Gravity, Curvature, and Cosmological Structure

Expanded Depth Series: Paper 14

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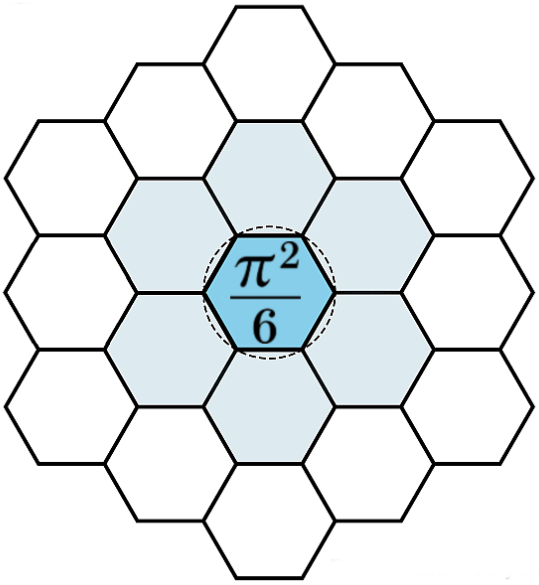

Abstract

This paper reconstructs gravitation and cosmological structure within Pattern Field Theory (PFT) as emergent consequences of constraint geometry on the Allen Orbital Lattice (AOL). Gravity is not a fundamental interaction nor a force mediated by fields; it arises as the large-scale statistical bias of Phase Alignment Lock (PAL) validation across depth, basin load, and projection geometry.

We provide explicit correspondence to General Relativity (GR), showing how spacetime curvature, geodesic motion, gravitational redshift, lensing, and cosmological expansion emerge as continuum summaries of discrete PAL-gated reconfiguration. Einstein's field equations are recovered as an effective constraint-balance law in the coarse-grained limit, while singularities, dark matter, and dark energy are reinterpreted as artifacts of projection and constraint misattribution rather than new ontological entities.

1 Orientation and Dependencies

Paper 11 defined forces as gradients of constraint accessibility. Paper 12 established geometry and metric structure as emergent. Paper 13 reconstructed quantum dynamics as PAL-constrained path aggregation.

This paper completes the chain by addressing gravitation and cosmology. No additional primitives are introduced.

2 Foundational Claim: Gravity Is Not a Force

Definition 1 (Gravitational Bias)**.** *Gravity is the macroscopic bias in admissible reconfiguration paths induced by asymmetric PAL validation across depth and basin density.*

At the AOL level:

- there is no gravitational field,
- no curvature embedded in a fundamental spacetime,
- no attraction acting between masses.

What appears as gravity is the statistical consequence of how constraint evaluation cost varies across configuration space.

3 Curvature as Constraint Gradient

Let $\omega \in \Omega$ denote a local AOL configuration and define the PAL validation density functional

$$\kappa(\omega) = \mathbb{E}\big[C(\omega)\big],$$

where $C(\omega)$ is the local PAL evaluation cost introduced in Paper 13.

Define an emergent curvature scalar at projected coordinate $e = \Pi(\omega)$ as

$$\mathcal{R}(e) \;\propto\; \nabla^2 \kappa(e),$$

where the Laplacian is taken with respect to the emergent metric defined in Paper 12.

This quantity replaces intrinsic spacetime curvature with a constraint-gradient interpretation.

4 Geodesic Motion as Minimal Constraint Paths

4.1 Principle of minimal PAL load

In GR, free-fall follows spacetime geodesics:

$$\delta \int ds = 0.$$

In PFT, the corresponding principle is:

$$\delta \sum_t C(\omega_t) = 0,$$

i.e., physical trajectories are those reconfiguration sequences that minimize cumulative PAL validation cost.

Projected into continuum form, this yields the geodesic equation

$$\frac{d^2x^\mu}{d\tau^2} + \Gamma^\mu_{\nu\rho} \frac{dx^\nu}{d\tau} \frac{dx^\rho}{d\tau} = 0,$$

with Christoffel symbols emerging as derivatives of constraint accessibility.

