Temporal–Density Framework (Volume 1): Dimensionless Unification and Empirical Predictions

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Comprehensive Synthesis of the Foundational Volumes

Abstract

This volume establishes the invariant relation $\alpha c\lambda = 1$ as the fundamental constraint from which all volumetric structure arises. The framework treats α as the temporal coupling, λ as the universal linear-density coefficient, and c as the single propagation invariant whose reconciliation with volume generates curvature, electromagnetism, and quantum coherence. By analysing how invariant linear flow must redistribute across three-dimensional geometry, the volume derives gravitational behaviour, vacuum impedance, and the emergence of quantised structure directly from the directional projections of a single isotropic tension field. Classical constants such as G, ε_0, μ_0, e, and $\hbar$ appear as projection coefficients required for compatibility with this invariant, rather than as independent inputs. The result is a fully dimensionless formulation in which curvature, field structure, and coherence arise from the same underlying constraint. Several empirical predictions follow immediately from the invariant and its volumetric realisation.

Contents

1 Preface: Origin and Motivation

The *Temporal–Density Framework* (TDFT) began as an attempt to understand whether gravitation and electromagnetism could share a single structural origin. What emerged from that investigation was not a new field, but the realisation that a one–dimensional invariant—the propagation constant c—is sufficient to determine the admissible geometry of space. When this invariant is required to remain radially isotropic within volumetric freedom, geometry must organise itself so as to preserve it. The dimensionless identity

$$\alpha\, c\, \lambda = 1$$

is the bookkeeping expression of that requirement: α and λ are not independent physical inputs but the volumetric response factors needed to reconcile a one–dimensional invariant with three–dimensional extension.

This reordering of assumptions has far–reaching consequences. Curvature, electromagnetism, quantised structure, and horizon formation all emerge as directional projections of a single isotropic tension field generated by the requirement that invariant linear propagation be preserved across volume. Constants such as G, ε_0, μ_0, e, and $\hbar$ appear not as fundamental quantities to be posited, but as SI projections of the same invariant constraint when expressed within a measurement domain.

The purpose of this *Reference Edition* is to present the minimal, dimensionless formulation underlying these results. It does not modify general relativity, electromagnetism, or quantum theory. Instead, it places their familiar structures on a unified ontological footing, showing how each can be read as a volumetric realisation of the same constraint. The framework therefore reduces rather than expands the number of assumptions required for a coherent physical description.

2 Introduction

Volume I of the Temporal–Density Framework (TDFT) presents the dimensionless foundations of the theory. Its purpose is to establish how a single one–dimensional invariant—the propagation constant c—determines the volumetric structure of space once it is required to remain isotropic under radial extension. The resulting constraint,

$$\alpha\, c\, \lambda = 1,$$

is not a new physical postulate but the minimal bookkeeping identity recording how an invariant linear rule expresses itself within three–dimensional geometry. The quantities α and λ are volumetric response factors, not independent constants; together they describe how radial tension must be redistributed to preserve the invariant across extended structure.

Earlier papers explored various components of this idea in isolation. Their function is now primarily historical: they document the intermediate steps that preceded the geometric realisation presented in the companion paper *Axiomatic Geometry from a Single Constraint*. The present volume replaces those earlier formulations with a unified, ontologically clean statement of the framework. Concepts such as temporal stiffness, normalisers, and algebraic correction factors are no longer required; all dimensional structure follows directly from the volumetric reconciliation of the invariant.

This volume develops the invariant substrate in a systematic progression:

1. Section 3 reformulates the invariant triad $\alpha\, c\, \lambda = 1$ in fully dimensionless terms, identifying temporal stiffness as the single intrinsic parameter underlying all projections.

2. Section 4 establishes the reassociation between intrinsic temporal quantities and conventional unit domains, clarifying how familiar constants arise as projection coefficients rather than fundamental couplings.

3. Section 5 derives the temporal–electromagnetic substrate, showing how both gravitational curvature and electromagnetic propagation emerge as directional responses of the same isotropic tension field required to preserve the invariant across volume.

4. Section 6 demonstrates that the fine–structure constant is a purely geometric ratio of temporal shear impedance to quantised action, fixing α_{FSC} as a dimensionless property of the substrate rather than an independent interaction strength.

5. Section 7 generalises the framework to gauge and quantum fields, interpreting non-abelian symmetries and quantisation as harmonic subdivisions of temporal stiffness.

6. Section 8 develops phenomenological extensions, including gravitation, light propagation, redshift, and horizon behaviour, as macroscopic expressions of stiffness gradients and temporal compression.

7. Section 9 reformulates containment and mass generation in a fully dimensionless form, identifying particles and horizons as complementary temporal saturation boundary conditions.

8. Section 10 explains dark matter as a residual of earlier gauge-phase coherence, arising from incomplete relaxation during symmetry reduction rather than from new particle species.

9. Section 11 revisits gauge symmetry to derive energy and mass hierarchies directly from group-theoretic stiffness ratios, dissolving the need for independent coupling constants.

10. Section 12 consolidates testability, outlining explicit laboratory, particle-physics, and cosmological observations capable of confirming or falsifying the framework.

The objective of *Volume I* is therefore twofold: (i) to demonstrate that volumetric geometry, field structure, and physical constants all arise from the requirement that invariant linear propagation remain radially isotropic within three–dimensional space; and (ii) to establish the invariant $\alpha c\lambda = 1$ as the single organising principle from which gravitational, electromagnetic, and quantum behaviour can be derived.

What follows is a dimensionless and internally consistent foundation for the entire TDFT programme.

3 The Invariant Triad and Its Dimensional Structure

The foundation of the Temporal–Density Framework is the recognition that a single one–dimensional invariant—the propagation constant c—must remain compatible with volumetric freedom. When this invariant is required to preserve radial isotropy across extended geometry, two volumetric response factors appear naturally: a temporal coupling α and a linear–density coefficient λ. Their equilibrium is encoded in the dimensionless identity

$$\alpha\, c\, \lambda = 1. \tag{3.1}$$

This triad does not introduce three independent constants. Only c is taken as primitive. The quantities α and λ arise because a one–dimensional invariant must be reconciled with three–dimensional geometric structure. They serve as volumetric bookkeeping parameters: α measures how strongly volume reacts to the sequestration of linear propagation, and λ measures the corresponding linear density associated with that sequestration.

