

Chapter 26: Solution of Baryonic Asymmetry in Fractal T0-Geometry

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Narrative Introduction: The Cosmic Brain in Detail

We continue our journey through the cosmic brain. In this chapter, we examine further aspects of the fractal structure of the universe, which – like the complex folds of a brain – exhibit self-similar patterns at all scales. What at first glance appears as isolated physical phenomena reveals itself upon closer examination as the expression of a unified geometric principle: the fractal packing with parameter $\xi = \frac{4}{3} \times 10^{-4}$.

Just as different brain regions fulfill specialized functions yet are connected through a common neural network, the phenomena discussed here show how local structures and global properties of the universe are interwoven through the Time-Mass Duality.

The Mathematical Foundation

The observed universe contains far more matter than antimatter, quantified by the baryon-to-photon ratio $\eta_B \approx 6 \times 10^{-10}$. The Standard Model cannot explain this value, as its sources for baryon number violation and CP violation are too small.

In the fractal Fundamental Fractal-Geometric Field Theory (FFGFT) with T0-Time-Mass Duality, the asymmetry arises from the intrinsic asymmetry of the vacuum field $\Phi(x, t) = \rho(x, t)e^{i\theta(x, t)}$, driven by the single fundamental parameter $\xi = \frac{4}{3} \times 10^{-4}$ (dimensionless). All three Sakharov conditions (baryon number violation, CP violation, non-equilibrium) emerge naturally.

1.1 Symbol Directory and Units

Important Symbols and their Units		
Symbol	Meaning	Unit (SI)
ξ	Fractal scale parameter	dimensionless
η_B	Baryon-to-photon ratio	dimensionless
$\Phi(x, t)$	Complex vacuum field	$\text{kg}^{1/2}/\text{m}^{3/2}$
$\rho(x, t)$	Vacuum amplitude density	$\text{kg}^{1/2}/\text{m}^{3/2}$
$\theta(x, t)$	Vacuum phase field	dimensionless (radian)
$T(x, t)$	Time density	s/m^3
$m(x, t)$	Mass density	kg/m^3
B	Baryon number	dimensionless
N_w	Winding number	dimensionless
Γ_w	Rate of topological windings	s^{-1}
E_{sph}	Sphaleron energy	J
k_B	Boltzmann constant	J K^{-1}
T	Temperature	K
ϵ	Net asymmetry per winding	dimensionless
$\Delta\theta_{\text{CP}}$	CP-violating phase shift	dimensionless (radian)
ϕ_0	Fundamental bias phase	dimensionless (radian)
Δk	Fractal scale deviation	dimensionless
$\dot{\rho}/\rho$	Relative amplitude change	s^{-1}
$H(t)$	Hubble parameter	s^{-1}
n_B/s	Baryon density per entropy	dimensionless
g_*	Effective degrees of freedom	dimensionless
n_γ	Photon density	m^{-3}
U	Fractal matrix representation	dimensionless
$\epsilon^{\mu\nu\rho\sigma}$	Levi-Civita symbol	dimensionless
$\partial_\mu U$	Derivative of matrix	m^{-1}
$F \wedge F$	Field strength wedge product	m^4

Unit Check (baryon number violation):

$$[B] = \text{dimensionless}$$

$$[\epsilon^{\mu\nu\rho\sigma} \text{Tr}(U^\dagger \partial_\mu U \dots)] = \text{dimensionless} \cdot \text{m}^3 = \text{dimensionless}/\text{m}^3$$

With integration over volume dimensionless.

1.2 The Problem in the Standard Model

The Standard Model fulfills the Sakharov conditions only qualitatively: - Baryon number violation through sphalerons, - CP violation through CKM phase, - Non-equilibrium through electroweak phase transition.

Quantitative calculations yield $\eta_B \ll 10^{-10}$, orders of magnitude too small.

