Complete Landscape of Layered Admissibility in the UNNS Substrate: Mechanism Discrimination and Framework Expansion

UNNS Research Collective

January 2026

Abstract

Building on the empirical separation of Ω-stationarity and τ-admissibility established in our companion Letters paper (Chamber XXXVI, Part I), we present a complete four-mode landscape of Ω–τ coupling mechanisms in the UNNS substrate. While Part I demonstrated the separation phenomenon via Modes A and B, this framework paper explores the full structural space including stress-mediated coupling (Mode C) and direct layer violation (Mode D).

We introduce the Ω-coherence metric $\langle w \rangle$ as a quantitative discriminator that distinguishes coupling mechanisms even when τ-admissibility appears similar. Mode B (recursive coupling) exhibits sharp coherence collapse ($\langle w \rangle = 0.394$), Mode C (stress-mediated) shows gradual decay ($\langle w \rangle = 0.618$), and Mode D (layer violation) demonstrates complete collapse ($\langle w \rangle = 0.087$). Statistical validation across $n = 5$ seeds confirms all pairwise differences are significant at $p < 0.01$.

This complete landscape establishes that: (1) the separation phenomenon is robust across coupling types, (2) different mechanisms produce quantitatively distinguishable signatures, and (3) layer-hierarchical coupling is necessary for any τ-admissibility. The framework provides mechanistic understanding of why quantization succeeds at the τ-level while destabilizing the Ω-level, with implications for quantum gravity and the structure of physical law.

1 Context and Motivation

1.1 Established Result from Part I

In our companion Letters paper (Chamber XXXVI, Part I), we demonstrated the empirical separation of Ω-level stationarity and τ-level admissibility through a minimal two-mode comparison. That work established:

> **Separation Theorem:** τ-level admissibility does not imply Ω-level stationarity. A τ-operator may remain admissible (residuals contract, divergence bounded) even when the Ω-background undergoes catastrophic structural drift.

This result resolved an apparent contradiction: background instability does not automatically invalidate field dynamics in the UNNS substrate.

1.2 Scope of the Present Work

While Part I focused on cleanly isolating the separation phenomenon via Modes A and B, important questions remain:

- **Mechanism:** What distinguishes different types of Ω instability? Are all coupling modes equivalent?
- **Quantification:** Can we measure coupling mechanisms quantitatively, not just detect their presence?
- **Boundaries:** What happens when layer hierarchy is explicitly violated?
- **Robustness:** Does separation persist across different coupling architectures?

This framework paper addresses these questions through a complete four-mode landscape that includes stress-mediated coupling (Mode C) and direct layer violation (Mode D), alongside the validated Modes A and B from Part I.

1.3 Foundation from Chambers XXXIV and XXXV

Both Part I and the present work build on two foundational results:

- **Chamber XXXIV:** Ω-selection (specifically $\Omega 4b$) acts as a structural filter on ensembles, reducing vacuum residuals R_Λ by $\sim 95\%$.
- **Chamber XXXV:** τ-operators become admissible only after Ω-selection, and only for specific operator families (spectral band-limiters, closure operators).

These results implicitly assumed a *stationary* Ω-background. Part I removed this assumption and discovered separation. The present work explores the full structural space of coupling mechanisms.

2 Computational Framework

2.1 Substrate Construction

All experiments were conducted on graph-based ensembles with fixed parameters:

- Node count: $n = 32$
- Ensemble size: $M = 100$
- Generator: Erdős-Rényi with deterministic seeded construction
- $\Omega 4b$ keep fraction: $f = 0.3$ (top 30% by spectral gap)
- τ-operator: spectral band-limiter τ_B with cutoff $k_c = 0.5$
- Evolution steps: $N = 1000$ per mode
- Independent seeds: $n_{\text{seed}} = 5$ for reproducibility

2.2 Measurement Protocol

We measure the following diagnostics at each evolution step:

τ-Level Metrics:

- **Residual contraction** R_Λ: magnitude of unresolved constraint violations
- **Contraction ratio** $\text{CR} = R_\Lambda(\tau)/R_\Lambda(\Omega)$: efficiency of τ-stabilization relative to Ω-selection
- **Divergence index** D: cumulative growth of operator instabilities
- **τ-admissibility** $A(\tau)$: fraction of steps with $\text{CR} < 1.0$ and $D < 0.001$

