# The Vacuum Radio: A Geometric Framework for Toroidal Matter Transmission under the Principium Geometricum

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**Abstract**

We propose a geometric framework in which *matter transmission* arises as a natural extension of wave propagation under the Principium Geometricum (PG). The vacuum is not an empty background but a geometric medium endowed with intrinsic tension, characterized by the unified constant $\alpha_U = k_e A_P$. Light and radio waves are open modes of this tensional field; matter corresponds to stationary toroidal oscillations.

We introduce a triplet $(A, \Theta, \Psi)$ that encodes the tensional amplitude, toroidal phase, and helicoidal topology of the vacuum. The associated signal

$$S(t) = \int_V \Phi(x,t)\, dx, \qquad \Phi(x,t) = A(x,t)\, e^{i\Theta(x,t)} \Psi(x,t),$$

acts as a "vacuum radio": a modulation of temporal tension capable of propagating the geometric signature of matter through space. At the receiving end, when the local vacuum reaches phase coherence with the incoming signal, a stationary toroidal pattern self-organizes and the corresponding atom (or structure) is recreated as a new instance of the same geometric state. No mass or charge is transported; only coherence information is.

The framework suggests a deep equivalence between energy, geometry, and information in the PG field. It bridges electromagnetism, gravitation and quantum-like discreteness in a single tensional ontology, and points towards a *matter transceiver* as a long-term technological realization: a device that encodes, transmits, and reconstructs matter as coherent patterns of vacuum tension.

**Keywords:** geometric vacuum; toroidal coherence; matter transmission; information physics; Principium Geometricum.

## Contents

# 1 Introduction

In conventional field theory, the vacuum is often treated as a passive background: a stage on which particles and fields interact. Quantum field theory refines this picture by endowing the vacuum with fluctuations and zero-point energy, yet the ontology remains dual: on one side "fields", on the other "particles" as excitations [7, 8]. Gravitation, in turn, is described as curvature of spacetime in general relativity [1], while matter is introduced as an external stress–energy source. The resulting patchwork is operationally successful but conceptually fragmented.

The Principium Geometricum (PG) offers an alternative: a unified geometric picture in which vacuum, light, inertia, gravity and matter arise as different regimes of a single fundamental oscillatory field defined on a toroidal spacetime manifold $T^3$. In this ontology, the vacuum possesses intrinsic *tension*, quantified by a unified constant

$$\alpha_U = k_e A_P, \qquad A_P = \ell_P^2 = \frac{\hbar G}{c^3}, \tag{1}$$

linking electromagnetism and gravitation in one scale [9, 10]. Matter appears as a toroidal soliton of this field; light and radio waves are its propagating modes.

This article pushes that idea one step further. If sound transmits pressure coherence through air, and electromagnetic radio transmits field coherence through the vacuum, then *matter transmission* can be understood as the coherent replication of the vacuum itself: the transport of a complete geometric pattern able to recreate a stationary toroidal node elsewhere.

We formalize this as a *vacuum radio*. A material entity is described by a triplet $(A, \Theta, \Psi)$ encoding amplitude (tensional density), toroidal phase (time-of-time modulation), and helicoidal topology (geometric spin). Its global projection $S(t)$ plays the role of a modulated carrier signal. When this signal crosses a region of vacuum capable of phase locking at the same fundamental frequency, the local geometry re-organizes into a copy of the original toroidal state. No substance is transported; instead, the vacuum reorganizes itself under precise coherence constraints. Energy provides amplitude; information provides form.

The goals of this paper are:

1. To formulate a consistent mathematical framework for the encoding of matter as a geometric signal $S(t)$ on the PG vacuum.

2. To derive the propagation equation for this signal, its energy and coherence constraints, and its relation to standard electromagnetic radio.

3. To describe the conditions under which propagation turns into stationary reconstruction: the "receiving" side of the vacuum radio.

4. To discuss the physical consequences, including hierarchical coherence of the Universe, information-theoretic implications, and the long-term possibility of a matter transceiver.

Our approach sits conceptually between Wheeler's geometrodynamics [2], Dirac's zero-point field ideas [3], and modern information-theoretic treatments of physics [4, 5, 6]. The difference is that the PG field is taken as the unique ontological entity: the field *is* the substance, and the substance *is* the field.

