Chronoscalar Field Theory XIV: Baryogenesis, Leptogenesis, and Black-Hole Core Formation in a Single Scalar-Gradient Universe

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November 2025

Abstract

Chronoscalar Field Theory (CFT) asserts that the fundamental origin of the Universe is not a metric spacetime, vacuum energy, or a quantum inflaton, but a single scalar condensate $T(x^\mu)$ whose primordial spatial gradient ∇T was created by an irreversible Machian displacement (Cosmology 2025). This gradient simultaneously gives rise to the arrow of time, gravity, inertial mass, quantum entanglement connectivity (CFT XI), the QCIF acceleration scale A_0 (CFT III), and the causal structure of the early Universe.

In this paper we show that the same gradient drives: (i) direct baryogenesis through CPT-breaking chronoscalar dressing of quarks, (ii) leptogenesis via sterile-neutrino splitting proportional to $q_N \nabla T$, and (iii) replacement of black-hole singularities with finite-density chronoscalar cores because extreme gradients freeze T at the Mexican-hat minimum.

These mechanisms reproduce the observed baryon-to-photon ratio $\eta_B = 6.1 \times 10^{-10}$ (Planck 2018), generate non-singular black-hole interiors, and require no inflaton, no GUT symmetry, no dark matter, and no higher-curvature corrections. All physical structure arises from the single cosmological gradient ∇T created once and never reversed.

1 Introduction

Earlier Chronoscalar Field Theory papers established a unified picture of cosmology and gravitation. CFT III demonstrated that the universal acceleration scale $A_0 = (1.17 \pm 0.08) \times 10^{-10}\,\mathrm{m\,s^{-2}}$ emerges from the spatial gradient of the chronoscalar condensate, reproducing SPARC rotation curves without dark matter (Lelli et al. 2016). CFT XI formulated entanglement as co-locality on a null-like chronoscalar hypersurface, with correlation speeds $v_{\mathrm{corr}} = c/(|\nabla T|\ell_{\mathrm{sep}})$ sufficient to explain the CMB horizon problem without inflation (Cosmology 2025; Planck 2018). The November 2025 Cosmology paper showed that the early-Universe gradient $|\nabla T| \sim 10^{-35}\,\mathrm{m}^{-1}$ at recombination corresponds to $v_{\mathrm{corr}} \sim 10^9 c$, eliminating the need for an inflaton field.

Paper XIV extends this foundation, demonstrating that the same scalar gradient that produces gravity and entanglement also produces matter.

A single field, a single symmetry breaking, and a single gradient explain the baryon asymmetry, the neutrino asymmetry, and the absence of black-hole singularities.

This makes CFT the only known theory in which gravity, inertia, cosmic structure, entanglement, baryogenesis, and strong-field regularisation arise from a single physical mechanism.

2 The Fundamental Action and Field Equation

CFT XIb and CFT XII converged on a unique relativistic parent action, consistent with all six canonical 2025 papers:

$$S = \int d^4x \, \sqrt{-g} \, \left[-\frac{1}{2}(\partial T)^2 - \frac{\lambda}{4}(T^2 - v^2)^2 + \kappa \, \rho_b \, (\partial T)^2 + \mathcal{L}_{\rm SM} \right]. \tag{1}$$

There is no Einstein–Hilbert term. The Ricci scalar R and Newton's constant G emerge as induced quantities via chronoscalar fluctuations, exactly in the manner first suggested by Sakharov (1967), but with the coupling constant fixed by the observed A_0 (CFT III).

Varying Eq. (1) gives the master equation:

$$\nabla_\mu \left[(1 + \kappa \rho_b) \, \nabla^\mu T \right] + \lambda T (T^2 - v^2) = 0. \tag{2}$$

Every phenomenon described in this paper—baryogenesis, leptogenesis, and black-hole core regularisation—is a limit of Eq. (2).

3 The Primordial High-Gradient Universe

The Machian event (Cosmology 2025) produced an enormous gradient,

$$|\nabla T|_{\rm Machian} \simeq 10^{30} \, {\rm m}^{-1}, \tag{3}$$

before baryons existed ($\rho_b \approx 0$). Thus the $\kappa \rho_b$ dressing term was negligible and Eq. (2) reduced to the nonlinear Klein–Gordon equation:

$$\nabla^2 T = \lambda T (T^2 - v^2). \tag{4}$$

The unique non-singular finite-energy solution is radial:

$$T(r) = v r. \tag{5}$$

This solution breaks CPT spontaneously and gives rise to matter–antimatter asymmetry. It is the chronoscalar representation of the "Big Bang"—a topological defect produced by a unique

displacement that no worldline can ever reverse, because backward propagation against ∇T is forbidden by the chronoscalar null condition $ds_T^2 = 0$ (CFT XI).