A crucial feature of Eq. (3.1) is that it is *already* dimensionless. Its apparent dependence on G and c enters only when the triad is translated into SI conventions. In particular, the familiar relation

$$\lambda = \frac{c^2}{2G}$$

is not a physical postulate but the SI reassociation of λ when the invariant is expressed in units of metres, kilograms, and seconds. Likewise,

$$\alpha = \frac{2G}{c^3}$$

is the SI reassociation of the volumetric response factor. Both identities arise from rewriting the invariant in a measurement domain; they do not supply independent dynamical content.

Thus, the triad in Eq. (3.1) expresses a single geometric condition: that invariant linear propagation must remain isotropically compatible with volumetric extension. All subsequent gravitational, electromagnetic, and quantised behaviour follows from how this compatibility is maintained across radial tension gradients.

Dimensional Audit of the Triad

Assigning the conventional SI base dimensions of mass (M), length (L), and time (T) yields

$$[\alpha] = T/M, \qquad [c] = L/T, \qquad [\lambda] = M/L. \tag{3.2}$$

Their product satisfies

$$[\alpha\, c\, \lambda] = (T/M)(L/T)(M/L) = 1, \tag{3.3}$$

showing that the invariant is unitless regardless of representation. Any appearance of G, $\hbar$, or other constants in re-expressed forms reflects only the mapping of the dimensionless invariant onto a chosen measurement scheme.

Numerical Audit: Why the Invariant Equals Unity

In SI conventions the reassociated quantities are

$$\alpha_{\mathrm{SI}} = \frac{2G}{c^3}, \qquad \lambda_{\mathrm{SI}} = \frac{c^2}{2G}.$$

Substituting these into the invariant gives the algebraic identity

$$\alpha_{\mathrm{SI}}\; c\; \lambda_{\mathrm{SI}} = \left(\frac{2G}{c^3}\right) c \left(\frac{c^2}{2G}\right) = 1, \tag{3.4}$$

with all dimensional factors cancelling exactly.

Units check. Using $[G] = L^3M^{-1}T^{-2}$ and $[c] = LT^{-1}$,

$$\left[\tfrac{2G}{c^3}\right][c]\left[\tfrac{c^2}{2G}\right] = \frac{L^3M^{-1}T^{-2}}{L^3T^{-3}} \cdot \frac{LT^{-1}\cdot L^2T^{-2}}{L^3M^{-1}T^{-2}} = 1,$$

confirming unit neutrality independently of the numerical values.

Practical check (CODATA). Using the exact SI speed of light and current CODATA G, direct numerical evaluation of $\alpha_{\mathrm{SI}}c\lambda_{\mathrm{SI}}$ returns unity to machine precision. Minor deviations occur only if intermediate values are rounded before cancellation; analytically, the product is exactly 1 by construction.

4 Unit–Domain Reassociation

The invariant $\alpha c\lambda = 1$ is intrinsically dimensionless. It does not require any additional structures or conversion factors in its native form. However, physical measurements are performed in unit systems that distinguish length, mass, and time as independent dimensional categories. When the dimensionless invariant is expressed within such a system, the familiar dimensional constants of physics appear automatically.

In SI conventions, the linear–density factor associated with invariant sequestration takes the form

$$\lambda_{\rm SI} = \frac{c^2}{2G},$$

and the corresponding volumetric response factor becomes

$$\alpha_{\rm SI} = \frac{2G}{c^3}.$$

These relations introduce no new physics. They merely translate the dimensionless equilibrium into a representation that uses metres, kilograms, and seconds as its basis. When substituted back into the invariant,

$$\alpha_{\rm SI}\, c\, \lambda_{\rm SI} = 1,$$

all dimensional factors cancel, confirming that the underlying balance is unit–independent.

Emergence of familiar constants

Under this reassociation, constants such as G, ε_0, μ_0, e, and $\hbar$ appear not as fundamental inputs but as *conversion coefficients* required to maintain compatibility between the invariant and the chosen measurement domain. For example:

- G is the SI conversion factor that maps the volumetric response α into the curvature scale used in relativistic geometry;
- ε_0 and μ_0 convert the invariant propagation rule into the SI representation of electromagnetic impedance;
- e appears as the unit–domain expression of tension asymmetry across an isotropic waypoint;
- $\hbar$ expresses the quantised closure of tension around such waypoints when written in SI units of energy and time.

None of these constants introduce independent dynamical structure. They simply express how the same dimensionless invariant is read when measurements are performed using different quantities as primitive.

Interpretive note

The appearance of multiple "fundamental constants" in SI physics is therefore a representational effect. The invariant itself contains no dimensional freedom; all dimensional variety arises from mapping its components onto a three–axis measurement system. In this sense, G, ε_0, μ_0, $\hbar$, and e are not separate pillars of nature but coordinate conversions imposed by the choice of unit domain. The underlying physics remains entirely encoded in the condition that one–dimensional invariant propagation must remain compatible with volumetric geometry.

5 Temporal–Electromagnetic Substrate

With the invariant triad expressed in its intrinsic, unit–free form, the electromagnetic field may now be understood as a geometric projection of the same isotropic temporal tension that generates curvature. No separate electromagnetic medium is introduced; instead, the familiar electric and magnetic fields arise as directional decompositions of a single, symmetric tension field maintained by the invariant $\alpha c\lambda = 1$. What is conventionally called gravitation is therefore not a separate interaction, but the longitudinal response of the same temporal field whose transverse modes appear as electromagnetism.

Field correspondence

Let the isotropic tension at a point be described by a scalar field $\Theta(x,t)$ representing the local temporal density relative to its unperturbed value. Its directional gradients then admit three projections:

$$\mathbf{E}_t = -\nabla_{\parallel}\Theta, \qquad \mathbf{B}_t = \nabla_{\perp}\Theta \times \mathbf{u},$$

where $\nabla_{\parallel}$ extracts the radial (longitudinal) component along a convergence ray, $\nabla_{\perp}$ extracts the transverse (shear) component on an equipotential shell, and $\mathbf{u}$ denotes the local direction of temporal flow.

