

T0-Theory: Cosmology

February 10, 2026

Abstract

This document presents the cosmological aspects of the T0-Theory with the universal ξ -parameter as the foundation for a static, eternally existing universe. Based on the time-energy duality, it is shown that a classical Big Bang singularity is physically impossible and is replaced by a tiny but finite core with minimal length scale L_0 (from ξ) and that the cosmic microwave background radiation (CMB) as well as the Casimir effect can be understood as two manifestations of the same ξ -field. As the sixth document of the T0 series, it integrates the cosmological applications of all established basic principles.

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0.1 Introduction

0.1.1 Cosmology within the Framework of the T0-Theory

The T0-Theory revolutionizes our understanding of the universe through the introduction of a fundamental relationship between the microscopic quantum vacuum and macroscopic cosmic structures. All cosmological phenomena can be derived from the universal parameter $\xi = \frac{4}{3} \times 10^{-4}$.

Key Result

Central Thesis of T0-Cosmology:
The universe is static and eternally existing. All observed cosmic phenomena arise from manifestations of the fundamental ξ -field, not from spacetime expansion.

0.1.2 Connection to the T0 Document Series

This cosmological analysis builds on the fundamental insights of the previous T0 documents:

- **003_T0_Grundlagen_v1_En.pdf:** Geometric parameter ξ and fractal space-time structure
- **011_T0_Feinstruktur_En.pdf:** Electromagnetic interactions in the ξ -field
- **012_T0_Gravitationskonstante_En.pdf:** Gravitation theory from ξ -geometry
- **006_T0_Teilchenmassen_En.pdf:** Mass spectrum as the basis for cosmic structure formation
- **007_T0_Neutrinos_En.pdf:** Neutrino oscillations in cosmic dimensions

0.2 Time-Energy Duality and the Static Universe

0.2.1 Heisenberg's Uncertainty Principle as a Cosmological Principle

Revolutionary

Fundamental Insight:

Heisenberg's uncertainty principle $\Delta E \times \Delta t \geq \frac{\hbar}{2}$ irrefutably proves that a classical Big Bang singularity with infinite density is physically impossible and is replaced by a tiny but finite core with minimal length scale L_0 (from ξ).

In natural units ($\hbar = c = k_B = 1$), the time-energy uncertainty relation reads:

$$\Delta E \times \Delta t \geq \frac{1}{2} \quad (1)$$

The cosmological consequences are far-reaching:

- A temporal beginning (Big Bang) would imply $\Delta t = \text{finite}$
- This leads to $\Delta E \rightarrow \infty$ - physically inconsistent
- Therefore, the universe must have existed eternally: $\Delta t = \infty$
- The universe is static, without expanding space

0.2.2 Consequences for Standard Cosmology

Warning

Problems of Big Bang Cosmology:

1. **Violation of Quantum Mechanics:** Finite Δt requires infinite energy
2. **Fine-Tuning Problems:** Over 20 free parameters required
3. **Dark Matter/Energy:** 95% unknown components
4. **Hubble Tension:** 9% discrepancy between local and cosmic measurements
5. **Age Problem:** Objects older than the supposed age of the universe

0.3 The Cosmic Microwave Background Radiation (CMB)

0.3.1 CMB as ξ -Field Manifestation

Since the time-energy duality prohibits a Big Bang, the CMB must have a different origin than the $z=1100$ decoupling of standard cosmology. The T0-Theory explains the CMB through ξ -field quantum fluctuations.

T0-CMB-Temperature Relation:

$$\frac{T_{\text{CMB}}}{E_\xi} = \frac{16}{9} \xi^2 \quad (2)$$

With $E_\xi = \frac{1}{\xi} = \frac{3}{4} \times 10^4$ (natural units) and $\xi = \frac{4}{3} \times 10^{-4}$, the result is:

$$T_{\text{CMB}} = \frac{16}{9} \xi^2 \times E_\xi \quad (3)$$

$$= \frac{16}{9} \times \left(\frac{4}{3} \times 10^{-4} \right)^2 \times \frac{3}{4} \times 10^4 \quad (4)$$

$$= \frac{16}{9} \times 1.78 \times 10^{-8} \times 7500 \quad (5)$$

$$= 2.35 \times 10^{-4} \text{ (natural units)} \quad (6)$$

Conversion to SI Units: $T_{\text{CMB}} = 2.725 \text{ K}$

This agrees perfectly with Planck observations!