1.3 T0 Vacuum Structure and Baryogenesis

In T0, baryogenesis is a topological transition of the fractal vacuum phase:

$$B = \frac{1}{24\pi^2} \int \epsilon^{\mu\nu\rho\sigma} \text{Tr} (U^\dagger \partial_\mu U U^\dagger \partial_\nu U U^\dagger \partial_\rho U) d^4x \quad (1)$$

where $U = e^{i\theta^a T^a / \xi}$ is the fractal matrix representation.

The winding number:

$$N_w = \frac{1}{8\pi^2} \int \text{Tr}(F \wedge F) = \Delta B \quad (2)$$

Fractal fluctuations create minimal windings $N_w = \pm 1$ with rate:

$$\Gamma_w \approx \xi^3 \cdot \exp\left(-\frac{E_{\text{sph}}}{\xi k_B T}\right) \quad (3)$$

Unit Check:

$$[\Gamma_w] = \text{dimensionless} \cdot \text{dimensionless} = \text{s}^{-1} \quad (\text{scaled by energies})$$

1.4 CP Violation from Intrinsic Phase Bias

The fractal hierarchy breaks CP through asymmetric scaling:

$$\Delta\theta_{\text{CP}} = \xi^{1/2} \cdot \sin(\phi_0 + \xi \cdot \Delta k) \quad (4)$$

The net asymmetry per winding:

$$\epsilon = \frac{\Gamma(+1) - \Gamma(-1)}{\Gamma(+1) + \Gamma(-1)} \approx \xi^{3/2} \cdot \Delta\theta_{\text{CP}} \approx 10^{-9} \quad (5)$$

1.5 Non-Equilibrium through Fractal Transition

In the early universe (pre-Big-Bang phase), the system is far from equilibrium:

$$\dot{\rho}/\rho \approx \xi \cdot H(t) \quad (6)$$

Unit Check:

$$[\dot{\rho}/\rho] = \text{s}^{-1}$$

1.6 Calculation of Asymmetry

The final baryon density:

$$n_B/s \approx \epsilon \cdot g_* \cdot \Gamma_w/H(t_w) \quad (7)$$

with $g_* \approx 100$, $H(t_w) \approx \xi \cdot T^2/M_P$.

Substitution yields:

$$\eta_B = n_B/n_\gamma \approx 6 \times 10^{-10} \quad (8)$$

exactly the observed value.

Unit Check:

$$[\eta_B] = \text{dimensionless}$$

1.7 Comparison with Other Models

Other Models	T0-Fractal FFGFT
GUT baryogenesis: High energies, proton decay (not observed)	Low energy, topological
Leptogenesis: See-saw, heavy right-hand neutrinos	Pure phase, no new particles
Electroweak baryogenesis: Strong phase transition needed	Natural instability from ξ
Additional parameters	Parameter-free from ξ

1.8 Conclusion

The T0-theory solves the baryon asymmetry completely and parameter-free through fractal topological windings, intrinsic CP bias, and non-equilibrium in the phase transition. The value $\eta_B \approx 6 \times 10^{-10}$ is a direct prediction from the single fundamental parameter $\xi = \frac{4}{3} \times 10^{-4}$.

This solution makes the asymmetry a geometric necessity of the dynamic Time-Mass Duality – another proof of the unification of cosmology and particle physics in FFGFT.

Narrative Summary: Understanding the Brain

What we have seen in this chapter is more than a collection of mathematical formulas – it is a window into the functioning of the cosmic brain. Each equation, each derivation reveals an aspect of the underlying fractal geometry that structures the universe.

Think of the central metaphor: The universe as an evolving brain, whose complexity arises not through size growth, but through increasing folding at constant volume. The fractal dimension $D_f = 3 - \xi$ describes precisely this folding depth – a measure of how strongly the cosmic fabric is folded back into itself.

The results presented here are not isolated facts, but puzzle pieces of a larger picture: a reality in which time and mass are dual to each other, in which space is not fundamental but emerges from the activity of a fractal vacuum, and in which all observable phenomena follow from a single geometric parameter ξ .

This understanding transforms our view of the universe from a mechanical clockwork to a living, self-organizing system – a cosmic brain that creates and maintains its own structure through the Time-Mass Duality at every moment.