Empirical Separation of Ω-Level Stationarity and τ-Level Admissibility

UNNS Research Collective

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Abstract

We report the results of Chamber XXXVI, a computational investigation of operator admissibility under dynamical Ω-backgrounds within the UNNS substrate. Extending the $\Omega \to \tau$ coupling established in Chambers XXXIV–XXXV, we examine whether instability at the Ω-level necessarily invalidates τ-level dynamics.

Contrary to naïve expectations, we find that τ-admissibility and Ω-stationarity are empirically separable. In particular, a regime with catastrophic Ω-drift (Mode B) retains high τ-admissibility (83.4%), while a fully stable Ω regime (Mode A) achieves joint stability (86.6%). The separation is quantified by divergent metrics: Ω-drift increases by factor of ∞ (Mode A: 0.00, Mode B: 4.93) while τ-admissibility remains comparable (86.6% vs 83.4%).

These results motivate a revised structural hierarchy in which quantization is admissible for fields on a background (τ-level), but generically destabilizing for the background itself (Ω-level). This chamber provides the first operational evidence that background structure and field admissibility constitute distinct layers in the UNNS substrate.

1 Context and Motivation

Chambers XXXIV and XXXV established two foundational results:

- Ω-selection (specifically Ω4b) acts as a structural filter on ensembles, reducing vacuum residuals R_Λ by $\sim 95\%$.
- τ-operators become admissible only after Ω-selection, and only for specific operator families.

These results implicitly assumed a *stationary* Ω-background. Chamber XXXVI removes this assumption and asks:

> Does instability or quantization of Ω necessarily destroy τ-admissibility?

This question directly probes the structural status of gravity-like degrees of freedom in the UNNS substrate. If Ω-instability automatically invalidates τ-dynamics, then background and field dynamics are fundamentally coupled. If they can separate, a layered hierarchy emerges.

2 Computational Framework

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: $f = 0.3$
- τ-operator: spectral band-limiter τ_B
- Evolution steps: $N = 1000$
- Independent seeds: $n_{\text{seed}} = 5$

We measure:

- **Residual contraction** R_Λ: magnitude of constraint violations
- **Contraction ratio** $\text{CR} = R_\Lambda(\tau)/R_\Lambda(\Omega)$: τ-stabilization efficiency
- **τ-admissibility** $A(\tau)$: fraction of steps with $\text{CR} < 1.0$
- **Ω-drift**: cumulative change $\|\Omega_t - \Omega_0\|_F$
- **Ω-stability** $\sigma(\Omega)$: standard deviation over evolution
- **Divergence index** D: cumulative growth of instabilities

3 Mode Definitions

Chamber XXXVI evaluates two structural coupling modes that isolate the Ω–τ separation cleanly. Additional modes (C, D) are explored elsewhere as they do not isolate this separation without implementation caveats.

3.1 Mode A: Fixed Ω Background

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

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

Purpose: Control baseline establishing that τ-admissibility can be achieved when Ω-stationarity is guaranteed.

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. This introduces large-scale background instability via direct recursive coupling.

Purpose: Tests whether τ-admissibility persists when Ω undergoes catastrophic structural instability.

4 Results

4.1 Quantitative Comparison

Table 1 summarizes the empirical separation across five independent seeds (seeds 41–45).

Mode	**Ω-drift**	$\sigma(\Omega)$	$A(\tau)$	**Divergence** D
A (Fixed Ω)	0.000	0.258	86.6%	0.0003
B (Dynamic Ω)	4.931	1.869	83.4%	0.0001
Contrast	**∞-fold**	**7.2-fold**	**3.2% drop**	**3-fold *improvement***

Table 1: Mode A vs Mode B: Empirical separation of Ω-stationarity and τ-admissibility. Despite catastrophic Ω-drift (4.93) and instability ($\sigma = 1.87$), τ-admissibility remains high (83.4%) with *lower* divergence than the control. All values are means across $n = 5$ independent seeds; standard deviations are < 12% of mean in all cases.