## 2 Geometric ontology of the vacuum

The PG postulate is simple: the vacuum is an active geometric medium with intrinsic tension and curvature. Every physical entity—from light to matter—is an oscillatory configuration of this medium. The fundamental oscillatory law of the PG vacuum is expressed through the "time-of-time" operator:

$$T(t) = \alpha_U \sin(\Omega t) + A_P \cos(\Omega t), \tag{2}$$

where $A_P = \ell_P^2$ is the Planck area, $\alpha_U = k_e A_P$ defines the unified impedance (or tensional constant) of space, and $\Omega$ is the fundamental frequency, naturally associated with the Planck time $t_P$, i.e. $\Omega \sim 1/t_P = \sqrt{c^5/(\hbar G)}$.

The vacuum is characterized not by a naive energy density, but by a *tensional density*, defined as

$$\rho_T = \frac{1}{2}\dot{T}^2 + \frac{1}{2}\Omega^2 T^2, \tag{3}$$

which measures the oscillatory inertia of the geometric field. In this language, matter is a *closed toroidal resonance* of $T(x,t)$: a self-sustained mode on $T^3$ satisfying a wave equation with topological closure.

At the level of a scalar field on spacetime, we write

$$\nabla^2 T - \frac{1}{c^2}\frac{\partial^2 T}{\partial t^2} = 0 \quad \Longrightarrow \quad T(x,t) = f(\alpha_U, \Omega)\,\sin(\Omega t + \varphi(x)), \tag{4}$$

subject to closure conditions on the toroidal manifold $T^3$. The function $T(x,t)$ describes the self-sustaining oscillation of the vacuum: the essence of what is perceived as "mass" or "particle".

This interpretation collapses the traditional dichotomy between "field" and "substance". A propagating wave is an open mode; matter is a closed mode. The transition from propagation to stationarity is governed by a *coherence condition*

$$\partial_t T = 0 \quad \text{(on average over a period)}, \tag{5}$$

which marks the stabilization of the vacuum into a stationary toroidal node.

In this view, every atom, planet or star is a specific configuration of the same vacuum substrate. The diversity of the Universe arises from differences in geometric phase and topology, not from multiple substances. The vacuum, in principle, contains all possible configurations of matter, awaiting only the correct phase information to self-organize.

## 3 Mathematical framework for matter encoding

If the vacuum is a geometric medium capable of supporting oscillatory modes, the complete description of a material entity must include three interdependent parameters: amplitude, phase, and topology. Under PG, these are grouped as the triplet

$$(A, \Theta, \Psi), \tag{6}$$

where $A(x,t)$ is the tensional amplitude, $\Theta(x,t)$ the toroidal phase, and $\Psi(x,t)$ the helicoidal topology.

### 3.1 The amplitude field

The amplitude $A(x,t)$ defines the local tensional density of the vacuum:

$$A(x,t) = \frac{\rho_T(x,t)}{\rho_T^{\max}}, \tag{7}$$

with $\rho_T$ given by (3) and $\rho_T^{\max}$ a reference scale, naturally taken at Planck tension. In an open (wave-like) regime, $A$ fluctuates around zero mean; in a closed (matter-like) regime, $A$ remains bounded and self-sustained, corresponding to a toroidal node of coherence.

### 3.2 The toroidal phase

The toroidal phase $\Theta(x,t)$ encodes the geometric information of the oscillation in the time-of-time domain:

$$\Theta(x,t) = \Omega t + \varphi(x), \tag{8}$$

where $\varphi(x)$ carries the local phase lag induced by curvature and torsion of the manifold. Changes in $\Theta$ represent microscopic shifts in the internal clock of the vacuum.

For two distinct regions $i$ and $j$, the relative phase difference

$$\Delta\Theta_{ij}(t) = \varphi_i(t) - \varphi_j(t) \tag{9}$$

acts as a generator of interaction: matter interacts because its local time-fields are out of phase. PG thus interprets forces as tendencies towards phase alignment or dephasing in $\Theta$.

### 3.3 The helicoidal topology

The third element, $\Psi(x,t)$, encodes the topological winding of the field lines—the geometric analogue of quantum spin. It can be represented by a three-component vector

$$\Psi(x,t) = (\psi_r, \psi_\theta, \psi_\phi), \tag{10}$$

with each component describing directional coherence of the toroidal mode. Transitions in $\Psi$ correspond to discrete torsional changes of the vacuum, analogous to spin flips in atomic transitions, but derived purely from topology and boundary conditions.

The winding number

$$n = \frac{1}{2\pi} \oint \nabla\Theta \cdot d\ell \tag{11}$$

quantizes the topology of the toroidal mode. It plays a role similar to topological charge or spin, but without invoking an independent internal space.

### 3.4 Unified representation of matter

Combining these three fields yields the complete state function of a geometric entity:

$$\Phi(x,t) = A(x,t)\, e^{i\Theta(x,t)}\, \Psi(x,t), \tag{12}$$

which plays the role of a *toroidal wavefunction*. Unlike the probabilistic $\psi$ of standard quantum mechanics, $\Phi$ is a deterministic field describing the instantaneous geometry of the vacuum.

