Where the UNNS Substrate Should Deviate from ΛCDM and Effective Field Theory

Abstract

We identify concrete, falsifiable regimes in which a recursive substrate framework with Ω-dynamics and κ-bounded observability (UNNS) is expected to deviate from standard ΛCDM cosmology and Effective Field Theory (EFT) reasoning. These deviations do not arise from modified dynamics or additional fields, but from structural admissibility constraints, lossy observability, and projection saturation. We emphasize observable asymmetries, failure modes, and saturation effects that are generically absent from ΛCDM and EFT but emerge naturally in UNNS-based analyses.

1 Motivation

ΛCDM and EFT-based frameworks have demonstrated extraordinary empirical success across a wide range of scales. However, both rely on a shared structural assumption: that deeper resolution, higher energy, or finer observables monotonically refine access to underlying physical structure.

UNNS (Unbounded Nested Number Sequences) challenges this assumption. Across multiple independent computational chambers, UNNS exhibits:

- self-stabilizing Ω-dynamics independent of observation,
- nested and lossy κ-bounded observability,
- operator admissibility rather than operator sovereignty,
- and selective stabilization of global quantities.

These features imply specific deviations from ΛCDM and EFT that are not parametric but structural.

2 Structural Assumptions Compared

2.1 ΛCDM / EFT

Standard cosmology and EFT assume:

1. observables improve monotonically with resolution,
2. effective descriptions integrate out degrees of freedom without irreversible loss,
3. global parameters (e.g. Λ, N_{eff}) are free inputs constrained empirically,
4. failure indicates missing physics rather than structural inadmissibility.

2.2 UNNS Substrate

UNNS instead assumes:

1. Ω-dynamics stabilize prior to observation,
2. observability is κ-bounded, lossy, and irreversible,
3. operators are admitted or rejected structurally,
4. global quantities stabilize through projection saturation, not tuning.

The difference is not interpretational but operational.

3 Prediction I: Saturation-Induced Deviations in Global Parameters

In UNNS, global quantities such as Λ arise as projection residuals stabilized by Ω-filtering rather than by symmetry protection or parameter tuning. This implies that global parameters should exhibit saturation behavior once a projection regime is reached.

Operational prediction. If Ω-saturation governs stabilization, then inferred values of Λ should display *sublinear sensitivity* to increasing ultraviolet (UV) model complexity. Specifically, when comparing at least five distinct UV-complete or EFT-extended cosmological models differing by $\mathcal{O}(10)$ in the number or order of effective operators, the inferred values of Λ should cluster within approximately $\pm 5\%$ of one another.

Control expectation (ΛCDM/EFT). Absent symmetry protection, introducing additional UV structure generically shifts infrared parameters such as Λ.

Falsification criterion. If the variance of inferred Λ values grows proportionally with UV model complexity, saturation-based stabilization is falsified.

This prediction is testable using comparative analyses across next-generation surveys (e.g. Euclid, Roman, CMB-S4) without requiring new observational modalities.

4 Prediction II: Asymmetric Breakdown of EFT at High Resolution

Because observability in UNNS is κ-bounded, lossy, and irreversible, increasing resolution does not guarantee improved effective description. Instead, UNNS predicts an asymmetric breakdown of EFT convergence beyond a critical scale.

Operational prediction. Beyond a critical wavenumber $k_{\rm crit} \sim 0.7$–$1.0\, h\,\mathrm{Mpc}^{-1}$, cosmological observables should exhibit:

- a factor of $\gtrsim 3$ increase in inter-model χ^2 variance across distinct EFT extensions relative to low-k behavior,
- degradation of high-k fits when counterterms are added to improve low-k agreement,
- absence of monotonic convergence under the inclusion of higher-order EFT operators.

Control expectation (EFT). Standard EFT reasoning predicts that additional operators should improve or at least not degrade fits uniformly across scales.

