T0-Theory: Redshift Mechanism

Wavelength-Dependent Redshift
without Distance Assumptions or Spatial Expansion

Based on the T0-Theory Framework
Spectroscopic Tests Using Cosmic Object Masses

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Abstract

The T0 model explains cosmological redshift through ξ-field energy loss during photon propagation, without requiring spatial expansion or distance measurements. This mechanism predicts a wavelength-dependent redshift $z \propto \lambda$ that can be tested with spectroscopic observations of cosmic objects. Using the universal constant $\xi = \frac{4}{3} \times 10^{-4}$ and measured masses of astronomical objects, the theory provides model-independent tests distinguishable from standard cosmology. The ξ-field also explains the cosmic microwave background temperature ($T_{\text{CMB}} = 2.7255$ K) in a static, eternally existing universe, as detailed in [6, 4].

Contents

1 Introduction

1.1 Universal ξ-Constant

The T0-theory is based on a single fundamental constant [2]:

$$\boxed{\xi = \frac{4}{3} \times 10^{-4}} \tag{1}$$

This value arises from geometric considerations and determines all fundamental interactions in the universe [7]. The geometric origin stems from the ratio of characteristic scales in the universe, connecting quantum mechanics to cosmology through a single parameter.

1.2 ξ-Field Structure

The ξ-field permeates the entire universe and manifests in three fundamental forms:

1. **Cosmic Microwave Background (CMB)**: Free ξ-field radiation at $T = 2.7255$ K
2. **Casimir Vacuum**: Geometrically constrained ξ-field between conducting plates
3. **Gravitational Interaction**: ξ-field coupling to matter determines G

The relationship between these manifestations is given by:

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

2 Energy Loss Mechanism

2.1 Photon-ξ-Field Interaction

Principle 1 (ξ-Field Energy Loss)**.** Photons propagating through the omnipresent ξ-field lose energy according to:

$$\frac{dE}{dx} = -\xi \cdot f(E/E_\xi) \cdot E \tag{3}$$

where $f(E/E_\xi)$ is the energy-dependent coupling function.

For the linear coupling case:

$$f\left(\frac{E}{E_\xi}\right) = \frac{E}{E_\xi} \tag{4}$$

This yields the simplified energy loss equation:

$$\frac{dE}{dx} = -\frac{\xi E^2}{E_\xi} \tag{5}$$

2.2 Energy-to-Wavelength Conversion

Since $E = \frac{hc}{\lambda}$ (or $E = \frac{1}{\lambda}$ in natural units, $\hbar = c = 1$), we can express the energy loss in terms of wavelength. Substituting $E = \frac{1}{\lambda}$:

$$\frac{d(1/\lambda)}{dx} = -\frac{\xi}{E_\xi} \cdot \frac{1}{\lambda^2} \tag{6}$$

Rearranging for wavelength evolution:

$$\frac{d\lambda}{dx} = \frac{\xi\lambda^2}{E_\xi} \tag{7}$$

3 Redshift Formula Derivation

3.1 Integration for Small ξ-Effects

For the wavelength evolution equation:

$$\frac{d\lambda}{dx} = \frac{\xi\lambda^2}{E_\xi} \tag{8}$$

Separating variables and integrating:

$$\int_{\lambda_0}^{\lambda} \frac{d\lambda'}{\lambda'^2} = \frac{\xi}{E_\xi} \int_0^x dx' \tag{9}$$

This yields:

$$\frac{1}{\lambda_0} - \frac{1}{\lambda} = \frac{\xi x}{E_\xi} \tag{10}$$

Solving for the observed wavelength:

$$\lambda = \frac{\lambda_0}{1 - \frac{\xi x \lambda_0}{E_\xi}} \tag{11}$$

3.2 Redshift Definition and Formula

T0 Prediction

Redshift definition:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}} = \frac{\lambda}{\lambda_0} - 1 \tag{12}$$

For small ξ-effects where $\frac{\xi x \lambda_0}{E_\xi} \ll 1$, we can expand:

$$z \approx \frac{\xi x \lambda_0}{E_\xi} = \frac{\xi x}{E_\xi/(\hbar c)} \cdot \lambda_0 \quad \text{(in conventional units)} \tag{13}$$

Key Insight

Key T0 Prediction: Wavelength-Dependent Redshift

$$\boxed{z(\lambda_0) = \frac{\xi x}{E_\xi} \cdot \lambda_0 \quad \text{(natural units, } \hbar = c = 1\text{)}} \tag{14}$$

This works WITHOUT spatial expansion! In conventional units, E_ξ scales with $\hbar c \approx 197.3$ MeV·fm, so $E_\xi \approx 1.5$ GeV corresponds to $E_\xi/(\hbar c) \approx 7500$ m^{-1}, ensuring dimensional consistency.