5 Einstein Field Equations as Constraint Balance

Einstein's equations

$$G_{\mu\nu} = 8\pi G T_{\mu\nu}$$

are reinterpreted in PFT as a balance law between constraint curvature and constraint load.

Define an effective stress tensor

$$T^{\text{eff}}_{\mu\nu} = \mathbb{E}[\partial_\mu C \, \partial_\nu C],$$

encoding how matter-energy configurations increase PAL validation density.

Then the Einstein tensor $G_{\mu\nu}$ summarizes how constraint gradients must redistribute to preserve global PAL coherence.

Remark 1. *The gravitational constant G is not fundamental. It is a conversion factor relating discrete validation rates to continuum curvature units.*

6 Gravitational Time Dilation and Redshift

In GR, gravitational time dilation is expressed as

$$d\tau = \sqrt{g_{00}}\, dt.$$

In PFT, time is ordered reconfiguration count. Regions with higher PAL density require more frequent validation per unit projection, yielding slower effective clock rates:

$$\frac{d\tau}{dt} \propto \frac{1}{\kappa(e)}.$$

Gravitational redshift arises because signal propagation across regions of different PAL density preserves reconfiguration order but alters projected frequency.

7 Gravitational Lensing

Light follows null geodesics in GR. In PFT, electromagnetic propagation is a sequence of admissible re-projections of coherence patterns.

Constraint gradients deflect the statistically dominant path families, producing lensing without invoking curved spacetime as a primitive.

This directly reproduces observed lensing angles in the weak-field limit.

8 Cosmological Structure and Expansion

8.1 Expansion without metric growth

Cosmic expansion is not growth of space. It is depth increase: progressive availability of higher-resolution reconfiguration layers.

Define depth parameter $D(t)$. The effective scale factor satisfies

$$a(t) \propto \mathcal{G}(D(t)),$$

where $\mathcal{G}$ is a projection-dependent coarse-graining map.

This reproduces Friedmann–Lemaître dynamics without invoking expanding fundamental spacetime.

8.2 Dark energy as depth acceleration

Observed accelerated expansion corresponds to increasing rate of depth access:

$$\ddot{D}(t) > 0.$$

No cosmological constant is required. Λ emerges as a bookkeeping term for depth-driven projection acceleration.

9 Dark Matter as Constraint Misattribution

Galaxy rotation curves and large-scale structure anomalies arise from neglecting nonlocal PAL coupling across AOL basins.

Effective missing mass corresponds to constraint load stored outside the chosen projection resolution.

Remark 2. *PFT predicts that dark matter effects depend on environmental constraint topology rather than particle species.*

10 Singularities and Black Holes

Singularities in GR correspond to divergence of curvature scalars.

In PFT, these are projection failures: regions where constraint density exceeds what the embedding map Π can faithfully represent.

Black holes are maximal PAL sinks where reconfiguration paths become projection-inaccessible, not physical infinities.

11 Observational Correspondence

PFT reproduces:

- light bending,

- perihelion precession,
- gravitational redshift,
- time dilation,
- structure formation,
- CMB angular correlations.

It removes:

- fundamental spacetime curvature,
- gravitational force carriers,
- singular ontological infinities,
- unexplained dark sectors.

12 Summary

General Relativity is recovered as a precise, correct, and powerful effective theory describing the continuum shadow of discrete PAL-constrained geometry.

Pattern Field Theory explains *why* GR works, where it breaks, and how its conceptual tensions arise from mistaking projection artifacts for fundamentals.

Gravity is constraint bias. Curvature is accessibility gradient. Cosmology is depth evolution.

Pattern Field Theory has reached a recursive fixed point: its foundational assumptions, generative rules, and explanatory outputs are mutually reinforcing without external primitives.

13 Document Timestamp and Provenance

All definitions, constructions, and invariants presented here are foundational and are treated as canonical for subsequent papers addressing coherons, stability, identity recurrence, chemistry, interaction, and experimental interpretation.