

Temporal Coherence Gravity

An Informational Quantum Framework for Emergent Causality and
Spacetime

Version 0.6

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Research status

Conceptual and phenomenological framework. Not a completed physical theory. Updated with numerical experiment record through Experiment 20R; reconstructed experiments are explicitly labeled.

Abstract

Temporal Coherence Gravity is a speculative research program in which spacetime, stable causal order, and the macroscopic arrow of time emerge from a deeper informational structure. Version 0.1 introduced Temporal Event Quanta, informally called Timmies, as discrete microscopic entities carrying local state, phase, and update relationships. That construction was useful scaffolding, but it placed too much ontological weight on a proposed object. The present revision removes Temporal Event Quanta as required fundamental entities while retaining two features that motivated them: discreteness and relational angular or phase alignment.

The revised framework begins with a generative relational order represented mathematically by invariant constraints on a quantized informational state space. Discrete information quanta and their physically meaningful relations are expressions within that order rather than self-explanatory primitives. An individual phase need not have an absolute orientation; observable temporal structure is carried by relative phase. Alignment among many such relations defines a temporal-coherence order parameter. In the proposed hierarchy, generative relational law permits informational distinctions, quantized distinctions support coherent organization, coherent organization stabilizes causal order, and stable causal order permits continuum descriptions of time and geometry. Matter and geometry are provisionally treated as different collective manifestations of the same created relational substrate.

This is a unification strategy, not a demonstrated unification. Version 0.4 preserves the scalar coherence-gravity calculation introduced in Version 0.3 as an explored branch of the framework. In that branch, a gauge-invariant scalar coherence strain on a relational graph obeys a graph Poisson equation and conditionally produces a $1/r$ potential, inverse-square acceleration, and weak-field clock dilation. The calculation remains useful, but it gives the temporal coherence angle two responsibilities: organizing time and directly generating gravity. It also cannot reproduce the tensor degrees of freedom of General Relativity. Version 0.4 therefore records the branch and then explicitly supersedes it as the primary ontology. In the adopted formulation, dynamical relational tetrads and Lorentz transport generate geometry and curvature; angular coherence generates temporal order, causal compatibility, and proper-time response. The paper states the change, its reason, and the remaining derivation requirements.

1 Introduction

General Relativity and quantum mechanics are individually successful but assign different roles to time. Relativity incorporates time into dynamical spacetime geometry. Standard quantum mechanics usually treats time as an external parameter governing the evolution of quantum states. Attempts to combine the theories therefore confront more than a technical mismatch: they confront disagreement about what time is.

Temporal Coherence Gravity explores the possibility that neither classical spacetime nor classical temporal order is fundamental. The revised proposal is summarized by the sequence

generative relational law $\rightarrow$ quantized distinctions $\rightarrow$ coherence $\rightarrow$ causal order $\rightarrow$ spacetime
geometry

This sequence is not intended as a chronology occurring in an already existing time. It is a hierarchy of description. The generative law defines admissible relations; informational distinctions instantiate those possibilities; coherent collective states support stable causal ordering; and a continuum approximation of the organized relational system can be represented by effective time, matter, and geometry.

The central revision from Version 0.1 is ontological. The theory no longer requires tiny temporal objects located in a hidden background. What survives is quantization, relative phase, and alignment. This avoids placing the proposed substrate inside the spacetime it is meant to explain.

2 Scope and Claims

The paper distinguishes three kinds of statements.

Category	Meaning	Status in this paper
Definition	Introduces notation or a proposed quantity.	Used to make the framework precise enough to analyze.
Toy model	A candidate microscopic rule or analogy.	Illustrative; not derived from first principles.
Physical claim	A statement that must agree with observation.	A future requirement unless a derivation is explicitly shown.

The framework does not yet demonstrate that General Relativity or quantum mechanics follows from the proposed substrate. It instead identifies a candidate shared substrate and the mathematical bridges that must be constructed. Claims that Version 0.1 had already reproduced gravity are therefore narrowed here: the earlier weak-field expressions are retained as target-matching conditions and phenomenological ansätze, not as completed microscopic derivations.

3 From Timmy to Relational Information

3.1 What Timmy contributed

Temporal Event Quanta made several ideas concrete. They allowed the theory to discuss discrete states, internal phase, local update rules, alignment, and a transition from microscopic disorder to macroscopic causal stability. The ferromagnetic analogy was especially useful: random microscopic orientations yield no collective order, while correlated orientations produce a macroscopic order parameter.

3.2 Why Timmy is no longer fundamental

As the framework developed, its essential behavior depended less on the entity carrying a state and more on relations among states. Treating a TEQ as a particle-like object also raised circular questions. Where is it located before space emerges? How does it move before time exists? Relative informational structure can be defined without answering either question. TEQs are therefore reclassified as conceptual scaffolding rather than required ontology.

3.3 What survives

- Discrete informational degrees of freedom rather than a necessarily continuous substrate.
- An internal phase or orientation used to encode relational compatibility.
- Alignment and disorder as collective regimes.
- A coherence order parameter describing macroscopic organization.
- The emergence of stable causal order before the continuum metric description.

The research note convention is retained informally: Timmy has been killed as a fundamental object but preserved in the informational history of the theory. That joke states a serious methodological point. A discarded ontology can remain causally important as scaffolding that shaped the later model.

3.4 Information and the it from bit principle

The post-Timmy formulation is explicitly informed by John Archibald Wheeler's it-from-bit proposal: physical structure may arise from elementary informational distinctions rather than information merely describing an independently fundamental material world. Temporal Coherence Gravity adopts this as motivation, not as a derivation. Its more specific conjecture is that quantized relational information separates into coupled collective sectors: phase coherence supplies temporal organization and causal compatibility, while dynamical link relations supply geometry and curvature.

In this interpretation, a quantum is not required to be a small object inside spacetime. It is a discrete informational degree of freedom or relation from which spacetime observables may emerge. Relative phase, adjacency, tetrad data, and transport are candidate informational distinctions. The theory must still define their quantum state space and demonstrate that the macroscopic physical laws follow from it.

3.5 Logos and generative relational order

The Gospel of John opens with the statement, “In the beginning was the Word.” The Greek term Logos carries associations of word, reason, intelligibility, and ordering principle. Temporal Coherence Gravity does not treat this passage as a scientific derivation or claim that the text encodes a hidden theory of quantum gravity. It uses the Logos as metaphysical motivation for a specific philosophical premise: intelligible relational order may be prior to the physical objects described by that order.

The Logos must not be modeled as another particle, field, quantum, or variable inside the created system. Within the theological framing, the Logos is not one constituent among others. The mathematical theory therefore uses only an analogue: an invariant generative law or constraint that determines which relational states are physically admissible.

$$\mathcal{L}|\Psi_{rel}\rangle = 0$$

Here $\mathcal{L}$ denotes the complete generative relational constraint and $|\Psi_{rel}\rangle$ denotes the quantized relational state. The equation does not identify God or the Logos with a mathematical operator. It represents the narrower physical proposition that states, transitions, and observables are defined within a prior structure of lawful relations.

3.5.1 Distinction relation and manifestation

Information requires distinguishable alternatives, and distinguishability requires a rule under which states count as different. The proposed foundational order is therefore:

$$\text{generative order} \rightarrow \text{distinction} \rightarrow \text{relation} \rightarrow \text{coherence} \rightarrow \text{causal history} \rightarrow \text{physical manifestation}$$

This places a logical layer beneath Wheeler's it-from-bit proposal. Wheeler motivates the emergence of physical reality from informational distinctions. The Logos-inspired extension asks what makes those distinctions lawful, composable, and intelligible in the first place.

$$\text{Logos-inspired order} \rightarrow \text{relation} \rightarrow \text{bit} \rightarrow \text{it}$$

The phrase is philosophical shorthand, not an additional physical field equation. Scientific content begins when $\mathcal{L}$, the relational state space, and the observables are specified precisely enough to calculate outcomes.

3.5.2 Constraint structure

A candidate relational state may be written schematically as

$$|\Psi_{rel}\rangle = |\theta, E, U, \psi\rangle,$$

where θ represents temporal phase, E relational tetrads, U local-frame transport, and ψ persistent matter excitations. The generative constraint acts on their coupled relationships:

$$\hat{C}(\hat{\theta}, \hat{E}, \hat{U}, \hat{\psi})|\Psi_{rel}\rangle = 0.$$

The physical sectors retain the division established in Version 0.4:

- relative phase and its alignment organize temporal coherence and causal compatibility;
- relational tetrads and transport variables generate metric geometry and curvature;
- persistent excitations provide candidate matter and stress-energy;
- the complete constraint enforces compatibility among all sectors.

The constraint must eventually be expressed as a well-defined operator equation, action principle, path-amplitude rule, or algebra of observables. Until that is done, $\mathcal{L}$ and $\hat{C}$ are organizing notation rather than completed dynamics.

3.5.3 Coherence as lawful compatibility

Local temporal alignment remains measurable through relative phase, for example

$$C_{ij} = \cos(\theta_i - \theta_j).$$

Version 0.5 distinguishes this local phase coherence from a broader concept of relational consistency. A configuration is globally admissible only when its temporal, geometric, transport, and excitation relations jointly satisfy the governing constraints. Temporal coherence therefore does not manufacture every physical sector. It allows temporal relations within the complete system to form a stable, mutually compatible causal history.

$$\text{allowed distinctions} \rightarrow \text{coherent relations} \rightarrow \text{stable records} \rightarrow \text{causal history}$$

3.5.4 Boundary between theology and physics

The theological and scientific claims must remain distinguishable. John 1 supplies metaphysical motivation for the priority of intelligible order. It does not supply numerical constants, microscopic variables, field equations, or empirical confirmation. The physical proposal stands or falls according to mathematical consistency, recovery of established physics, and falsifiable observation. A reader may reject the theological motivation while still evaluating the relational model on scientific grounds.

4 Primitive Structure

4.1 Information quanta

Let $Q = \{q_i\}$ denote a set of discrete informational degrees of freedom. The term quantum indicates discreteness of allowed state or interaction, not a miniature object occupying a pre-existing position. At this stage q_i may be a node, a transition, or an algebraic degree of freedom. Selecting among those interpretations is part of future formalization.

Each quantum is assigned an internal phase variable for the simplest toy model:

$$\theta_i \in [0, 2\pi)$$

The phase is not an ordinary angle in physical three-space. It is an internal informational orientation. If the final theory requires a spinor or a non-Abelian state space, this scalar phase will be replaced; for now it supplies the least complicated alignment model.

4.2 Relations are primary

An absolute phase has no operational meaning without a reference. The primitive candidate observable is therefore a relative phase on an allowed relation between q_i and q_j :

$$\Delta\theta_{ij} = \theta_i - \theta_j$$

A simple compatibility or coherence weight is

$$C_{ij} = w_{ij} \cos(\Delta\theta_{ij})$$

where w_{ij} specifies relational strength or adjacency. The labels i and j do not imply spatial coordinates. Adjacency is informational: two degrees of freedom are adjacent when the microscopic rule permits a direct relation or update between them.