The signal to be transmitted is the temporal projection of this field over a volume $V$:

$$S(t) = \int_V \Phi(x,t)\, dx, \tag{13}$$

which represents the encoded pattern of coherence. Equation (13) is formally analogous to the modulation of a radio signal: ordinary radio transmits variations of electromagnetic amplitude and phase; the *vacuum radio* transmits variations of geometric tension and toroidal phase.

### 3.5 Implications for information theory

In this sense, matter itself is an information carrier. Its encoding can be seen as a geometric compression of the vacuum's degrees of freedom. The minimal informational content required to specify a particle is tied to the resolution with which the triplet $(A, \Theta, \Psi)$ must be defined.

According to Landauer's principle, erasing one bit of information requires a minimal energy $k_B T \ln 2$ [4]. In PG, this corresponds to the minimal tensional change necessary to disturb the coherence of the vacuum. The state function $\Phi$ and signal $S(t)$ thus provide both a geometric and informational definition of matter: a localized, self-referential pattern of oscillation capable of being encoded, transmitted, and reconstructed.

## 4 Transmission through the vacuum

Once the local toroidal state $\Phi(x,t)$ is encoded into its temporal projection $S(t)$, the next step is to describe its *propagation* through the vacuum medium. Under PG, the vacuum supports both stationary (matter-like) and propagating (wave-like) solutions of the same underlying field equation. Transmission corresponds to the coherent transport of the time-of-time phase across the continuum.

### 4.1 Tensional wave equation

The propagation of geometric tension follows a generalized wave equation for $S(x,t)$:

$$\nabla^2 S - \frac{1}{v_T^2}\frac{\partial^2 S}{\partial t^2} = 0, \tag{14}$$

where $v_T$ is the velocity of tensional propagation in the vacuum. In free space we expect $v_T \approx c$; under curvature or local coherence constraints, $0 < v_T < c$. Equation (14) is analogous to a scalar version of Maxwell's equations, but with amplitude and phase replaced by geometric variables $(A, \Theta)$.

In complex exponential form,

$$S(x,t) = S_0 \exp[i(k \cdot x - \Omega t)], \tag{15}$$

with dispersion relation

$$\Omega^2 = v_T^2\, k^2. \tag{16}$$

This describes a "toroidal carrier": a coherent oscillation of the vacuum's tensional field.

### 4.2 Modulation and information encoding

In analogy with electromagnetic modulation, a material signal is encoded by small variations of amplitude and phase around a carrier:

$$S(x,t) = [A_0 + \delta A(x,t)]\ \exp\Big(i[\Omega t + \delta\Theta(x,t)]\Big), \tag{17}$$

where $\delta A$ and $\delta\Theta$ carry the informational content of the encoded geometry. The coherence of these modulations determines whether the transmitted pattern reconstructs matter, radiation, or simply disperses as noise at the receiver.

For stable transmission, the coherence length $L_c$ of the vacuum must satisfy

$$L_c \gg \lambda_T = \frac{2\pi v_T}{\Omega}, \tag{18}$$

ensuring that the geometric phase remains synchronized over the distance between transmitter and receiver.

### 4.3 The vacuum as carrier medium

Unlike electromagnetic waves, which propagate in a medium characterized by permittivity $\varepsilon_0$ and permeability $\mu_0$, the geometric waves propagate through a medium characterized by the tensional constant

$$\alpha_U = k_e A_P. \tag{19}$$

The intensity of the transmission is given by

$$I_T = \frac{1}{2}\,\alpha_U\, v_T\, |S|^2, \tag{20}$$

which quantifies the rate of tensional energy flow per unit area.

Because $\alpha_U$ links the Coulomb constant $k_e$ with the Planck area $A_P$, (20) naturally bridges electromagnetic and gravitational regimes in a single scale parameter. In regions of strong curvature (e.g., near massive bodies), the effective $v_T$ decreases, leading to a local redshift in the transmitted frequency—analogous to gravitational redshift, but expressed in tensional terms.

### 4.4 Energy and coherence conservation

The transmission process conserves two key quantities:

1. *Tensional energy*, proportional to $|S|^2$, representing the instantaneous deformation energy of the vacuum.
2. *Geometric phase coherence*, quantified by

$$\Gamma = \oint \nabla\Theta \cdot d\ell = 2\pi n, \tag{21}$$

which is quantized in integer multiples of $2\pi$.

Quantization of $\Gamma$ implies that transmission occurs in discrete phase packets—"quanta of geometric coherence". These packets carry no rest mass but encode the local phase signature of matter.

