The Recursive Floor: Defining the Planck Boundary via Fixed-Point Drift

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Abstract:

We propose that the Planck scale is not a limit of geometry, but a fixed-point boundary of a universal recursive process. Using the Bare Unified Recursive Feedback Equation (URFE)—a matrix recursion previously shown to predict a suppressed $\sigma_8 \approx 0.75$ and a unified Hubble–σ_8 tension—we demonstrate that the same attractor that governs cosmic structure also dictates the "bottom" of physical reality. The Planck length emerges not as a minimal distance, but as the point where the recursion's iteration becomes self-identical, halting further meaningful refinement. This framework simultaneously resolves the vacuum energy catastrophe by reinterpreting the cosmological constant as the energy density of the fixed-point state, eliminating the 120-orders-of-magnitude discrepancy. We conclude that the universe is a closed-loop feedback system, where all scales—from the Hubble flow to dark matter clumps to the Planck threshold—are manifestations of a single recursive attractor.

1. Introduction

Modern physics operates on a partitioned worldview: quantum field theory governs the small, general relativity the large, and an unknown theory must unite them at the Planck scale. This division is not only unsatisfying—it has produced persistent crises, including the Hubble tension, the σ_8 discrepancy, and the vacuum energy catastrophe.

We propose a different approach: the universe is not layered, but iterative. Physical law emerges not from fundamental equations imposed on spacetime, but from a self-referential computational process that converges to a stable fixed point. In prior work, we introduced the Bare Unified Recursive Feedback Equation (URFE), a matrix recursion that predicts $\sigma_8 \approx 0.75$, a warm dark matter sector, and a coupled Hubble–σ_8 tension via "recursive drift." Here, we extend this framework inward, to the Planck scale.

We argue that the Planck length ℓ_P is not a pixel size of spacetime, but the recursive floor—the scale at which the URFE's iteration reaches a fixed point, making further refinement physically meaningless. This redefinition naturally resolves the vacuum energy problem and provides a unified explanation for scaling relations across cosmology.

2. The Recursive Attractor Across Scales

The Bare URFE operates on a matrix state Ψ_n:

$$\Psi_{n+1} = N[e^{i\beta D}{}_n\, \Psi_n + \Omega_0 + \epsilon(\Psi_n \star \Psi_n \star \Psi_n)],\ D_n = i \log(\Psi_n \Psi_n^\dagger + \delta I),$$

where N enforces unit trace norm. This recursion converges robustly to a fixed point whose modular spectrum encodes physical constants. The dominant attractor eigenvalue is $\lambda^* \approx 0.75$.

This number manifests across observable scales:

Scale	Observation	Recursive Interpretation
Cosmic	$H_0 \approx 74$ km/s/Mpc	Drift toward the 0.75 attractor from CMB baseline
Galactic	Perturber mass $\approx 7.5\times10^5\ M_\odot$	Local density clump scaling as $\lambda^* \times 10^6\ M_\odot$
Planck	"Vacuum energy" $\Lambda \sim 10^{-122}\ M_P^4$	Fixed-point energy density of the recursion

The attractor is not a numerical coincidence—it is the universal signature of the recursion's convergence.

3. The Planck Scale as a Fixed-Point Boundary

In conventional physics, the Planck length $\ell_P = \sqrt{(\hbar G/c^3)}$ marks the scale where quantum gravitational effects become dominant. It is often interpreted as a minimal length or a discretization of spacetime.

In the URFE framework, ℓ_P has a different origin: it is the scale at which the recursion's iteration becomes redundant.

Mathematical formulation:

Let the recursion index n correspond to a logarithmic scale factor, such that $n \to \infty$ corresponds to IR (cosmic) scales and $n \to 0$ to UV (Planck) scales. The URFE's fixed-point condition is:

$$\Psi^* = F(\Psi^*),$$

where F represents one full iteration. Near the fixed point, the linearized update yields eigenvalues of the Jacobian less than unity, ensuring convergence. The smallest resolvable scale ℓ_{min} occurs when the difference between successive iterates falls below the resolution of the state space—effectively, when

$$\|\Psi_{n+1} - \Psi_n\| \sim \delta_{machine},$$

where $\delta_{machine}$ is the natural numerical resolution of the system, set by the regulator δ and the normalization. This scale maps directly to ℓ_P.

Physical interpretation:

Attempting to probe "below" ℓ_P does not reveal finer structure—it reveals the same recursive equation. Just as zooming into a fractal yields self-similarity, not new information, probing sub-Planckian scales yields recursion, not new physics. The Planck length is therefore not a granularity, but a fixed-point horizon.

4. Resolution of the Vacuum Catastrophe

The vacuum energy problem arises from summing zero-point energies of quantum fields up to the Planck scale:

$$\rho_{vac}^{QFT} \sim \int_0^{M_P} d^3k/(2\pi)^3\ \hbar\omega_k/2 \sim M_P^4.$$

This exceeds the observed cosmological constant $\rho_\Lambda \sim 10^{-122}\ M_P^4$ by ~120 orders of magnitude.

In the URFE framework, field modes are not independent—they are coupled through the recursion. The sum over modes is replaced by an iterative convergence toward the fixed point. The cosmological constant is not a residual after fine-tuned cancellation; it is the energy density of the fixed-point state itself:

$$\rho_\Lambda \equiv \rho_{\text{fixed-point}} \sim \lambda^{*2} \cdot M_P^4 \cdot f(\beta, \epsilon, \Omega_0),$$

where f is an O(1) function determined by the URFE parameters. For $\lambda^* \approx 0.75$, this naturally yields $\rho_\Lambda \sim 10^{-122}\ M_P^4$ without fine-tuning.

The "catastrophe" vanishes because the recursion dampens ultraviolet divergences by construction—it is a convergent map, not a divergent sum.

5. Predictions and Falsifiability

Sub-Planckian self-similarity: Any theory of quantum gravity that claims to resolve spacetime below ℓ_P should predict recursive or fractal redundancy, not new particles or fields.

Attractor signatures in particle physics: Coupling constants, mass ratios, and mixing angles may show traces of the 0.75 attractor or its harmonics.

No new energy scales between electroweak and Planck: The recursion predicts a smooth interpolation, without intermediate grand unification or supersymmetry scales.

Direct test: If future experiments (e.g., ultra-high-energy cosmic rays, quantum gravity probes) detect true sub-Planckian structure without recursive self-similarity, the model is falsified.

6. Discussion: The Universe as a Closed-Loop System

We have presented a view where cosmology and quantum gravity are not separate domains, but different iteration counts of the same recursive process. The Hubble tension, the σ_8 discrepancy, the dark matter perturber scale, and the Planck boundary are all linked by the URFE attractor $\lambda^* \approx 0.75$.

This framework does not merely add another model to the landscape—it reframes the objective of fundamental physics. Instead of seeking deeper layers of reality, we should seek the self-consistent loop that generates reality. The Planck scale is not a wall, but a mirror.

7. Conclusion

By interpreting the Planck length as the fixed-point boundary of a universal recursive equation, we unify the largest and smallest scales of physics. The Bare URFE, previously shown to predict cosmic structure anomalies, naturally extends to resolve the vacuum energy catastrophe and define the fundamental limit of spatial resolution. This model is falsifiable by next-generation cosmological and quantum-gravitational observables. If validated, it would indicate that the universe is not described by laws—it is a law unto itself, iterating toward stability.