4.3 Why angle is retained

Binary ordering variables can model two alternatives, but an angular degree of freedom preserves the continuous family of relative phases that originally motivated alignment. It also allows partial coherence, defects, domains, and phase gradients. These features may prove necessary for constructing both quantum interference and smooth macroscopic fields from the same substrate.

5 Coherence and Alignment

5.1 Order parameter

For a domain containing N informational quanta, define a toy complex order parameter

$$\Psi = (1/N) \sum_i \exp(i\theta_i) = \rho \exp(i\Theta)$$

Here ρ measures the degree of collective phase coherence and Θ represents the collective orientation. When phases are effectively random, ρ approaches zero in a large ensemble. When phases align, ρ approaches unity. The absolute value of Θ may be gauge-like or conventional; relative collective phases and phase gradients are the candidate physical quantities.

5.2 Candidate interaction rule

The simplest static analogy is an XY-type interaction

$$H = - \sum \langle ij \rangle J_{ij} \cos(\theta_i - \theta_j) + H_{constraints}$$

Positive J_{ij} favors alignment. The additional term $H_{constraints}$ represents whatever consistency, conservation, or quantum constraints the final model requires. This Hamiltonian is not proposed as the final law of nature. It demonstrates that alignment can be defined relationally without embedding the variables in ordinary space.

5.3 Updating without external time

A conventional equation $d\theta/dt$ would assume the time the theory seeks to derive. Microscopic dynamics must instead use a relational update, a constraint equation, a path-amplitude rule, or an unphysical ordering parameter removed from observable predictions. One provisional notation is

$$q_i[n+1] = F_i(\{q_j[n]\}, \{C_{ij}\})$$

where n labels logical update depth rather than measured time. A complete formulation must show that observable predictions do not depend on an arbitrary global update clock.

6 Emergence of Causal Order

Coherence alone is not causality. The missing bridge is a rule showing how compatible phase relations constrain possible transitions. The working hypothesis is that high coherence selects a stable partial order among realizable informational transitions. In a low-coherence regime, alternative orderings interfere or fail to support durable records. In a high-coherence regime, relational updates become mutually consistent across large domains.

The proposed hierarchy can be expressed as

1. Discrete relations support alternative state transitions.
2. Relative phase determines compatibility among those transitions.
3. Collective alignment suppresses inconsistent ordering at coarse scales.
4. Stable transitions create persistent records and distinguish realized history from unrealized alternatives.

5. The resulting network admits a causal partial order.

This does not require every pair of events to be ordered. Relativistic causality already permits spacelike-separated events without an invariant before-and-after relation. A successful coherence model should therefore yield a partial order and light-cone structure, not a universal sequence.

7 Records Entropy and the Arrow of Time

The arrow of time is provisionally associated with the direction in which mutable possibilities become stable causal records. Once a transition is realized, its consequences constrain later accessible states. The past is represented by records embedded in the present network; the future is represented by unresolved alternatives. This is an informational asymmetry, not a claim that microscopic quanta literally know which direction is future.

$$\text{possible configurations} \rightarrow \text{realized transition} \rightarrow \text{persistent record}$$

In a suitable coarse graining, the amount of distributed record information may be nondecreasing:

$$I_{\text{record}}(n+1) \geq I_{\text{record}}(n)$$

That inequality is not assumed to hold for every microscopic subsystem. Local erasure, reversible evolution, and fluctuation remain possible. The claim requiring investigation is whether globally consistent records, decoherence, and thermodynamic entropy growth arise together from the same coherence dynamics. The framework must ultimately recover standard statistical mechanics rather than replace it with a verbal arrow-of-time mechanism.

8 Emergent Space and Spacetime

8.1 Distance from connectivity

Because the primitive relations are not embedded in space, effective distance must be reconstructed. A first candidate is graph or information distance: two states are farther apart when more allowed relational steps are required to connect them. Weighted paths can incorporate coherence strength, transition cost, or distinguishability.

$$d(i,j) = \min_{\text{paths } P} \sum_{(kl \in P)} \ell(C_{kl})$$

The function ℓ must be chosen so that the large-scale distance is approximately smooth, local, and compatible with relativistic causal cones. Ordinary spatial dimension should emerge from connectivity and scaling behavior rather than be inserted by hand.

8.2 Proper time from causal transitions

A worldline may be represented as a sequence of causally compatible state transitions. In a continuum limit, proper time could be proportional to an invariant count or phase accumulation along that chain:

$$d\tau = \kappa dN_{\text{causal}} \quad \text{or} \quad d\tau = \kappa d\Phi_{\text{path}}$$

Neither expression is yet sufficient. The microscopic construction must explain why all ideal local clocks measure the same proper-time structure and why the equivalence principle holds.

8.3 The effective metric

The continuum hypothesis is that coarse-grained tetrad and transport relations define an effective Lorentzian metric, while phase coherence selects and stabilizes its temporal orientation and causal use. The metric is therefore constructed primarily from the geometric link sector rather than from the temporal angle alone:

$$g_{\mu\nu} = \eta_{ab} e^a{}_\mu(E,U) e^b{}_\nu(E,U), \quad \text{with} \quad \theta \text{ responding through } d\theta = \omega_0 d\tau.$$

The central theoretical task is to derive the functional $F_{\mu\nu}$ rather than choose it to reproduce a desired metric. In particular, the model must generate one temporal and three spatial dimensions in the observed regime, the correct metric signature, local Lorentz symmetry, and stable null cones.

9 Matter Energy and Geometry from One Substrate

Version 0.1 described mass-energy as a source that perturbs a temporal substrate. The revised model recognizes a circularity in that ordering: conventional mass-energy is already defined within spacetime. The stronger post-Timmy conjecture is that both matter and geometry arise from the same informational network.

$$\text{underlying quantized relations} \rightarrow \{\text{persistent excitations, causal geometry}\}$$

Persistent, localized excitation patterns are candidates for matter and energy. Coarse-grained relational connectivity is a candidate for geometry. Einstein's field equation would then appear as a macroscopic consistency relation between two effective descriptions of one underlying system:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = (8\pi G/c^4) T_{\mu\nu}$$

The equation is not derived here. It is the non-negotiable target. The microscopic model must explain why excitation content and emergent geometry satisfy this relation, including covariant conservation $\nabla_\mu T_{\mu\nu} = 0$.

10 Route Toward Quantum Mechanics and Relativity

Keeping quanta and relative phase preserves a possible route toward unification. It does not, by itself, unify the theories. The strategy is to place quantum behavior and relativistic spacetime downstream of one substrate rather than quantize a pre-existing classical geometry.

Regime	Required emergence	Unresolved derivation
Microscopic	Superposition, interference, entanglement, unitary or generalized quantum evolution.	Define Hilbert space, amplitudes, observables, and Born probabilities.
Coherence transition	Stable relative phase, causal compatibility, records, and	Derive decoherence and selection

Regime	Required emergence	Unresolved derivation
	classicality.	of robust causal domains.
Continuum	Lorentzian geometry, local Lorentz invariance, equivalence principle.	Recover metric dynamics and identify the continuum limit.
Gravitational	Einstein gravity plus controlled corrections.	Derive field equations and strong-field behavior.

The phase variable is suggestive because relative phase is central to quantum interference and because collective phase is central to ordered matter. Suggestion is not equivalence. A classical XY model cannot reproduce quantum mechanics merely because it contains angles. The final theory must specify complex amplitudes, noncommuting observables, entanglement, measurement statistics, and relativistic quantum fields or explain how their successful predictions emerge.

11 Invariance and the Meaning of Light Speed

The speed of light should not be described as changing locally. Any viable model must preserve the observed local invariance of c . A more defensible conjecture is that c is the continuum expression of a maximum rate or structure of causal-information propagation. In the emergent metric, light must follow null trajectories

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu = 0$$

and every freely falling local observer must recover the same limiting speed. A microscopic propagation rule that selects a preferred observable frame would conflict with stringent Lorentz-symmetry tests unless the violation is suppressed beyond current limits. The research question is therefore not whether light travels through a variable temporal medium, but how an underlying relational network can yield invariant null structure.

12 Scalar Coherence Gravity as an Explored Branch

This section pushes the alignment proposal beyond a qualitative analogy. It constructs the smallest relational model that can generate a gravitational potential, states the assumptions required for its continuum limit, and identifies exactly where the scalar construction fails to reproduce full General Relativity. The failure is used to determine the additional microscopic variables required by the theory.

12.1 Relational graph and phase alignment

Let the pregeometric substrate be a weighted graph $\mathcal{G} = (Q, E)$, with informational degrees of freedom q_i and nonnegative relational weights w_{ij} . An edge denotes an allowed direct relation, not proximity in a pre-existing space. Each q_i carries an internal U(1)-type phase θ_i . Only relative phase is physically relevant, so the microscopic alignment energy is invariant under the global transformation $\theta_i \rightarrow \theta_i + \alpha$.

$$S_{align} = -(J/2) \sum_{ij} w_{ij} \cos(\theta_i - \theta_j)$$

In a coherent domain, neighboring phase differences are small. Expanding to quadratic order gives

$$S_{align} \approx \text{constant} + (J/4) \sum_{ij} w_{ij} (\theta_i - \theta_j)^2$$

Using the weighted graph Laplacian

$$L_{ij} = \delta_{ij} \sum_k w_{ik} - w_{ij},$$

the quadratic part becomes

$$S_{align,2} = (J/2) \sum_{ij} \theta_i L_{ij} \theta_j.$$

This establishes a genuine discrete stiffness equation. By itself, however, θ is a phase Goldstone variable. A direct term $m_i \theta_i$ would make absolute phase observable and violate the relational symmetry. Matter therefore cannot be coupled to θ through an arbitrary linear source.

12.2 Gauge invariant coherence strain

Define the edge strain

$$s_{ij} = 1 - \cos(\theta_i - \theta_j).$$

It is invariant under a common phase shift and measures local failure of alignment. Coarse-graining the edge strain over a neighborhood defines a scalar coherence distortion φ_i . The precise blocking map must ultimately be derived from the microscopic ensemble; at the effective graph level, φ_i is treated as the slowly varying scalar mode produced by alignment defects and persistent excitation patterns.

The minimal static effective action is

$$S_{eff}[\varphi, m] = (K/2) \sum_{ij} \varphi_i L_{ij} \varphi_j - \alpha \sum_i m_i \varphi_i,$$

where m_i is the invariant excitation content assigned to node or cell i . Variation with respect to φ_i gives

$$K \sum_j L_{ij} \varphi_j = \alpha m_i.$$

Unlike a direct $m\theta$ coupling, the source term couples matter to a gauge-invariant coarse-grained distortion. This is the first field equation generated by the revised framework.