### 4.5 Analogy with conventional radio

Phenomenologically, the process is close to conventional radio. The emitter modulates the local tensional field according to the encoded pattern $S(t)$; this modulation travels through the vacuum, preserving coherence as long as $\alpha_U$ and $\Omega$ remain stable. The receiver, tuned to the same $\Omega$, interprets the phase oscillations as geometric tension, reconstructing a stationary toroidal state (see Section 5).

Where classical radio oscillates the electromagnetic field, the vacuum radio oscillates the *tension of spacetime itself.*

## 5 Reception and toroidal reconstruction

When the transmitted signal $S(t)$ reaches a region of the vacuum tuned to the same fundamental frequency $\Omega$, reconstruction occurs through phase locking between incoming and local oscillations. The receiver is not an external device but a portion of the vacuum forced into resonance with the transmitted geometric phase.

### 5.1 Phase synchronization condition

Reconstruction begins when the local field $T_r(x,t)$ satisfies the coherence condition

$$\Delta\Theta(x,t) = \Theta_r(x,t) - \Theta_s(x,t) \longrightarrow 0, \tag{22}$$

where $\Theta_s$ is the phase of the transmitted signal and $\Theta_r$ that of the receptor region. Once this synchronization is achieved, the local vacuum adopts the same oscillatory pattern as the source, and the toroidal resonance re-emerges:

$$T_r(x,t) = A_r(x,t)\, e^{i\Theta_s(x,t)}\, \Psi_r(x,t). \tag{23}$$

If $\Psi_r$ obeys the same topological boundary conditions as $\Psi_s$, the reconstructed field retains the same helicoidal orientation, recreating the same geometric structure of the original matter.

### 5.2 Energy threshold for geometric reorganization

Reconstitution of matter requires that the incoming signal supply a minimum tensional energy density,

$$\rho_T^{(r)} \geq \rho_T^{(\mathrm{crit})} = \frac{\alpha_U^2\, \Omega^2 A_P^2}{2}, \tag{24}$$

which corresponds to the energy necessary to deform the local vacuum up to Planck-area curvature. Below this threshold, the signal propagates as a pure wave (information without embodiment); above it, the field collapses into a stationary toroidal configuration—the creation of a particle-like node.

### 5.3 Self-organization of the toroidal node

The transition from propagation to stationarity follows a self-focusing dynamics for the amplitude:

$$\frac{\partial A}{\partial t} = -\gamma\,(A - A_0) + \beta\,|\nabla A|^2, \tag{25}$$

where $\gamma$ is a local damping rate and $\beta$ is a non-linear self-coupling of the tension field. When $\beta > \gamma/\nabla^2$, solutions become spatially localized: toroidal solitons of coherence. This mechanism reproduces, in geometric form, stable bound states that in quantum mechanics appear as atomic orbitals.

### 5.4 Topological memory and identity preservation

Because the toroidal topology $\Psi$ is quantized by the winding number $n$ in (11), any reconstruction with the same $n$ reproduces the same physical identity. Matter is not *copied* but *instantiated*: each reconstruction is a new realization of the same topological code. Identity is preserved even when different instances are spatially separated, reminiscent of entanglement but expressed in strictly geometric, local terms.

### 5.5 Coherence feedback and stability

After reconstruction, the new toroidal node enters feedback with the ambient vacuum. The system stabilizes when the net flux of tensional energy through its boundary vanishes:

$$\oint_{\partial V} \mathbf{J}_T \cdot d\mathbf{A} = 0, \qquad \mathbf{J}_T = \alpha_U \, S \, \nabla\Theta, \tag{26}$$

and the structure becomes a stationary pattern of the vacuum.

Creation, persistence and destruction of matter thus correspond to three regimes of a single dynamical field: non-coherence, coherence, and saturation.

### 5.6 Physical interpretation

From the perspective of conventional physics, (24) suggests that matter reconstruction requires energy densities comparable to high-intensity lasers or plasma focus devices. PG adds a key twist: what ultimately limits the process is not *energy*, but *coherence*. If phase and topology of the incoming signal match those of the local vacuum region, reconstruction could—at least in principle—occur with minimal energy input, analogously to stimulated emission in lasers.

The Universe, in this sense, acts as a distributed resonator, capable of reproducing localized structures wherever geometric coherence conditions are met.

## 6 Discussion and physical consequences

The previous sections suggest that matter, radiation and gravitation are different manifestations of a single oscillatory substrate. The vacuum radio model establishes a continuous hierarchy of oscillatory modes, from microscopic toroidal solitons to macroscopic astrophysical structures.

