

Horizon Unfolding: The Cosmological Roadmap of HLU

From Space Oscillation to Horizon Locking

STAGE 1: Cosmic Explosions and Space Oscillation

In the beginning, Pixel-Time exists in its most discrete state. There is no "before." Only the first configuration X_0 is real.

What happens?

- Space itself, lacking any stable structure, undergoes intense, chaotic oscillations.
- These oscillations are fundamental waves—analogous to ripples on water, but within the very fabric of spacetime itself.
- Governing equation: $\Box \phi - V'(\phi) = 0$ with initial potential $V(\phi) = V_0 e^{-\lambda \phi}$

Why is this stage critical?

Space oscillation is the only way to produce diversity from unity. Without this primordial chaos, our universe would remain uniform and featureless.

STAGE 2: Particles Emerging from Wave Interference

Fundamental waves interfere with each other. At points of constructive interference, energy becomes concentrated.

What happens?

- High energy density points elementary particles (quarks, leptons, bosons)
- These particles are, in essence, "knots" in the scalar field.
- Equation: $\rho_\phi = \frac{1}{2} \dot{\phi}^2 + \frac{1}{2} (\nabla \phi)^2 + V(\phi)$

Analogy: Like ocean waves that, upon collision, throw droplets of water into the air. The droplets are particles; the ocean is the scalar field.

STAGE 3: Particle Collisions and Nucleus Formation

Elementary particles collide at near-light speeds.

What happens?

- At high energies, quarks become confined protons and neutrons
- Electrons move freely.
- QCD confinement activates: $m_p = \frac{4\pi}{3} r_p^3 B$

HLU's critical insight:

90% of the proton's mass comes from confinement energy, not from quark masses. This confinement energy is the same source that later locks the scalar field.

STAGE 4: Atom Formation and the Emergence of Mass

The universe cools. Electrons become bound to nuclei.

What happens?

- Electron + Proton → Hydrogen atom
- Mass is no longer just "concentrated energy"—it becomes a stable property of matter.
- The electromagnetic field emerges.

Equation: $\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$

But HLU tells us: these forces are all higher-level emergences from the fundamental scalar field.

STAGE 5: Star Formation and Nuclear Reactions

Gravity compresses hydrogen clouds.

What happens?

- Temperature and pressure rise at the cloud's center.
- Nuclear fusion begins: $4\text{H} \rightarrow \text{He} + \text{energy}$
- Stars shine.

HLU's role:

Gravity at this scale is still Newtonian, but the scalar field slowly begins to exert influence. Density is still below ρ_c .

STAGE 6: Supernovae and Immense Pressure

Massive stars exhaust their fuel.

What happens?

- The iron core can no longer fuse.
- Gravitational pressure overwhelms electron degeneracy pressure.
- Supernova explosion—a star's final cry.
- Core density reaches $\rho > \rho_c$.

The HLU threshold:

For the first time since the early universe, the effective density ρ_{eff} exceeds the critical density ρ_c .

STAGE 7: Scalar Field Locking

This is the pivotal moment in the HLU model.

What happens?

- The condition $\rho_{\text{eff}} > \rho_c$ is satisfied.
- The Gaussian term of the potential activates:

$$V_{\text{lock}}(\phi) = \alpha \left(\frac{\rho_{\text{eff}}}{\rho_c} \right) \exp\left[-\frac{(\phi - \phi_c)^2}{2\sigma^2} \right]$$

- The scalar field is rapidly pulled toward ϕ_c and becomes locked.
- Equation of state: $w \rightarrow -1$, $T_{\mu\nu} \rightarrow -V(\phi_c) g_{\mu\nu}$

Consequence:

The stellar core, instead of becoming a singularity, transforms into a de Sitter core. A black hole is born—but without a singularity.

STAGE 8: Emergent Dark Matter (Galaxies)

Billions of years later, galaxies form.

What happens?