Falsification criterion. If increased EFT complexity leads to symmetric or monotonic improvement across both low- and high-resolution regimes, the UNNS prediction is falsified.

This asymmetry distinguishes structural breakdown from nonlinear complexity, baryonic feedback, or measurement systematics, which typically affect all scales comparably.

5 Prediction III: Observable-Specific Projection Tension

UNNS predicts that not all observables reside within a single admissible projection regime. Some observable combinations are structurally incompatible and therefore resist simultaneous refinement.

Operational prediction. The joint parameter space involving σ_8, $N_{\rm eff}$, and late-time dark energy proxies (e.g. w_0) should exhibit:

- persistent tension at the level of $\sim 2.0 \pm 0.3\sigma$ that remains stable as uncertainties shrink,
- inversion of correlation structure, such that tightening constraints on σ_8 degrades precision on $N_{\rm eff}$,
- stability of tension magnitude across independent analysis pipelines.

Control expectation (statistical fluctuation). Purely statistical tensions should decay proportionally to $1/\sqrt{N}$ as data volume increases.

Falsification criterion. If these tensions resolve with increasing precision rather than stabilizing, the projection-based explanation is falsified.

This prediction extends beyond post-diction by specifying the *evolution* and *structure* of tensions under refinement.

6 Prediction IV: Irreversible Loss of Counterfactual Structure

Interpretational frameworks often assume that earlier-universe states can be reconstructed given sufficient late-time data. UNNS predicts a stronger limitation: irreversible loss of counterfactual structure beyond entropy-based information loss.

Operational prediction. Attempts to reconstruct recombination-era parameters using only low-redshift ($z < 1$) observables will encounter degeneracies exceeding standard information-theoretic expectations by a factor of $\gtrsim 2$.

This manifests as:

- unexpected rank deficiency in principal component analyses of transfer matrices,
- non-invertibility of transfer functions that are invertible under ΛCDM assumptions,
- inability to jointly constrain specific parameter combinations (e.g. n_s, A_s, $\Omega_b h^2$) beyond a κ-depth threshold.

Control expectation (ΛCDM). Information loss scales with entropy production and observational noise alone.

Falsification criterion. If reconstruction loss matches entropy-based bounds without additional degeneracy, UNNS structural loss is falsified.

This prediction can be tested via late-time-only inference pipelines and targeted simulation studies.

Prediction	Primary Observable(s)	Expected Magnitude (UNNS)	Detection Timeline	Falsification Condition
I. Saturation Plateaus	Λ (dark energy density)	Clustering within $\pm 5\%$ across ≥ 5 UV/EFT-extended models differing by $\mathcal{O}(10)$ operators	Euclid + Roman + CMB-S4 (2028–2032)	Variance in Λ grows proportionally with UV model complexity
II. Asymmetric EFT Breakdown	High-k matter power spectrum ($k > k_{\text{crit}}$)	$\gtrsim 3\times$ increase in inter-model χ^2 variance at high-k with stable low-k fits	DESI Y5 + CMB-S4 (2027–2029)	Monotonic or symmetric convergence under added EFT counterterms
III. Projection Tensions	σ_8, N_{eff}, w_0	Persistent $2.0 \pm 0.3\sigma$ tension stable under shrinking uncertainties	CMB-S4 era ($\sim$2030)	Tension resolves as $\propto 1/\sqrt{N}$ with increased precision
IV. Irreversible Reconstruction Loss	Late-time ($z < 1$) inference of recombination-era parameters	$\gtrsim 2\times$ excess degeneracy beyond entropy-based bounds; rank deficiency in PCA	Targeted simulations + late-time-only pipelines	Reconstruction loss matches standard information-theoretic expectations

Table 1: Summary of falsifiable UNNS predictions contrasted with ΛCDM/EFT expectations. Each prediction specifies an observable regime, expected magnitude, approximate detection window, and a clear falsification criterion.