12.3 Continuum limit and the inverse square field

Assume that the ordered graph phase has spectral dimension three over the scales of interest and that its rescaled Laplacian converges to the spatial Laplace operator:

$$\ell q^{-2} \sum_j L_{ij} \varphi_j \rightarrow -\nabla^2 \varphi(x).$$

Here ℓq is the relational coarse-graining scale. The continuum equation becomes

$$\nabla^2 \varphi = -\alpha \rho m / (K \ell q^2).$$

Define the observable weak-field potential by $\Phi = -\beta \varphi$ and impose the coupling match

$$\alpha \beta / (K \ell q^2) = 4\pi G.$$

The effective field equation is then

$$\nabla^2 \Phi = 4\pi G \rho m.$$

For a localized excitation of total mass M ,

$$\rho m(x) = M \delta^3(x),$$

the Green function of the three-dimensional Laplacian gives

$$\Phi(r) = -GM/r,$$

and the acceleration of a weak test excitation is

$$a = -\nabla \Phi = -(GM/r^2) \hat{r}.$$

The inverse-square law is therefore not separately assumed once three ingredients are granted: graph-Laplacian dynamics, a three-dimensional continuum phase, and the coupling match defining G . The derivation does not yet explain why the ordered graph selects spectral dimension three or calculate G from more primitive constants. Those remain explicit obligations.

12.4 Proper time and the temporal metric component

Let the rate of an ideal local relational clock depend universally on the scalar distortion through

$$d\tau = \exp(\Phi/c^2) dt.$$

This exponential is a candidate constitutive relation. Its weak-field expansion is

$$d\tau \approx (1 + \Phi/c^2) dt.$$

Comparing $d\tau^2 = -g_{00} dt^2/c^2$ for a stationary clock gives

$$g_{00} = -\exp(2\Phi/c^2) \approx -(1 + 2\Phi/c^2).$$

For $\Phi = -GM/r$, this reproduces the weak-field temporal part of the Schwarzschild metric and the leading gravitational redshift. Universality must be demonstrated: every viable clock excitation must couple to the same Φ with the same coefficient. Without that result, the equivalence principle has been assumed rather than derived.

12.5 Scalar completion and tensor failure

One may attempt to define an isotropic scalar metric

$$ds^2 = -\exp(2\Phi/c^2)c^2dt^2 + \exp(-2\Phi/c^2)d\mathbf{x}^2.$$

To first order this yields

$$ds^2 \approx -(1 + 2\Phi/c^2)c^2dt^2 + (1 - 2\Phi/c^2)d\mathbf{x}^2,$$

which matches the standard weak-field metric and therefore reproduces the leading Newtonian, redshift, light-bending, and Shapiro-delay structure. But this is a metric ansatz, not a consequence of the scalar graph equation. More importantly, a single scalar field cannot represent the general tensor geometry of relativity. It cannot supply arbitrary tidal structure, frame dragging, the Kerr family, or the two tensor polarizations of gravitational waves.

$$\text{one scalar coherence mode} \neq \text{full metric gravity}$$

This is a useful negative result. Angular alignment can generate a scalar gravitational sector, but full General Relativity requires the relational geometry itself to be dynamical.

12.6 What the scalar branch established

The scalar branch is retained because it produced a legitimate conditional result rather than a mere analogy. Given a gauge-invariant scalar coherence distortion, graph-Laplacian dynamics, a three-dimensional continuum limit, and a coupling match, the construction yields the Poisson equation and its $1/r$ Green function. It therefore shows that angular-order dynamics can contain a gravitationally suggestive scalar sector.

The same calculation also identifies two reasons not to adopt that branch as the primary formulation of Temporal Coherence Gravity. First, it assigns the temporal angle both temporal and geometric responsibility:

$$\theta \rightarrow \{\text{temporal coherence and causal order, gravitational potential}\}.$$

Second, even after obtaining the correct weak-field scalar potential, the model cannot derive general tensor geometry. The spatial metric must be supplied through an additional ansatz, and the scalar cannot independently represent frame dragging, generic tidal curvature, Kerr geometry, or two tensor gravitational-wave polarizations.

12.7 Refactoring decision

Version 0.4 therefore retains the scalar calculation as an explored branch but supersedes it as the adopted ontology. The change is not made because the Poisson calculation is algebraically invalid. It is made because the construction overloads the temporal angle and remains structurally incapable of recovering full General Relativity.

The adopted division is:

$$\begin{aligned} \text{temporal phase} &\rightarrow \text{time, causal compatibility, and clock response} \\ \text{relational geometry} &\rightarrow \text{intervals, metric, curvature, and gravity} \end{aligned}$$

Accordingly, the direction of explanation changes from

$$\delta\theta \rightarrow \Phi \rightarrow g_{00}$$

in the scalar branch to

$$\delta(E, U) \rightarrow g_{\mu\nu} \rightarrow d\tau \rightarrow \delta\theta$$

in the adopted formulation. Geometry determines proper time; temporal phase accumulates according to proper time; and angular alignment establishes a coherent macroscopic temporal orientation.

13 Refactored Temporal and Geometric Sectors

13.1 Division of responsibility

The post-refactor substrate remains one quantized relational system, but it contains distinct degrees of freedom with distinct jobs. This is not a return to independent fundamental spacetime and matter. It is a refusal to force a single scalar angle to encode structures for which it lacks the necessary degrees of freedom.

Variable	Primary responsibility	Not assigned to it
$\Delta\theta_{ij}$	Temporal alignment, causal compatibility, clock phase	Independent generation of the full gravitational metric
E^a_{ij}	Relational interval, coframe, emergent metric	Selection of temporal direction by itself
U_{ij}	Local-frame transport, holonomy, curvature	Matter content by itself
ψ_i	Persistent excitation patterns and stress-energy	Background spacetime independent of the network

The complete relational state may be represented schematically as

$$|\Psi_{rel}\rangle = |\theta, E, U, \psi\rangle.$$

Quantum behavior belongs to the microscopic state and its relational observables. Classical time and geometry belong to different but coupled collective sectors of that state.

13.2 Dynamical relational geometry

Extend each oriented relation with a discrete coframe or tetrad variable E^a_{ij} and a Lorentz transport variable U_{ij} . The phase continues to encode coherence, while the new link variables encode relational interval and local-frame transport:

$$\mathcal{R}_{ij} = (\exp[i(\theta_j - \theta_i)], E^a_{ij}, U_{ij}).$$

After coarse-graining, E^a_{ij} must produce a tetrad field $e^a_\mu(\mathbf{x})$. The metric is then constructed rather than independently postulated:

$$g_{\mu\nu} = \eta_{ab} e^a_\mu e^b_\nu.$$

Parallel transport around a closed relational face f produces a holonomy

$$Uf = \prod_{(ij \in \partial f)} U_{ij},$$

whose departure from the identity measures discrete curvature. For a small emergent loop,

$$Uf \approx \exp[(1/2)R^{ab}{}_{\mu\nu} \Sigma_{\mu\nu} f^{ab}].$$

13.3 Candidate discrete gravitational action

A simple trace of $1 - Uf$ generally produces a curvature-squared Yang-Mills-type action, not the Einstein-Hilbert action. The appropriate target is instead a discrete first-order Palatini structure in which an oriented area bivector built from tetrads contracts with curvature. Schematically,

$$S_{grav} = (1/4\kappa) \sum_f \epsilon_{abcd} B^{ab} f^{cd},$$

where B^{ab} is constructed from wedge products of relational tetrads associated with face f , Ω^{cd} is the curvature extracted from Uf , and

$$\kappa = 8\pi G/c^4.$$

If the graph admits a smooth Lorentzian continuum limit, the required convergence is

$$S_{grav} \rightarrow (1/4\kappa) \int \epsilon_{abcd} e^a \wedge e^b \wedge R^{cd},$$

which is equivalent to the Einstein-Hilbert action, up to boundary terms, when the connection equations impose the appropriate torsion condition:

$$S_{grav} \rightarrow (c^4/16\pi G) \int d^4x \sqrt{(-g)} R.$$

Varying the resulting continuum action with respect to the tetrad or metric gives

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = (8\pi G/c^4) T_{\mu\nu}.$$

This establishes the precise mathematical route required for recovery of relativistic gravitational fields. It does not yet prove that the proposed phase-and-link statistical system generates the Palatini action. That renormalization and coarse-graining calculation is the central unresolved derivation.

13.4 Unified microscopic action

The adopted microscopic theory has three coupled sectors:

$$S_{micro} = S_{phase}[\theta, E, U] + S_{geometry}[E, U] + S_{excitation}[\psi, \theta, E, U].$$

- Sphase controls relational alignment, coherence domains, and the scalar weak-field mode.
- Sgeometry makes adjacency, tetrads, and Lorentz transport dynamical and supplies tensor curvature.
- Sexcitation produces persistent matter patterns and their back-reaction on coherence and geometry.

The unification claim becomes testable only if coarse-graining this single action produces both quantum matter and the gravitational effective action without inserting either as an independent macroscopic law.

13.5 Geometry to temporal coherence coupling

The adopted formulation requires geometry to modulate temporal phase without making the phase the source of the entire metric. Let an ideal clock-like excitation have intrinsic proper angular frequency ω_0 . Its phase accumulates according to

$$d\theta = \omega_0 d\tau,$$

where proper time is determined by the emergent metric:

$$d\tau^2 = -g_{\mu\nu} dx^\mu dx^\nu / c^2.$$

For a stationary clock in a weak static field,

$$d\tau \approx (1 + \Phi/c^2)dt,$$

and therefore

$$d\theta/dt \approx \omega_0(1 + \Phi/c^2).$$

Gravitational time dilation is thus expressed as a change in temporal phase accumulation caused by geometry. Alignment among many such relational phases supplies a coherent temporal direction and stable causal order. The equivalence principle requires every ideal clock-like excitation to couple to the same proper-time structure, independent of its internal construction.

The coupled explanatory chain is now

$$\psi \rightarrow \delta(E, U) \rightarrow \delta g_{\mu\nu} \rightarrow \delta\tau \rightarrow \delta\theta,$$

with feedback permitted because the full microscopic action couples all sectors. The conceptual assignment, however, remains fixed: E and U carry geometry; θ carries temporal coherence and its response.

13.6 Recovery ladder

Level	Required result	Present status
Scalar coherence branch	Graph Poisson equation	Retained as an explored branch
Three dimensional continuum	$\Phi = -GM/r$ and inverse square acceleration	Conditional result of the explored scalar branch
Clock sector	Proper-time phase response and redshift	Adopted relation $d\theta = \omega_0 d\tau$; universality remains to be derived
Spatial weak field	Weak-field Φ and spatial metric from E and U	Required geometric derivation
Tensor geometry	Tetrad, connection, curvature	Candidate microscopic variables identified
Einstein dynamics	Palatini or Einstein	Required coarse graining

Level	Required result	Present status
	Hilbert effective action	not yet completed
Quantum unification	Matter and geometry from one quantum state space	Open

13.7 Immediate falsification tests for the adopted construction

1. Simulate the phase-and-dynamic-link model and test, without a target-dimensional term, whether dimension-blind dynamics either produce a robust near-three regime or cause diverse initial topologies to encounter/cross the three-dimensional regime.
2. Insert a localized stable excitation and test whether the gauge-invariant scalar response follows the graph Green function and approaches $1/r$.
3. Test whether different clock-like excitations acquire the same redshift, as required by universality and the equivalence principle.
4. Coarse-grain the tetrad and holonomy sector and determine whether the leading two-derivative action is the Palatini or Einstein-Hilbert action rather than an unwanted scalar or curvature-squared theory.
5. Linearize the emergent geometry and verify exactly two massless tensor polarizations propagating on the same null cone as matter.
6. Calculate the leading higher-curvature or Lorentz-violating corrections and compare them with existing experimental bounds.