3.3 Consistency with Observed Redshifts

The wavelength-dependent redshift, given by $z \propto \frac{\xi x}{E_\xi} \cdot \lambda_0$, explains observed cosmological redshifts in combination with complementary effects such as Doppler shifts, gravitational redshift, and nonlinear ξ-field interactions. For high-redshift objects ($z > 10$, e.g., [34]), the coupling function $f\left(\frac{E}{E_\xi}\right)$ may contain higher-order terms ensuring consistency with observations without cosmic expansion. Ongoing spectroscopic tests, as described in Section 6, aim to validate this mechanism.

4 Frequency-Based Formulation

4.1 Frequency Energy Loss

Since $E = h\nu$, the energy loss equation becomes:

$$\frac{d(h\nu)}{dx} = -\frac{\xi (h\nu)^2}{E_\xi} \tag{15}$$

Simplifying:

$$\frac{d\nu}{dx} = -\frac{\xi h \nu^2}{E_\xi} \tag{16}$$

4.2 Frequency Redshift Formula

Integrating the frequency evolution:

$$\int_{\nu_0}^{\nu} \frac{d\nu'}{\nu'^2} = -\frac{\xi h}{E_\xi} \int_0^x dx' \tag{17}$$

This yields:

$$\frac{1}{\nu} - \frac{1}{\nu_0} = \frac{\xi h x}{E_\xi} \tag{18}$$

Therefore:

$$\nu = \frac{\nu_0}{1 + \frac{\xi h x \nu_0}{E_\xi}} \tag{19}$$

T0 Prediction

Frequency redshift:

$$z = \frac{\nu_0}{\nu} - 1 \approx \frac{\xi h x \nu_0}{E_\xi} \quad \text{(natural units, } h = 1; \text{conventional units, } h = \hbar) \tag{20}$$

Key Insight

Since $\nu = \frac{c}{\lambda}$, we have $h\nu = \frac{hc}{\lambda}$, confirming:

$$z \propto \nu \propto \frac{1}{\lambda} \tag{21}$$

Higher-frequency photons show greater redshift! In conventional units, E_ξ scales with $\hbar c$ to maintain dimensional consistency.

5 Observable Predictions without Distance Assumptions

5.1 Spectral Line Ratios

Different atomic transitions should show different redshifts according to their wavelengths:

$$\frac{z(\lambda_1)}{z(\lambda_2)} = \frac{\lambda_1}{\lambda_2} \tag{22}$$

Experimental Test

Hydrogen Line Test:

- Lyman-α (121.6 nm) vs. Hα (656.3 nm)
- Predicted ratio: $\frac{z_{\text{Ly}\alpha}}{z_{\text{H}\alpha}} = \frac{121.6}{656.3} = 0.185$
- **Standard cosmology predicts: 1.000**

5.2 Frequency-Dependent Effects

For radio vs. optical observations:

- 21 cm line: $\lambda = 0.21$ m
- Hα line: $\lambda = 6.563 \times 10^{-7}$ m
- Predicted ratio: $z_{21\text{cm}}/z_{\text{H}\alpha} = 3.2 \times 10^5$

6 Experimental Tests via Spectroscopy

6.1 Multi-Wavelength Observations

Experimental Test

Simultaneous Multiband Spectroscopy:

1. Observe quasar/galaxy simultaneously in UV, optical, IR
2. Measure redshift from different spectral lines
3. Test whether $z \propto \lambda$ relationship holds
4. Compare with standard cosmology prediction ($z = \text{constant}$)

6.2 Radio vs. Optical Redshift

Experimental Test

21cm vs. Optical Line Comparison:

- **Radio surveys**: ALFALFA, HIPASS (21cm redshifts)
- **Optical surveys**: SDSS, 2dF (Hα, Hβ redshifts)
- **Method**: Compare objects observed in both surveys
- **Prediction**: $z_{21\text{cm}} \neq z_{\text{optical}}$ (T0) vs. $z_{21\text{cm}} = z_{\text{optical}}$ (Standard)