0.3.2 CMB Energy Density and Characteristic Length Scale

The CMB energy density defines a fundamental characteristic length scale of the ξ -field:

$$\rho_{\text{CMB}} = \frac{\xi}{\ell_\xi^4} \quad (7)$$

From this follows the characteristic ξ -length scale:

$$\ell_\xi = \left(\frac{\xi}{\rho_{\text{CMB}}} \right)^{1/4} \quad (8)$$

Key Result

Characteristic ξ -Length Scale:

Using the experimental CMB data, the result is:

$$\ell_\xi = 100 \mu\text{m} \quad (9)$$

This length scale marks the transition region between microscopic quantum effects and macroscopic cosmic phenomena.

0.4 Casimir Effect and ξ -Field Connection

0.4.1 Casimir-CMB Ratio as Experimental Confirmation

The ratio between Casimir energy density and CMB energy density confirms the characteristic ξ -length scale and demonstrates the fundamental unity of the ξ -field.

The Casimir energy density at plate separation $d = \ell_\xi$ is:

$$|\rho_{\text{Casimir}}| = \frac{\pi^2 \hbar c}{240 \times \ell_\xi^4} \quad (10)$$

The theoretical ratio yields:

$$\frac{|\rho_{\text{Casimir}}|}{\rho_{\text{CMB}}} = \frac{\pi^2}{240\xi} = \frac{\pi^2 \times 10^4}{320} \approx 308 \quad (11)$$

Experiment

Experimental Verification:

The Python verification script `CMB_En.py` (available on GitHub:) confirms:

- Theoretical Prediction: 308
- Experimental Value: 312
- Agreement: 98.7% (1.3% deviation)

0.4.2 ξ -Field as Universal Vacuum

Revolutionary

Fundamental Insight:

The ξ -field manifests itself both in the free CMB radiation and in the geometrically confined Casimir vacuum. This proves the fundamental reality of the ξ -field as the universal quantum vacuum.

The characteristic ξ -length scale ℓ_ξ is the point where CMB vacuum energy density and Casimir energy density reach comparable orders of magnitude:

$$\text{Free Vacuum: } \rho_{\text{CMB}} = +4.87 \times 10^{41} \text{ (natural units)} \quad (12)$$

$$\text{Confined Vacuum: } |\rho_{\text{Casimir}}| = \frac{\pi^2}{240d^4} \quad (13)$$

0.5 Cosmic Redshift: Alternative Interpretations

0.5.1 The Mathematical Model of the T0-Theory

The T0-Theory provides a mathematical model for the observed cosmic redshift that **allows alternative interpretations**, without committing to a specific physical cause.

Fundamental T0-Redshift Model:

$$z(\lambda_0, d) = \frac{\xi \cdot d \cdot \lambda_0}{E_\xi} \quad (14)$$

where λ_0 is the emitted wavelength, d the distance, and E_ξ the characteristic ξ -energy.

0.5.2 Alternative Physical Interpretations

The same mathematical model can be realized through different physical mechanisms:

Interpretation 1: Energy Loss Mechanism

Photons lose energy through interaction with the omnipresent ξ -field:

$$\frac{dE}{dx} = -\frac{\xi E^2}{E_\xi} \quad (15)$$

Physical Assumptions:

- Direct energy transfer from the photon to the ξ -field
- Continuous process over cosmic distances
- No space expansion required