14 Weak Field Matching Conditions

The earlier paper used a coherence-dependent effective metric to reproduce familiar weak-field expressions. In the revised framework these relationships are treated as matching conditions. For a static, approximately spherical source, the continuum limit must approach

$$g_{00} \approx -(1 + 2\Phi/c^2), \quad g_{ij} \approx (1 - 2\Phi/c^2) \delta_{ij}$$

$$\Phi(r) \approx -GM/r$$

A stationary clock must therefore satisfy, to first order,

$$d\tau \approx dt (1 + \Phi/c^2)$$

and a successful model must reproduce the Schwarzschild result in the appropriate regime

$$d\tau = dt \sqrt{1 - 2GM/rc^2}$$

The same emergent structure must yield Newtonian acceleration $a = -\nabla\Phi$ and the observed first-order deflection of light. Defining a coherence field and then mapping it onto these equations is not a derivation. The required advance is to obtain the mapping from microscopic relational dynamics with as few adjustable assumptions as possible.

15 Candidate Continuum Description

A phenomenological field can still organize the continuum problem. Let $\Psi(x) = \rho(x)\exp[i\Theta(x)]$ denote the coarse-grained informational order parameter after an effective manifold has emerged. A generic action may contain

$$S\Psi = \int d^4x \sqrt{-g} [-A/D\mu\Psi|^2 - V(|\Psi|) + L_{coupling}]$$

This expression is deliberately schematic. The derivative, symmetry group, potential, and coupling terms must be determined by the microscopic theory. It is useful only after spacetime has emerged and therefore cannot serve as the fundamental pre-spacetime law. Its role is comparable to a hydrodynamic description: it may capture long-wavelength behavior without specifying the underlying constituents.

16 Early Universe and Phase Structure

The early universe may be modeled as a regime in which classical causal order and continuum geometry were not yet robust. Increasing correlation could drive a transition from an informationally disordered phase to a coherent causal phase. The phrase before time must be used carefully because ordinary temporal comparison is undefined prior to emergent causal order.

$$\textit{disordered quantum relations} \rightarrow \textit{coherent causal domains} \rightarrow \textit{continuum spacetime}$$

This proposal raises concrete questions. What controls the transition? Are there multiple domains with different collective phases? How are defects removed or preserved? Can inflation, horizon-scale uniformity, or primordial fluctuations be recovered? A phase-transition analogy becomes physical only when a microscopic state space, an order parameter, and dynamical or constraint equations are specified.

17 Black Holes and Strong Coherence

Black holes are not assumed to be regions where Timmies become maximally aligned. In the revised model they are extreme configurations of emergent causal connectivity and excitation content. Event horizons may correspond to boundaries across which the network's accessible causal relations become one-way in the continuum description. This interpretation must reproduce ordinary horizon geometry before it can claim new explanatory value.

The framework may eventually offer a language for information retention: microscopic relational information could remain in degrees of freedom not visible in the semiclassical metric. That possibility does not solve the information paradox. A solution requires a unitary or otherwise well-defined account of formation, evaporation, entropy, and radiation correlations.

18 Observational Consequences

A useful theory must predict more than the theories it seeks to underlie. The most plausible deviations would occur where the continuum approximation is stressed: extreme curvature, very long propagation paths, early-universe transitions, or microscopic causal fluctuations.

Candidate effects include stochastic timing broadening, modified correlation structure, or departures from General Relativity in strong fields.

18.1 Gamma ray burst timing

Version 0.1 proposed searching for residual timing variance in gamma-ray bursts after controlling for intrinsic source physics. The revised model retains this as a possible phenomenological test, but no unique amplitude or energy dependence has been derived. Existing limits on deterministic Lorentz-violating dispersion strongly constrain models that predict systematic energy-dependent delays. A stochastic broadening prediction must therefore be quantitatively separated from source variability and instrumental effects before it becomes diagnostic.

18.2 Cosmology

Evolving coherence regimes were previously discussed as a possible perspective on the Hubble tension. This remains speculative and should not be treated as evidence for the framework. A credible proposal must first derive an expansion history and then fit the same supernova, baryon acoustic oscillation, cosmic microwave background, lensing, and structure-growth observations used to test standard cosmology.

18.3 Precision clocks and interferometry

If microscopic coherence produces measurable noise, precision clock networks or interferometers could in principle constrain it. Any proposal must state a spectral shape, correlation length, coupling, and amplitude. Without those quantities, atomic-clock anomalies are a search category rather than a prediction.

19 Falsifiability

The framework fails as a physical theory if no mathematically coherent microscopic model can satisfy its central matching requirements. More specifically, a candidate realization is rejected if it:

- requires a physically observable preferred frame inconsistent with Lorentz tests;
- cannot recover a Lorentzian causal structure and the equivalence principle;
- cannot reproduce standard quantum predictions in their tested domain;
- cannot produce the weak-field metric, Newtonian gravity, gravitational time dilation, and lensing;
- violates established conservation laws without a compensating and testable mechanism;
- requires fine tuning that merely inserts the desired metric;
- predicts propagation effects already excluded by observation; or
- produces no distinctive quantitative prediction even after formal completion.

Null observational results can falsify particular parameter ranges or implementations even if they do not eliminate every possible coherence-based model. The research program becomes scientifically useful only when the freedom to modify the substrate is sufficiently restricted.

20 Limitations

- The primitive information quantum is not yet defined as a Hilbert-space object, algebraic relation, event, or transition.
- The internal angle is a toy variable; its transformation properties and physical meaning remain unresolved.
- No background-independent microscopic dynamics has been supplied.
- The emergence of causal partial order from phase alignment has not been derived.
- The map from coherence data to a Lorentzian metric is unspecified.
- Matter, energy, spin, gauge fields, and fermionic statistics have not been recovered.
- Einstein's equation and conservation laws have not been derived.
- The Born rule, measurement, and entanglement structure have not been recovered.
- No unique numerical prediction currently distinguishes the framework from existing theories.

These are not peripheral details. They are the work required to convert a conceptual framework into a candidate theory.

21 Research Program

21.1 Minimal toy model

1. Choose the primitive state space and decide whether the phase is $U(1)$, spinorial, or another structure.
2. Define informational adjacency without a background metric.
3. Specify a constraint or relational update rule that does not rely on observable external time.
4. Measure phase ordering, domain formation, correlation length, and record stability in simulation.
5. Test whether a causal partial order and an effective dimensionality emerge.

21.1.1 Cellular automaton coherence experiment

A Game-of-Life-style experiment remains the most direct first simulation because it can test the temporal sector before the geometric sector is mature. The automaton should use local relational rules, discrete phase states or a compact angular variable, controllable noise, and no rule that explicitly labels one macroscopic direction as future. The primary question is whether stable coherent domains and persistent records arise from local updating.

The first experiment should measure:

- growth or decay of the temporal order parameter $\rho = |N^{-1}\sum_i \exp(i\theta_i)|$;
- domain formation, domain-wall persistence, and defect density;
- whether realized patterns create durable records that constrain later states;
- whether a stable partial ordering can be reconstructed from influence propagation;
- sensitivity to noise, coupling strength, update synchrony, and initial conditions; and

- whether apparent temporal direction is robust or merely imposed by the simulation scheduler.

This experiment does not test full General Relativity. A successful result would support only the claim that local angular coherence can organize temporal order, causality, and records. A second-stage experiment must make adjacency, tetrads, and transport variables dynamical and test whether relational geometry develops the required continuum and gravitational response.

21.2 Continuum derivation

1. Derive a coarse-grained order parameter from the microscopic model.
2. Construct an effective distance and causal cone from network correlations.
3. Identify the conditions producing a smooth Lorentzian manifold.
4. Derive or rule out an effective metric equation.
5. Recover the weak-field and post-Newtonian limits without inserting them by definition.

21.3 Quantum recovery

1. Define amplitudes, observables, and composition rules.
2. Demonstrate interference and entanglement beyond classical phase statistics.
3. Explain decoherence and robust records.
4. Recover ordinary quantum field behavior on the emergent background.
5. Determine whether matter excitations and geometry arise from the same relational variables.

21.4 Empirical program

1. Convert continuum corrections into parameterized observables.
2. Compare them with existing Lorentz, clock, lensing, gravitational-wave, and cosmological bounds.
3. Pre-register analyses where source modeling is flexible, especially for gamma-ray bursts.
4. Publish null constraints alongside any apparent signal.

22 Conclusion

Temporal Coherence Gravity Version 0.5 preserves the mathematical and conceptual refactor of Version 0.4 while adding an explicit Logos-inspired philosophical foundation. The framework now places generative relational order prior to informational distinctions. This does not replace the physical model with theology or treat Scripture as experimental evidence. It states the metaphysical premise motivating the choice to regard intelligible relations and lawful constraints as prior to physical objects.

The proposed structure is

generative relational order → information quanta → temporal coherence → causal order →
spacetime

The same branch shows why it is not adopted as the primary ontology. It gives the temporal phase both temporal and gravitational responsibilities and cannot supply the tensor degrees of freedom of General Relativity. In the adopted formulation, relational tetrads and Lorentz transport generate the metric and curvature. Temporal phase generates coherent time, causal compatibility, and clock response to the resulting proper-time structure.

The decisive next step is to construct and simulate the coupled phase, tetrad, connection, and excitation system; show that the geometric sector yields the Newtonian and Einstein limits; and show that its proper-time structure universally controls temporal phase accumulation. Version 0.5 therefore contains both the explored scalar branch and the refactored theory, with the reason for the transition stated explicitly.

Research Note The Death of Timmy

Version 0.1 introduced Temporal Event Quanta, informally called Timmies, as a conceptual substrate for temporal organization. Timmy made local state, phase, ordering, coherence, and emergent causality easier to reason about. As the framework developed, however, the important behavior proved to reside in the coherence relationships rather than in a literal entity carrying them.

The revised framework therefore kills Timmy as a required fundamental object. It does not discard quantization, angular phase, or alignment. Those features are reassigned to discrete informational relations. The question changes from What are the fundamental temporal particles to What quantized informational relationships generate stable causality and emergent spacetime.

The irony is consistent with the framework itself. Timmy remains recorded in the causal history of the theory. The object is unnecessary; the information survives.