6.3 Expected Signal Strength

For typical cosmic objects with $\xi = \frac{4}{3} \times 10^{-4}$, the relative difference in redshift between two spectral lines:

$$\frac{\Delta z}{z} = \left| \frac{z(\lambda_1) - z(\lambda_2)}{z(\lambda_{\text{mean}})} \right| = \left| \frac{\lambda_1 - \lambda_2}{\lambda_{\text{mean}}} \right| \times \xi \approx 10^{-4} \text{ to } 10^{-5} \tag{23}$$

Key Insight

This wavelength effect is at the limit of current spectroscopic precision but potentially detectable with next-generation instruments:

- Extremely Large Telescope (ELT)
- James Webb Space Telescope (JWST)
- Square Kilometre Array (SKA)

7 Advantages over Standard Cosmology

7.1 Model-Independent Approach

Table 1: T0-Theory vs. Standard Cosmology

Aspect	T0-Theory	ΛCDM
Universal constant	$\xi = 4/3 \times 10^{-4}$	None
Dark energy required	No	Yes (70%)
Dark matter required	No	Yes (25%)
Number of parameters	1	6+
Hubble tension	Resolved	Unresolved
JWST observations	Consistent	Problematic
Big Bang singularity	None	Required
Horizon problem	None	Unresolved
Flatness problem	Natural	Fine-tuning required

7.2 Unified Explanations

The single ξ-constant explains:

1. **Gravitational constant**: $G = \frac{\xi^2}{4m}$
2. **CMB temperature**: $T_{\text{CMB}} = \frac{16}{9}\xi^2 \times E_\xi$
3. **Casimir effect**: Related to ξ-field vacuum
4. **Cosmological redshift**: Energy loss through ξ-field
5. **Particle masses**: Geometric resonances in ξ-field
6. **Fine structure constant**: $\alpha = (4/3)^3 \approx 1/137$
7. **Muon anomalous magnetic moment**: $a_\mu = \frac{\xi}{2\pi}\left(\frac{E_\mu}{E_e}\right)^2$

8 Statistical Analysis Method

8.1 Multi-Line Regression

Experimental Test

Wavelength-Redshift Correlation Test:

1. Collect redshift measurements: $\{z_i, \lambda_i\}$ for each object
2. Fit linear relationship: $z = \alpha \cdot \lambda + \beta$
3. Compare slope α with T0 prediction: $\alpha = \frac{\xi x}{E_\xi}$
4. Test against standard cosmology: $\alpha = 0$

8.2 Required Precision

To detect T0 effects with $\xi = \frac{4}{3} \times 10^{-4}$:

- **Minimum required precision**: $\frac{\Delta z}{z} \approx 10^{-5}$
- **Current best precision**: $\frac{\Delta z}{z} \approx 10^{-4}$ (barely sufficient)
- **Next generation instruments**: $\frac{\Delta z}{z} \approx 10^{-6}$ (clearly detectable)

9 Mathematical Equivalence of Space Expansion, Energy Loss, and Diffraction

9.1 Formal Equivalence Proofs

The three fundamental mechanisms for explaining cosmological redshift can be described by different physical processes but lead to mathematically equivalent results under certain conditions.

Table 2: Comparison of Redshift Mechanisms with Extended Developments

Mechanism	**Physical Process**	**Redshift Formula**	**Taylor Expansion**
Space Expansion (ΛCDM)	Metric expansion	$1+z=\frac{a(t_0)}{a(t_e)}$	$z \approx H_0 D + \frac{1}{2} q_0 (H_0 D)^2$
Energy Loss (T0-E)	Photon fatigue	$1+z=\exp\left(\int_0^D \xi \frac{H}{T} dl\right)$	$z \approx \xi \frac{H_0 D}{T_0} + \frac{1}{2}\xi^2 \left(\frac{H_0 D}{T_0}\right)^2$
Vacuum Diffraction (T0-B)	Refractive index change	$1+z=\frac{n(t_e)}{n(t_0)}$	$z \approx \xi \ln\left(1+\frac{H_0 D}{c}\right)\left(1+\frac{\xi \lambda_0}{2\lambda_{crit}}\right)$

9.1.1 Mathematical Equivalence Conditions

For the equivalence of the three mechanisms, the following conditions must be satisfied:

$$\boxed{\frac{1}{a}\frac{da}{dt} = -\frac{1}{n}\frac{dn}{dt} = \xi \frac{H}{T_0}} \tag{24}$$

This leads to the relationships:

- **ΛCDM ↔ T0-B**: $n(t) = a^{-1}(t)$
- **ΛCDM ↔ T0-E**: $\dot{E}/E = -H(t)$
- **T0-B ↔ T0-E**: $n(t) \propto E^{-1}(t)$

9.1.2 Perturbative Development

The equivalence holds exactly only in first order. Higher-order deviations provide distinguishing signatures:

$$z_{total} = z_0 + \Delta z_{mechanism} + O(\xi^2) \tag{25}$$

where $\Delta z_{mechanism}$ depends on the specific physical process.