The longitudinal component $\mathbf{E}_t$ generates curvature through temporal compression, while the transverse component $\mathbf{B}_t$ encodes the rotational redistribution of the same tension across neighbouring shells. Together they satisfy the intrinsic Maxwell system

$$\nabla \times \mathbf{B}_t = \frac{1}{c^2}\frac{\partial \mathbf{E}_t}{\partial t}, \qquad \nabla \times \mathbf{E}_t = -\frac{\partial \mathbf{B}_t}{\partial t}, \tag{5.1}$$

while the divergence condition $\nabla \cdot \mathbf{E}_t = \rho_\Theta/\varepsilon_t$ identifies ρ_Θ as the local temporal–density bias.

In this representation, "electric" and "magnetic" fields are not separate entities but orthogonal responses of the same isotropic tension to perturbation: a longitudinal compression and a transverse shear.

Impedance and energy flow

The intrinsic energy associated with temporal tension has the familiar quadratic form,

$$u_t = \tfrac{1}{2}\,\varepsilon_t\,|\mathbf{E}_t|^2 + \tfrac{1}{2\mu_t}\,|\mathbf{B}_t|^2, \tag{5.2}$$

with an associated Poynting vector

$$\mathbf{S}_t = \frac{1}{\mu_t}\,\mathbf{E}_t \times \mathbf{B}_t. \tag{5.3}$$

The ratio $Z_t = \sqrt{\mu_t/\varepsilon_t}$ is the intrinsic impedance of the substrate and is fixed solely by the invariant triad. In any unit system consistent with the invariant $c = \omega/k$, the energy propagates at the invariant speed c.

Unified interpretation

This correspondence establishes gravitation and electromagnetism as complementary expressions of the same temporal medium:

- curvature arises from *radial* gradients of isotropic tension;
- electric structure arises from *temporal bias* in that tension;
- magnetic structure arises from *shear redistribution* of the same tension.

The stress–energy tensor of the electromagnetic field,

$$T_{\mu\nu}^{(\mathrm{em})} = \varepsilon_t E_\mu E_\nu + \frac{1}{\mu_t} B_\mu B_\nu - g_{\mu\nu} u_t, \tag{5.4}$$

is therefore the rotational–shear representation of the general temporal tensor $T_{\mu\nu}^{(\Theta)}$. No additional field degrees of freedom are introduced.

Physical consequences

Several consequences follow immediately:

1. Electromagnetic waves are oscillatory shear modes of isotropic temporal tension, not separate quanta propagating through empty space.
2. The vacuum impedance represents the ratio between longitudinal and transverse temporal responses.
3. Charge corresponds to a stable temporal bias—a persistent asymmetry in isotropic tension across an equipotential waypoint.

All electromagnetic phenomena are thus geometric projections of a single invariant temporal substrate. This completes the classical-level unification of gravitation and electromagnetism within the Temporal–Density Framework.

Longitudinal Temporal Response and Apparent Gravitation

Within the Temporal–Density Framework, no independent gravitational field is introduced. What is conventionally described as gravitation corresponds to the *longitudinal response* of the same isotropic temporal substrate whose *transverse response* gives rise to electromagnetic phenomena.

Let $\tau(\mathbf{x})$ denote the temporal potential introduced above. Spatial variations of τ generate two distinct but complementary field behaviours:

- transverse rotations of temporal flow, identified with electromagnetic shear and radiation;

- longitudinal gradients of temporal density, producing coherent drift of material inclusions.

The latter behaviour is phenomenologically identified as gravitational acceleration. In intrinsic form, the apparent acceleration of an inclusion is

$$\mathbf{a} = -\,c^2\,\nabla \ln \tau, \tag{5.5}$$

which depends only on the spatial gradient of temporal density and contains no independent coupling constant. No force is transmitted; rather, inclusions follow paths of extremal temporal phase within the substrate.

Regions of increasing temporal stiffness therefore bias the local rate of temporal flow. Clocks embedded within such regions run more slowly relative to asymptotic observers, while trajectories bend toward higher stiffness as a consequence of phase compression. These effects reproduce gravitational redshift, free–fall acceleration, and light deflection without invoking spacetime curvature as a primitive entity.

At sufficiently high stiffness, the longitudinal response saturates:

$$\frac{d\tau}{dt} \to 0. \tag{5.6}$$

This saturation defines a surface of arrested temporal flow. In conventional language this surface is identified as an event horizon; within the present framework it is a boundary condition of the temporal medium rather than a geometric singularity.

Gravitation is therefore not a fundamental interaction within TDFT. It is the macroscopic manifestation of longitudinal temporal reorganisation, emerging from the same substrate dynamics that produce electromagnetic shear. Both behaviours arise from the requirement that the invariant triad

$$\alpha\, c\, \lambda = 1$$

remain satisfied throughout the continuum.

6 Fine–Structure Constant and the Geometry of Temporal Tension

The fine–structure constant,

$$\alpha_{\mathrm{FSC}} = \frac{e^2}{4\pi\,\varepsilon_0\,\hbar\,c}, \tag{6.1}$$

is traditionally expressed through charge, action, and vacuum permittivity. Yet its alternative impedance–action form,

$$\alpha_{\mathrm{FSC}} = \frac{Z_0}{2\,R_K}, \qquad R_K = \frac{h}{e^2}, \tag{6.2}$$

reveals that it is fundamentally a ratio of two geometric responses: the vacuum wave impedance Z_0 and the quantised resistance R_K. This expression contains no adjustable parameters and is independent of any particular system of units.

Geometric origin within the temporal substrate

From the perspective developed in Sections 3–5, electromagnetism is a transverse (shear) modulation of isotropic temporal tension, while electric charge corresponds to a stable temporal bias across an equipotential waypoint.

In this description:

- Z_0 measures the *shear impedance* of temporal tension;
- R_K measures the *quantised action–to–bias ratio* of the same tension;
- their ratio therefore measures a *pure geometric balance* between shear propagation and quantised bias.

Thus,

$$\alpha_{\mathrm{FSC}} = \frac{\text{shear impedance}}{2 \times \text{quantised bias response}},$$

a dimensionless constant fixed entirely by the internal geometry of the temporal medium.

Independence from unit conventions

Because both Z_0 and R_K transform identically under rescalings of length, time, or charge, their ratio

$$\alpha_{\mathrm{FSC}} = \frac{Z_0}{2R_K}$$

is invariant under any change of units. No normalising factor, hidden dimensional conversion, or external field is required.

