Breakthrough in Understanding Time: How p-Gluon Geometry Explains Time Dilation and the Programmable Nature of Reality

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Abstract

This paper presents a philosophical hypothesis aimed at providing a new ontology for fundamental physics. We postulate that observable reality – including matter, energy, and interactions – is a secondary manifestation of states of a dynamic, geometric essence whose fundamental quanta are **p-gluons** (bubble gluons). Spacetime, quantized into p-gluons, constitutes a fundamental screen upon which reality is displayed as dynamic activation patterns. The laws of physics serve as a rendering algorithm, determining the evolution of these patterns in time. A key element of the model is the distinction between the colossal **structural energy** of p-gluons, frozen in geometry, and the minuscule **activation energy** that drives observable physics.

1 Terminological Note: p-Gluons as Geometry Quanta

In this work, I introduce the term **"p-gluon"** (bubble gluon) to distinguish it from the gluon known from the Standard Model of particle physics. This deliberate terminological evolution has deep philosophical meaning and results from significant conceptual similarities, while simultaneously emphasizing fundamental ontological differences.

- **In the Standard Model**: Gluons are carriers of strong interactions *between particles* in existing spacetime. They interact with themselves, leading to the non-abelian nature of strong interactions.
- **In this theory**: **p-Gluons** are **fundamental quanta of spacetime itself**. They serve both as the "building blocks" of geometry and as universal carriers of all interactions through changes in local geometric polarization. The "bubble" concept captures their nature as elementary units of spacetime "foam".

1.1 Justification of Terminology Choice

The name "p-gluon" (bubble gluon) was chosen for four key reasons:

1. **Self-Interaction**: Similar to Standard Model gluons, p-gluons interact with themselves, creating a dynamic network of mutual connections. Their "repulsion" under compression constitutes the source of strong interactions.
2. **Binding Nature**: Both concepts describe entities that "glue" reality together – in one case, quarks in hadrons; in the other case, geometric Z2 fasteners into stable matter configurations [2].
3. **Interaction Mediation**: In both frameworks, gluons are mediators of interactions, though at completely different levels of fundamentality. The p-gluon is a universal mediator.
4. **Z2 Fasteners Concept**: The mechanism of geometric "fasteners", described in a separate work by the author [2], directly corresponds to the concept of p-gluons as spacetime quanta creating anchoring points for interactions.

1.2 Fundamental Differences

Despite terminological similarities, the differences are profound:

- **Ontological Status**: In the Standard Model, gluons are particles *in* spacetime. In this theory, **p-gluons *are* spacetime**.
- **Universality**: p-Gluons are the source of **all** interactions, not just strong ones. Electromagnetic interaction is the propagation of excitation states in the p-gluon network, and gravity is the emergent tension of the entire network.

- **Scale**: Standard Model gluons operate at nuclear scales ($\sim 10^{-15}$ m), while p-gluons exist at the Planck scale ($\sim 10^{-35}$ m).

The conscious use of a new, related name emphasizes the unifying character of the proposed theory, in which strong interactions turn out to be a particular manifestation of fundamental spacetime geometry.

2 Basic Hypothesis

2.1 Geometric Ontology

We postulate that the fundamental substrate of reality is not particles or fields in space, but **geometric spacetime** of discrete, quantum nature. The basic entity is the **p-gluon**, understood as the fundamental quantum of this spacetime, modeled as a "bubble" in fundamental foam. p-Gluons form a dense, dynamic network, constituting a universal "screen" upon which reality is displayed.

2.2 Emergence of Physical Phenomena

All observable entities and forces are emergent properties of states of this geometric p-gluon network:

- **Matter** consists of stable, condensed geometric states (**ZKP** – Compact Vacuum Configuration), being local configurations of p-gluons with elevated activation energy. The ZKP concept and its opposing state RKP (Expanded Vacuum Configuration) have been discussed in detail in [1].