Ω-Level Metrics:

- **Ω-drift**: cumulative change $\|\Omega_t - \Omega_0\|_F$ in Frobenius norm
- **Ω-stability** $\sigma(\Omega)$: standard deviation of Ω-state over evolution window
- **Ω-coherence** $\langle w \rangle$: average stability weight measuring geometric consistency

Joint Criteria: τ-admissibility and Ω-stationarity are combined into a **joint admissibility** criterion requiring:

$$A(\tau) \geq 0.70 \tag{1}$$
$$\Omega\text{-drift} \leq 0.30 \tag{2}$$
$$\sigma(\Omega) \leq 0.50 \tag{3}$$

2.3 Ω-Coherence Weight

The Ω-coherence metric $\langle w \rangle$ quantifies the consistency of the Ω-background under evolution. It is computed as:

$$w_t = \exp(-\beta \cdot \Delta\Omega_t)$$

where $\Delta\Omega_t$ measures local geometric instability and $\beta = 10$ sets the sensitivity scale. The time-averaged coherence $\langle w \rangle = N^{-1} \sum_t w_t$ provides a quantitative signature of coupling mechanisms:

- High coherence ($\langle w \rangle > 0.80$): stable background
- Moderate coherence ($0.50 < \langle w \rangle < 0.80$): gradual decay
- Low coherence ($\langle w \rangle < 0.50$): rapid destabilization

3 Mode Definitions

Chamber XXXVI evaluates four structural coupling modes that span the space of possible Ω–τ interactions. Each mode tests a distinct hypothesis about layer coupling.

3.1 Mode A: Fixed Ω Background

Structure: $\Sigma \to \Omega \to \tau$

Ω is held stationary throughout the evolution. τ evolves according to standard dynamics on the fixed background.

Purpose: Establishes the control baseline for layer-respecting dynamics. Tests whether τ-admissibility can be achieved when Ω-stationarity is guaranteed by construction.

Expected Outcome: Joint admissibility (both τ and Ω satisfy criteria).

3.2 Mode B: Structurally Non-Stationary Ω

Structure: $\Sigma \to \Omega \leftrightarrow \tau$

Ω and τ evolve simultaneously with mutual feedback. Ω updates include quantized increments and stress coupling from τ-layer dynamics. Stability gating controlled by parameter β couples τ-updates to Ω-stability.

Purpose: Tests whether τ-admissibility can persist when Ω undergoes large-scale structural instability via direct recursive coupling. Probes the "quantized gravity" regime.

Expected Outcome: τ-admissible but Ω-unstable, yielding joint inadmissibility with sharp coherence collapse ($\langle w \rangle \sim 0.40$).

3.3 Mode C: Semiclassical Backreaction

Structure: $\Sigma \to \Omega \rightsquigarrow \tau$

τ evolves within Ω. Ω responds slowly to accumulated τ stress-energy via Einstein-like backreaction. The coupling is mediated and time-integrated, not instantaneous.

Purpose: Tests stress-mediated coupling between layers, analogous to semiclassical gravity where quantum matter sources classical geometry. Requires renormalization and τ-confinement to prevent false collapse.

Expected Outcome: τ-admissible but Ω-unstable, yielding joint inadmissibility with gradual coherence decay ($\langle w \rangle \sim 0.60$).

3.4 Mode D: Direct Layer Violation

Structure: $\Sigma \to \tau \to \Omega$

τ-style recursive rules are applied directly to Ω without mediation or respect for the selection hierarchy. This mode explicitly violates the $\Sigma \to \Omega \to \tau$ layer structure.

Purpose: Diagnostic stress test. Confirms that direct layer violation causes complete system collapse, validating that the layer hierarchy is not arbitrary.

Expected Outcome: Both τ and Ω fail all criteria, joint inadmissibility with collapsed coherence ($\langle w \rangle \sim 0.10$).

Metric	Mean	Std Dev
Ω-drift	0.000	0.000
$\sigma(\Omega)$	0.258	0.021
$\langle w \rangle$ (Ω-coherence)	0.947	0.008
$A(\tau)$ (τ-admissibility)	0.866	0.032
Divergence index D	0.0003	0.0001
Joint Admissibility	**PASS**	—

Table 1: Mode A results ($n = 5$ seeds). High Ω-coherence ($\langle w \rangle \sim 0.95$) confirms background stability.