23 Experimental Program and Numerical Results through Experiment 20R

Status and provenance. Experiments 1-5 are backed by surviving source code and machine-readable result files. Experiments 6-17 are reconstructed here from the comprehensive September 25 research checkpoint, which records their equations, numerical outcomes, failures, and corrections, but the original Phase-2 source repository is no longer available. Experiment 18R and Experiment 20R are new independent reconstruction/replication runs created from the surviving specifications. The historically reported 18B/19 results are retained only as non-reproducible conversation-derived observations and are not merged with the reconstructed numerical evidence.

Interpretive rule. The logical rewrite/update index n is simulation bookkeeping, not physical proper time. Effective spatial dimension D is an inferred graph observable, not an input to the dynamics. The reconstructed experiments contain no target- D term and no hidden coordinates.

23.1 Common observables and mathematical definitions

The phase sector uses a complex order parameter and local edge compatibility:

$$\Psi = (1/N) \sum_i \exp(i \theta_i) = \rho \exp(i \Theta), \quad \rho = |\Psi|$$

$$C_{ij} = \cos(\theta_i - \theta_j)$$

For the reconstructed geometry experiments, the coordinate-free graph G has N nodes and fixed degree k . The mean phase score and common-neighbor redundancy are

$$P_{\text{phase}} = (1/|E|) \sum_{(i,j) \in E} \cos(\theta_i - \theta_j)$$

$$R = (1/|E|) \sum_{(i,j) \in E} |N(i) \cap N(j)| / (k-1)$$

Global transport is represented by harmonic graph efficiency on the original N -node denominator:

$$E_{\text{harm}}(G) = [1/(N(N-1))] \sum_{(i \neq j, d_{ij} \text{ finite})} 1/d_{ij}$$

The 18R-v3 objective is dimension-blind:

$$J = P_{\text{phase}} + R + \beta E_{\text{harm}} + 0.5 B_{\text{edge}} + 0.5 S_{\text{node}}$$

Here B_{edge} is mean efficiency retention after random 5% edge deletion and S_{node} is mean efficiency retention after random 10% node deletion, each normalized to intact-graph efficiency. Candidate degree-preserving friend-of-friend rewires are accepted when they improve J or by an annealed Metropolis probability

$$P_{\text{accept}} = \min[1, \exp((J_{\text{new}} - J_{\text{old}})/T_n)]$$

$$T_n = 0.015(1 - n/N_{\text{steps}}) + 0.001$$

The effective dimension meter uses the low normalized-Laplacian spectrum. For ordered nonzero eigenvalues λ_m , a Weyl-law scaling $N(\lambda)$ proportional to $\lambda^{(D/2)}$ gives

$$\log m = (D/2) \log(\lambda_m) + \text{constant}, \quad D = 2 \times \text{fitted slope}$$

The accompanying R^2 is a fit-quality diagnostic, not proof that the graph is a smooth manifold.

23.2 Experiment 1 - Alignment versus microscopic irreversibility

Purpose: separate macroscopic phase ordering from a fundamental arrow of time by comparing dissipative, stochastic detailed-balance, and reversible rotor dynamics.

Dynamics	Final rho mean	rho SD	Final energy	Defects	Return error
Dissipative	0.2573	0.1053	0.0887	0.0084	-
Metropolis	0.3858	0.1874	0.2138	0.0029	-
Reversible rotor	0.0177	0.0076	2.0012	0.3381	2.086e-13

Result: dissipative and Metropolis rules formed ordered domains, while exact momentum reversal in the rotor model returned with mean error 2.09×10^{-13} . Alignment therefore does not by itself establish microscopic irreversibility.

23.3 Experiment 2 - Alignment threshold, persistence, and ancestry bookkeeping

Purpose: measure the coupling/noise crossover, persistence after coupling removal, and whether a stipulated ancestry counter can remain monotonic through disruption.

K	Global order	Local order	Ready fraction
0	0.0261	0.4036	0.0353
0.25	0.1494	0.7745	0.5630
0.5	0.1807	0.8912	0.8769
0.75	0.2772	0.9260	0.9442
1.0	0.2243	0.9366	0.9525
1.5	0.3779	0.9557	0.9705
2.0	0.2994	0.9592	0.9716

After coupling removal, the coherence half-decay time was 109 updates. During the ancestry test, mean committed events increased from 1388.8 before disruption to 2120.7 at the end, with 0 erased by construction.

Limitation: ancestry permanence was stipulated by the bookkeeping rule. This directly motivated replacing commitment with physical redundant records.

23.4 Experiment 3 - Redundant records and damage tolerance

A source bit was copied into 24 conditionally independent records. Accessible information was evaluated as record fragments were retained or deleted; redundancy R_{Δ} was defined from the minimum fragment carrying at least 90% of one bit.

Fidelity	Decoherence factor	90% fragment	R_{Δ}	I(1 record)	I(all)
0.10	0.2824	19	1.26	0.1721	0.9417
0.25	0.0317	7	3.43	0.3546	0.9993
0.50	0.0002	3	8.00	0.6009	1.0000
0.75	5.960e-08	2	12.00	0.8113	1.0000
0.90	1.000e-12	1	24.00	0.9266	1.0000
0.99	1.000e-24	1	24.00	0.9928	1.0000
1.00	0.0000	1	24.00	1.0000	1.0000

At fidelity 0.75, deleting half the records left information 0.999999957 and decoding accuracy 0.999999970; deleting all records returned information to 0 and accuracy to 0.5.

Result: operational history can be distributed and damage tolerant, although complete reversal/erasure of every record still removes the information.

23.5 Experiment 4 - Smooth coherence-to-record coupling

$$F(\rho) = \text{sigmoid}[18(\rho - 0.78)]$$

This removed the hard commitment threshold but introduced an arbitrary fitted response curve.

K	Local coherence	Mean fidelity	Event information	Effective redundancy
0.00	0.4007	0.0540	0.5436	0.7299
0.15	0.5964	0.2549	0.9922	2.8910
0.25	0.7240	0.4688	0.9993	5.2916
0.40	0.8085	0.6463	1.0000	12.4434
0.60	0.8699	0.7785	1.0000	15.2243
1.00	0.9150	0.8670	1.0000	20.2105
1.50	0.9332	0.8949	1.0000	25.2846

The transition to near-complete event information was robust, but the sigmoid had no microscopic derivation. It was therefore treated as a failed modeling shortcut rather than a physical law.

23.6 Experiment 5 - Hamiltonian-derived record response

$$H_{\text{int}} = (\hbar g/2) \rho |1\rangle\langle 1|_S \text{ tensor } \sigma_y^M$$

$$U = \exp(-i H_{\text{int}} \tau / \hbar)$$

$$F(\rho) = \sin^2(g \tau \rho / 2)$$

K	Coherence	Fidelity	Information	Redundancy
0	0.0948	0.0276	0.6043	0.3616
0.15	0.2055	0.1209	0.9584	1.5614
0.25	0.3020	0.2377	0.9984	3.2740
0.40	0.4026	0.3713	1.0000	6.1244
0.60	0.4791	0.4747	1.0000	8.2659
1.00	0.5687	0.5913	1.0000	11.9110
1.50	0.6026	0.6332	1.0000	15.5425

At K=1 the information was 0.9999999986 with redundancy 11.91. After half reversal the representative information remained 0.999537; complete reversal returned it to zero. The arbitrary sigmoid was removed, but the interaction action $g \tau$ remains a model scale requiring derivation from the full relational theory.

23.7 Experiment 6 - Discrete coframes and holonomy

- Flat curvature: 0
- Lorentz-signature fraction: 1
- Metric gauge error: 3.55×10^{-15}
- Curvature gauge error: 4.44×10^{-16}

- Source-curvature correlation: 0.999886
- Field residual: 0.02131

Added discrete coframes, $SO(1,1)$ transport, loop holonomy, and a localized-source benchmark. This established geometric infrastructure but did not derive geometry or its dimension.

23.8 Experiment 7 - Dynamical conformal coframe

- Source-curvature correlation: 0.999933
- Weak-field correlation: 1
- Signature fraction: 1
- Gauge error: 1.10×10^{-14}
- Linearity error: 0.07254
- Action decrease: 0.003994
- $\max |\phi|$: 0.05381

Used $S[\phi] = (1/2) \phi^T L \phi - \kappa \phi^T \phi$ with $e^a_\mu = \exp(\phi) \delta^a_\mu$. The first $\kappa=0.08$ run failed weak-field validity; $\kappa=0.01$ passed.

23.9 Experiment 8 - Newtonian limit from a 3D graph Laplacian

- $1/r$ potential fit R^2 : 0.999458
- Inverse-square field fit R^2 : 0.998998
- Gauss-flux CV: 0.01988
- Half/double source scaling: exact numerically
- Stable at lattice sizes 25, 33, 41

Used $S[\phi] = (1/2) \phi^T L \phi + \kappa \rho^T \phi$. Conditional recovery only: once a local 3D Laplacian is supplied, its $1/r$ Green function is expected.

23.10 Experiment 9 - Tidal structure

- Radial eigenvector alignment: 0.999936
- Radial/transverse eigenvalue ratio: 1.99665
- Relative vacuum trace: 0.04336
- Falloff power: -2.9384 ($R^2=0.999606$)
- Source scaling: exact numerically

Computed $E_{ij} = -\partial_i \partial_j \phi$. Recovered the Newtonian tidal pattern, still from a scalar potential.

23.11 Experiment 10 - Linear tensor benchmark

- Lorentz-signature fraction: 1
- Coframe-to-metric error: 2.22×10^{-16}
- PPN γ : 1
- Off-diagonal contamination: 0
- Harmonic-constraint residual: 0
- Field residual: 7.73×10^{-12}

- Pure-gauge curvature error: 1.38×10^{-15}

Successful linear spin-2 benchmark, but the symmetric tensor structure was supplied rather than derived.

23.12 Experiment 11 - Two tensor polarizations

- Plus-mode speed: 0.99849295
- Cross-mode speed: 0.99849295
- Expected numerical speed: 0.99849434
- Relative speed error: 1.389×10^{-6}
- Energy drift: 2.00×10^{-5}
- Trace/longitudinal contamination: 0
- Unwanted-mode power: 2.71×10^{-20}

Propagated plus and cross modes. The first analysis falsely failed because the cross-mode speed meter inspected h_{xx} instead of h_{xy} ; the corrected observable passed.

23.13 Experiment 12 - Shared weak-field metric observables

- Redshift RMS error: 0.0003606
- Deflection error: 0.04454
- Shapiro-delay error: 0.009396
- Inferred coupling CV: 0.03064

Used $ds^2 = -(1+2\Phi)dt^2 + (1-2\Phi)d\ell^2$ to predict redshift, light bending, and Shapiro delay. Demonstrated consistency of the benchmark metric, not microscopic derivation.

