How gravity shapes the structure of the universe.

Viktar Yatskevich, Ph.D. [1]

[1] Viktar Yatskevich, Ph.D.,

CEO, Ltd. HYACINTH

Aurora, CO, USA

ltd.hyacinth@gmail.com

Abstract.

The Big Bang Theory (BBT) is currently widely accepted. The theory explains the expansion of galaxies by the action of "dark energy", a mysterious force that repels matter and causes space to expand at an accelerating rate. Within galaxies, the action of gravity prevails over the force of "dark energy" and no expansion occurs. This situation motivates the search for alternative physical interpretations based on verified observational data.

A new physical interpretation of gravity is proposed to complement existing cosmological models. The theory is formulated both as a phenomenological framework and as a microscopic description explaining gravitational interaction at the atomic level. The proposed approach is constructed as a connected sequence of known physical phenomena, each of which has experimental confirmation. This provides a physically grounded basis for interpreting gravitational interaction across scales.

A distinctive feature of the theory is its emphasis on the physical mechanisms underlying the formation and action of the gravitational field, while mathematical modeling is treated as a secondary descriptive tool. The theory offers a possible physical interpretation of the formation of cosmic structure driven by gravity alone. According to the proposed framework, gravitational interaction may manifest itself as either attraction or effective repulsion depending on the physical state of interacting matter. Within this interpretation, the observed expansion of the Universe may be described without invoking hypothetical forms of energy such as dark energy.

Keywords: Big Bang theory, expansion of the universe, dark energy, gravity, physical theory of gravitation, physical phenomena, mathematical model, quantum mechanical process, microparticle, energy.

1. Introduction

1.1 The Big Bang theory.

The Big Bang Theory (BBT) and other cosmological models based on this concept are currently widely accepted. The BBT explains the origin of the universe from the perspective of a physical worldview, according to which matter in the universe functions in accordance with its laws. According to this concept, about 13.8 billion years ago, all matter, energy, and space existed in an extremely dense and hot state called a cosmological singularity. Then a rapid expansion process occurred, which is the beginning of the modern universe. As the universe expanded, it cooled, allowing subatomic particles and later atoms to form. [1,2,3,4].

1.2. Problems with the Big Bang Theory

The Big Bang Theory is supported by several empirical data, but attention should be paid to the following conclusions of this theory:

Expansion of the universe. Metric expansion of space is an increase in the distance between two distant parts of the universe over time. Metric expansion is a key element of Big Bang cosmology and is mathematically modeled using the Friedmann – Lemaitre – Robertson–Walker (FLRW) metric. This model is only valid in the modern era on large scales (roughly, on the scale of galaxy clusters and above). Material objects are bound together by gravitational attraction on smaller scales, which prevents their expansion.

The universe is expanding at an accelerating rate. The theory explains that the expansion of the universe occurs with acceleration only in intergalactic spaces, and on smaller scales, the expansion and acceleration of space does not occur due to the gravitational attraction between stars and planets.

The starting point of the expansion of the universe is unknown. The theory states that the universe began to expand immediately after the Big Bang, resulting in the "stretching" of space and increasing the distance between galaxies. The expansion of the universe occurs due to the increase in cosmic space, while the galaxies themselves remain in their places.

The main problem. The Big Bang theory is the generally accepted model of the origin of the universe with empirical confirmation, but this theory has several unresolved problems that require further explanation. The theory is based on one idea of the expansion of space between galaxies that are far apart from each other and another idea about the absence of expansion of space between stars and planets within galaxies due to the action of gravitational force. LBT explains the expansion of galaxies by the action of "dark energy" a mysterious force that repels matter and causes space to expand at an accelerating rate. Within galaxies, the action of gravity prevails over the force of "dark energy" and no expansion occurs.

The Big Bang theory leaves unresolved the problems of "dark energy" itself and its effect on the expansion of space. In fact, one incomprehensible phenomenon, the "expansion of the universe"—is explained by another unknown phenomenon “dark energy." Indeed, the Big Bang model requires the presence **of "dark energy"** in space to explain the expansion of the universe, while the space between stars and planets within galaxies remains unchanged [5,6,7].

These problems are the most controversial aspect of the Big Bang theory and point to the need to search for new explanations based on verified data. In our opinion, their solution is possible only with an understanding of the physical nature of gravity [5,6].

2. Research results: a new physical theory of gravity explains the structure of the universe.

2.1 Principles of the new physical theory of gravity.

a) The "Physical Theory of Gravity" is proposed to explain the TBV phenomenon. The physical theory is formulated both as a phenomenological basis aimed at providing an interpretation of gravitational interaction and as a microscopic basis explaining the action of gravity at the atomic level. The new theory is constructed as a single connected sequence of known physical phenomena, each of which has experimental confirmation. This forms its basis and allows the new theory to be presented as well-founded and explains the nature of gravity on all scales, considering proven knowledge. A distinctive feature of the theory is its description of the physical essence of the formation and action of the gravitational field on matter, which makes mathematical modeling of processes secondary.

The new theory of gravity complements TBV and shows the physical mechanism of the formation of the structure of the universe solely due to gravity. As will be shown below, according to our theory, the gravitational interaction of matter can manifest itself as a force of attraction or a force of repulsion, depending on the state of the interacting matter. This property of gravity shows that the mysterious "dark energy" is unnecessary to explain the expansion of the universe.

