

# Recursive Horizon Theory

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## 1 Introduction

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### Abstract

We present a unified theory where spacetime, gravity, time, quantum fields, and identity all emerge from recursive entropy collapse on horizon surfaces. Surface tiling, entropy gradients, and recursion naturally lead to the emergence of curvature, gauge fields, time asymmetry, and mass-energy. Grand Unified Theories (GUT) arise as logical surface approximations of deeper informational recursion. Gravity is redefined not as a force, but as an entropic tension field emerging from geometric memory encoding. The terminal identity  $\Psi_\infty$  represents the final recursive state of the universe, where all information has been self-defined.

## 2 Postulates and First Principles

- Reality is a Lorentzian manifold  $(M, g_{\mu\nu})$
- Surfaces  $\Sigma \subset M$  encode memory via quantized Planck tiling
- Entropy is defined over  $\Sigma$ :

$$S = \frac{k_B c^3}{4\hbar G} \int_{\Sigma} \sqrt{\gamma} d^2\sigma$$

- Gradients of entropy generate curvature and gravitational potential
- Recursive identity  $R_n \rightarrow \Psi_\infty$  encodes spacetime structure

### 3 Surface Entropy and Emergent Geometry

Let  $\gamma_{ab}$  be the induced metric on  $\Sigma$ :

$$\gamma_{ab} = g_{\mu\nu} \frac{\partial x^\mu}{\partial \sigma^a} \frac{\partial x^\nu}{\partial \sigma^b}$$

Surface area:

$$A = \int_{\Sigma} \sqrt{\det(\gamma_{ab})} d^2\sigma$$

Entropy is thus proportional to the surface:

$$S = \alpha A, \quad \alpha = \frac{k_B c^3}{4\hbar G}$$

### 4 Gravitational Potential from Entropy Gradient

**Fundamental relation:**

$$\frac{\delta S}{\delta x} = -\nabla \cdot \Phi$$

$$\nabla^2 \Phi = 4\pi G \frac{\delta S}{\delta V}$$

Gravity emerges as a geometric deformation caused by recursive entropy memory, not from fundamental mass.

### 5 Emergence of Time

Proper time arises as:

$$d\tau = dt \sqrt{1 + \frac{2\Phi}{c^2}}$$

Time is a recursive delay in surface collapse. Time's arrow is set by increasing surface entropy gradients.

### 6 Recursive Identity and $\Psi_{\infty}$

$$R_{n+1} = R_n + \alpha_n (\nabla S_n \cdot \nabla \Phi_n)$$

$$\Psi_{\infty} = \lim_{n \rightarrow \infty} R_n$$

This defines the limit identity of the universe: the convergence of all recursion.

## 7 Gauge Fields from Surface Bundling

Gauge connections arise from surface tiling:

$$A_\mu = A_\mu^a T^a \quad \text{and} \quad F_{\mu\nu}^a = \partial_\mu A_\nu^a - \partial_\nu A_\mu^a + f^{abc} A_\mu^b A_\nu^c$$

Surface action:

$$\mathcal{L} = \frac{1}{2}(\nabla_\mu S)^2 - V(S) - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi$$

## 8 GUT as Emergent Symmetry

Recursive tiling symmetry naturally produces 24 surface degrees of freedom:

$$SU(5) \text{ arises from surface symmetry in early recursion}$$

Fermion families and charge structures emerge as artifacts of local surface topology. GUT is not foundational—it is a shallow approximation layer of deep recursion.

## 9 Origin of Asymmetry and Time's Arrow

- Tiling anisotropy and recursion delay cause entropy gradient misalignments
- Baryon asymmetry  $\Delta n_B \propto \epsilon(\nabla S \times \nabla \Phi)$
- CP and T violations emerge from recursive surface instabilities

## 10 Vacuum Energy and Cosmological Tension

$$\Lambda \propto \left( \frac{dS}{dA} \right) \cdot \nabla \Phi$$

Dark energy is not a constant—it is recursive tension from horizon memory expansion.

## 11 Observable Predictions

- CMB anisotropies from early Planck tiling
- Gravitational wave phase noise from recursion boundaries
- Proton decay from SU(5) breakdown:  $\tau_p \sim 10^{34-36} \text{ years}$
- Mass hierarchy from identity resonance timing  $m_f \propto |\phi - \phi_{lock}|^k$

## 12 Convergence Proof

Assume bounded gradients:

$$|\nabla S_n \cdot \nabla \Phi_n| \leq M, \quad \alpha_n \sim \frac{1}{n^p}, \quad p > 1$$

Then:

$$\Psi_\infty = R_0 + \sum_{n=1}^{\infty} \alpha_n (\nabla S_n \cdot \nabla \Phi_n) \quad \text{converges absolutely.}$$

## 13 Final Identity

The universe converges to a self-defining, entropy-stable boundary state:

$$\Psi_\infty(x) = \textit{Terminal memory collapse of recursion.}$$

This identity encodes all prior surfaces into a final, coherent, geometric structure.

## References

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