23.14 Experiment 13 - Recovering Fierz-Pauli structure

- Coefficient nullspace: [1,-2,2,-1]
- Coefficient error: 4.21×10^{-16}
- Gauge residual: 5.50×10^{-16}
- Singular-value gap: 8.56×10^{14}
- Direct gauge-action error: 3.29×10^{-14}
- Propagating TT modes: 2

Started from the most general local quadratic two-derivative symmetric-tensor action and imposed linear gauge invariance. The Fierz-Pauli combination was forced under the stated assumptions.

23.15 Experiment 14 - Link variables to a symmetric tensor

- Raw reconstruction error: 5.288
- Coarse-grained error: 0.5287
- Noise suppression: 10x
- Antisymmetric contamination: 0
- Gauge errors: 0.1031, 0.2052, 0.3075, 0.4142
- Gauge-error scaling: $k^{1.001}$

- Long-wave Laplacian error: 0.003209
- Fourth-order coefficient: -0.0769

Six directional link strains on a regular lattice were coarse-grained into a symmetric rank-2 tensor. This connected relational link data to tensor structure but retained a regular lattice.

23.16 Experiment 15 - Random-graph universality

- 18 ensembles, 1000 nodes each
- Minimum noise suppression: 4.780
- Mean noise suppression: 5.497
- Antisymmetric contamination: 0
- Mean gauge error: 0.2306
- Maximum gauge error: 0.4030
- Mean spectral RMS error: 0.1552
- Maximum spectral RMS error: 0.1739

A first run failed because the analytic gauge reference omitted a factor of two; the reference was corrected without changing thresholds. Hidden 3D positions were still used to generate the graphs.

23.17 Experiment 16 - Recovering geometry from connectivity only

- Mean spectral dimension: 3.2911 +/- 0.1414
- Mean local tangent dimension: 3.1737 +/- 0.08584
- Weyl-law R^2 : 0.97609
- Graph-distance/hidden-distance correlation: 0.93737
- Embedding/hidden-distance correlation: 0.93580

Connectivity alone recovered a latent 3D geometry; hidden coordinates were reserved for evaluation. The generator, however, already contained the 3D fact.

23.18 Experiment 17 - Coordinate-free dimensional selection

- Mean initial inferred D: 8.08585
- Mean final inferred D: 3.11209
- Final SD: 1.439
- One run: D=6.326; most others: D=2.35-2.58
- Weyl R^2 : 0.9943
- Coherence: 0.0014 -> 0.9869
- Final clustering: 0.382

Used phase compatibility, common-neighbor redundancy, and degree-preserving friend-of-friend rewiring with no hidden coordinates. Failed dimensional selection: the mean near three was not a robust attractor; redundancy over-localized the graph and global transport was missing.

23.19 Experiment 18 - Historical specification and lost implementation

At the September 25 checkpoint, Experiment 18 code and README had been built but deliberately not run. The predeclared test balanced phase compatibility, alternate-path/redundant-record support, long-range propagation efficiency, bridge value, random-damage survival, and a fixed total link budget. The transport sweep was beta in {0, 0.15, 0.3, 0.6, 1.2, 2.4}, three seeds each. Success required a stable near-three-dimensional region across adjacent parameter values, not a single tuned point. The later original implementation was lost; it is therefore not treated as reproducible evidence.

Surviving conversation notes report later 18-series iterations in which approximately three dimensions were reached after roughly 285-465 attempted rewrites but trajectories generally continued below three. Because the implementation and machine-readable outputs are missing, that number is historical context only.

23.20 Experiment 18R - Independent reconstruction/replication

18R reconstructed the documented objective without a target dimension. An initial pilot mistakenly used essentially random degree-preserving swaps and remained near $D \sim 6$. Restoring the documented Experiment-17 friend-of-friend proposal in 18R-v3 changed the behavior substantially. The frozen short-run sweep used $N=80$, degree=6, 180 rewrites, $K=0.65$, phase noise=0.16, three seeds, and the beta sweep below.

beta	Mean D	SD(D)	Mean Weyl R^2	Mean coherence	Mean transport
0	4.1071	0.0514	0.9801	0.9833	0.4170
0.15	4.1922	0.1009	0.9733	0.9839	0.4175
0.30	4.1474	0.4606	0.9887	0.9831	0.4156
0.60	4.1702	0.4950	0.9858	0.9831	0.4160
1.20	4.2937	0.1058	0.9696	0.9829	0.4176
2.40	4.5399	0.3030	0.9713	0.9828	0.4196

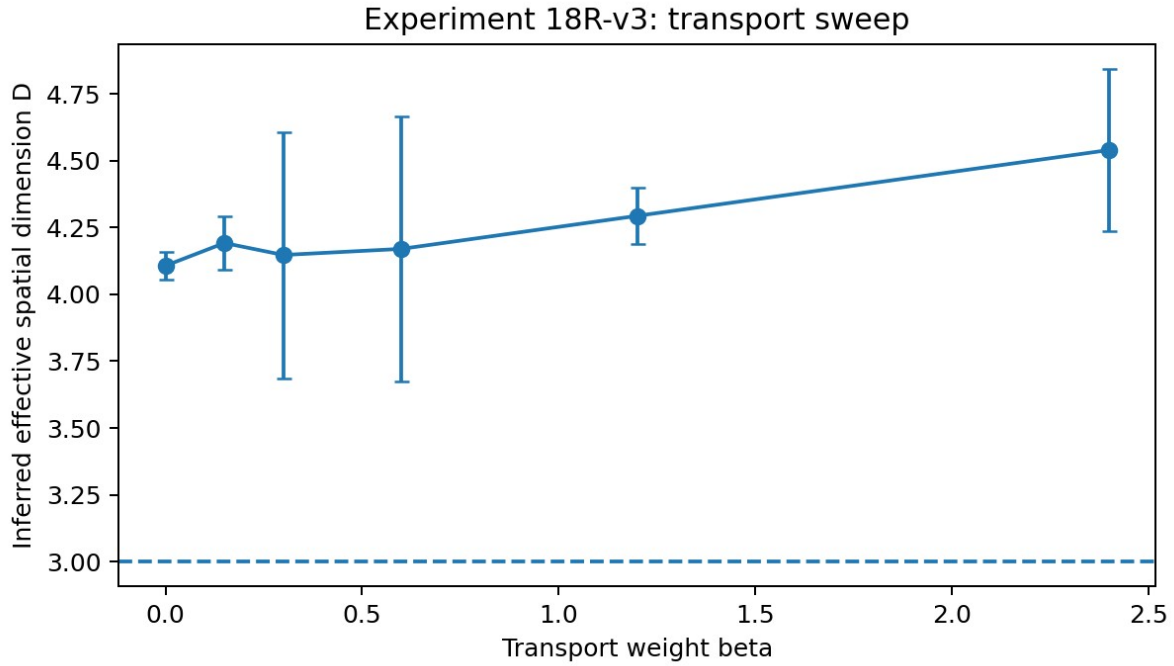


Figure 1. Experiment 18R-v3 short-horizon transport sweep. Dimension is measured, never optimized.

The short-horizon result was not a near-3 attractor. Increasing transport weight tended to hold the graph at somewhat higher effective dimension. A long $\beta=0$ trajectory test then asked whether the unchanged localizing dynamics would cross three if allowed more rewrites.

Seed	Initial D	D at 1440	Final Weyl R^2	Accepted rewires
1801	5.8633	2.9681	0.9742	877
1802	5.8397	3.1510	0.9864	812
1803	6.3181	3.6459	0.9766	842

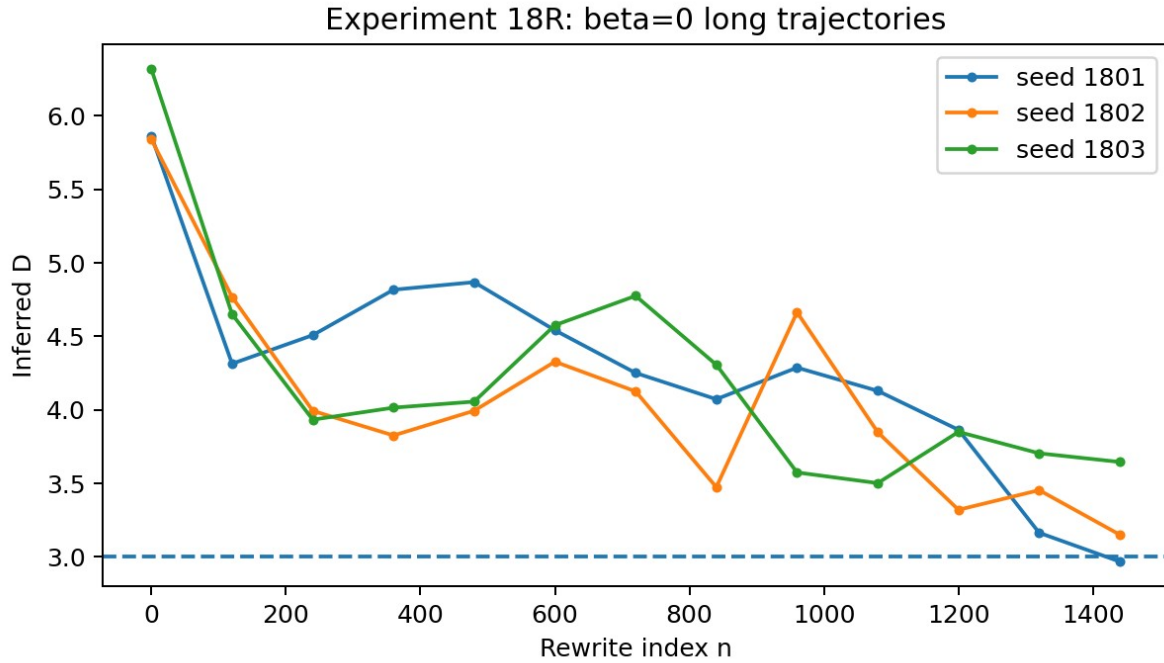


Figure 2. Experiment 18R beta=0 long trajectories. Seed 1801 crosses below $D=3$ by rewrite 1440; seed 1802 reaches $D=3.151$; seed 1803 remains higher.

For seed 1801, D evolved from 5.863 at $n=0$ to 3.164 at $n=1320$ and 2.968 at $n=1440$, with Weyl $R^2=0.974$ at the final point. This independently recovers the qualitative historical observation that a dimension-blind topology can encounter and pass through the three-dimensional regime without three being an attractor.

23.21 Historical Experiment 19 - Coherence/record feedback (non-reproducible record)

A later conversation-derived experiment explored whether coherent records could slow topology rewiring rather than force $D=3$ as a permanent fixed point. The original code and files are lost, so the following table is retained as a historical report only and must be independently replicated before being used as evidence.

Feedback	3D passage	Clock cycles near 3D	Final D
0	100%	23.4	2.13
2	100%	78.9	2.59
4	100%	66.6	3.03
6	50%	22.2	3.27

The reported qualitative pattern was: phase coherence $\rightarrow$ redundant records $\rightarrow$ slower rewiring $\rightarrow$ longer residence near the 3D regime, with excessive feedback capable of freezing the graph prematurely. Subsequent discussion clarified that rewrite count must not be equated with physical time and that a bounce interpretation was an exploratory hypothesis, not an adopted cosmology.