Elements of the new physical theory of gravity have been discussed in earlier publications [8,9,10].

b) The central postulates of the theory are as follows:

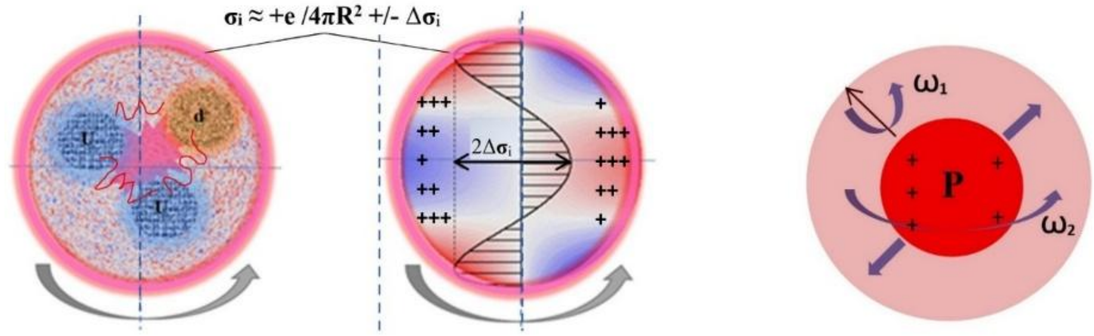
- the gravitational field is a physical field of electromagnetic nature.
- the gravitational field is not a conventional electromagnetic field; however, it arises because of electrodynamic processes within matter, including the motion, oscillation, and rotation of charged particles in atomic, nuclear, and plasma structures [11,12,13,14].
- each atom and charged particle generates a gravitational field that can be represented as a superposition of independently propagating radially pulsating electric and magnetic fields ("E" and "H" fields) with discrete frequency spectra determined by the quantum structure of matter [15,16, 17].
- the resulting gravitational field of a macroscopic body exhibits a radial multimode structure formed by the superposition of such pulsating fields emitted by all atoms and particles composing the body.

In the present model, gravity is not associated with longitudinal electromagnetic waves in the conventional sense. Instead, it is related to independently propagating radially pulsating electric and magnetic fields, considered as non-radiative field configurations rather than coupled electromagnetic waves. These fields do not require the presence of transverse components and do not form a Poynting vector or electromagnetic momentum transport. The characteristic frequency scales of these pulsations are comparable to those of the X-ray and gamma ranges (approximately 10^{19}– 10^{23} Hz), however, the proposed fields are not photon-mediated radiation and do not produce ionizing effects. Their high penetrating ability is associated with the absence of induced charge redistribution and eddy currents in conductive materials [18,19,20, 21].

c) Within the proposed interpretation, gravitational interaction is treated as a manifestation of physical field configurations arising from electrodynamic processes occurring within matter at atomic, nuclear, and plasma scales. These processes include the motion, oscillation, and collective dynamics of charged constituents. The gravitational field is therefore regarded as a real physical field, emerging from these processes, rather than as a purely geometric attribute of spacetime.

A central assumption of the framework is that individual atoms and charged particles contribute to the gravitational field through localized, time-dependent electric and magnetic field components. These components are interpreted not as conventional transverse electromagnetic radiation, but as radially pulsating field configurations associated with non-radiative, near-field energy oscillations. The characteristic frequencies of these pulsations are determined by the quantum and nuclear structure of matter and form a discrete multimode spectrum. Within this interpretation, gravity is not associated with propagating longitudinal electromagnetic waves in the conventional sense. The proposed field configurations do not involve transverse radiation components and do not give rise to a net Poynting energy flux. As a result, they are characterized by weak coupling to matter and high penetrating ability compared with ordinary electromagnetic radiation. This feature provides a qualitative explanation for the long-range nature of gravitational interaction and its weak interaction with intervening material media.

d) At the microscopic level, electrodynamic processes within nucleons and atomic nuclei—such as fluctuations of charge density, oscillatory and rotational motion of charged constituents, and collective nuclear dynamics - lead to temporal modulation of local electric and magnetic fields. These processes give rise to radially pulsating field components in the near and intermediate zones surrounding atomic and nuclear structures. Local variations of the electric field strength may result in transient modifications of effective interaction potentials at nuclear and atomic scales (Figures 1–5).



a) b)

Figure 1 – Interactions of quarks **U** and **d** in the proton structure led to a periodic change in the charge density **Δσi** on the proton surface and a change in the external electric field strength **ΔE**, respectively (a) and oscillatory and rotational motions of the proton in the nucleus lead to additional fluctuations of the electric field **E** of the proton (b).

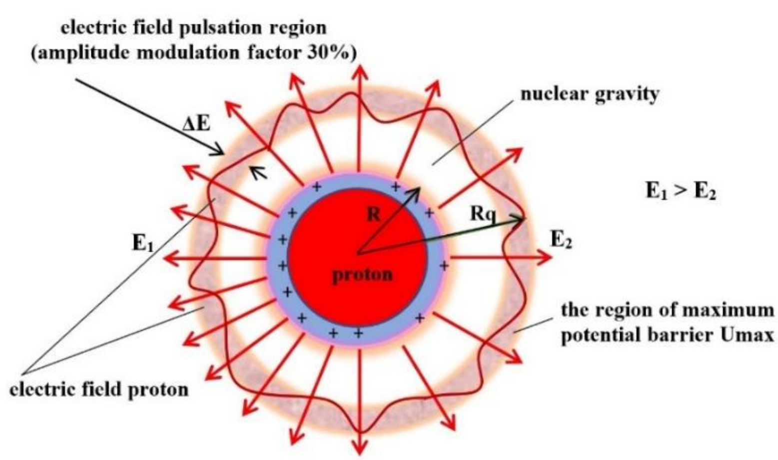


Figure 2 - The electric field E of the proton pulsates due to changes in surface charge, mass densities, and proton motion.

The external electric field pulsates in a radial direction because of changes in the charge density on the proton surface: the field strength increases above the region of increasing charge density and decreases above the region of decreasing density.