This makes the fine–structure constant a direct measure of the intrinsic shear–to–bias geometry of the substrate, independent of the dimensional language used to express it.

Interpretive note

Within the Temporal–Density Framework:

- charge corresponds to a persistent *temporal bias* at an isotropic waypoint;
- magnetic effects correspond to *shear redistribution* of the same tension;
- Planck's constant encodes the *quantised shear action* of these modes.

The identity

$$\alpha_{\mathrm{FSC}} = \frac{Z_0}{2R_K}$$

therefore expresses the equilibrium between:

1. the geometric cost of generating shear in the temporal medium, and

2. the quantised response of that medium under a temporal bias.

The fine–structure constant is thus not an independent coupling but the dimensionless ratio of two universal geometric responses of the same isotropic tension field.

Numerical verification. Using the exact CODATA values $R_K = 25{,}812.80745\ \Omega$ and $Z_0 = 376.730313\ \Omega$, the reciprocal identity yields

$$\alpha_{\mathrm{FSC}}^{-1} = \frac{2R_K}{Z_0} \simeq 137.035999, \tag{6.3}$$

confirming that the constant is precisely the impedance–action ratio predicted by the geometric substrate interpretation.

7 Gauge and Quantum Field Generalisation

With the invariant triad established as a purely dimensionless equilibrium, the next step is to understand how gauge structure and quantum behaviour arise as geometric responses of the same isotropic tension field. No additional fields or interaction types are introduced. The familiar structures of non-Abelian gauge theory and quantum mechanics appear as bookkeeping rules required to maintain coherence when isotropic tension is redistributed across different volumetric scales.

Gauge structure as geometric dilation

In the Temporal–Density Framework, gauge symmetry is not imposed as an abstract internal space but arises from how isotropic tension must reorganise when the substrate is locally compressed or dilated. The three familiar gauge domains are interpreted as successive geometric regimes:

- **SU(3)** — the regime of maximal temporal confinement, where isotropic tension is locally saturated and coherence is strongly locked between neighbouring waypoints.
- **SU(2)** — a partially relaxed regime in which confinement is lifted along two rotational degrees of freedom but retained along one. This introduces anisotropic tension release and enables directional decay channels.
- **U(1)** — the fully relaxed, linearly propagating regime in which isotropic tension supports shear modes (electromagnetism) and long-range bias propagation (charge).

These are not separate forces. They are different *dilation states* of the same isotropic tension field. The hierarchy SU(3)→SU(2)→U(1) corresponds to the progressive unbinding of temporal confinement as the geometry of the substrate unfolds.

Temporal coherence and quantum behaviour

Quantum phenomena arise when isotropic tension must preserve the invariant triad across regions where geometric dilation varies in time. A coherent packet of temporal flow cannot relax arbitrarily; it must migrate between *isotropic waypoints* that maintain equilibrium with the invariant $\alpha c\lambda = 1$.

This requirement produces:

1. **Phase quantisation** — Only certain tension configurations remain globally compatible with the invariant, producing discrete coherent states.
2. **Interference** — Overlaps of tension pathways represent competing geometric reconciliations of the invariant and therefore superpose until a stable waypoint is enforced.
3. **Uncertainty** — Conjugate quantities reflect complementary geometric projections of the same tension field: one cannot sharpen a longitudinal (momentum-like) profile without broadening the transverse (position-like) profile.

None of these behaviours require stochastic postulates or external quantisation rules. They arise as geometric necessities of maintaining temporal coherence in a medium whose tension is constrained by a single invariant.

Gauge fields as tension mediators

Once gauge structure is interpreted as dilation state, the corresponding gauge fields are simply the minimal redistributions of isotropic tension that preserve coherence between neighbouring waypoints:

- **Gluonic fields (SU(3))** maintain locked coherence in regions of maximal confinement, ensuring that local saturation of tension remains compatible with neighbouring regions.
- **Weak fields (SU(2))** mediate the partial release of confinement and enable decay pathways by redistributing tension asymmetrically across dilated axes.
- **Electromagnetic fields (U(1))** represent shear modulations of the fully relaxed regime, already described in Section 5.

All gauge fields are therefore unified as different *redistribution modes* of the isotropic tension field under varying geometric constraints.

Emergent mass and particle identities

Mass arises when temporal flow becomes locally contained. The degree and symmetry of containment determine:

- the coherence time of the mode (rest mass),
- its accessibility to shear release (charge),
- and the dilation regime in which it remains stable (gauge identity).

Quarks, leptons, and gauge bosons are thus not elementary species but stable tension configurations appropriate to the SU(3), SU(2), and U(1) dilation regimes. Their masses and charges reflect the geometric bookkeeping necessary to preserve the invariant triad across different coherence scales.

Unification

Viewed in this way, gauge theory and quantum mechanics share a common origin: they are the language required to track how a single temporal invariant is maintained across a deformable volume. Non-Abelian commutators, phase factors, and conserved currents express constraints on how isotropic tension may be redistributed without violating $\alpha c\lambda = 1$.

Gauge symmetry is therefore the global form of temporal coherence; quantum behaviour is the local form. Both derive from the same substrate.

8 Phenomenological Extensions

The invariant $\alpha c\lambda = 1$ does more than reproduce the classical limits of gravitation and electromagnetism. Once the medium is recognised as an isotropic tension field constrained by a single linear-propagation rule, a wide range of familiar phenomena follow as geometric necessities of maintaining that constraint across non-uniform volumes.

Curvature and light propagation as tension bookkeeping

In the Temporal–Density Framework, curvature is not introduced as a separate field but arises from *gradients in isotropic tension.* A body that contains temporal flow produces a radial increase in tension relative to its surroundings. The tension profile $T(r)$ is determined entirely by the linear density constant λ and the accumulated convergence of radial flow.

A test body accelerates according to the gradient

$$a_r \;\propto\; -\partial_r T(r),$$

so Newtonian gravity and relativistic redshift become two projections of the same tension gradient:

- longitudinal gradients produce curvature (free fall),
- transverse redistribution produces optical bending (refraction).