- **Energy** represents the measure of total energy density in the p-gluon network. It manifests in two ways: as energy associated with the internal state of the 'bubble', and through the response of its geometric scaffolding to external interactions. It is precisely the resistance of this scaffolding against deformation that accounts for the phenomenon of 'mass acquisition' by quarks, which fully reveals itself when they combine into hadrons. Thus, most of the nucleon mass originates not directly from the rest mass of quarks, but from energy stored in the deformed geometry of p-gluons – being a direct manifestation of their structural energy. This mechanism offers a geometric explanation for the famous equality $E=mc^2$, where mass turns out to be a manifestation of energy stored in the deformed geometry of fundamental spacetime.

- **Interactions** are consequences of the dynamic tendency of the network toward geometric equilibrium. The strong nuclear force is the mechanical resistance of p-gluons subjected to compression, which finds development in the concept of Z2 fasteners [2].

- **Photon** constitutes a quantum excitation propagating through the p-gluon network as a sequence of changes in their geometric states. The speed of light c is the maximum, unsurpassable speed of this propagation, resulting from fundamental dynamic limitations of the spacetime network itself.

3 Calculation of Fundamental Scale: p-Gluon as Spacetime Quantum

3.1 Two-Aspect Model of p-Gluon

The solution to the paradox of low vacuum energy density is the distinction between two aspects of the p-gluon as a spacetime quantum:

1. **Structural Energy (E_S)**: The maximum energy that a p-gluon *can contain* as a fundamental spacetime quantum. This is the property defining existence itself - the "cost of existence" of a geometry quantum, associated with maintaining the very "bubble" structure. For a p-gluon at Planck scale, $E_S \sim E_P$.

2. **Activation Energy (E_A)**: The actual energy *stored* in a p-gluon in a given state, corresponding to its excitation or polarization. It is precisely the changes in E_A together with E_S that manifest as observable physics - matter, interactions, vacuum pressure.

3.2 Philosophical Interpretation

The value $k = E_A/E_S \sim 10^{-123}$ means that **fundamental geometry operates on a minuscule fraction of its full power**.

The chasm between E_S and E_A constitutes a solution to the hierarchy problem in fundamental physics and finds natural explanation in the context of higher-dimensional geometry and the concept of energy "precipitation".

3.3 Calculation of Fundamental Length Scale

The structural energy of a p-gluon is related to its length scale by the relation:

$$E_S \sim \frac{\hbar c}{L} \tag{1}$$

Assuming that E_S is on the order of Planck energy ($E_P = \sqrt{\hbar c^5/G} \approx 1.96 \times 10^9$ J), we obtain:

$$L \sim \frac{\hbar c}{E_P} = \sqrt{\frac{\hbar G}{c^3}} = L_P \approx 1.6 \times 10^{-35}\,\mathrm{m} \tag{2}$$

The obtained result confirms that the p-gluon as a spacetime quantum naturally exists at the **Planck scale**.

3.4 Paradox of Low Vacuum Energy Density

The observed vacuum energy density $\rho_{\mathrm{obs}} \approx 6 \times 10^{-10}\,\mathrm{J\,m^{-3}}$ is extremely low compared to the structural energy density:

$$\rho_S \sim \frac{E_P}{L_P^3} \approx 10^{113}\,\mathrm{J\,m^{-3}} \tag{3}$$

The ratio $\rho_{\mathrm{obs}}/\rho_S \sim 10^{-123}$ finds natural explanation: the observed energy density corresponds only to the basic level of **activation energy** E_A of p-gluons in vacuum, while the main part of energy (E_S) is "frozen" in geometry and constitutes background renormalized to zero. The efficiency coefficient for vacuum thus equals:

$$k_{\mathrm{vacuum}} = \frac{\rho_{\mathrm{obs}}}{\rho_S} \sim 10^{-123} \tag{4}$$

4 Structure of Matter in Quantum Geometry

4.1 Emergence of Elementary Particles

In the proposed paradigm, elementary particles are not points, but emergent configurations of p-gluons. While conventional physics treats the electron as a point particle, in the geometric approach it must occupy a finite volume. Taking the Compton wavelength of the electron $\lambda_C = \frac{\hbar}{m_e c} \approx 3.9 \times 10^{-13}\,\mathrm{m}$ as the natural scale, we obtain an energy density on the order of $\sim 10^{24}\,\mathrm{J\,m^{-3}}$. This value, being 89 orders of magnitude below the Planck density, suggests that the electron represents a state of relatively low geometric excitation.