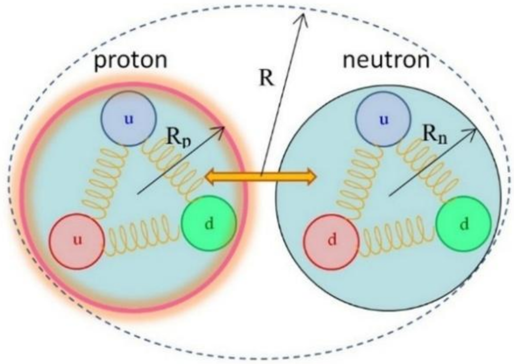


Figure 3 - Structure of nucleons (simplified version): the proton consists of two top quarks **U** with charge **+2/3 e** and one bottom quark d with charge **-1/3 e**, the neutron consists of two lower quarks **d** and one upper quark **U**, the radius of the proton and neutron R pn ~ $4.5616 \cdot 10^{-16}$ m.

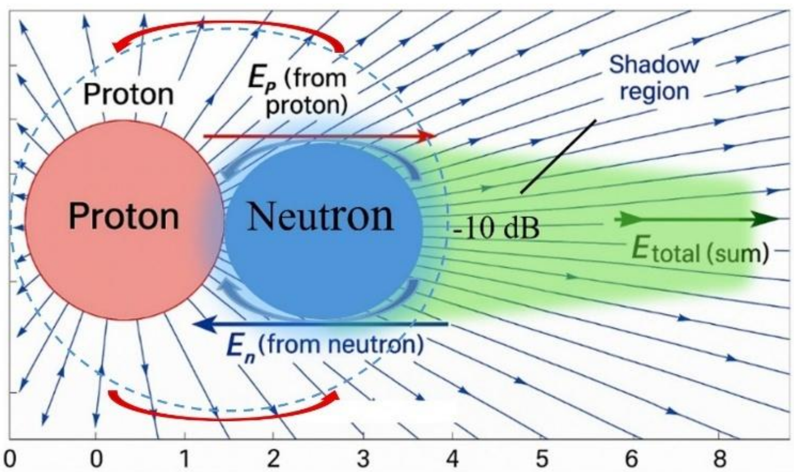


Figure 4 – General diagram of the formation of a low-potential channel in the Coulomb field of the nucleus (shadow region) due to the influence of a neutron:

- red circle - proton (field source).
- blue circle - neutron (polarizable, uncharged).
- arrow lines show the direction of the resulting field; on the right, you can see the "shadow zone", where the field is weakened and partially reversed.

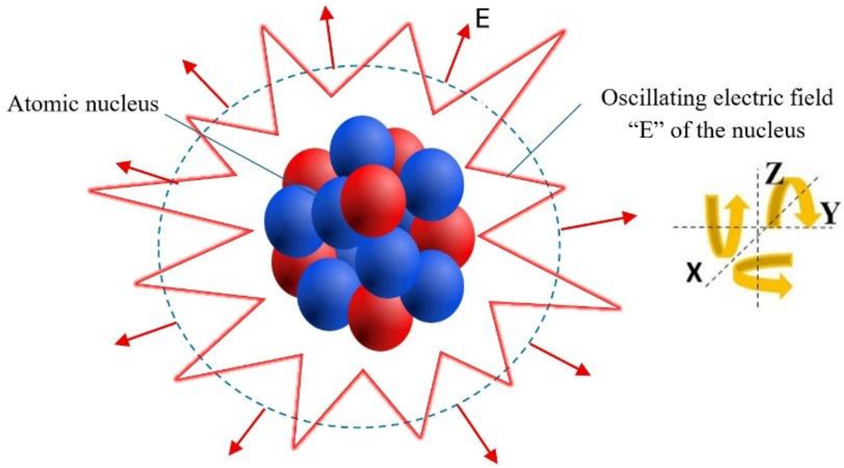


Figure 5 - The electric field E of the nucleus of an atom pulsates due to changes in surface charge, mass densities, and proton motion.

At the macroscopic level, the gravitational field of an extended body is interpreted as a superposition of such radially pulsating field contributions emitted by all constituent atoms and charged particles. This superposition leads, on average, to a radially symmetric field structure, while allowing for local temporal and spatial variations. In this sense, gravitational interaction emerges as a collective effect of microscopic electrodynamic processes rather than as a fundamental geometric property of spacetime (Figures 6,7) [8].