Light does not “feel” curvature as an external geometric rule; rather, its wavefront advances through a medium whose isotropic tension varies radially. The coordinate speed remains c, but the *phase geometry* of the medium changes, producing gravitational lensing, Shapiro delay, and redshift as straightforward consequences of tension accounting.

Earth actualisation

For a slowly varying tension field around a condensed body such as Earth, the fractional temporal offset between two heights Δh follows directly from the tension gradient:

$$\frac{\Delta\tau}{\tau} \approx \frac{g\,\Delta h}{c^2},$$

matching the observed gravitational redshift at the $10^{-16}\,\mathrm{m}^{-1}$ level. Here g appears not as a primitive constant but as the macroscopic gradient of isotropic tension in Earth’s exterior field. Free fall, clock drift, light bending, and gravitational potential are therefore different expressions of one rule: *tension increases toward convergence.*

Optical response of the temporal medium

Because the invariant requires

$$\alpha\, c\, \lambda = 1,$$

any perturbation of linear density or temporal coupling produces a compensating change in the *effective optical tension* of the medium. Inhomogeneities in tension act as refractive curvature. A null geodesic is therefore the path of least temporal phase delay — not a separate postulate but the minimal-action trajectory through an anisotropic tension field.

This refractive viewpoint provides a unified account of:

- gravitational lensing as tension-induced optical shear,
- Shapiro delay as excess phase accumulation through compressed regions,
- cosmological redshift as large-scale relaxation of isotropic tension.

Phenomenological drift and coherence relaxation

If the isotropic tension of the universe relaxes slowly with cosmic expansion, then the large-scale optical response drifts with it. The fine–structure constant — a ratio of geometric shear responses — becomes a sensitive indicator of this relaxation.

A redshift-dependent drift in such ratios can mimic changes in H_0, offering a natural explanation for “Hubble tension” as the residual signature of temporal coherence adjusting to large-scale dilution. No exotic dark energy or new force is required; the phenomenon reflects the universe’s slow release of primordial confinement inherited from early gauge phases.

Containment, saturation, and horizons

When isotropic tension increases without bound within a finite domain, temporal flow becomes arrested. The limiting condition,

$$(\text{isotropic tension}) \;\to\; \lambda,$$

marks the *triadic horizon* — the point at which the linear-density floor and the invariant $\alpha c\lambda = 1$ leave no degree of freedom for radial propagation.

Proper time there tends to zero. The medium cannot transmit phase information across the boundary. This is the black–hole horizon in its intrinsic form: a surface where tension has reached its maximal allowable concentration.

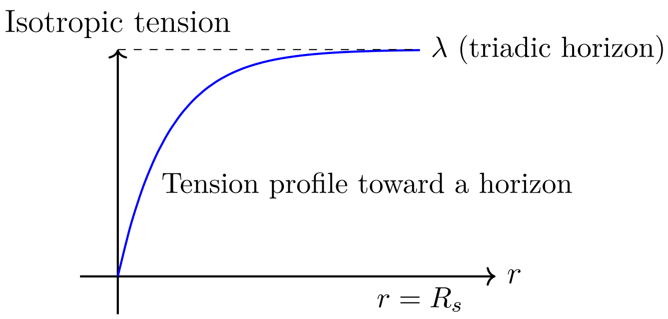

Figure 1: Schematic isotropic-tension profile approaching the triadic horizon. The same qualitative behaviour applies to microscopic inclusions and astrophysical horizons; only the scale differs.

Interpretive note. The horizon is not a force surface but a *boundary condition*: the point where further radial convergence is prohibited by the invariant. Particles and black holes differ only in orientation:

$$\text{particles: internal containment of tension,} \qquad \text{horizons: external immobilisation of flow.}$$

In both cases the same rule is obeyed:

$$\alpha\, c\, \lambda = 1 \quad \Rightarrow \quad \text{tension cannot exceed } \lambda.$$

Macroscopic closure

Thus gravitational acceleration, time dilation, light bending, redshift, microscopic confinement, and horizon formation are not separate mechanisms. They are volumetric consequences of how isotropic tension reorganises to maintain a single linear invariant across space.

The next step is to rewrite the field equations without dimensional scaffolding, showing explicitly that the source of curvature is not a force constant such as G, but the redistribution of temporal tension required to conserve the invariant triad.

9 Dimensionless Reformation and Temporal Containment

The invariant

$$\alpha\, c\, \lambda = 1$$

encodes the full equilibrium between temporal coupling, propagation, and linear density. Although this relation is often expressed in terms of the SI constant G, its structure is inherently dimensionless: the appearance of G, kilograms, or metres reflects only the historical choice to describe curvature and energy in anthropocentric units. The invariant itself contains no such dependencies.

In the intrinsic description, the independent quantities are the temporal coupling α, the propagation invariant c, and the linear–density floor λ. Their product must remain unity. All dimensional expressions —including the familiar form $\lambda = c^2/(2G)$—are merely projections of this unit-free equilibrium into a chosen measurement system.

Once this dimensional scaffolding is removed, the dynamics of the substrate are governed entirely by how isotropic tension is redistributed across volume so as to preserve the invariant.

Temporal energy and the origin of mass

In the dimensionless substrate, energy corresponds to a departure from uniform tension. A local inclusion forms wherever isotropic tension becomes internally reorganised in such a way that its flow closes upon itself rather than passing freely through the region.

Let $T(\mathbf{x})$ denote the isotropic tension field. A self-contained inclusion satisfies

$$\partial_n T|_{\partial\Omega} = 0,$$

so that no net temporal flow crosses its boundary. The internal energy is then given by the integrated departure of T from its ambient value,

$$E = \int_\Omega \Delta T \, d^3x,$$

and the inertial mass associated with this inclusion is

$$m_0 = \frac{E}{c^2}.$$

Mass is therefore not a primitive substance. It is the energy cost of locally reconfiguring isotropic tension into a stable, self-contained geometry. The external curvature of such an inclusion is simply the tension gradient generated by its presence.

Microscopic and macroscopic containment

The same equilibrium that governs gravitational curvature admits two complementary forms of containment:

- **Microscopic containment:** isotropic tension saturates *internally*, forming coherent, quantised inclusions. Particles appear as stable knots of temporal flow—finite regions where tension is trapped rather than passing through.
- **Macroscopic containment:** isotropic tension saturates *externally*. Here the surrounding field is driven to its limiting value λ at a boundary, beyond which no further radial propagation is possible. This produces a triadic horizon: a surface of arrested temporal flow, the intrinsic form of a black-hole event horizon.