### 6.1 Hierarchical coherence of the Universe

Each level of organization—particle, atom, planet, star, galaxy—can be viewed as a toroidal resonance of the vacuum tension field. Their characteristic frequencies obey a hierarchical cascade:

$$\Omega_n = \Omega_P \, 10^{-N_n}, \tag{27}$$

where $\Omega_P$ is the Planck frequency and $N_n$ indexes the coherence scale. This scaling naturally produces distinct bands where structures are stable, echoing the hierarchy observed from atomic orbitals to planetary orbits and galactic patterns [9, 11].

### 6.2 Relation to conventional physics

In the low-frequency limit, (14) reduces to an effective Maxwell-like description if torsional components of $\Psi$ are neglected. In the high-frequency (Planck) limit, the same underlying tensional dynamics average to an Einstein-like tensor, as discussed in other PG formulations [10, 9]. Electromagnetism and gravitation thus emerge as complementary projections of the same tensional vacuum.

The quantization of phase circulation (21) translates into discrete energy levels for bound toroidal states, explaining quantization without positing an independent probabilistic postulate: quantization is geometric and topological.

### 6.3 Implications for information physics

Equation (13) implies that any material structure can, in principle, be encoded as a finite signal of phase and amplitude. This bridges geometry and computation: matter is a self-referential algorithm of the vacuum. The picture resonates with the Landauer bound, with Bekenstein's entropy bound [5], and with the idea of the universe as a quantum computer [6]. PG provides an explicit geometric model for that computational substrate.

### 6.4 Technological perspective: the matter transceiver

In principle, a device able to control the triplet $(A, \Theta, \Psi)$ could scan and reproduce any localized pattern of the vacuum field. The emitter would encode the toroidal geometry of a sample into a modulated tensional signal; the receiver, by phase locking to that signal, would reorganize the local vacuum, reinstating the same matter configuration.

Such a *matter transceiver* extends radio and laser technologies into the geometric domain. Its feasibility depends not on raw energy, but on extremely precise coherence control. The vacuum becomes not a void but a programmable medium.

### 6.5 Cosmological implications

At cosmological scales, the same mechanism explains the persistence of structure across space and time. Galaxies and cosmic filaments can be viewed as large-scale toroidal resonances of the cosmic vacuum field. Gravitational waves correspond to weak modulations of $\Theta$, propagating coherence information across the Universe. Observation itself—the exchange of light—becomes a synchronization process between distant vacuum nodes.

### 6.6 Ontological closure

The PG ontology closes in a single statement:

> Everything that exists is a coherent oscillation of the vacuum; propagation, interaction and perception are three modes of the same geometric act.

The vacuum radio framework crystallizes this statement operationally: what we call "matter" is a re-excitation of form in a single geometric substrate.

### 6.7 Experimental outlook

Experimental verification can proceed along two main lines:

1. **Coherence resonance:** search for non-linear coupling between intense electromagnetic fields and weak gravitational potentials at controlled frequencies; in PG language, cross-modulation of $\Theta$ and $A$.
2. **Vacuum tension mapping:** measure tiny variations in effective dielectric and magnetic response predicted when $\alpha_U = k_e A_P$ is interpreted as a real tensional parameter. Ultra-high-$Q$ cavities or superconducting resonators provide natural testbeds.

These experiments could reveal the first empirical signatures of toroidal vacuum tension and test the quantitative predictions of the PG framework.

## 7 Conclusion

We have presented a coherent geometric framework in which matter, radiation and gravitation arise as distinct manifestations of a single oscillatory field: the geometric vacuum of the Principium

Geometricum. Within this ontology, the vacuum possesses intrinsic tension quantified by the unified constant $\alpha_U = k_e A_P$, linking the electromagnetic and gravitational domains.

The concept of a *vacuum radio* emerges naturally: if the vacuum is the carrier of all physical coherence, then modulations of its tension can transmit not only light and sound, but the complete geometric information of matter itself. The formalism developed here shows that a localized material entity can be expressed by the triplet $(A, \Theta, \Psi)$ and encoded into a coherent signal $S(t)$ whose transmission and reception obey deterministic wave equations of tensional geometry.

Matter creation, in this picture, is not violation of conservation laws but reorganization of existing vacuum tension under precise phase coherence. Energy supplies amplitude; information supplies form. The Universe behaves as a self-sustaining network of toroidal oscillators, continuously exchanging coherence between its parts.

In summary, the field is the substance, and the substance is the field. The vacuum radio framework provides a concrete step towards a unified geometric and informational description of physics and suggests a long-term technological horizon: devices that encode, transmit and reconstruct matter as patterns of vacuum tension.

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