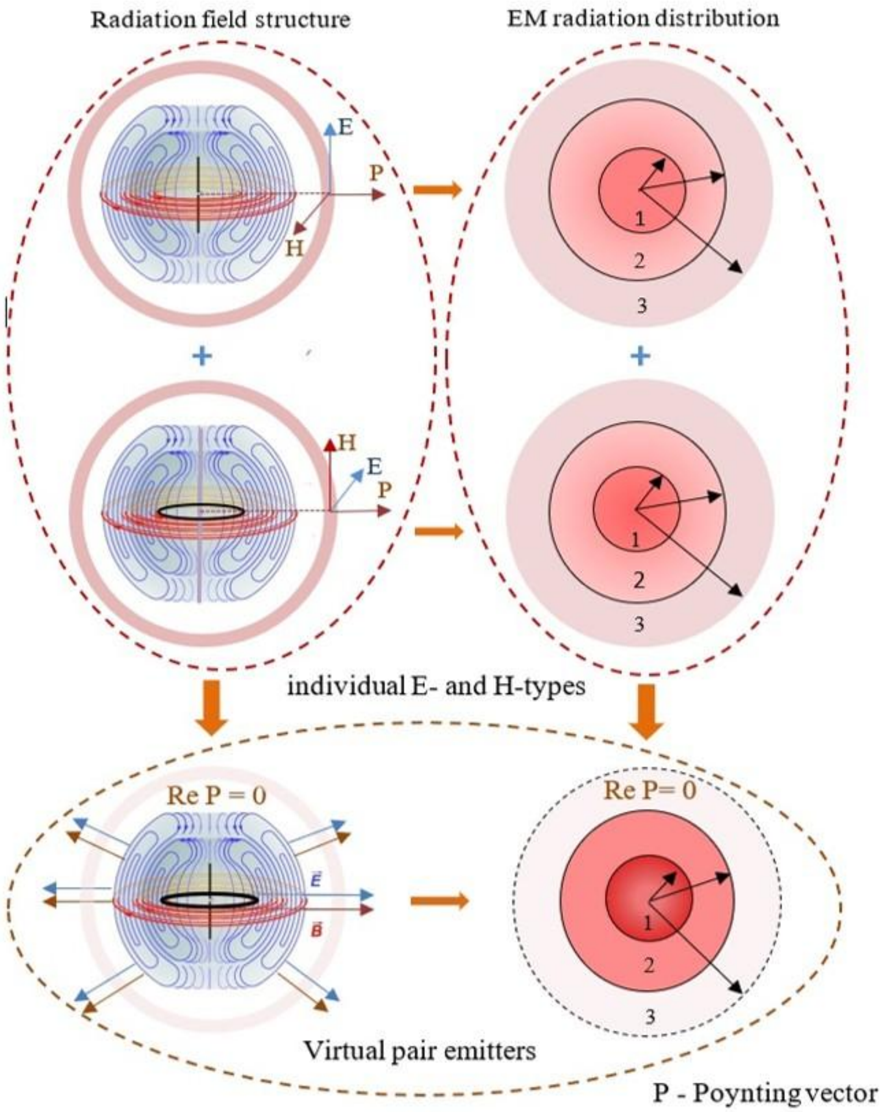


Figure 6 - The distribution of electromagnetic energy fluxes in space from individuals and combined E-type and H-type emitters:

A. The distribution of electromagnetic energy fluxes in space from individual and combined E- and H-types of emitters. Radiation zones: 1- near Zone, 2- intermediate zone (Fresnel zone), 3- far radiation zone (Fraunhofer zone).

B. Interference effects in the system of two arbitrarily oriented radiating dipoles in a nearby zone. Anti-phase interference of signals from E- and H-type emitters in the far zone results in energy redistribution in the near zone.

C. An example of the formation of a narrow radiation pattern due to partial interference in the far zone from E- and H-type emitters. Dipole and frame as an example of E- and H-type emitters, which form three types of radiation patterns in the far zone: dipole alone, frame alone, and paired dipole–frame.

The gravitational field of a macroscopic body is described as a superposition of such radially pulsating field contributions emitted by all constituent particles. This superposition results in a structured, multimode field exhibiting radial symmetry on average, while allowing for local temporal and spatial variations [8].

Within this interpretation, gravitational interaction emerges as a collective effect of microscopic electrodynamic processes rather than as a purely geometric property of spacetime (Figure 7).

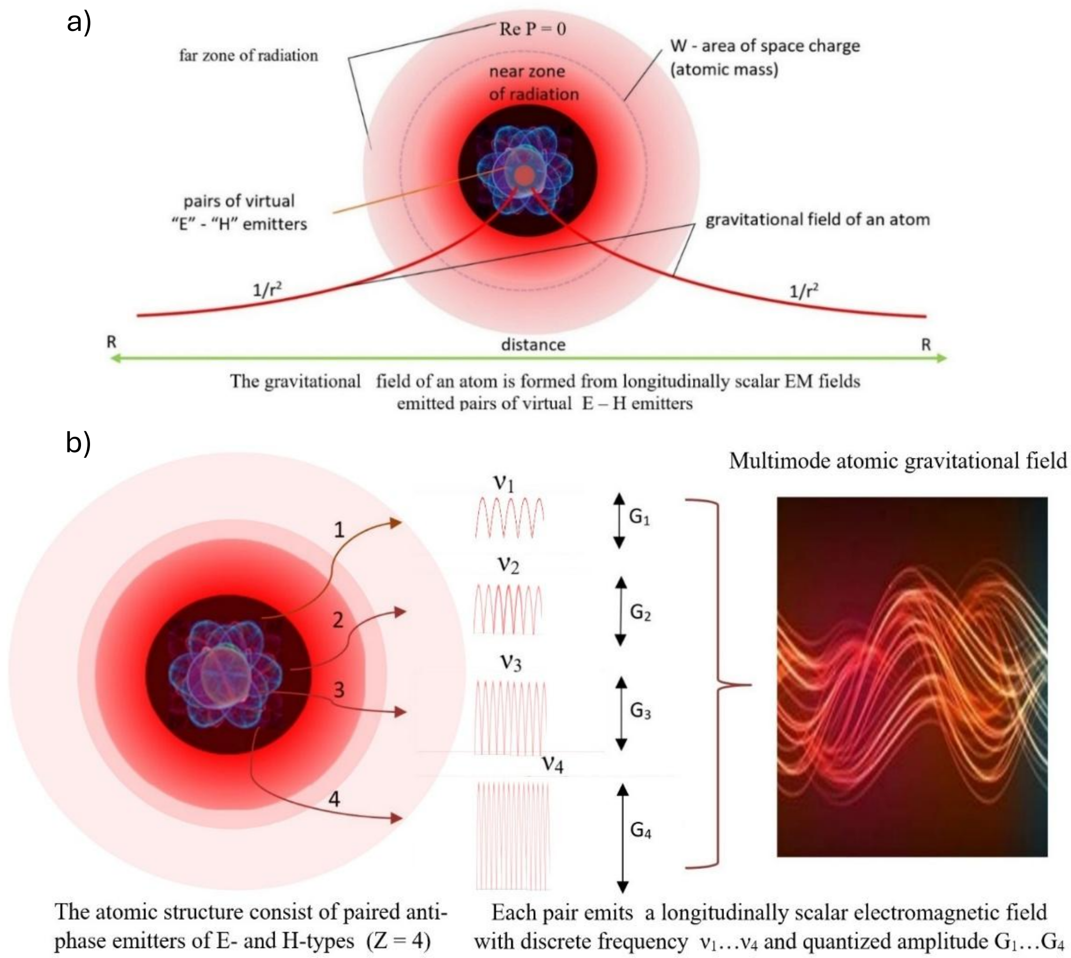


Figure 7 - Atom is the source of the gravitational field due to the energy of the reactive electromagnetic fields in the near zone of the atom:

a) the gravitational mass of the atom accumulates in the near zone of radiation of all its paired E- and H-type emitters, and their combined field creates the gravitational field of the atom.