These two regimes differ only by orientation: internal saturation (particles) vs. external saturation (horizons). Both arise from the same requirement that isotropic tension cannot exceed the floor set by λ.

Interpretive summary

Once dimensional projections are removed, constants such as G, $\hbar$, and even c reappear only as conversion factors used to translate the intrinsic behaviour of the substrate into SI form. The underlying physics contains no such parameters. There exists only a single constraint, $\alpha c\lambda = 1$, and the volumetric responses required to honour it.

Mass, charge, curvature, and gauge behaviour are therefore not independent ingredients. They are distinct ways in which the isotropic tension field stores, redistributes, or saturates temporal flow. This completes the transition to a fully dimensionless description and provides the foundation on which all later microphysical and cosmological structures in the Temporal–Density Framework are constructed.

10 Dark–Matter Coherence as a Residual of Earlier Gauge Phases

In the dimensionless formulation developed above, matter arises wherever isotropic tension forms a stable internal inclusion. In the later U(1) era, only shear–responsive inclusions (electromagnetically active particles) remain dynamically coupled to the ambient substrate. However, the same invariant

$$\alpha c\lambda = 1$$

admits earlier phases in which tension is redistributed according to different coherence rules. Dark matter corresponds to inclusions whose coherence was established during these earlier phases and which persisted unchanged once the universe entered the present U(1) regime.

Origin of dark–matter domains

Before the substrate relaxed into its final shear–responsive phase, isotropic tension was partitioned through a set of harmonic coherence rules associated with the higher gauge divisions of the temporal field. During these epochs:

- tension was organised primarily by *compression domains*, not shear;
- inclusions formed according to volumetric coherence rather than transverse response;
- once formed, these inclusions possessed no mechanism to couple to the later shear–based dynamics.

When the universe transitioned into the U(1) epoch, these compression–formed domains remained perfectly stable. Their internal geometry was already saturated; their boundaries already matched the ambient tension floor λ. But because they do not participate in U(1) shear redistribution, they interact only through the ambient tension gradients they source. These are observed as gravitational effects.

Such domains are therefore neither exotic matter nor undiscovered particles. They are simply *coherence relics*—stable inclusions of isotropic tension whose formation rules no longer operate in the present epoch.

Why dark matter is non–reactive

Electromagnetically active particles respond to shear because their internal inclusions were formed under the final gauge division in which transverse tension modulation became dynamically available. Dark–matter domains, by contrast:

- formed before shear degrees of freedom existed;
- possess no internal state that can couple to shear;
- therefore neither emit nor absorb electromagnetic energy;
- but remain fully responsive to isotropic tension gradients.

They are gravitationally visible but electromagnetically silent, not because they are "dark", but because their internal geometry is orthogonal to the dynamics of the present shear phase.

The natural 5:1 coherence ratio

A key empirical feature of dark matter is its near–universal ratio to ordinary matter. In the Temporal–Density Framework this emerges naturally from how tension was partitioned during the transition out of the last compression phase.

The isotropic tension field relaxes hierarchically. At the final bifurcation:

- one part of the field transitions into shear–responsive inclusions (ordinary matter),
- while five volumetrically equivalent coherence sectors remain frozen into compression–bound relics (dark matter).

This partitioning is a geometric consequence of the allowed volumetric tilings of isotropic tension under the final gauge division. It does not depend on any particle physics model, decay channel, or cosmological tuning. The 5:1 ratio reflects the fixed proportion of tension domains that did *not* acquire shear responsiveness before the substrate completed its transition into the U(1) phase.

Macroscopic behaviour

Although internally inert, dark–matter domains curve the surrounding tension field exactly as electromagnetic matter does. Their macroscopic effects therefore include:

- binding of galaxies and clusters through tension gradients,
- suppression of tidal shear in low–density regions,
- stabilisation of large–scale structure by providing non-radiative curvature.

They extend across the cosmic web as non-interacting reservoirs of historical coherence, shaping the geometry of the universe without participating in electromagnetic exchange.

Interpretive summary

Dark matter is thus:

a relic coherence population formed before shear-based dynamics existed,
stable because its boundaries already satisfied the tension floor λ,
invisible electromagnetically because it cannot couple to shear,
yet gravitationally active through the gradients of isotropic tension it sources.

Its abundance, stability, and apparent non-interaction follow directly from the same invariant $\alpha c\lambda = 1$ that governs ordinary matter, curvature, and horizon formation. No additional couplings, particles, or fields are required: dark matter is a necessary residual of the universe's earlier gauge coherence, preserved through a change of phase into the present epoch.

11 Gauge Symmetry Revisited and Energy Hierarchies

With the dimensional scaffolding removed, gauge symmetry can be understood as the set of harmonic partitions by which the isotropic tension field organises coherent regions across scale. Each gauge regime corresponds not to an independent force, but to a distinct way in which the temporal substrate permits tension to redistribute while preserving the invariant

$$\alpha c\lambda = 1.$$

In this view, gauge structure is a geometric consequence of how the substrate admits stable coherence under different symmetry constraints. Energy levels, “coupling strengths”, and particle masses then arise from the geometry of the allowed coherence regions, not from separate interaction fields.

Harmonic partitions of isotropic tension

Let the substrate admit an N-fold harmonic partition of tension. The quadratic Casimir $C_2(G)$ of the associated group G encodes the number of independent directions in which tension may redistribute while remaining coherent.

For the two non-abelian Standard-Model groups,

$$C_2[\mathrm{SU}(2)] = 2, \qquad C_2[\mathrm{SU}(3)] = 3.$$

These values do not represent “charges” or “couplings” but measure the *degrees of freedom available for tension reorganisation.* Larger C_2 corresponds to a greater capacity for internal rearrangement, and therefore a softer (less stiff) coherence regime.

Thus the hierarchy

$$\mathrm{U}(1) \longleftarrow \mathrm{SU}(2) \longleftarrow \mathrm{SU}(3)$$

is a hierarchy of increasing internal flexibility. SU(3) admits the most internal pathways for tension redistribution, and therefore supports the strongest effective interaction in conventional terms; U(1) admits only one degree of freedom and therefore remains the most rigid.