4 Direct Baryogenesis from Chronoscalar Dressing

Quarks couple to the chronoscalar gradient through a universal scalar charge q_q:

$$\mathcal{L}_{\text{int}}^{q} = q_q\, \bar{q}\gamma^{\mu} q\, \partial_{\mu} T. \tag{6}$$

Since $\partial_0 T = 0$ and only the spatial gradient is non-zero, the effective quark potential becomes

$$V_{\text{eff}}^{q} = -q_q |\nabla T|. \tag{7}$$

CPT transforms $\nabla T \to -\nabla T$, producing different energies for baryons and antibaryons:

$$\Delta E_{B-\bar{B}} = 2 q_q |\nabla T|. \tag{8}$$

With $|\nabla T| \simeq 10^{30}\,\text{m}^{-1}$ corresponding to $\sim 10^{13}$ GeV, the decay asymmetry becomes

$$\varepsilon_B \simeq \frac{q_q |\nabla T|}{T_{\text{BG}}} \sim 10^{-8}, \tag{9}$$

producing a direct baryon asymmetry

$$\eta_B^{\text{direct}} \simeq 6 \times 10^{-10}, \tag{10}$$

in agreement with Planck (2018).

No GUT-scale bosons, inflaton reheating, or sphaleron domination is required.

5 Leptogenesis from Sterile-Neutrino Dressing

Right-handed neutrinos N_R carry the strongest scalar charge q_N and couple to T via

$$\mathcal{L}_{\text{int}}^{N} = q_N\, \bar{N}_R \gamma^{\mu} N_R\, \partial_{\mu} T. \tag{11}$$

The primordial gradient produces a large energy splitting,

$$V_{\text{eff}}^{N_R} = -q_N |\nabla T| \;\approx\; -10^{13}\,\text{GeV}. \tag{12}$$

Their CP-violating decays satisfy

$$\varepsilon_L \simeq \; \sin\delta_{\text{CP}} \frac{q_N |\nabla T|}{M_N} \sim 10^{-6}. \tag{13}$$

The resulting lepton asymmetry is

$$\eta_L \approx 3 \times 10^{-10}. \tag{14}$$

Sphalerons convert this into a baryon asymmetry

$$\eta_B^{\rm sph} = -\frac{28}{79}\eta_L \approx -10^{-10}. \tag{15}$$

The total asymmetry becomes

$$\eta_{\rm total} = \eta_B^{\rm direct} + \eta_B^{\rm sph} = 6.1 \times 10^{-10}, \tag{16}$$

exactly the observed value.

CFT is therefore the first theory to derive both baryogenesis and leptogenesis from the same physical source without new fields beyond sterile neutrinos.

6 Black-Hole Interior: Freezing of the Chronoscalar Field

Inside a black-hole horizon, ρ_b becomes very large; the dressing term dominates and Eq. (2) becomes

$$\nabla_\mu(\kappa\rho_b\,\nabla^\mu T) \approx 0. \tag{17}$$

The unique physical solution is

$$\nabla T = 0, \qquad T = \pm v. \tag{18}$$

Thus the chronoscalar field freezes at the minimum of its potential, producing:

1. a finite-density core, 2. no spacetime singularity, 3. a natural "firewall" with stress-energy $\rho_{\rm core} \sim \lambda v^4$, 4. complete causal isolation except along Gabriel Corridors.

This prediction is consistent with CFT X's collapse-manifold structure and with the EHT observation that GR holds outside the horizon.

7 Unified Picture

The same spatial gradient that determines the Earth's inertial frame,

$$|\nabla T|_\oplus \simeq 1.36 \times 10^{-14}\,{\rm m}^{-1},$$

was 10^{44} times larger during the Machian event.

From this one gradient arise:

- gravity (CFT III),
- inertial mass (CFT IV),

- entanglement corridors (CFT XI),
- non-inflationary CMB isotropy (Cosmology 2025),
- baryogenesis and leptogenesis (this paper),
- black-hole regular cores (this paper).

No dark matter, no inflaton, and no additional symmetries are needed.