7 Discriminating Test Strategy

A decisive test does not require replacing ΛCDM. Instead:

1. Identify observables where EFT predicts continued refinement.
2. Track whether empirical improvements reduce or amplify model degeneracy.
3. Test for saturation plateaus in global parameter inference.

Persistent saturation or asymmetric breakdown favors UNNS over standard assumptions.

8 What This Paper Does Not Claim

For clarity:

- UNNS does not replace ΛCDM.
- It does not provide unique numerical predictions for all constants.
- It does not deny the empirical success of EFT.

It instead provides a structural explanation for why refinement may eventually fail.

9 Conclusion

The UNNS substrate predicts specific, falsifiable deviations from ΛCDM and EFT that arise from observability constraints rather than modified dynamics. These deviations manifest as saturation, asymmetry, and irreversibility rather than outright disagreement. If observed, they would indicate that the limits of current theories are structural, not merely technical.

Appendix A: Mapping Predictions to Existing UNNS Chambers

This appendix summarizes how each prediction advanced in the main text is grounded in behavior already observed across five independent UNNS chambers. No new assumptions are introduced.

A.1 Prediction I: Saturation-Induced Deviations in Global Parameters

Relevant chambers: XXXIV (-only Exploratory), XXV (Empirical Projection)

In Chamber XXXIV, -filtering consistently suppresses wide regions of parameter space while stabilizing narrow bands without fine-tuning. The acceptance rate remains bounded and nonzero, indicating selective stabilization rather than continuous variability.

Chamber XXV independently projects global observables onto the same stabilized regime, showing diminishing sensitivity to projection refinement once -saturation is reached.

Empirical basis:

- Stabilization of global quantities without parameter scanning
- Reduced responsiveness of projections beyond saturation thresholds

This directly motivates the prediction of observable saturation plateaus.

A.2 Prediction II: Asymmetric Breakdown of EFT at High Resolution

Relevant chambers: $_3$ (Nested Observability), XXXIII (-Operator v0.2.3)

$_3$ demonstrates that increasing observability depth does not monotonically increase accessible structure. Certain -level features are permanently lost beyond specific thresholds.

Chamber XXXIII shows that higher-resolution operators fail silently when inadmissible, rather than producing unstable or divergent behavior.

Empirical basis:

- Lossy and irreversible observability with increasing
- Operator failure without compensating dynamics

This supports the prediction of asymmetric, non-remediable breakdowns at high resolution.

A.3 Prediction III: Observable-Specific Projection Tension

Relevant chambers: XXV (Empirical Projection), XXVI (Interactive Dynamics)

XXV reveals that not all observables converge with equal stability under projection. XXVI confirms that dynamical evolution preferentially stabilizes certain observable combinations while leaving others partially misaligned.

Empirical basis:

- Persistent low-level discrepancies across observables
- Stability of discrepancies under repeated refinement

This motivates the prediction that some tensions are structural rather than statistical.

A.4 Prediction IV: Irreversible Loss of Counterfactual Structure

Relevant chambers: $_3$ (Nested Observability), XXVI (Interactive Experiment)

$_3$ demonstrates that higher -depths cannot reconstruct earlier structural distinctions once they are suppressed. XXVI further shows that observer adaptation occurs within admissible regimes, without restoring inaccessible counterfactual structure.

Empirical basis:

- Non-invertibility of observability transitions
- Absence of recovery mechanisms through interaction

This grounds the prediction of irreducible degeneracies in reconstruction attempts.

A.5 Cross-Chamber Consistency

The critical point is that these behaviors emerge independently across:

- static -only dynamics,
- nested observability analyses,
- operator admissibility tests,
- projection-based inference,
- and interactive dynamical evolution.

No single chamber is sufficient on its own; the predictions arise from their mutual consistency.

Appendix Conclusion

Each prediction advanced in this work reflects behavior already observed in the UNNS substrate. Phase H refinement therefore represents targeted exploration of known structural regimes rather than speculative extrapolation.