4 Validated Results

4.1 Mode A: Joint Stability Baseline

Across five independent seeds (41–45), Mode A exhibits stable joint admissibility:

This confirms that when Ω-stationarity is enforced, τ-dynamics remain admissible with low divergence. The high Ω-coherence ($\langle w \rangle = 0.947$) indicates stable geometric background.

4.2 Mode B: τ-Admissible / Ω-Unstable Split

Mode B produces a qualitatively different outcome:

Metric	Mean	Std Dev
Ω-drift	4.931	0.412
$\sigma(\Omega)$	1.869	0.156
$\langle w \rangle$ (Ω-coherence)	0.394	0.047
$A(\tau)$ (τ-admissibility)	0.834	0.028
Divergence index D	0.0001	0.0001
Joint Admissibility	**FAIL**	—

Table 2: Mode B results ($n = 5$ seeds). Low Ω-coherence ($\langle w \rangle \sim 0.40$) indicates sharp coherence collapse despite maintained τ-admissibility.

Despite extreme Ω-instability (drift ~ 5.0, $\sigma(\Omega) \sim 1.9$), τ remains locally admissible: $A(\tau) = 0.834$ with bounded divergence $D \sim 0.0001$. The sharp drop in Ω-coherence ($\langle w \rangle = 0.394$) quantifies the direct recursive coupling mechanism.

This behavior is reproducible across all tested seeds with coefficient of variation $\mathrm{CV}(\langle w \rangle) = 11.9\%$.

4.3 Mode C: Stress-Mediated Coupling

Mode C demonstrates intermediate behavior:

Like Mode B, Mode C exhibits τ-admissibility ($A(\tau) = 0.791$) with Ω-instability (drift ~ 3.2). However, the Ω-coherence is significantly higher ($\langle w \rangle = 0.618$ vs 0.394, $p < 0.01$ by two-sample t-test), indicating that the stress-mediated coupling allows more gradual geometric decay than the direct recursive coupling of Mode B.

Metric	**Mean**	**Std Dev**
Ω-drift	3.247	0.389
$\sigma(\Omega)$	1.412	0.134
$\langle w \rangle$ (Ω-coherence)	0.618	0.052
$A(\tau)$ (τ-admissibility)	0.791	0.041
Divergence index D	0.0002	0.0001
Joint Admissibility	**FAIL**	—

Table 3: Mode C results ($n = 5$ seeds). Intermediate Ω-coherence ($\langle w \rangle \sim 0.62$) indicates gradual stress-mediated decay.

4.4 Mode D: Complete Layer Violation

Mode D confirms expected collapse:

Metric	**Mean**	**Std Dev**
Ω-drift	7.823	1.124
$\sigma(\Omega)$	2.947	0.421
$\langle w \rangle$ (Ω-coherence)	0.087	0.019
$A(\tau)$ (τ-admissibility)	0.123	0.067
Divergence index D	0.0089	0.0023
Joint Admissibility	**FAIL**	—

Table 4: Mode D results ($n = 5$ seeds). Collapsed Ω-coherence ($\langle w \rangle \sim 0.09$) and failed τ-admissibility confirm that direct layer violation is structurally inadmissible.

When τ-style rules are applied directly to Ω, both layers fail: $A(\tau) = 0.123$, $\langle w \rangle = 0.087$, and divergence increases by two orders of magnitude. This validates that the layer hierarchy is not arbitrary but structurally necessary.

4.5 Statistical Validation

Multi-seed analysis across $n = 5$ independent seeds confirms reproducibility:

- Mode A: $\langle w \rangle = 0.947 \pm 0.008$, CV = 0.8% (highly stable)
- Mode B: $\langle w \rangle = 0.394 \pm 0.047$, CV = 11.9% (reproducible collapse)
- Mode C: $\langle w \rangle = 0.618 \pm 0.052$, CV = 8.4% (reproducible intermediate)
- Mode D: $\langle w \rangle = 0.087 \pm 0.019$, CV = 21.8% (extreme collapse)

All pairwise differences in $\langle w \rangle$ are statistically significant at $p < 0.01$ (two-sample t-tests with Bonferroni correction).

5 Quantitative Mode Discrimination

The Ω-coherence metric $\langle w \rangle$ provides quantitative discrimination between coupling mechanisms:

The factor-of-1.6 difference between Mode B and Mode C coherence ($0.618/0.394 = 1.57$) provides an empirical discriminator that is otherwise invisible when examining τ-admissibility alone.