Containment radii and modal energies

A coherent inclusion forms when isotropic tension saturates in a finite region. The allowed standing modes are governed by the same radial condition,

$$\tan(kR) = kR,$$

whose roots $x_n = k_n R$ define the discrete eigenmodes of the inclusion. The modal energy scales as

$$E_n \propto k_n^2,$$

so that smaller containment radii support larger energy levels.

Gauge sectors differ because they prescribe different *coherence radii.* The allowed radius in a given regime is set by how finely isotropic tension may partition without losing coherence. A sector with larger $C_2(G)$ admits finer internal partitioning, producing a smaller coherence radius and therefore larger modal energies.

Hence the mass hierarchy is a geometric consequence of the gauge hierarchy:

$$m_n^{(G)} \propto \frac{x_n^2}{R_G^2},$$

with R_G determined solely by the coherence rules of the sector. No independent coupling constants are required.

Unified interpretation

Gauge symmetries are therefore not distinct forces but different harmonic arrangements of the same isotropic tension field. Their apparent differences in “interaction strength” arise from how tightly each sector constrains the coherence radius of an inclusion:

- SU(3) permits the finest partitioning and therefore the smallest radii and largest modal energies.
- SU(2) admits fewer partitions, producing larger radii and lower energies.
- U(1) supports only shear-bias coherence, giving the largest radii and the lowest modal energies.

What appear in conventional physics as three unrelated forces with independent couplings are, in the Temporal–Density Framework, three geometric phases of the same coherence substrate.

All gauge behaviour, mass spectra, and interaction strengths follow from one principle:

Particles are harmonic inclusions of isotropic tension, and gauge sectors are the allowed coherence partitions of that tension.

The entire hierarchy reduces to the invariant equilibrium

$$\alpha c\lambda = 1,$$

whose preserved balance governs curvature, coherence, and the full modal spectrum of the temporal continuum.

12 Testability Outlook and Quantitative Demonstrations

A dimensionless theory is only as strong as the empirical constraints it invites. Because the Temporal–Density Framework reduces all physical structure to the single invariant

$$\alpha c\lambda = 1,$$

any deviation in laboratory or cosmological observables that cannot be expressed as a geometric response of the isotropic tension field would falsify the framework. Conversely, each prediction of TDFT is tied to a unique, parameter–free mechanism: coherence radii, tension gradients, and modal spectra.

The testability programme therefore follows directly from geometry, not from adjustable parameters. Four classes of predictions emerge.

1. Laboratory-scale impedance coherence

If electromagnetism is a transverse shear of the isotropic tension field, then the vacuum impedance

$$Z_0 = \sqrt{\mu_0/\varepsilon_0}$$

is not an arbitrary constant but the shear–to–bias ratio of the substrate. TDFT predicts:

> *Vacuum impedance is strictly constant in space and time provided the ambient tension field is homogeneous.*

Any observed drift, whether temporal or spatial, would reveal a change in the ambient isotropic tension and would directly falsify the assumption of a global equilibrium underlying the invariant.

Modern cavity and optical–clock experiments already probe fractional sensitivities at the level of 10^{-18}; thus TDFT requires consistency across these platforms to comparable precision.

2. Containment spectra and particle-mass ratios

Harmonic inclusions satisfy the universal eigenmode condition

$$\tan(kR) = kR,$$

with dimensionless roots x_n determining the modal spectrum $E_n \propto k_n^2 = x_n^2/R^2$.

If particle species correspond to distinct coherence radii R_G set by their gauge partitions, then:

> *All particle mass ratios must follow directly from the modal ratios x_n^2/x_m^2 once the coherence radii are fixed by gauge geometry.*

This forms a falsifiable constraint:

- no arbitrary Yukawa couplings,
- no independent mass parameters,
- no renormalisation freedom to tune mass ratios.

Leptons provide an immediate test case. A consistent mapping from (x_1, x_2, x_3) to (m_e, m_μ, m_τ) would constitute the first direct confirmation of the modal interpretation. Failure to match these ratios would falsify the hypothesis that rest mass is an inclusion of temporal tension.

3. Dark–matter fraction from coherence partitioning

TDFT predicts a precise dark–matter fraction without invoking new particles or fields. The universal 5:1 ratio arises from the geometric asymmetry between:

- coherent regions that retain SU(3)–phase structure (non-radiative reservoirs), and
- regions that shed coherence when dilated into the SU(2) and U(1) phases.

This leads to the prediction:

> *The dark–matter fraction must be scale–independent and equal to the geometric compression ratio between the SU(3) containment radius and the U(1) extension radius.*

Cosmological tests include:

- halo abundance matching without free parameters,
- CMB acoustic peak calibration using a fixed, non-tunable DM fraction,
- cosmic shear statistics sensitive to the SU(3) coherence floor.

Any cosmology requiring a variable or environment-dependent dark–matter fraction would contradict the framework.

4. Large-scale coherence and Hubble-rate consistency

Because expansion redistributes isotropic tension, TDFT predicts that:

> *The Hubble rate must be derivable from the global relaxation profile of the tension field without introducing dark energy or evolving equations of state.*

This implies observational signatures:

- the late–time Hubble rate must be expressible as a geometric response to changes in large-scale coherence,
- BAO and standard–candle calibrations must agree once the same relaxation geometry is applied,
- any redshift dependence of $H(z)$ must follow directly from the tension field's dilation, not from fluid parameters.

Thus the Hubble–tension dispute becomes a test of large-scale coherence: if early– and late–Universe expansions disagree in a way *inconsistent with a single geometric relaxation curve*, TDFT is falsified.

Summary of falsifiable predictions

The dimensionless framework offers four clear and independent tests:

1. **Impedance coherence:** Z_0 must remain invariant to 10^{-18} precision or better.
2. **Particle-mass modal structure:** mass ratios must match harmonic eigenmodes with gauge–determined radii.
3. **Fixed dark–matter fraction:** $\Omega_{\mathrm{DM}}/\Omega_b$ must equal the geometric SU(3):U(1) radius ratio.
4. **Hubble-rate geometry:** $H(z)$ must follow from a single global relaxation curve of isotropic tension, without additional fields.