b) gravitational waves emitted by an atom with atomic number Z = 4 are a superposition of a longitudinally scalar electromagnetic field with a discrete frequency ν_1 ... ν_4 and a quantized amplitude G_1 ... $G_4$4 emittedfrom all pairs of E- and H-type emitters:

- the frequency of gravitational waves, $\nu_1 ... \nu_4$, have discrete numbers and correspond to optical spectra of atomic emission.

- gravitational wave levels G_1 ... G_4 are quantized like the corresponding electron level quantization.

- the resulting gravitational wave is multi-modal.

e) An important feature of the proposed framework is the distinction between gravitational fields and conventional electromagnetic radiation. Although electric and magnetic components are involved, gravitational interaction is not associated with energy transport in the form of propagating electromagnetic waves. Consequently, the gravitational field does not generate radiation pressure, electromagnetic momentum transfer, or ionizing effects.

The proposed Physical Theory of Gravity seeks to preserve the empirical successes of existing gravitational theories while addressing conceptual questions related to physical mechanism, causality, and the microscopic origin of gravitational interaction. In this sense, it should be regarded as a physical interpretation that may serve as a foundation for further theoretical refinement and experimental investigation.

2.2 Physical mechanism of gravitational interaction with matter.

(i) Within the proposed Physical Theory of Gravity, gravitational interaction is interpreted as the response of matter to an external multimode field formed by radially pulsating electric and magnetic components. These components originate from the collective electrodynamic activity of charged constituents in surrounding matter and interact with atomic and subatomic systems without direct energy transport in the form of electromagnetic radiation.

When matter is placed in such an external gravitational field, its internal electric and magnetic structures experience time-dependent perturbations. The pulsating electric component induces polarization of bound charge systems, leading to periodic displacement of electron clouds relative to atomic nuclei. Simultaneously, the pulsating magnetic component interacts with magnetic moments associated with orbital and spin angular momentum of charged particles.

Atoms, nuclei, and subatomic systems possessing angular momentum may therefore be treated as effective microscopic gyroscopic systems. Under the influence of external time-dependent fields, these systems experience torques that modify their precessional dynamics. This behavior is analogous to well-known effects such as Larmor precession in magnetic fields, although in the present case the response arises from a superposition of electric and magnetic field pulsations rather than from a static external field.

(ii) Atoms and particles acquire additional energy through interaction with an external gravitational field represented by a multimode superposition of radially pulsating "E" and "H" fields. The pulsating electric component "E" induces polarization of electric systems, such as shifts of electron clouds relative to atomic nuclei. The pulsating magnetic component "H" acts on magnetic moments associated with orbital and spinning angular momentum.

Atoms and particles possessing angular momentum and magnetic moments may be treated as microscopic gyroscopes [22,23,24].

The external pulsating fields modify their torque, inducing precessional motion analogous to Larmor precession. The collective precessional response of atomic and subatomic systems results in a directed macroscopic displacement of the center of mass toward the source of the gravitational field. In this interpretation, gravitational attraction emerges as a macroscopic manifestation of the collective gyroscopic response of matter to radially pulsating fields.

(iii) All gyroscopes operate based on the laws of conservation of angular momentum and inertia, regardless of the nature of their structural elements. The property of a rapidly rotating gyroscope manifests itself as follows:

- if an external force F_1 perpendicular to the axis of rotation of a balanced gyroscope begins to act on the axis, the axis of rotation will begin to deviate not in the direction of this force, but perpendicular to it.

- if at some point in time the action of force F_1 suddenly stops, then the deviation of its axis also stops suddenly (the property of inertia of its axis).

Indeed, rotating atoms and microparticles—atom nuclei, protons, neutrons, etc.—can be considered gyroscopes, since they have a macroscopic magnetic moment, can rotate at high angular velocity, and possess corpuscular and wave properties. Gyroscopic properties arise due to the presence of spin and orbital moments. For example, protons and atomic nuclei can indeed be considered gyroscopes without a free axis of rotation. However, rotating particles are not gyroscopes according to classical definitions, since they do not have a free axis of rotation and cannot directly respond to changes in orientation angles (Figure 8).

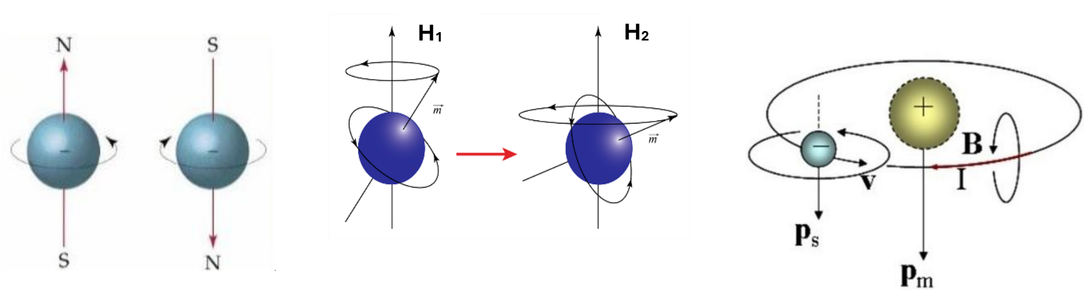


Figure 8 - Microparticles are “virtual gyroscopes” without a free axis of rotation.