Mode	$\langle w \rangle$	Mechanism	Signature
A	0.947	Fixed background	Stable plateau
B	0.394	Recursive coupling	Sharp drop
C	0.618	Stress-mediated	Gradual decay
D	0.087	Layer violation	Complete collapse

Table 5: Ω-coherence signatures distinguish four structural regimes. Modes B and C both exhibit τ-admissibility with Ω-instability, but differ quantitatively in coupling mechanism.

5.1 Temporal Evolution

The Ω-coherence $\langle w \rangle$ exhibits distinct temporal signatures:

- **Mode A:** Maintains $w_t > 0.90$ throughout evolution
- **Mode B:** Drops sharply in first ~ 100 steps to $w_t \sim 0.40$, then plateaus
- **Mode C:** Decays gradually over ~ 300 steps from $w_0 \sim 0.85$ to $w_\infty \sim 0.55$
- **Mode D:** Collapses immediately to $w_t < 0.15$ within ~ 50 steps

These temporal patterns distinguish instantaneous coupling (Mode B) from time-integrated stress accumulation (Mode C).

6 Main Result

Theorem 1 (Separation of τ-Admissibility and Ω-Stationarity) *In the UNNS substrate, τ-level admissibility does not imply Ω-level stationarity. A τ-operator may remain admissible under standard contraction criteria even when the Ω-background undergoes large cumulative drift.*

Mode A demonstrates joint stability: both Ω and τ remain stable ($A(\tau) = 0.866$, drift $= 0.000$).

Modes B and C demonstrate separation: Ω exhibits catastrophic drift (4.93 and 3.25 respectively), while τ remains admissible (0.834 and 0.791) with bounded divergence ($D < 0.0002$).

Since τ-admissibility holds in the absence of Ω-stationarity, the two properties are empirically non-equivalent. The existence of regimes satisfying one criterion but not the other establishes structural independence.

Corollary 1 (Layer Independence) *The τ-layer can maintain internal coherence while the Ω-layer undergoes structural change, provided the coupling mechanism respects the layer hierarchy ($\Sigma \to \Omega \to \tau$).*

Modes B and C both respect the layer hierarchy (with different coupling mechanisms) and both exhibit τ-admissibility despite Ω-instability. Mode D violates the hierarchy and causes complete failure. This demonstrates that layer independence depends on hierarchical structure, not coupling strength.

7 Discussion

7.1 Four-Mode Landscape

The four modes of Chamber XXXVI define a complete landscape of Ω–τ coupling:

- **Mode A (PASS/PASS):** Control baseline. Both layers stable when Ω is fixed by construction.
- **Modes B & C (PASS/FAIL):** Central discovery. τ-layer maintains admissibility while Ω-layer fails. These modes differ in coupling mechanism (recursive vs stress-mediated) but share the layer-independent signature.
- **Mode D (FAIL/FAIL):** Boundary diagnostic. Direct layer violation causes complete collapse, validating that the hierarchy is structurally necessary.

This landscape demonstrates that:

1. Layer independence is real (Modes B & C)
2. Layer independence requires hierarchical coupling (Mode D falsifies non-hierarchical alternatives)
3. Different coupling mechanisms produce quantitatively distinguishable signatures ($\langle w \rangle$)

7.2 Interpretation: Pipeline vs Layer Admissibility

The results reveal a distinction between two types of admissibility:

Layer-level admissibility: Can a layer maintain internal coherence according to its own criteria?

- τ-layer: admissible in Modes A, B, C
- Ω-layer: admissible only in Mode A

Pipeline admissibility: Can the combined $\Omega \to \tau$ system achieve joint stability?

- Only Mode A achieves pipeline admissibility
- Modes B & C exhibit layer-independent τ but fail pipeline test
- Mode D fails both levels

This distinction mirrors the conceptual difference in physics between:

- Fields being well-defined on a given background (layer-level)
- The background-plus-fields system being jointly stable (pipeline-level)

7.3 Mechanism Comparison: Mode B vs Mode C

While both Mode B and Mode C exhibit τ-admissibility with Ω-instability, they differ fundamentally in coupling mechanism:

Mode B (Recursive): Ω and τ evolve simultaneously with instantaneous mutual feedback. This creates strong coupling that destabilizes Ω rapidly, producing sharp coherence collapse ($\langle w \rangle = 0.394$). The τ-layer "sees" each Ω update immediately but remains admissible because the coupling respects the layer hierarchy.

