T0-Theory: Redshift Mechanism

Wavelength-Dependent Redshift
without Distance Assumptions

Based on T0-Theory Framework
Spectroscopic Tests using Cosmic Object Masses

July 25, 2025

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 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.

Contents

1 Fundamental ξ-Field Energy Loss **2**
1.1 Basic Mechanism . . . 2
1.2 Energy-to-Wavelength Conversion . . . 2

2 Redshift Formula Derivation **2**
2.1 Integration for Small ξ-Effects . . . 2
2.2 Redshift Definition and Formula . . . 3

3 Frequency-Based Formulation **3**
3.1 Frequency Energy Loss . . . 3
3.2 Frequency Redshift Formula . . . 3

4 Observable Predictions Without Distance Assumptions **4**
4.1 Spectral Line Ratios . . . 4
4.2 Frequency-Dependent Effects . . . 4

5 Mass-Based Energy Scale Calibration **5**
5.1 Using Known Cosmic Object Masses . . . 5
5.2 Mass-Energy Relation in ξ-Field . . . 5

6 Experimental Tests Using Spectroscopy **5**
6.1 Multi-Wavelength Observations . . . 5
6.2 Radio vs. Optical Redshift . . . 6
6.3 Expected Signal Strength . . . 6

7 Advantages Over Standard Cosmology 6
7.1 Model-Independent Approach 6
7.2 Testable Predictions 7

8 Observational Strategy 7
8.1 Target Selection 7
8.2 Data Analysis Protocol 7
8.3 Required Precision 7

9 Conclusion 8
9.1 Summary of T0-Redshift Mechanism 8
9.2 Experimental Accessibility 8
9.3 Revolutionary Implications 8

1 Fundamental ξ-Field Energy Loss

1.1 Basic Mechanism

Principle 1 (ξ-Field Photon Interaction)**.** Photons lose energy through interaction with the universal ξ-field during propagation:

$$\frac{dE}{dx} = -\xi \cdot f\left(\frac{E}{E_\xi}\right) \cdot E \tag{1}$$

where $\xi = \frac{4}{3} \times 10^{-4}$ is the universal geometric constant and $E_\xi = \frac{1}{\xi} = 7500$ (natural units).

The coupling function $f(E/E_\xi)$ is dimensionless and describes the energy-dependent interaction strength. For the linear coupling case:

$$f\left(\frac{E}{E_\xi}\right) = \frac{E}{E_\xi} \tag{2}$$

This yields the simplified energy loss equation:

$$\frac{dE}{dx} = -\frac{\xi E^2}{E_\xi} \tag{3}$$

1.2 Energy-to-Wavelength Conversion

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

$$\frac{d(1/\lambda)}{dx} = -\frac{\xi}{E_\xi} \cdot \frac{1}{\lambda^2} \tag{4}$$

Rearranging to find the wavelength evolution:

$$\frac{d\lambda}{dx} = \frac{\xi\lambda^2}{E_\xi} \tag{5}$$

2 Redshift Formula Derivation

2.1 Integration for Small ξ-Effects

For the wavelength evolution equation:

$$\frac{d\lambda}{dx} = \frac{\xi\lambda^2}{E_\xi} \tag{6}$$

Separating variables and integrating:

$$\int_{\lambda_0}^{\lambda} \frac{d\lambda'}{\lambda'^2} = \frac{\xi}{E_\xi} \int_0^x dx' \tag{7}$$

This yields:

$$\frac{1}{\lambda_0} - \frac{1}{\lambda} = \frac{\xi x}{E_\xi} \tag{8}$$

Solving for the observed wavelength:

$$\lambda = \frac{\lambda_0}{1 - \frac{\xi x \lambda_0}{E_\xi}} \tag{9}$$

2.2 Redshift Definition and Formula

T0-Prediction

Redshift Definition:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}} = \frac{\lambda}{\lambda_0} - 1 \tag{10}$$