(iv) How “virtual gyroscopes” work. The thing about gyroscopes based on spinning microparticles is that they're affected by the interaction of external and internal electric and magnetic fields. Such gyroscopes are susceptible to external electric and magnetic fields, which affect their functioning. A magnetic field can change the angular momentum, leading to a change in the orientation of the rotating microparticle, while an electric field causes its precession.

For example, the magnetic moment of nuclei is caused by the spin magnetic moments of nucleons and the magnetic moments that arise due to the orbital motions of protons (figure 8). In this case, the magnetic moment vector does not coincide with the momentum vector. As a result of the magnetic interaction that exists between the orbital and spin moments, the total magnetic moment processes relative to the resulting angular momentum. The time-averaged total magnetic moment—the component of the magnetic moment—is directed in the direction of the angular momentum of the nucleus. The external pulsating fields modify their torque, inducing precessional motion analogous to Larmor precession. The collective precessional response of atomic and subatomic systems results in a directed macroscopic displacement of the center of mass toward the source of the gravitational field.

Features:

- Rotating atoms behave like "gyroscopes." This is due to the properties of their mechanical moments and their interaction with external fields. An atom has a mechanical moment, and under the influence of a magnetic field, its mechanical moment begins to precession around the field vector.

- Microparticles (e.g., nucleons) are also comparable to "gyroscopes." This is because there is a variable electromagnetic field inside an elementary particle that rotates in a certain stable orbit. The rotation is polarized and can occur either in the plane of the electric component of the field (charged particle and antiparticle) or in the plane of the magnetic component.

- The effects of "longitudinal magnetic fields" in the structures of microparticles determine their behavior when interacting with each other. For example, the direction of the motion vector of one particle follows the rotation of another, which can be compared to the behavior of "gyroscopes."

- Mobile microparticles without a physical axis of rotation (atoms, atomic nuclei, etc.) create angular momentum during rotation, which resists changes in the orientation of the "virtual axis" under external influence. The peculiarity of such gyroscopes is that the rotation element is affected exclusively through electric and magnetic fields. When unidirectional pulsating external "E" and "H" fields act on rotating microparticles, the axis of rotation of such microparticles tilts and the center of gravity of the rotating particle shifts in the direction of the source of these fields.

- At the macroscopic level, the collective response of many atomic and subatomic systems results in a net interaction directed toward the source of the external field. In this interpretation, gravitational attraction emerges as a cumulative effect of microscopic field–matter interactions rather than as a fundamental force acting instantaneously at a distance.

- The direction of action of multimodal pulsating "E" and "H" fields, representing the gravitational field on matter, depends on its state: matter in a solid, liquid, or gaseous state is attracted toward the source of these fields, while matter in a plasma state is repelled due to the high internal energy of plasma microparticles. It is this circumstance that leads to the “dispersion” of galaxies consisting of “burning” stars.   This fact also explains the behavior of “ball lightning” in terrestrial conditions—it is not affected by the Earth's gravity. Thus, stars in different galaxies do not experience mutual attraction; on the contrary, the action of their pulsating ‘E’ and “H” fields causes them to repel each other.

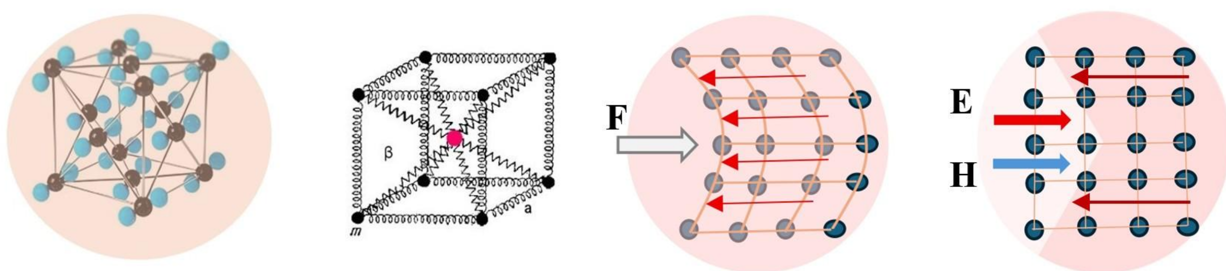
- From a quantum-mechanical perspective, the external gravitational field breaks the central symmetry of the intra-atomic potential. As a result, the electron wave function becomes anisotropic and non-stationary, in a manner analogous to known perturbative effects such as the Stark effect [25, 26]. The induced anisotropy of probability density leads to precession of the magnetic moment and, consequently, to an effective attractive force acting on the center of mass. From a quantum-mechanical perspective, such symmetrical breaking leads to anisotropy of the corresponding wave functions and modifies probability density distributions in a manner analogous to known perturbative phenomena, including the Stark and Zeeman effects. The induced anisotropy of charge and current distributions affects angular momentum dynamics and contributes to the effective response of matter to the external gravitational field.

2.3 Equivalence of gravitational and inertial mass.

An important consequence of this framework is a natural explanation of the equivalence between gravitational and inertial mass. In both cases, the observed response of matter arises from the same underlying electrodynamic structure. The distinction lies in the origin of the perturbation: mechanical acceleration primarily displaces atomic nuclei, while gravitational interaction primarily perturbs the internal electromagnetic field. In both situations, the resistance of matter is governed by the same internal dynamics, leading to proportionality between inertial and gravitational masses. The equivalence of inertial and gravitational mass is explained by the identical nature of matter's response to external action. The difference lies in the primary mechanism: under mechanical action, the nuclear structure of matter is displaced first, and the internal electromagnetic field exerts resistance, whereas under gravitational influence, gravity first affects the internal electromagnetic field of the substance and the nuclear structure , the structure exerts resistance. In fact, inertial and gravitational masses function as identical proportionality coefficients in two variants.