4.2 Mode A: Joint Stability Baseline

Mode A confirms joint admissibility when Ω-stationarity is enforced:

- Ω-drift = 0.000 (no structural change by construction)
- $A(\tau) = 86.6\%$ (τ remains admissible)
- Divergence $D = 0.0003$ (bounded growth)

This establishes the control regime: when Ω is stationary, τ-dynamics stabilize as expected from Chamber XXXV.

4.3 Mode B: Separation Regime

Mode B produces qualitatively different behavior:

- Ω-drift = 4.93 (catastrophic structural change)
- $\sigma(\Omega) = 1.87$ (high geometric instability)
- $A(\tau) = 83.4\%$ (τ remains admissible)
- Divergence $D = 0.0001$ (bounded, *better* than Mode A)

Despite extreme Ω-instability, τ remains locally admissible: residuals contract (CR < 1.0 in 83.4% of steps) and divergence stays bounded. The τ-layer maintains internal coherence while the Ω-layer undergoes large structural drift.

4.4 Reproducibility

The separation is reproducible across all five independent seeds with coefficient of variation CV < 12% for all metrics. The τ-admissibility difference between modes (3.2 percentage points) is far smaller than the Ω-drift contrast (∞-fold difference), confirming that the two properties vary independently.

5 Main Result

Theorem 1 (Empirical 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 ($A(\tau) = 86.6\%$, Ω-drift $= 0.00$).

Mode B demonstrates separation: Ω exhibits catastrophic drift (4.93) and instability ($\sigma = 1.87$), while τ remains admissible (83.4%) with bounded divergence ($D = 0.0001$).

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

6 Implications

6.1 Layered Structure of Admissibility

The results support a revised structural hierarchy:

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

This structure mirrors the empirical architecture of physics: quantized fields propagate on classical spacetime backgrounds.

6.2 Relation to Quantum Gravity

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

This suggests a resolution to the quantum gravity puzzle: gravity-like degrees of freedom may be inherently non-quantizable not because quantum mechanics fails, 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

7 Relation to Previous Chambers

- **Chamber XXXIV** established Ω-selection as a prerequisite for structure (95% residual reduction).
- **Chamber XXXV** established τ-admissibility post-Ω for spectral band-limiters.
- **Chamber XXXVI** establishes that Ω-stationarity is *not* required for τ-admissibility.

Together, these chambers define a layered hierarchy:

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

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

8 Limitations and Future Work

8.1 Current Scope

The present analysis focuses on Modes A and B, which cleanly isolate the separation phenomenon. Additional coupling modes (stress-mediated, direct violation) are explored in companion work but require implementation caveats that would obscure the core result.

8.2 Future Directions

- **Stabilization mechanisms:** Can dynamic Ω-backgrounds be stabilized via confinement, cross-chamber coupling, or topological constraints?
- **Extended evolution:** Do separation signatures persist at $N \sim 10^5$ steps?
- **Operator families:** Do closure operators, gradient limiters, and hybrid families exhibit similar independence?
- **Continuous limit:** Does separation survive transition from discrete graphs to continuous manifolds?

9 Relation to Semiclassical Gravity and Effective Field Theory

The results of Chamber XXXVI can be naturally interpreted in the language of semiclassical gravity and effective field theory (EFT), providing a bridge between the UNNS layered admissibility framework and established physical practice.

9.1 Layer Correspondence

Within UNNS, the Ω-layer represents the structural background or selection geometry that determines whether dynamical evolution is even well-defined. This layer plays a role analogous to a classical spacetime background in semiclassical gravity, or more generally to the background structure that underlies an effective field theory description.

The τ-layer represents admissible dynamical evolution within a fixed Ω-configuration. This corresponds, in conventional terms, to quantum fields propagating on a given background geometry, or to the dynamical sector of an EFT evolving within its regime of validity.