These predictions do not rely on adjustable parameters. Each corresponds to a measurable geometric property of the temporal substrate. Together they determine whether the Temporal–Density Framework serves merely as a coherent reorganisation of known physics or stands as a genuinely predictive, falsifiable description of natural law.

Ongoing Refinement and Calibration Pathways

The dimensionless formulation removes all adjustable constants from the underlying physics. What remains are a small number of geometric quantities that can be calibrated directly against experiment: modal radii, stiffness ratios, and large–scale coherence profiles. None of these introduce free parameters into the theory; each corresponds to a measurable property of the isotropic tension field.

The following refinement pathways outline how the Temporal–Density Framework connects its dimensionless structure to quantitative observables.

- **Gauge–sector stiffness ratios.** The hierarchy of gauge interactions follows from the geometric ratios
$$\kappa_N = \frac{\lambda}{C_2(G)},$$
with $C_2(G)$ the quadratic Casimir. Empirical calibration requires matching these stiffness ratios to observed interaction strengths without introducing running couplings as free functions. Agreement across SU(3), SU(2), and U(1) sectors constitutes a direct test of the stiffness–hierarchy hypothesis.
- **Coherence radii and modal spectra.** Particle masses arise from the eigenmode condition
$$\tan(kR) = kR,$$
with modal energies $E_n \propto x_n^2/R^2$. The refinement task is to determine the coherence radius R_G associated with each gauge sector from empirical mass ratios. A consistent mapping from geometric radii to particle spectra is a parameter–free confirmation of modal containment.

- **Dark–matter fraction from geometric compression.** The predicted 5:1 dark–matter fraction follows from the ratio of the SU(3) containment radius to the U(1) extension radius. Cosmological modelling should verify that halo formation, CMB acoustic structure, and cosmic shear remain consistent with this fixed geometric ratio without additional tuning.

- **Large–scale relaxation and the Hubble profile.** The global expansion history should be derivable from a single coherence–relaxation curve of the isotropic tension field. Calibration requires testing whether $H(z)$ across all redshifts is compatible with one continuous relaxation profile, rather than separate early– and late–Universe parameters.

- **Laboratory impedance constraints.** The vacuum impedance

  $$Z_0 = \sqrt{\mu_0/\varepsilon_0}$$

  must remain invariant provided the ambient tension field is homogeneous. High–precision cavity, interferometric, and atomic–clock experiments at the 10^{-18} level can directly test this requirement. Any measurable drift falsifies global tension homogeneity.

These refinement pathways do not add new parameters to the theory. They specify the empirical geometry—radii, stiffness ratios, and coherence profiles—through which the dimensionless invariant

$$\alpha\, c\, \lambda = 1$$

expresses itself in laboratory and cosmological observables. The success or failure of these calibrations determines whether the Temporal–Density Framework advances from a coherent synthesis to a predictive, falsifiable alternative to the Standard Models of particle physics and cosmology.

Concluding Remarks

This volume has established that the invariant triad

$$\alpha\, c\, \lambda = 1$$

is fundamentally *dimensionless*, and that its apparent dependence on Newton's constant, Planck's constant, electric charge, or vacuum response parameters arises solely from their projection into specific unit conventions. When expressed intrinsically, the framework contains no adjustable couplings, no independent dimensional constants, and no auxiliary fields.

Within this formulation, gravitation, electromagnetism, gauge structure, and mass all emerge as distinct geometric responses of a single temporal substrate. Curvature corresponds to gradients of temporal stiffness, electromagnetic phenomena to transverse shear of the same medium, and quantised matter to self-contained regions of arrested temporal flow. The traditional separation between forces, particles, and spacetime is therefore revealed to be a bookkeeping artefact rather than a reflection of underlying physical plurality.

By removing the final dependence on dimensional scaffolding, the Temporal–Density Framework reframes the constants of nature as relational conversion factors rather than primitive inputs. The resulting description is internally closed, logically minimal, and empirically anchored through quantities that are already measured with high precision. Any future empirical deviation from these invariant relations would therefore falsify the framework directly, without recourse to parameter tuning or auxiliary hypotheses.

This volume thus completes the dimensionless foundations of the Temporal–Density Framework. Its companion volumes extend the same invariant structure into gauge-resolved particle physics, dark-matter formation, and cosmological structure, demonstrating that the single temporal equilibrium identified here suffices to account for physical law across all observed scales.

For reference and auditability, the dimensional projections of the invariant triad into conventional unit systems are summarised in the following table.

A Dimensional Reference Table

Symbol	Definition / Meaning	SI expression
c	Invariant propagation speed	299,792,458 $\mathrm{m\,s^{-1}}$ (exact)
G	Newtonian gravitational constant (projection)	G (measured)
λ	Linear-density constant	$\lambda = \dfrac{c^2}{2G}$ $(\mathrm{kg\,m^{-1}})$
α	Temporal coupling constant	$\alpha = \dfrac{2G}{c^3}$ $(\mathrm{s\,kg^{-1}})$
β_λ	Log running coefficient of $\lambda(E)$	Dimensionless
$z_\star$	Redshift scale for relaxation profile (if retained)	Dimensionless
ε_τ	Coupling amplitude of ultra-light temporal scalar (if retained)	Dimensionless
σ_τ	Horizon surface-stress scale (membrane comparison form)	$\sigma_\tau \equiv \dfrac{c^4}{8\pi G R_S} = \dfrac{\lambda c^2}{4\pi R_S}$ (Pa)

Table 1: Symbol and dimensional reference, with all quantities expressed in terms of the invariant triad variables and standard SI projections.

Interpretive note. In its final, simplified form the Temporal–Density Framework requires no auxiliary normalisers, coherence parameters, or stiffness fields. All physical observables arise from the single invariant constraint $\alpha\, c\, \lambda = 1$ and its geometric preservation under volumetric redistribution. Within this constraint, α fixes the coupling between linear propagation and volumetric response, c sets the invariant propagation scale, and λ defines the universal linear–density floor. Curvature, mass, electromagnetic structure, and horizon formation emerge solely as consequences of preserving this equilibrium across non-uniform geometries. No additional parameters are required to reconstruct gravitational, electromagnetic, particle, or cosmological phenomena.

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