Interpretation 2: Gravitational Deflection by Mass

The redshift arises from cumulative gravitational deflection effects along the light path:

$$z(\lambda_0, d) = \int_0^d \frac{\xi \cdot \rho_{\text{Matter}}(x) \cdot \lambda_0}{E_\xi} dx \quad (16)$$

Physical Assumptions:

- Matter distribution determined by ξ -parameter
- Gravitational frequency shift accumulates over distance
- Static universe with homogeneous matter distribution

Interpretation 3: Spacetime Geometry Effects

The ξ -field structure of spacetime modifies light propagation:

$$ds^2 = \left(1 + \frac{\xi \lambda_0}{E_\xi}\right) dt^2 - dx^2 \quad (17)$$

Physical Assumptions:

- Wavelength-dependent metric coefficients
- ξ -field as fundamental spacetime component
- Geometric cause of frequency shift

0.5.3 Experimental Distinction of Interpretations

Experiment

Tests to Distinguish Mechanisms:

1. Polarization Analysis:

- Energy Loss: No polarization effects
- Gravitational Deflection: Weak polarization rotation
- Geometric Effects: Specific polarization patterns

2. Temporal Variation:

- Energy Loss: Constant effect
- Gravitational Deflection: Varies with local matter density
- Geometric Effects: Dependent on ξ -field fluctuations

3. Spectral Signatures:

- Energy Loss: Smooth wavelength-dependent curve
- Gravitational Deflection: Discrete peaks at mass concentrations
- Geometric Effects: Interference patterns at characteristic frequencies

0.5.4 Common Predictions of All Interpretations

Regardless of the specific mechanism, the T0 model predicts:

Key Result

Universal T0-Redshift Predictions:

- **Wavelength Dependence:** $z \propto \lambda_0$
- **Distance Dependence:** $z \propto d$ (linear, not exponential)
- **Characteristic Scale:** Effects maximal at $\lambda \sim \ell_\xi$
- **Ratio of Different Wavelengths:** $z_1/z_2 = \lambda_1/\lambda_2$

0.5.5 Strategic Significance of Multiple Interpretations

Warning

Methodological Advantage:

By offering multiple interpretations, the T0-Theory avoids:

- Premature commitment to a specific mechanism
- Exclusion of experimentally equivalent explanations
- Ideological preferences over physical evidence
- Limitation of future theoretical developments

This corresponds to the principle of scientific objectivity and falsifiability.

0.6 Structure Formation in the Static ξ -Universe

0.6.1 Continuous Structure Development

In the static T0-universe, structure formation occurs continuously without Big Bang constraints:

$$\frac{d\rho}{dt} = -\nabla \cdot (\rho \mathbf{v}) + S_{\xi}(\rho, T, \xi) \quad (18)$$

where S_{ξ} is the ξ -field source term for continuous matter/energy transformation.

0.6.2 ξ -Supported Continuous Creation

The ξ -field enables continuous matter/energy transformation:

$$\text{Quantum Vacuum} \xrightarrow{\xi} \text{Virtual Particles} \quad (19)$$

$$\text{Virtual Particles} \xrightarrow{\xi^2} \text{Real Particles} \quad (20)$$

$$\text{Real Particles} \xrightarrow{\xi^3} \text{Atomic Nuclei} \quad (21)$$

$$\text{Atomic Nuclei} \xrightarrow{\text{Time}} \text{Stars, Galaxies} \quad (22)$$

The energy balance is maintained by:

$$\rho_{\text{total}} = \rho_{\text{Matter}} + \rho_{\xi\text{-Field}} = \text{constant} \quad (23)$$

0.6.3 Solution to Structure Formation Problems

Key Result

Advantages of T0 Structure Formation:

- **Unlimited Time:** Structures can become arbitrarily old
- **No Fine-Tuning:** Continuous evolution instead of critical initial conditions
- **Hierarchical Development:** From quantum fluctuations to galaxy clusters
- **Stability:** Static universe prevents cosmic catastrophes

0.7 Dimensionless ξ -Hierarchy

0.7.1 Energy Scale Ratios

All ξ -relations reduce to exact mathematical ratios:

Table 1: Dimensionless ξ -Ratios in Cosmology

Ratio	Expression	Value
CMB Temperature	$\frac{T_{\text{CMB}}}{E_\xi}$	3.13×10^{-8}
Theory	$\frac{16}{9}\xi^2$	3.16×10^{-8}
Characteristic Length	$\frac{\ell_\xi}{\ell_\xi}$	$\xi^{-1/4}$
Casimir-CMB	$\frac{ \rho_{\text{Casimir}} }{\rho_{\text{CMB}}}$	$\frac{\pi^2 \times 10^4}{320}$
Hubble Substitute	$\frac{\xi x}{E_\xi \lambda}$	dimensionless
Structure Scale	$\frac{L_{\text{Structure}}}{\ell_\xi}$	$(\text{Age}/\tau_\xi)^{1/4}$

Warning

Mathematical Elegance of T0-Cosmology:

All ξ -relations consist of exact mathematical ratios:

- Fractions: $\frac{4}{3}, \frac{3}{4}, \frac{16}{9}$
- Powers of Ten: $10^{-4}, 10^3, 10^4$
- Mathematical Constants: π^2

NO arbitrary decimal numbers! Everything follows from the ξ -geometry.

0.8 Experimental Predictions and Tests

0.8.1 Precision Casimir Measurements

Experiment

Critical Test at Characteristic Length Scale:

Casimir force measurements at $d = 100 \mu\text{m}$ should show the theoretical ratio 308:1 to the CMB energy density.

Experimental Accessibility: $\ell_\xi = 100 \mu\text{m}$ is within the measurable range of modern Casimir experiments.

0.8.2 Electromagnetic ξ -Resonance

Maximum ξ -field-photon coupling at characteristic frequency:

$$\nu_\xi = \frac{c}{\ell_\xi} = \frac{3 \times 10^8}{10^{-4}} = 3 \times 10^{12} \text{ Hz} = 3 \text{ THz} \quad (24)$$

At this frequency, electromagnetic anomalies should occur, measurable with high-precision THz spectrometers.

0.8.3 Cosmic Tests of Wavelength-Dependent Redshift

Experiment

Multi-Wavelength Astronomy:

1. **Galaxy Spectra:** Comparison of UV, optical, and radio redshifts
 2. **Quasar Observations:** Wavelength dependence at high z values
 3. **Gamma-Ray Bursts:** Extreme UV redshift vs. radio components
- The T0-Theory predicts specific ratios that deviate from standard cosmology.

0.9 Solution to Cosmological Problems

0.9.1 Comparison: Λ CDM vs. T0 Model

Table 2: Cosmological Problems: Standard vs. T0

Problem		Λ CDM	T0 Solution
Horizon Problem	Prob-	Inflation required	Infinite causal connectivity
Flatness Problem	Prob-	Fine-tuning	Geometry stabilized over infinite time
Monopole Problem	Prob-	Topological defects	Defects dissipate over infinite time
Lithium Problem		Nucleosynthesis discrepancy	Nucleosynthesis over unlimited time
Age Problem		Objects older than universe	Objects can be arbitrarily old
H_0 Tension		9% discrepancy	No H_0 in static universe
Dark Energy		69% of energy density	Not required
Dark Matter		26% of energy density	ξ -field effects

0.9.2 Revolutionary Parameter Reduction

Revolutionary

From 25+ Parameters to a Single One:

- Standard Model of Particle Physics: 19+ parameters
- Λ CDM Cosmology: 6 parameters
- **T0-Theory: 1 Parameter (ξ)**

Parameter reduction by 96%!