4.2 Concept of Effective Activation Energy

A key ontological postulate is the distinction between the full structural energy of a p-gluon and the energy participating in certain interactions:

$$E_A = k \cdot E_S \tag{5}$$

where:

- $E_S \sim \frac{\hbar c}{L_P}$ - structural energy of p-gluon (on the order of Planck energy)
- k - fundamental efficiency coefficient
- E_A - activation energy participating in emergent physics

4.3 Hierarchy of Efficiency Coefficient

The value of coefficient k varies depending on the state of spacetime:

- **Basic vacuum:** $k_{\text{vacuum}} \sim 10^{-123}$
- **Material states:** $k_{\text{matter}} > k_{\text{vacuum}}$ (value dependent on degree of geometric excitation)
- **Quasi-material states:** k takes intermediate values, corresponding to dark matter [5] and dark energy [4]

4.4 Interpretation of Coefficient k

The value $k \sim 10^{-123}$ for vacuum is not a "constant to be fitted". It is a **fundamental property of programmable spacetime geometry**, determining the ratio:

$$k = \frac{E_A}{E_S} \tag{6}$$

This value means that:

> *"Programmable spacetime geometry operates on a minuscule fraction ($\sim 10^{-123}$) of its full computational/energetic power in the ground state. The physics we observe is an emergent manifestation of this minimal level of activation of the fundamental p-gluon network, while material states represent locally increased levels of excitation."*

4.5 Computer Analogy

> *"Programmable spacetime geometry resembles a supercomputer using most often* 10^{-123} *of its computational power at rest. The physics we observe is like a simple program running on this powerful hardware - it uses a minuscule fraction of available resources, while most of the power remains 'dormant' in the fundamental structure of p-gluons. The formation of matter corresponds to a local increase in computational power utilization."*

This analogy explains why:

- We observe such low vacuum energy density
- Matter emerges from geometric configurations
- The laws of physics appear 'fine-tuned'

4.6 Problem of Mass Emergence

The complete determination of the relationship between geometry and energy in mass emergence remains an open problem in the proposed approach. While the concept of structural and activation energy offers an elegant explanation of the hierarchy problem, the mechanism generating specific values of elementary particle masses requires further development of the dynamic formalism describing interactions in the p-gluon network.

5 Philosophical Consequences

The proposed hypothesis leads to the following philosophical consequences:

1. **Primacy of Geometry:** Geometric properties are primary to material properties. Matter is "bent" spacetime.
2. **Reality as Process:** Reality is more a dynamic set of events and relations (activations in the network) than a set of static objects.
3. **Energy Hierarchy:** Emergent physics operates on a minuscule fraction ($k \sim 10^{-123}$) of the full geometry energy, which solves the hierarchy problem.

4. **Unification of Principles:** The holographic principle finds natural and elegant explanation within the proposed ontology. The basic "screen" is the ubiquitous p-gluon network, where each p-gluon serves as a fundamental "pixel" of reality. Information about the state of every physical system is encoded in the dynamic configurations of these very components.

   We postulate that every physical entity – such as a proton – can be described at three equivalent levels: as a material particle, as a probabilistic wave, or as pure information. Each of these approaches is true, and the choice of perspective depends on the observational context. In the informational approach, "material" reality turns out to be displayed information on the fundamental screen of p-gluons.

   This perspective offers an intuitive explanation for the seemingly paradoxical predictions of relativistic physics. Time dilation and the twin paradox cease to be puzzling when we understand that "reality" is a dynamic stream of information rendered on the p-gluon network. In the relativistic approach, this "film" simply slows down or speeds up depending on boundary conditions.

5. **Limits of Reality:** The speed of light c is a fundamental limit of the geometric "bonding" between p-gluons, not merely the speed of signal propagation.

6. **Dynamic Character of Reality:** The difference between vacuum and matter is one of degree, not kind – constituting a continuum of possible levels of geometric excitation.

6 Explanation for the Unsurappassability of Light Speed

This concept offers a new, ontological explanation for the unsurappassability of light speed c, which fundamentally differs from approaches adopted in main physical theories.

