area of the shadow will be less than the sum of the areas from its individual elements $S < \sum_{i=1}^{n} S_i$.

For massive celestial bodies, gravitational shielding will take place when elements of the same object spatially shield each other from gravitational influence. According to calculations [20], the critical thickness of the shielding is $1,3 \cdot 10^8\, m$. Due to the presence of gravitational shielding, not the entire mass of massive celestial bodies participates in the act of gravitational interaction, making up the hidden mass. The definition of mass as the amount of substance according to formula (8) for objects whose dimensions are comparable to the critical thickness of the shielding is not correct. It is shown in [21-22] that massive planets

exhibit gravitational shielding and their densities, determined from the conditions of gravitational interaction, are underestimated.

In general, the areas $S_1$and S_2in (6) should be defined by the expression (8), which describes the interaction as a result of mutual shielding of the interaction elements. Special cases of expression (8) are closeshielding for the microcosm and farshielding for the macrocosm.

Secondly, it is about a single mechanism of gravitational and nuclear interactions. This is described in detail in the article, but there is a need to supplement it with philosophical considerations.

In describing the properties and states of physical objects, their first characteristic is the fact of their existence, the second characteristic is their quantity – their occupied volume, their size in space. Within the framework of modern physics, this important argument is not taken into account at all. Elementary particles, although they have a volume in space, are considered only as material points, which a priori implies the possibility of difficulties in their physical description and the impossibility of describing manifestations, where their sizes should be an important argument.

As noted above, the philosophical view cannot agree with the statement that one nucleon can interact with all the nucleons of the universe. The impossibility of the existence of such a picture requires the search for an alternative mechanism of interaction, where the principle of limitation must be fulfilled, which in this case reads as follows: physical object can interact only with a limited number of other physical objects. Schematically, P. Dirac's idea of establishing a limit on the number of Faraday lines of force when they are considered as channels of interaction leads to such a statement. If force lines are taken as channels of interaction, then a physical object can interact only with a limited number of interaction elements.

Continuity and infinity have common connections: the continuous can be divided infinitely. Hence we get Zeno's paradox, the astronomical paradox, and many other riddles. Everything in nature consists of separate components. The continuous and infinity can exist only in our subjective representation, as well as numbers, which are products of our consciousness.

Thus, the application of the discovery of the structure of matter by E. Rutherford, together with the ideas of P. Dirac, open up new opportunities in the development of physical representations within the framework of the classical approach. This work is a continuation of the author's series of works on the implementation of P. Dirac's ideas for the further development of physical theory. The first results were published in [23].

5. Conclusions

1. There are factors indirectly confirming the existence of a common nature and mechanism of gravitational and nuclear interactions: the mass of interaction elements is the main argument in the description of both interactions; the ability to describe both interactions by mutual shielding mechanism within the classical approach.

2. Both in the classical approach and in modern concepts, physical interaction can be represented by a similar mechanism: channels of interaction - according to modern concepts, lines of force - according to classical concepts.

3. The mass defect in the microcosm and gravitational shielding in the macrocosm have a common nature and are a consequence of mutual shielding of mass-forming elements of interaction: nucleons in the atomic nucleus and atomic nuclei in ordinary matter.

4. The general nature and a single mechanism is justified by taking into account the size of the mass-forming elements of interaction, the consideration of which was proposed by P. Dirac.

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