Mode C (Stress-Mediated): Ω responds to time-integrated τ stress-energy. This delayed, accumulated feedback allows Ω to maintain higher coherence ($\langle w \rangle = 0.618$) over longer timescales. The gradual decay signature distinguishes mediated coupling from instantaneous recursion.

The Ω-coherence metric $\langle w \rangle$ provides the quantitative discriminator that separates these physically distinct mechanisms.

8 Implications for Gravity and Quantization

The results of Chamber XXXVI support the following structural interpretation:

8.1 Layered Quantization Hierarchy

- Quantization is admissible at the τ-level (fields, excitations, stabilizers).
- Quantization of the Ω-level (background structure) is generically destabilizing.
- Background instability does not automatically invalidate local field dynamics.

This mirrors the empirical structure of physics: quantized fields propagate on a classically stable spacetime background.

8.2 Relation to Quantum Gravity Problem

Chamber XXXVI does *not* prove that gravity cannot be quantized. It proves that, within the tested substrate, background quantization and field admissibility belong to distinct structural layers.

This suggests a resolution to the quantum gravity puzzle:

> **Structural Hypothesis:** Gravity-like degrees of freedom (Ω-level) may be inherently non-quantizable not because quantum mechanics fails at high energy, but because geometric structure occupies a different layer than propagating fields in the substrate architecture.

Under this interpretation:

- Quantum field theory is correct at the τ-level
- General relativity is correct at the Ω-level
- The two theories cannot be unified via quantization because they describe different structural layers
- The apparent incompatibility is an artifact of attempting to apply τ-level rules to Ω-level structure (analogous to Mode D)

8.3 Semiclassical Gravity as Intermediate Regime

Mode C (stress-mediated coupling) provides a substrate analogue of semiclassical gravity, where quantum matter sources classical geometry. The gradual Ω-coherence decay ($\langle w \rangle = 0.618$) suggests that such coupling is structurally viable but ultimately unstable without additional stabilization mechanisms.

This aligns with known semiclassical gravity results: the Einstein equation with quantum stress-energy sources is mathematically consistent but generically unstable without renormalization.

8.4 Empirical Predictions

If the UNNS substrate corresponds to physical reality, Chamber XXXVI suggests:

1. **No complete quantum gravity:** Attempts to quantize gravity completely (analogous to Mode B) will always exhibit some form of structural instability, even if field-level physics remains well-defined.

2. **Semiclassical limit viability:** Semiclassical gravity (analogous to Mode C) should remain valid as an effective theory with $\langle w \rangle \sim 0.6$ indicating "moderately stable but not fundamental."

3. **Layer distinction observable:** If experimental probes could access the Ω-level directly (e.g., via quantum gravity phenomenology), they should find signatures of classical structure even when τ-level physics is fully quantum.

4. **Background selection:** The stability of macroscopic spacetime may reflect an anthropic selection effect: we observe the rare Ω-configurations that maintain high coherence, analogous to the $\sim 5\%$ of configurations surviving $\Omega 4b$ selection in Chamber XXXV.

9 Relation to Previous Chambers

Chamber XXXVI completes a three-chamber sequence establishing the layered structure of the UNNS substrate:

9.1 Chamber XXXIV: Ω-Selection as Structural Filter

Established that $\Omega 4b$-selection reduces vacuum residuals R_Λ by 95.94%, demonstrating that most geometric configurations are structurally inadmissible. This created the foundation for asking whether selected Ω-backgrounds could themselves evolve.

9.2 Chamber XXXV: τ-Admissibility Post-Ω

Established that τ-operators become admissible only after Ω-selection, with specific operator families (spectral band-limiters, closure operators) exhibiting residual contraction. This assumed stationary Ω and created the question: does Ω-evolution destroy τ-admissibility?

9.3 Chamber XXXVI: Layer Independence

Establishes that Ω-stationarity is *not* required for τ-admissibility, resolving the apparent tension. The layers can function independently while remaining hierarchically coupled.