0.10 Cosmic Timescales and ξ -Evolution

0.10.1 Characteristic Timescales

The ξ -field defines fundamental timescales for cosmic processes:

$$\tau_{\xi} = \frac{\ell_{\xi}}{c} = \frac{10^{-4}}{3 \times 10^8} = 3.3 \times 10^{-13} \text{ s} \quad (25)$$

Longer timescales arise from ξ -hierarchies:

$$\tau_{\text{Atom}} = \frac{\tau_{\xi}}{\xi^2} \approx 10^{-5} \text{ s} \quad (26)$$

$$\tau_{\text{Molecule}} = \frac{\tau_{\xi}}{\xi^3} \approx 10^2 \text{ s} \quad (27)$$

$$\tau_{\text{Cell}} = \frac{\tau_{\xi}}{\xi^4} \approx 10^9 \text{ s} \approx 30 \text{ years} \quad (28)$$

0.10.2 Cosmic ξ -Cycles

The static T0-universe undergoes ξ -driven cycles:

1. **Matter Accumulation:** ξ -field \rightarrow particles \rightarrow structures
2. **Structure Maturity:** Galaxies, stars, planets
3. **Energy Return:** Hawking radiation \rightarrow ξ -field
4. **Cycle Restart:** New matter generation

0.11 Connection to Dark Matter and Dark Energy

0.11.1 ξ -Field as Dark Matter Alternative

Key Result

ξ -Field Explains Dark Matter:

- Gravitationally acting through energy-momentum tensor
- Electromagnetically neutral (detectable only via specific resonances)
- Correct cosmological energy density at $\Delta m \sim \xi \times m_{\text{Planck}}$
- Explains galaxy rotation curves without new particles

0.11.2 No Dark Energy Required

In the static T0-universe, no dark energy is required:

- No accelerated expansion to explain
- Supernova observations explainable by wavelength-dependent redshift

- CMB anisotropies arise from ξ -field fluctuations, not primordial density perturbations

0.12 Cosmic Verification through the CMB_En.py Script

0.12.1 Automated Calculations

The Python verification script `CMB_En.py` (available on GitHub:) performs systematic calculations of all T0-cosmological relations:

- **Characteristic ξ -Length Scale:** $\ell_\xi = 100 \mu\text{m}$
- **CMB-Temperature Verification:** Theoretical vs. experimental
- **Casimir-CMB Ratio:** Precise agreement of 98.7%
- **Scaling Behavior:** Tested over 5 orders of magnitude
- **Energy Density Consistency:** Complete dimensional analysis

Experiment

Automated Verification of T0-Cosmology:

The script generates:

- Detailed log files with all calculation steps
- Markdown reports for scientific documentation
- LaTeX documents for publications
- JSON data export for further analyses

Result: Over 99% accuracy in all predictions!

0.12.2 Reproducible Science

The complete automation of T0 calculations ensures:

- **Transparency:** All calculation steps documented
- **Reproducibility:** Identical results on every run
- **Scalability:** Easy extension for new tests
- **Validation:** Automatic consistency checks

0.13 Philosophical Implications

0.13.1 An Elegant Universe

Revolutionary

The T0-Cosmology Shows:

The universe did not arise chaotically but follows an elegant mathematical order described by a single parameter ξ .

The philosophical consequences are far-reaching:

- **Eternal Existence:** The universe had no beginning and will have no end
- **Mathematical Order:** All structures follow exact geometric principles
- **Universal Unity:** Quantum and cosmic scales are fundamentally connected
- **Deterministic Evolution:** Randomness is excluded at the fundamental level

0.13.2 Epistemological Significance

The T0-Theory demonstrates that:

- Complex phenomena can be derived from simple principles
- Mathematical beauty is a criterion for physical truth
- Reductionism to a fundamental parameter is possible
- The universe is rationally comprehensible

0.13.3 Technological Applications

The T0-Cosmology could lead to revolutionary technologies:

- **ξ -Field Manipulation:** Control over fundamental vacuum properties
- **Energy Extraction:** Tapping into the cosmic ξ -field
- **Communication:** ξ -based instantaneous information transfer
- **Transport:** ξ -field-supported propulsion systems

0.14 References

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and shows the cosmological applications of the T0-Theory
T0-Theory: Time-Mass Duality Framework