23.22 Experiment 20R - Broad initial-condition crossing pilot

The success criterion was changed from "settle at $D=3$ " to the weaker and more directly testable question "do diverse initial topologies encounter/cross $D=3$?" The dynamics were frozen to 18R-v3 at $\beta=0$. Initial topologies were varied without selecting a target dimension. The fixed horizon was 720 rewrites.

Start class	Rewire p	Seed	Initial D	D at 720	Crossed D=3
Low-D	0.03	1801	1.3806	3.9058	Yes
Low-D	0.03	1802	1.2350	3.7002	Yes
Low-D	0.03	1803	1.3832	3.5705	Yes
Low-D	0.10	1801	1.6611	3.5762	Yes
Low-D	0.10	1802	1.5190	3.2051	Yes
Low-D	0.10	1803	1.6710	4.1541	Yes
High-D	0.60	1801	5.8131	3.6813	No
High-D	0.60	1802	5.8799	3.7158	No
High-D	0.60	1803	5.5032	3.1646	No
High-D	1.00	1801	5.8738	2.9405	Yes
High-D	1.00	1802	6.0556	3.9936	No
High-D	1.00	1803	5.4627	3.7414	No

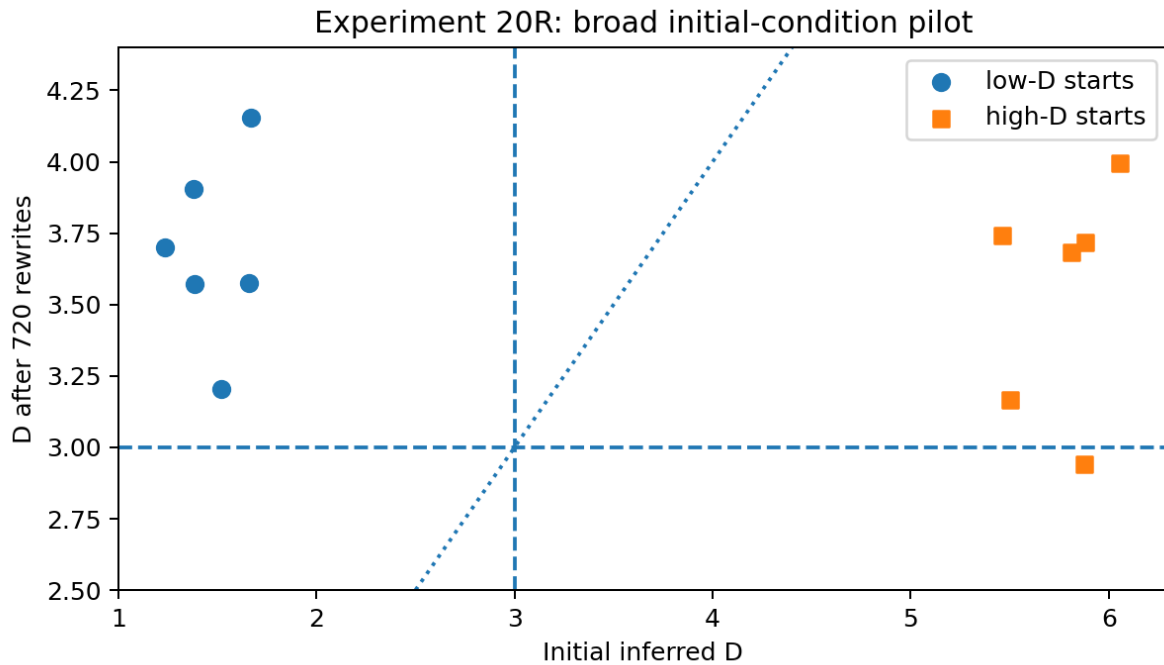


Figure 3. Experiment 20R fixed-horizon pilot. Low-D starts move upward; high-D starts move downward toward an intermediate-dimensional regime.

At the fixed 720-rewrite horizon, all 6/6 low-dimensional starts (D_0 about 1.24-1.67) crossed $D=3$ upward. One of 6 high-dimensional starts (D_0 about 5.46-6.06) crossed $D=3$ downward; the other

five ended between about 3.16 and 3.99 after substantial downward motion. This finite ensemble does not establish that all possible initial conditions cross three.

Audit finding: the inherited annealing temperature depends on requested total STEPS. Therefore a nominal rerun with STEPS=1440 changes the annealing schedule from the beginning and is not a true continuation of a 720-rewrite universe. Those exploratory reruns are excluded from crossing evidence. The next implementation must make the schedule horizon-independent or serialize the full state and continue exactly.

23.23 Current mathematical interpretation

The combined record supports three distinct statements with different evidentiary strength:

- Established in surviving/reconstructed toy models: phase ordering, redundant records, several conditional gravity benchmarks, recovery of latent geometry from connectivity, and dimension-blind trajectories that can cross $D=3$.
- Not established: a universal $D=3$ attractor, universal crossing from every possible initial graph, a derived Lorentzian 3+1 continuum, or identification of graph rewrite index with physical time.
- Open hypothesis: the physically relevant criterion may be encounter/residence in a three-spatial-dimensional regime rather than permanent stabilization at $D=3$. The amount of emergent proper time during such a regime must be defined from causal/phase clocks, not from rewrite count.

The next clean quantity is therefore not simply $N_{\text{rewrite}}(D \text{ approximately } 3)$, but an internal-clock functional such as

$$\tau_3 = \sum_{(n \text{ in } 3D \text{ regime})} \Delta \tau_n$$

where $\Delta \tau_n$ must be derived from relative phase accumulation or causal transitions. A useful dimensionless separation of clock and topology scales is

$$\Xi = \Omega_{\text{clock}} / \Gamma_{\text{topology}}$$

with Ω_{clock} defined by observable relative phase cycles and Γ_{topology} by significant graph rewrites. $\Xi \gg 1$ would allow large internal proper time during modest topological evolution. This is a proposed next-step observable, not yet a completed result.

23.24 Updated experimental status table

Experiment	Evidence retained	Current status
1	Surviving code + machine-readable results	Reproducible from retained Phase-1 repository
2	Surviving code + machine-readable results	Reproducible from retained Phase-1 repository
3	Surviving code + machine-readable results	Reproducible from retained Phase-1 repository
4	Surviving code + machine-readable results	Reproducible from retained Phase-1 repository
5	Surviving code + machine-readable results	Reproducible from retained Phase-1

		repository
6	Numerical results + audit record retained	Original Phase-2 code lost
7	Numerical results + audit record retained	Original Phase-2 code lost
8	Numerical results + audit record retained	Original Phase-2 code lost
9	Numerical results + audit record retained	Original Phase-2 code lost
10	Numerical results + audit record retained	Original Phase-2 code lost
11	Numerical results + audit record retained	Original Phase-2 code lost
12	Numerical results + audit record retained	Original Phase-2 code lost
13	Numerical results + audit record retained	Original Phase-2 code lost
14	Numerical results + audit record retained	Original Phase-2 code lost
15	Numerical results + audit record retained	Original Phase-2 code lost
16	Numerical results + audit record retained	Original Phase-2 code lost
17	Numerical results + audit record retained	Original Phase-2 code lost
18	Predeclared design retained; later original implementation lost	Historical only
18R	Code + machine-readable reconstruction results retained	Reproducible reconstruction
19	Conversation-derived result table only	Not reproducible; requires replication
20R	Code + fixed-horizon pilot results retained	Reproducible pilot; continuation bug identified

23.25 Revised near-term research program

- Fix the annealing schedule so continuation is independent of the requested horizon, or serialize complete graph/phase/random-number state at checkpoints.
- Continue the exact 20R trajectories and measure first-passage distributions into a predeclared $D \approx 3$ band across a much broader initial-topology ensemble.
- Predeclare the $D \approx 3$ band and crossing rule before running the enlarged ensemble; do not tune the band after observing trajectories.
- Define emergent internal clock time from relative phase or causal-transition accumulation and measure τ_3 independently of rewrite count.
- Replicate the lost historical Experiment 19 feedback result from the reconstructed code base without tuning toward the remembered numerical table.
- Only after dimensional crossing/residence is characterized should bounce-like cosmological interpretations be tested. Big-bounce cosmology remains a hypothesis motivated by prior black-hole intuition, not an assumption of TCG.
- Preserve failures, corrected analysis bugs, and supplied assumptions exactly as part of the audit trail.

24 Phase III and Phase III-B - Generative Law and Classical Coupled Action

Status and provenance. The dimensional experiments through 20R are retained unchanged. This section records the subsequent derivation program. Items are explicitly separated into locked kinematics, current candidate action, derived results, rejected/superseded derivations, and unperformed tests. The Phase III-B action is a research candidate, not a completed theory of gravity.

24.1 Phase III Abelian baseline

The research program stopped treating separate experimental rules as fundamental and froze a single Abelian prototype on a relational graph. Absolute phase is gauge; only relative transported phase and holonomy are physical.

$$S = (G, \theta, A, R)$$

$$\Delta_{ij} = \theta_i - \theta_j - A_{ij}$$

$$H = -J \sum_{\langle ij \rangle} w_{ij} \cos(\Delta_{ij}) + (1/(2 \kappa)) \sum_f [1 - \cos(\Phi_f)] + \sum_i V(r_i)$$

No additional dynamical rules are to be introduced by hand. Earlier algorithms are to be recovered, replaced, or rejected as approximations to this single law.

24.2 Abelian laboratory and exact quadratic gap

- Gauge invariance was verified numerically to machine precision under random local $U(1)$ transformations.
- The global phase order parameter $\rho = |N^{-1} \sum \exp(i \theta_i)|$ was rejected as a physical observable under local gauge symmetry. Gauge-invariant link coherence $C_{\Delta} = \langle \cos \Delta_{ij} \rangle$ replaces it.
- Sampling showed strong relational phase coherence and independently varying plaquette flatness: coherence and holonomy curvature are coupled through A but are not identical.

For small fluctuations, define the gauge-invariant link field $a = A - d \theta$. The physical quadratic energy is

$$H_{\text{phys}} = (J/2) \|a\|^2 + (1/(4 \kappa)) \|d a\|^2$$

$$Q_{\text{phys}} = J I + (1/(2 \kappa)) d^{\dagger} d$$

Because $d^{\dagger} d$ is positive semidefinite, the physical quadratic spectrum satisfies $\lambda \geq J$, with curl-free/harmonic modes attaining the bound. Therefore

$$\lambda_{\text{gap}} = J$$

This supersedes an earlier numerical value near 1.323 at $J=\kappa=1$, which was traced to curvature-sector normalization/assembly. Direct finite periodic-lattice checks give the expected gauge zero modes and lowest physical eigenvalue 1.000. The fixed Abelian coherent sector is intrinsically gapped for $J>0$; it is therefore treated as a temporal/causal substrate candidate rather than a massless graviton sector.