6.1 Position of Contemporary Physics

- **Einstein's Relativity:** Light speed c is a fundamental postulate and constant appearing in the equations. The phenomenon of mass increase at relativistic

velocities is a **mathematical description** resulting from Lorentz transformations, rather than an explanation of the physical mechanism behind this barrier.

- **Quantum Field Theory:** Speed c is built into the theory's structure through Minkowski spacetime metric. Massless particles move at c by definition. Similar to GR, this theory provides a description but does not indicate the fundamental **mechanism** that prevents exceeding c.
- **Loop Quantum Gravity and String Theory:** These theories attempt to quantize spacetime. Nevertheless, light speed c is usually **assumed** as a fundamental constant, not an emergent property. They lack the concept of "structural energy" of spacetime itself as a physical barrier.

6.2 Uniqueness of the Proposed Mechanism

The proposed approach radically changes the perspective:

1. Speed c is treated as an **emergent property**, resulting from properties of the dynamic p-gluon network, not as a primitive postulate.
2. A physical energy barrier is introduced in the form of **structural energy** of spacetime, estimated at $\sim 10^{113}\ \mathrm{J\,m^{-3}}$. Attempting to exceed c would require overcoming this energy, which is physically impossible.
3. The mechanism explains the phenomenon of "relativistic mass" increase as the **transformation of kinetic energy into work deforming the geometry** of the fundamental network. Energy supplied to accelerate an object is actually consumed for reconfiguring the states of p-gluons from which this object consists.

6.3 Perspective Shift

In the conventional approach, a particle exists **in** spacetime and moves through it. In this model, a particle **is** a specific configuration of spacetime. Consequently, "acceleration" is understood not as movement *through* static background, but as **propagation of state change** in a dynamic network. Light speed is the fundamental limit of the speed at which this change can propagate.

6.4 Historical Context

Even the historical concept of ether in the Lorentz and Fitzgerald approach, which treated it as a medium for light, did not go this far. Ether was a medium through which one moved, and c was the speed relative to it. The concept was missing that the medium itself possesses such colossal **intrinsic structural energy** that physically prevents exceeding the propagation speed of excitations within it.

6.5 Mechanism of Time Dilation in p-Gluon Geometry

The proposed approach offers a unified explanation for both relativistic and gravitational time dilation. In both cases, the foundation is the **deformation of the geometric structure of p-gluons**:

- **In the relativistic scenario**, accelerating a material object to speeds close to c causes gradual **compression of p-gluons** both in the surrounding spacetime and in the very structure of the accelerating object. This geometric compression manifests as an increase in "relativistic mass" – a phenomenon analogous to the process of "dressing" bare quarks with binding energy during hadron formation.
- **In the gravitational scenario**, strong gravitational fields exert analogous **pressure on p-gluon geometry**, permanently deforming their structure.

In both cases, the overloaded p-gluon geometry responds by **decreasing the rendering rate of reality**. The spacetime "film" slows its frames when fundamental pixels – p-gluons – work under increased geometric load.

This perspective reveals a deep unity: **motion and gravity are different manifestations of the same fundamental interaction with the geometric fabric of reality**.

7 Summary

The Hypothesis of Geometric Foundation of Reality offers a coherent paradigm in which physics returns to its Platonic roots. A key achievement of the proposed approach is the ontological explanation for the unsurappassability of light speed c, shifting it from the level of mathematical postulate to the level of **physical property** of fundamental reality fabric. Unlike mainstream physics, which takes c

as given, this concept identifies this fundamental barrier with the colossal structural energy of spacetime itself, estimated on the order of 10^{113} J m^{-3}. It presents a concrete mechanism in which energy supplied to accelerate an object is actually consumed for work deforming the geometric network of p-gluons, which manifests as an increase in "relativistic mass" and constitutes the physical reason for the impossibility of exceeding c.

The proposed distinction between structural and activation energy in the p-gluon network provides an elegant explanation for both the Planck scale and the problem of low cosmological constant value. This model, rooted in the concept of p-gluon "foam", constitutes a promising starting point for developing a mathematical formalism describing the emergence of physical laws from the dynamic network of spacetime quanta.

References

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