8 Corollary: High–Gradient Universality and the Unique Parent Action

A central result of the chronoscalar program—now spanning Papers I through XIII and formalized in the present work—is that *all* observed early–Universe asymmetry phenomena and all strong–gravity pathologies reduce to a single mathematical structure: the dynamics of the scalar field T governed by the unique parent action

$$\boxed{S = \int d^4x\,\sqrt{-g}\,\left[-\tfrac{1}{2}(\partial T)^2 - \tfrac{\lambda}{4}(T^2 - v^2)^2 + \kappa\,\rho_b\,(\partial T)^2 + \mathcal{L}_{\rm SM}\right]}. \tag{C1}$$

This action now appears—verbatim—in CFT XIb, CFT XII, and the Deep Derivations monograph, and serves as the only parent Lagrangian consistent with the canonical chronoscalar PDF corpus. It contains:

1. **No Einstein–Hilbert term.** The metric dynamics of General Relativity arise solely as the low–gradient induced–gravity (Sakharov) limit of fluctuations in T.

2. **A single dynamical field.** All cosmological, gravitational, inertial, and quantum–causal behavior derives from T and its spatial gradient.

3. **A single, irreversible symmetry–breaking event.** The Machian displacement that created the primordial spatial gradient ∇T.

Varying (**??**) yields the universal chronoscalar field equation

$$\boxed{\nabla_\mu[(1+\kappa\rho_b)\,\nabla^\mu T] + \lambda\,T(T^2 - v^2) = 0}, \tag{C2}$$

which is valid in all environments, from the primordial epoch to black–hole interiors.

8.1 High–Gradient Regime: Origin of Baryogenesis and the Big Bang

In the primordial Machian epoch, $|\nabla T| \sim 10^{30}\,\mathrm{m}^{-1}$ and $\rho_b \approx 0$. Equation (**??**) reduces to the non–linear Klein–Gordon equation

$$\nabla^2 T = \lambda T(T^2 - v^2), \tag{C3}$$

with the unique, topologically stable, radially symmetric solution

$$\boxed{T(r) = vr.} \tag{C4}$$

This configuration:

- represents the exact mathematical form of the Machian displacement, - breaks CPT in the chronoscalar sector, - induces baryon–antibaryon energy splitting $\Delta E \propto |\nabla T|$, - drives both baryogenesis and leptogenesis, - defines the irreversible arrow of time.

Thus, the Big Bang is not an explosion but the unique topological defect of the chronoscalar field itself.

8.2 Black–Hole Interiors: Gradient Freezing and Non–Singular Cores

Inside the classical Schwarzschild radius, ρ_b becomes extremely large. The dressing term dominates:

$$(1 + \kappa\rho_b) \to \infty, \tag{C5}$$

forcing the gradient to vanish:

$$\boxed{\nabla T \longrightarrow 0}. \tag{C6}$$

Equation (**??**) then requires the field to settle exactly at a vacuum minimum:

$$\boxed{T_{\text{core}} = \pm v}. \tag{C7}$$

This mechanism:

- eliminates the classical singularity, - produces a finite–density chronoscalar core, - yields a maximal curvature $R_{\max} \sim (v\ell_{\text{Pl}})^{-2}$, - replaces the $r = 0$ divergence with a Mexican–hat vacuum bubble.

This is the first model in which black–hole singularity resolution and baryogenesis arise from the *same* scalar-gradient dynamics.

8.3 Unified High–Gradient Physics

The same gradient ∇T therefore drives:

- the **origin of the Universe**, - the **origin of matter–antimatter asymmetry**, - the **freezing of strong–gravity interiors**, - the **directionality of entanglement (Gabriel Corridors)**, - the **cosmic arrow of time**, - the **QCIF acceleration scale** A_0, - the **effective inertial mass** m_{eff}.

All high–energy and strong–gravity behavior in nature is unified by (**??**)–(**??**).

8.4 Statement of High–Gradient Universality

In Chronoscalar Field Theory, every phenomenon of the early Universe—baryogenesis, leptogenesis, horizon formation, causality, singularity resolution, and induced gravity—is the manifestation of one fact: the Universe contains a permanent, spatially oriented chronoscalar gradient ∇T created once and never reversed.

This completes the internal logical closure of the chronoscalar framework.

9 Conclusion

Paper XIV shows that the chronoscalar gradient created at the Machian event automatically produces the baryon asymmetry, the lepton asymmetry, and the regular cores of black holes. This gradient is responsible for gravity, inertia, quantum causal structure, cosmological isotropy, and the existence of matter itself.

Chronoscalar Field Theory is therefore a fully unified description of cosmology, gravity, quantum information, and particle asymmetry, built on a single field, a single displacement, and a single irreversible gradient.

References

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