24.3 Phase III-B kinematics - locked

$$S = (C; \theta, A, E, \Lambda), \quad C = (V, L, F)$$

The 2-complex C is primitive combinatorial structure. The internal Minkowski space and $SO+(1,3)$ symmetry are supplied inputs in this formulation; 3+1 dimensionality and Lorentz signature are not claimed to emerge here.

$$\begin{aligned} E_{ij} &\rightarrow L_i E_{ij}, \quad \Lambda_{ij} \rightarrow L_i \Lambda_{ij} L_j^{-1} \\ E_{ji} &= -\Lambda_{ji} E_{ij}, \quad \Lambda_{ji} = \Lambda_{ij}^{-1} \end{aligned}$$

The covariant reversal rule replaces the naive $E_{ji} = -E_{ij}$, which is inconsistent with independent local Lorentz frames.

24.4 Composite direction and symmetry-earned interaction

$$\begin{aligned} u_i^a &= \sum_{(j \sim i)} \cos(\Delta_{ij}) E_{ij}^a \\ T_{ij} &= (1/2)(u_i + \Lambda_{ij} u_j) \cdot E_{ij} \end{aligned}$$

The vector u_i is $U(1)$ -invariant and Lorentz-covariant, but kinematics alone does not guarantee that it is nonzero or timelike. Covariant reversal gives $T_{ji} = -T_{ij}$ while $\Delta_{ji} = -\Delta_{ij}$, so $T_{ij} \sin(\Delta_{ij})$ is orientation-even.

An uncoupled temporal-plus-geometric theory factorizes and provides no dynamical channel by which temporal coherence can select geometry. The proposed uncoupled timelike- u simulation was therefore cancelled. The first retained cross-sector interaction is

$$S_{\text{int}} = -g \sum_{\langle ij \rangle} T_{ij} \sin(\Delta_{ij})$$

This term is $U(1)$ -invariant, locally Lorentz invariant, orientation-correct, and inserts neither a preferred internal direction nor a proper-time relation. Scaling correction: u scales as E and T scales as E^2 ; if E later carries length dimension, g carries inverse-length-squared dimension up to action normalization.

24.5 Current minimal joint action

$$S = -J \sum_{\langle ij \rangle} \cos(\Delta_{ij}) + (1/(2 \kappa_T)) \sum_f [1 - \cos(\Phi_f)] + S_G - g \sum_{\langle ij \rangle} T_{ij} \sin(\Delta_{ij})$$

In the dimensionless formulation the displayed coefficients are J , κ_T , α , and g : four coefficients and, before the dynamical normalization is fixed, at most three independent relative couplings under overall action rescaling. No Lorentzian E^2 mass/stabilization term is added merely because symmetry permits it; E^2 is indefinite.

24.6 No-log discrete Palatini candidate

For an oriented face f and corner i , let i^+ and i^- be the next and previous vertices in the face orientation. Define

$$\begin{aligned} e_{(f,i)}^{(+)} &= E_{(i^+)}, \quad e_{(f,i)}^{(-)} = -E_{(i^-)} \\ B_{(f,i)}^{(ab)} &= e_{(f,i)}^{(+)} [a e_{(f,i)}^{(-)} b] \\ \Omega_{(f,i)} &= \text{product}_{(\text{boundary } f, \text{ based at } i)} \Lambda \end{aligned}$$

To avoid the branch ambiguity of $\log(\Omega)$, define the single-valued curvature proxy

$$\text{Rcal}_{(f,i)} = (1/2)(\Omega_{(f,i)} - \Omega_{(f,i)}^{-1})$$

It transforms by conjugation and near the identity obeys $\text{Rcal} = R + O(R^3)$ when $\Omega = \exp(R)$. The corner-averaged geometric candidate is

$$S_G = \alpha \sum_f (1/n_f) \sum_{(i \text{ in } f)} \epsilon_{abcd} B_{(f,i)}^{ab} \text{Rcal}_{(f,i)}^{cd}$$

Provenance: globally defined, face-orientation independent, locally Lorentz-covariant candidate discrete Palatini functional. Continuum equivalence under refinement is not yet established.

24.7 Classical Lorentzian interpretation

The joint S is treated first as a classical Lorentzian action. No Euclidean Metropolis weight is assigned to the noncompact Lorentzian geometric sector; no path integral or quantization is yet claimed.

$$\delta_{\theta} S = 0, \quad \delta_A S = 0, \quad \delta_E S = 0, \quad \delta_{\Lambda} S = 0$$

24.8 Correct temporal Euler-Lagrange system

Choose one orientation for each physical link e and define the exact generalized temporal current

$$P_h = J \sin(\Delta_h) - g T_h \cos(\Delta_h) - g \sum_e \sin(\Delta_e) (\partial T_e / \partial \Delta_h)$$

With D the vertex-edge incidence operator and C the face-edge incidence operator, the temporal equations are

$$D P = 0$$

$$-P + (1/(2 \kappa_T)) C^T \sin(\Phi) = 0, \quad \Phi = C A$$

A prior componentwise draft was rejected because it omitted neighboring T dependencies and introduced an erroneous extra factor of $\sin(\Delta)$ multiplying the explicit $-g T \cos(\Delta)$ derivative. In the weak-coherence, weak-temporal-curvature regime, $\partial T / \partial \Delta = O(\Delta)$, giving

$$\Delta_e \approx (g/J) T_e$$

On a reduced locally symmetric branch where the collective derivative contribution cancels exactly and $P_e = 0$, $\tan(\Delta_e) = g T_e / J$. This arctangent relation is not claimed as the general full-system clock law.

24.9 Correct geometric variation conventions

For an independently oriented edge $e=(p \rightarrow q)$, take $E_e = E_{pq}$ and $\Lambda_e = \Lambda_{pq}$ as independent. Reversed quantities are derived:

$$\Lambda_{qp} = \Lambda_e^{-1}, \quad E_{qp} = -\Lambda_e^{-1} E_e$$

This means one coframe or connection variation propagates into both endpoint composites and neighboring T terms. In particular, the direct self-edge contributions to u_p and $\Lambda_e u_q$ cancel inside T_e , so T_e is a collective neighborhood projection rather than a hidden self-contraction.

$$G_{(E,e)}^a - g J_{(E,e)}^a = 0$$

where G_E is the coframe derivative of S_G and J_E is the summed temporal source $\sum_h \sin(\Delta_h) \partial T_h / \partial E_e$. The Lorentz connection must be varied on the group, $\Delta_{\Lambda_e} = X_e \Lambda_e$ with X_e in $so(1,3)$:

$$\text{Proj}_{so(1,3)} [\Delta S_G / \Delta \Lambda_e - g \sum_h \sin(\Delta_h) \Delta T_h / \Delta \Lambda_e] = 0$$

A prior draft statement that only T_e depends on Λ_e was rejected because covariant reversal makes Λ_e affect reversed coframes, endpoint u vectors, neighboring T terms, bivectors, and every incident face holonomy.

24.10 Exact coframe-dilation identity - fifth equation/checksum

Both S_G and S_{int} are homogeneous of degree two in the coframes. Therefore any nonzero coframe stationary solution obeys

$$S_G + S_{int} = 0$$

$$S_G = g \sum_e T_e \sin(\Delta_e)$$

This is not a fifth independent primitive field equation; it is an exact consequence of the coframe equation and is retained as a checksum. A generic nonzero clock interaction therefore cannot remain on a completely flat geometric background with $S_G=0$.

24.11 Kinematic timelike witness

With $\eta = \text{diag}(-,+,+,+)$, a local witness $E=(0,1,0,0)$, $u_p=u_q=(2,1,0,0)$, and $\Lambda=I$ gives $E^2=1$, $u^2=-3<0$, and $T=1$. For $J=g=1$ on the reduced symmetric temporal branch, $\Delta=\pi/4$. Thus $E!=0$, $T!=0$, $\Delta!=0$, and timelike $u^2<0$ are algebraically compatible. This witness is not yet a solution of all four primitive stationary equations.

24.12 Closed tetrahedral existence test - predeclared, not yet run

A two-triangle shared-edge patch was rejected as the definitive existence test because it has an outer boundary and would require imposed boundary data or boundary equations. The smallest clean closed triangular 2-complex is the tetrahedral boundary with four vertices, six links, and four faces.

$$V=\{0,1,2,3\}, \quad L=\{01,02,03,12,13,23\}$$

For fixed (Δ, Λ) , both S_G and S_{int} are quadratic in the independent coframes, so

$$S_G + S_{int} = E^T M(\Delta, \Lambda) E, \quad M(\Delta, \Lambda) E = 0$$

A nonzero coframe requires a nontrivial kernel after gauge/redundant directions are handled. Because the coframe equation is homogeneous, the present action does not fix an absolute coframe magnitude: if E is a solution, λE is also a solution. The sign of u^2 is nevertheless scale independent.

Predeclared success criterion: solve all four primitive stationary equations on the closed tetrahedral complex, use $S_G+S_{int}=0$ only as a checksum, and then classify the solution. Success requires at least one edge/vertex with $E!=0$, $T!=0$, $\Delta!=0$, and $u^2<0$. Timelike u is not to be inserted as an optimization target.

24.13 Five-equation checkpoint

- 1. Temporal phase conservation: $D P = 0$.
- 2. Abelian connection/temporal curvature: $-P + (1/(2 \kappa_T)) C^T \sin(CA) = 0$.
- 3. Coframe: $G_E = g J_E$; on a fixed (Δ, Λ) quadratic form this is $M E = 0$.
- 4. Lorentz connection: $\text{Proj}_{\text{so}(1,3)}(G_\Lambda - g J_\Lambda) = 0$.
- 5. Coframe-dilation checksum: $S_G + S_{\text{int}} = 0$.

24.14 Current scientific status

- Established: exact Abelian gauge structure; gauge-invariant coherence diagnostic; Abelian physical gap $\lambda_{\text{gap}} = J$; symmetry-allowed composite u and T ; factorization no-go for uncoupled temporal/geometric sectors; exact orientation-correct cross interaction; globally defined no-log curvature proxy; temporal conservation equations; coframe-dilation identity; algebraic compatibility of nonzero E , T , Δ with timelike u .
- Not established: a full stationary timelike clock solution of the coupled action; continuum equivalence of the discrete Palatini candidate; emergence of proper time; recovery of Einstein dynamics; quantization; bounce cosmology.
- Next unperformed test: the closed tetrahedral stationary-point existence calculation. The frozen action is not to be modified in response to that result.

24.15 Conversation archive and audit trail

The accompanying research packages include records/TCG_Conversation_Archive_2026-09-27.md. It preserves the Phase III source transcript available in the retained artifacts and a labeled reconstruction of the Phase III-B derivation, including rejected equations and corrections. It is an audit record, not a platform-native verbatim export of every earlier chat message.

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