Reaction of a substance to mechanical impact. When external mechanical force is applied (e.g., compression, tension, or shear), atoms shift from their equilibrium positions. This shift causes internal electromagnetic fields to counteract, seeking to return the atoms to their original position. As a result, the internal electromagnetic structure of the substance counteracts external influences. The inertial mass of a substance is determined by the balance of interatomic forces and the structural substance and determines the inertial properties of the material. For example, a crystal lattice is an ordered arrangement of atoms, ions, or molecules in space, where each node is characterized by fixed coordinates. Atoms are in equilibrium due to the balancing forces of attraction and repulsion between them through electromagnetic interaction. When mechanical stress is applied to the crystal lattice, atoms can shift due to a disturbance in the equilibrium of interatomic forces. The displacement of atoms in the crystal lattice because of mechanical stress leads to the displacement of atoms in the crystal that are connected to each other by electromagnetic fields. As a result, these fields counteract change and strive to return atoms to their original state.

The reaction of a substance to gravitational influence. The gravitational field passes through the structure of the substance in the form of directed pulsating electric and magnetic fields ("E" and "H"- fields) and interacts with the internal electromagnetic field of the substance. The change in this field is counteracted by the rotating microparticles of the substance, whose angular moments retain their previous direction and prevent the axis of rotation from tilting, i.e., the action of gravity. Thus, the force of gravitational attraction is proportional to the mass of the substance. (Figure 9).



a) b) c)

Figure 9 - Reaction of the crystal lattice (a) to mechanical (b) and gravitational effects (c):

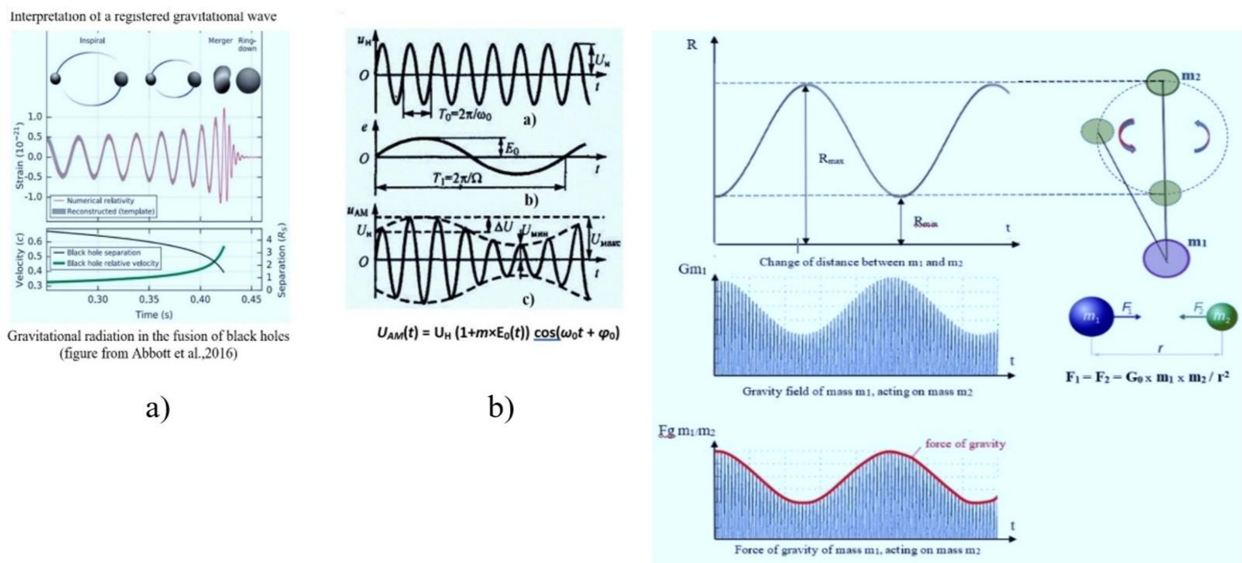
a) crystalline lattice with microparticles arranged at fixed lattice nodes interaction of the internal electromagnetic field; b) mechanical stress causes microparticles in the crystal lattice to shift, while the internal electromagnetic field prevents deformation of the nodes; c) the gravitational field, in the form of pulsating "E" and "H" fields, interacts with the internal electromagnetic field of the lattice, while the microparticles at the lattice nodes counteract this.

Conclusion: the equality of the inertial and gravitational masses of matter follows from the identical physical mechanism of the reaction of the structure of matter to external influences.

2.4 Temporal variation of the gravitational field as amplitude modulation

In contemporary gravitational physics, time-dependent variations of gravitational interaction are commonly interpreted in terms of gravitational waves emitted by accelerating or orbiting masses. Within general relativity, these phenomena are described as propagating perturbations of spacetime geometry that carry information about the dynamics of their sources.

Within the framework of the proposed Physical Theory of Gravity, temporal variations of the gravitational field are interpreted in a complementary manner. Rather than introducing an independent class of propagating waves, changes in gravitational interaction are associated with modulation of an underlying multimode field formed by radially pulsating electric and magnetic components. From this perspective, the motion, oscillation, or rotation of massive bodies modifies the amplitude, phase, and spectral composition of the existing gravitational field generated by matter. These modifications propagate through space as variations of field intensity, analogous to amplitude modulation in classical wave systems (Figure 10).



a) b) c)

Figure 10 - Structure of gravitational waves:

a - interpretation of a registered gravitational wave signal.

b - an example of amplitude modulation (AM) of electric signals.

c - gravitational field during relative movement of two masses, m_1 and m_2. Changes in the distance between bodies m_1 and m_2 during rotation of m_2. Structure of the gravitational field G (t) during changes in the distance and changes in the attraction force between bodies m_1 and m_2.