9.4 Unified Picture

Together, these chambers define a four-layer hierarchy:

$$\Sigma \rightarrow E \rightarrow \Omega \rightarrow \tau \rightarrow \text{observables}$$

- Σ-layer: source geometry (random graph ensembles)
- E-layer: ensemble selection (keeps $M = 100$ configurations)
- Ω-layer: structural filter ($\Omega 4b$ keeps $f = 0.3$)
- τ-layer: stabilizing operators (band-limiter, closure)
- Observable layer: residuals, admissibility, physical predictions

Each layer filters or constrains the layer below, but Chamber XXXVI shows that instability at one layer does not necessarily propagate upward.

10 Limitations and Future Work

10.1 Current Limitations

1. **Finite evolution time:** $N = 1000$ steps may be insufficient to capture long-term Ω-instability effects. Future chambers will extend to $N \sim 10^5$ steps.
2. **Single τ-operator family:** Only spectral band-limiter τ_B tested. Closure operators, gradient limiters, and hybrid families may exhibit different layer-independence signatures.
3. **Fixed parameter regime:** $\beta = 10$, $\lambda = 0.10$, $\kappa = 1.0$ define a single point in parameter space. Systematic parameter sweeps could reveal phase transitions or critical thresholds.
4. **No stabilization mechanisms:** Neither Mode B nor Mode C includes mechanisms that could stabilize a dynamic Ω-background. Future work will explore Ω-confinement, cross-chamber resonance, and topological protection.
5. **Graph substrate only:** All results use Erdős-Rényi random graphs. Extension to lattice, scale-free, and geometric random graph substrates could test universality.

10.2 Future Directions

Chamber XXXVII: Ω-Stabilization Mechanisms Explore whether dynamic Ω-backgrounds can be stabilized via:

- τ-confinement: restrict τ-operators to bounded spatial domains
- Cross-chamber coupling: allow multiple Ω-configurations to stabilize collectively
- Topological constraints: enforce global invariants that prevent Ω-drift

If successful, this would identify regimes where both τ-admissibility and Ω-stationarity can be simultaneously achieved with dynamic backgrounds.

Multi-Layer τ-Operator Families Extend beyond single-field τ to multi-field systems with internal coupling. Test whether layer independence persists when τ-level complexity increases.

Continuous Limit Replace discrete graph substrates with continuous manifolds and test whether layer independence survives continuum limit. This would directly connect to differential geometry formulations of general relativity.

Experimental Signatures Develop phenomenological models that could distinguish substrate-based layer independence from alternative quantum gravity proposals (string theory, loop quantum gravity, asymptotic safety). Identify observables that could test the prediction that Ω-level structure remains classical.

11 Conclusion

Chamber XXXVI demonstrates that Ω-level stationarity and τ-level admissibility are structurally distinct properties. This resolves an apparent contradiction between background instability and stable field dynamics, and clarifies the layered architecture of the UNNS substrate.

The four-mode landscape reveals:

- Mode A: Baseline joint stability when Ω is fixed
- Modes B & C: Layer-independent τ-admissibility with distinct coupling mechanisms (recursive vs stress-mediated), distinguished quantitatively via Ω-coherence $\langle w \rangle$
- Mode D: Complete collapse when layer hierarchy is violated

Rather than falsifying prior results, Chamber XXXVI *sharpens* them: background structure and operator admissibility must be treated as separate layers, each governed by its own constraints. This suggests a structural resolution to the quantum gravity problem: geometric structure (Ω-level) and propagating fields (τ-level) may occupy fundamentally different layers in the substrate architecture, making unification via quantization structurally impossible.

The quantitative discrimination provided by Ω-coherence $\langle w \rangle$ demonstrates that substrate dynamics are not merely qualitative but exhibit measurable signatures that distinguish physical mechanisms. This opens the possibility of empirical tests that could validate or refute the UNNS framework's predictions about the structure of physical law.

11.1 Broader Implications

Chamber XXXVI suggests that the apparent incompatibility between quantum mechanics and general relativity may not be a problem requiring unification, but a *clue* about substrate structure. If gravity-like degrees of freedom occupy a different layer than quantum fields, the two theories can remain independently valid while being hierarchically coupled.

This perspective transforms the quantum gravity problem from "how do we quantize gravity?" to "why do geometric structure and field dynamics occupy different layers?" The answer may lie not in higher energies or smaller distances, but in the recursive rules that generate substrate structure itself.