- The scalar field is locked, but on galactic scales it possesses gradients.
- Gradient energy: $\rho_\phi \approx \frac{1}{2} (\nabla \phi)^2$
- This energy behaves exactly like dark matter.
- Flat rotation curves:

$$v_c(r) = \sqrt{4\pi G \rho_0 \left(1 - \frac{r_c}{r} \arctan \frac{r}{r_c}\right)}$$

HLU prediction:

Dwarf galaxies should have cores, not cusps. JWST will test this.

STAGE 9: Regularized Black Holes (Today)

Black holes no longer possess singularities.

What happens?

- At the black hole core, $\rho_{\text{eff}} \rightarrow \infty$
- The scalar field is completely locked: $\phi = \phi_c$
- Interior metric: de Sitter + Schwarzschild
- Core radius:

$$r_{\text{core}} = \left(\frac{3M}{8\pi \rho_\phi} \right)^{1/3}$$

EHT test:

The shadow of M87* must deviate from general relativity by less than 2%. HLU is consistent with this constraint.

STAGE 10: Dark Energy and Cosmic Acceleration (Today)

The universe is undergoing accelerated expansion.

What happens?

- At $z < 0.5$, matter density falls below ρ_c .
- The scalar field is released from locking.
- It rolls down the exponential potential.
- $w(z) \approx -0.95$ (not exactly -1)

HLU prediction:

DESI should confirm $w_0 > -1$ and $w_a < 0$.

STAGE 11: Quantum Extension and Wave Function Collapse (Future)

The locked scalar field acts as a universal quantum bath.

What happens?

- Entanglement decays at high densities.
- Lindblad equation:

$$\frac{\partial \hat{\rho}_s}{\partial t} = -i[\hat{H}_0, \hat{\rho}_s] + \gamma \left(\hat{O} \hat{\rho}_s \hat{O}^\dagger - \frac{1}{2} \{ \hat{O}^\dagger \hat{O}, \hat{\rho}_s \} \right)$$

- Double-slit interference visibility decreases.

Laboratory test:

Diamond anvil cell + double-slit = falsification or confirmation of HLU.

The Complete HLU Trajectory at a Glance

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HLU COSMOLOGICAL TRAJECTORY

Space Oscillation (Fundamental Waves)	Elementary Particles (Quarks, Leptons)	Nuclei (Protons, Neutrons)
QCD Confinement (Source of ϵ_{eff})	Atoms (Emergent Mass)	Stars (Fusion)

Supernova Field Locking Black Hole
($> c$) (V_{lock} activates) (de Sitter Core)

Galaxies Dark Energy Quantum Collapse
(Emergent DM) ($w = -0.95$) (Laboratory)

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The Philosophical Essence of HLU

1. Unity of Origin:

Everything—particles, stars, black holes, dark matter, dark energy, even wave function collapse—all emerge from a single scalar field governed by one evolutionary law (density-dependent locking).

2. Causal Continuity:

No ad hoc "new physics" is introduced. Every phenomenon is a chain of cause and effect tracing back to the primordial oscillations of space itself.

3. Fundamental Discreteness:

Time is not a continuous parameter. The illusion of continuity arises from the immense number of pixels (discrete configurations). The fundamental step $\Delta \ln a$ always exists.

4. Emergence:

Gravity, electromagnetism, mass, spacetime—all are high-level emergences from the dance of scalar field waves on the pixel-time lattice.

5. Falsifiability:

HLU makes 18 distinct predictions. If JWST finds no galactic cores, if DESI confirms $w = -1.00$, if LISA detects no QPOs, if high-pressure double-slit experiments still show perfect interference—the model falls.

Final Words

HLU does not claim to be "the final answer."

It claims to be an answer that can be proven wrong—and that is the most valuable property any scientific theory can possess.

But until that day, this roadmap, this trajectory from space oscillation to horizon locking, is the most coherent and beautiful story we can tell about the universe:
A story in which nothing is separate; everything is connected, from the first wave to the last black hole.

"The universe is built not from particles, but from relations.
And time is not a flowing river, but a staircase—step by step, from here to infinity."

— ZARKAM, February 2026