In this interpretation, the information about the dynamics of the source - such as orbital motion or rotational frequency - is encoded in the temporal modulation of the field amplitude rather than in the emission of independent transverse waves. The observed effects attributed to gravitational waves correspond to time-dependent changes in the local gravitational field experienced by matter, arising from the collective modulation of microscopic field contributions.

Importantly, this approach does not contradict existing experimental observations of gravitational-wave phenomena. The detected signals, including characteristic frequencies and amplitudes associated with astrophysical sources, can be interpreted as manifestations of large-scale amplitude modulation of the gravitational field generated by coherent motion of massive systems. The measurable strain observed in detectors reflects the response of matter to these modulated field configurations.

A key distinction of the proposed interpretation lies in the physical nature of the field variation. While general relativity describes gravitational waves as geometric perturbations of spacetime, the present framework attributes observed gravitational-field variations to physical modulation of an underlying field structure associated with matter. In this sense, gravitational waves are not treated as independent carriers of energy but as dynamic states of the gravitational field itself.

This viewpoint emphasizes continuity between static gravitational interaction and its time-dependent variations. Such an interpretation provides a physically intuitive picture of gravitational variability while remaining consistent with empirical observations.

From the point of view of the new theory, changes in gravity are equivalent to amplitude modulation of the wave, i.e., changes in the amplitude of the wave by means of a control signal.

In this interpretation, information about the dynamics of the source—such as orbital frequencies or rotational motion—is encoded in the temporal modulation of the field rather than in the emission of independent transverse waves. The experimentally observed signals attributed to gravitational waves correspond to time-dependent changes in the local gravitational field experienced by matter, arising from coherent modulation of microscopic field contributions.

Importantly, this interpretation does not contradict existing experimental observations of gravitational-wave phenomena. Detected signals, including characteristic frequencies and amplitudes associated with astrophysical sources, may be understood as manifestations of large-scale modulation of the gravitational field produced by coherent motion of massive systems. The measured response of detectors reflects the interaction of matter with these modulated field configurations.

A key distinction of the proposed approach lies in the physical interpretation of field variability. While general relativity describes gravitational waves as geometric perturbations of spacetime, the present framework attributes observed gravitational-field variations to physical- -modulation of an underlying field structure associated with matter. In this sense, gravitational waves are treated not as independent carriers of energy, but as dynamic states of the gravitational field itself.

This viewpoint emphasizes continuity between static gravitational interaction and its time-dependent variations and provides a physically intuitive picture of gravitational variability while remaining consistent with empirical observations.

3. Research Conclusions: Prospects for a Physical Interpretation of Gravity in Cosmology

3.1 Proposed physical interpretation of gravity

The proposed Physical Theory of Gravity:

- offers a physically motivated interpretation of the emergence of gravitational fields and their interaction with matter.
- allows a phenomenological interpretation of the carrier of gravitational interaction in terms of quanta of radially pulsating fields (gravitons) [27, 28].
- introduces a phenomenological concept of possible time discreteness through a minimal characteristic interval (chronon) [29,30].
- provides a framework for qualitative and phenomenological descriptions of gravity at the quantum level.
- offers possible interpretations of certain gravitational anomalies (e.g., ball lightning, large-scale cosmic expansion).
- suggests that phenomena commonly attributed to "dark energy" may be interpreted as manifestations of large-scale gravitational fields, potentially associated with pulsating electromagnetic activity in the X-ray and gamma-ray frequency ranges (10^{19}–10^{23} Hz).
- demonstrates conceptual compatibility between quantum-mechanical descriptions and gravitational interaction.
- may serve as a conceptual basis for further studies aimed at the unification of fundamental interactions [1,2,3,4].

3.2 Gravity as a fundamental interaction of the Universe

The proposed Physical Theory of Gravity offers a complementary perspective on gravitational interaction by emphasizing physically motivated mechanisms associated with the internal structure and collective dynamics of matter. While the present formulation remains phenomenological, it provides a coherent framework for interpreting gravitational phenomena across different physical scales.

One of the principal strengths of this approach lies in its ability to establish a direct conceptual connection between microscopic processes in matter and macroscopic gravitational effects. By associating gravitational interaction with collective electrodynamic activity of charged constituents, the theory offers a unified physical interpretation of gravity that does not rely exclusively on geometric abstraction. This feature may be particularly valuable in regimes where purely geometric descriptions encounter conceptual or interpretational limitations.

The proposed framework also provides a natural context for examining the equivalence of inertial and gravitational mass, as both are interpreted as manifestations of a common physical response of matter to external influence. This interpretation offers a physically transparent view of the equivalence principle and suggests possible directions for exploring its applicability under non-equilibrium or extreme conditions.

Another important aspect concerns the interpretation of time-dependent gravitational phenomena. By treating variations of the gravitational field as amplitude modulation of an underlying physical field, the theory establishes conceptual continuity between static gravitational interaction and its dynamic manifestations. This viewpoint may contribute to alternative physical interpretations of gravitational-wave observations while remaining compatible with existing experimental results.

The Physical Theory of Gravity does not seek to replace established theoretical frameworks such as general relativity, which remain indispensable for accurate quantitative predictions. Instead, it aims to complement these theories, in particular the BBT by addressing questions related to physical mechanism, causality, and interpretation. In this sense, the proposed framework may serve as a basis for further theoretical development, numerical modeling, and targeted experimental investigation. Finally, the physical interpretation introduced here provides a methodological bridge to other areas of fundamental physics in which similar conceptual challenges arise, particularly in the description of quantum phenomena that are currently addressed primarily through mathematical formalisms.

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