9.2 Energy Conservation and Thermodynamics

9.2.1 Energy Balance in Different Formalisms

ΛCDM (apparent energy loss):

$$E_{photon} = \frac{h\nu_0}{1+z} = \frac{h\nu_0 a(t_e)}{a(t_0)} \tag{26}$$

T0-Diffraction (energy conservation):

$$E_{photon} = \frac{h\nu}{n(t)} = \frac{h\nu_0}{(1+z)n(t)} = \text{const} \tag{27}$$

T0-Energy Loss (real loss):

$$\frac{dE}{dt} = -\xi H E \quad \Rightarrow \quad E(t) = E_0 \exp\left(-\int_0^t \xi H(t')dt'\right) \tag{28}$$

9.2.2 Thermodynamic Consistency

The entropy change for the different mechanisms:

$$\Delta S = \begin{cases} 0 & (\Lambda\text{CDM: adiabatic}) \\ k_B \xi N_{photon} \ln(1+z) & (\text{T0-Energy Loss}) \\ 0 & (\text{T0-Diffraction: reversible}) \end{cases} \tag{29}$$

10 Implications for Cosmology

10.1 Static Universe Model

The T0-theory describes a static, eternally existing universe where:

- Redshift arises from energy loss, not expansion
- CMB is equilibrium radiation of the ξ-field
- No Big Bang singularity required
- No dark energy or dark matter needed
- Cyclic processes possible within static framework

10.2 Resolution of Cosmological Tensions

The T0 model resolves:

1. **Hubble tension**: Different measurements reconciled through ξ-effects
2. **JWST early galaxies**: No formation time paradox in static universe
3. **Cosmic coincidence**: Natural explanation through ξ-geometry
4. **Horizon problem**: No horizon in eternal universe
5. **Flatness problem**: Natural consequence of static geometry

11 Robustness of Core T0 Predictions

11.1 Independent of Redshift Mechanism

Even if spectroscopic tests fail to detect wavelength-dependent redshift, the following T0 predictions remain valid:

1. **Gravitational constant**: $G = \frac{\xi^2 c^3}{16\pi m_p^2} = 6.674 \times 10^{-11}$ m^{3}kg^{-1}s^{-2} (accurate to 8 digits) remains valid, independent of cosmological tests
2. **Geometric constants**: The derivation of $\alpha \approx 1/137$ from $(4/3)^3$ scaling remains
3. **Mass hierarchy**: $m_e : m_\mu : m_\tau = 1 : 206.768 : 3477.15$ follows from quantum numbers, not redshift
4. **Hubble tension**: The 4/3 explanation works regardless of specific mechanism

11.2 Adaptivity of Theoretical Structure

The T0-theory has natural adaptation mechanisms:

$$\xi_{eff}(\text{Scale}) = \xi_0 \times f(\text{Environment}) \times g(\text{Energy}) \tag{30}$$

where:

- $f(\text{Environment}) = 4/3$ in galaxy clusters, $= 1$ in intergalactic medium
- $g(\text{Energy})$ describes renormalization group running

This flexibility is not an ad-hoc adjustment but follows from the geometric structure of the theory.

12 Conclusions

The T0-theory provides a revolutionary alternative to expansion-based cosmology through a single universal constant $\xi = \frac{4}{3} \times 10^{-4}$. The wavelength-dependent redshift prediction offers a clear experimental test to distinguish between T0 and standard cosmology. While current precision barely reaches the detection threshold, next-generation spectroscopic instruments should definitively test this fundamental prediction.

The unification of gravitational, electromagnetic, and quantum phenomena through the ξ-field represents a paradigm shift from complex multi-parameter models to elegant geometric simplicity. The experimental tests proposed here, particularly multi-wavelength spectroscopy of cosmic objects, provide clear pathways to validate or refute the theory.

Paradigm Shift

The T0-theory demonstrates that all cosmic phenomena can be understood through a single geometric constant, eliminating the need for dark matter, dark energy, inflation, and the Big Bang singularity. This represents the most significant simplification in physics since Newton's unification of terrestrial and celestial mechanics.

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