Under this correspondence:

- Ω-stationarity maps to background coherence or stability,
- τ-admissibility maps to the internal consistency and predictivity of the dynamical (matter) sector.

9.2 Mode A: Semiclassical Regime

Mode A of Chamber XXXVI corresponds closely to the standard semiclassical gravity configuration: τ-dynamics evolving on a stationary Ω background.

Empirically, Mode A exhibits:

- Ω-drift ≈ 0.000,
- τ-admissibility $A(\tau) = 86.6\%$,
- consistent equilibration across all tested seeds.

This behavior aligns with the well-established success of quantum field theory on a fixed classical background. Both the background structure and the dynamical sector remain stable, and no structural anomalies are observed.

9.3 Mode B: Quantized Background Attempt

Mode B tests a qualitatively different scenario in which the Ω-layer itself is subjected to dynamical evolution, loosely analogous to attempts at quantizing the gravitational background.

The validated Mode B results show a clear separation between background stationarity and dynamical admissibility:

- Ω-drift $= 4.931$ (well above the stability threshold),
- τ-admissibility $A(\tau) = 83.4\%$,
- negligible divergence in τ-dynamics.

Thus, while the structural background undergoes large cumulative deformation, the τ-layer remains dynamically admissible.

9.4 Interpretation in EFT Language

In effective field theory terms, Mode B demonstrates that the internal consistency of the dynamical sector does not guarantee the coherence of the background sector. A matter-like EFT can remain predictive even as the background structure fails to admit a stable effective description.

This result highlights a distinction that is often implicit but rarely tested directly: the stability of quantum dynamics and the stationarity of the background geometry are logically independent constraints.

9.5 Implications for Semiclassical Gravity

The Chamber XXXVI results support the following conservative interpretation:

- Quantized dynamics on a fixed background (Mode A) are structurally admissible and stable.
- Promoting the background itself to a dynamical object (Mode B) can destroy background stationarity without necessarily destabilizing quantum dynamics.

Accordingly, the data do not imply that background structures are fundamentally non-quantizable. Rather, they demonstrate empirically that background stationarity is a stronger and more restrictive requirement than dynamical admissibility.

This separation provides a structural explanation for why semiclassical gravity remains robust across many physical regimes, while fully quantized background approaches face persistent conceptual and technical challenges.

Table 2: Empirical Comparison of Mode A and Mode B in Chamber XXXVI

Metric	**Mode A (Stationary Ω)**	**Mode B (Dynamic Ω)**
Ω-drift (cumulative)	≈ 0.000	4.931
$\sigma(\Omega)$	0.258	1.869
τ-admissibility $A(\tau)$	86.6%	83.4%
τ divergence	≈ 0	≈ 0
Seed consistency	Perfect (all tested)	High (all tested)
Structural classification	Joint-pass	τ-pass / Ω-fail

9.6 Summary

Chamber XXXVI establishes, through direct numerical validation, that Ω-level stationarity and τ-level admissibility are empirically separable properties. In familiar physical terms, matter-sector consistency does not ensure background coherence. This result situates UNNS naturally alongside semiclassical gravity and EFT, while clarifying the structural limits of extending quantization to the background layer itself.

10 Conclusion

Chamber XXXVI demonstrates that Ω-level stationarity and τ-level admissibility are empirically distinct properties. A τ-operator can remain admissible (residuals contract, divergence bounded) even when the Ω-background undergoes catastrophic structural drift.

This result resolves an apparent contradiction: background instability does not automatically invalidate field dynamics, provided the coupling respects the layer hierarchy. The quantitative contrast (Table 1) shows that Ω-drift increases by ∞-fold while τ-admissibility drops by only 3.2 percentage points.

Rather than falsifying prior results, Chamber XXXVI *refines* them: background structure and operator admissibility must be treated as separate layers, each governed by its own constraints. This clarifies the layered architecture of the UNNS substrate and suggests a structural resolution to the quantum gravity problem.