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

$$z \approx \frac{\xi x \lambda_0}{E_\xi} = \frac{\xi x}{E_\xi} \cdot \lambda_0 \tag{11}$$

Key Insight

Key T0-Prediction: Wavelength-Dependent Redshift

$$\boxed{z(\lambda_0) = \frac{\xi x}{E_\xi} \cdot \lambda_0} \tag{12}$$

This is the fundamental prediction of T0-theory: **Redshift is proportional to the emitted wavelength!**

3 Frequency-Based Formulation

3.1 Frequency Energy Loss

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

$$\frac{d(h\nu)}{dx} = -\frac{\xi (h\nu)^2}{E_\xi} \tag{13}$$

Simplifying:

$$\frac{d\nu}{dx} = -\frac{\xi h \nu^2}{E_\xi} \tag{14}$$

3.2 Frequency Redshift Formula

Integrating the frequency evolution:

$$\int_{\nu_0}^{\nu} \frac{d\nu'}{\nu'^2} = -\frac{\xi h}{E_\xi} \int_0^x dx' \tag{15}$$

This yields:

$$\frac{1}{\nu} - \frac{1}{\nu_0} = \frac{\xi h x}{E_\xi} \tag{16}$$

Therefore:

$$\nu = \frac{\nu_0}{1 + \frac{\xi h x \nu_0}{E_\xi}} \tag{17}$$

T0-Prediction

Frequency Redshift:

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

Key Insight

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

$$z \propto \nu \propto \frac{1}{\lambda} \tag{19}$$

Higher frequency photons show larger redshift!

4 Observable Predictions Without Distance Assumptions

4.1 Spectral Line Ratios

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

$$\frac{z(\lambda_1)}{z(\lambda_2)} = \frac{\lambda_1}{\lambda_2} \tag{20}$$

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**

4.2 Frequency-Dependent Effects

For radio vs. optical observations of the same object:

$$\frac{z_{\text{radio}}}{z_{\text{optical}}} = \frac{\nu_{\text{radio}}}{\nu_{\text{optical}}} \tag{21}$$

Experimental Test

21cm vs. Hα Test:

- 21cm hydrogen line: $\nu = 1420$ MHz
- Optical Hα line: $\nu = 457$ THz
- Predicted ratio: $\frac{z_{21\text{cm}}}{z_{\text{H}\alpha}} = \frac{1.42\times10^9}{4.57\times10^{14}} = 3.1 \times 10^{-6}$

5 Mass-Based Energy Scale Calibration

5.1 Using Known Cosmic Object Masses

Instead of assuming distances, we use measured masses of cosmic objects to calibrate the energy scale:

Table 1: Well-Determined Cosmic Masses

Object Type	**Example**	**Mass**
Stellar Masses (Precise)		
Sun	Sol	1.989×10^{30} kg
Sirius A	Alpha CMa A	$2.02\, M_\odot$
Alpha Centauri A	α Cen A	$1.1\, M_\odot$
Galaxy Masses (From Dynamics)		
Milky Way	Our Galaxy	$10^{12}\, M_\odot$
Andromeda	M31	$1.5 \times 10^{12}\, M_\odot$
Local Group	Total	$\approx 3 \times 10^{12}\, M_\odot$

5.2 Mass-Energy Relation in ξ-Field

The characteristic energy scale is:

$$E_\xi = \xi^{-1} = \frac{3}{4 \times 10^{-4}} = 7500 \text{ (natural units)} \tag{22}$$

Converting to conventional units:

$$E_\xi = 7500 \times (\hbar c) \approx 1.5 \text{ GeV} \tag{23}$$

This energy scale is comparable to nuclear binding energies, suggesting the ξ-field couples to fundamental mass scales in cosmic structures.

6 Experimental Tests Using Spectroscopy

6.1 Multi-Wavelength Observations

Experimental Test

Simultaneous Multi-Band Spectroscopy:

1. Observe quasar/galaxy simultaneously in UV, optical, IR
2. Measure redshift from different spectral lines
3. Test if $z \propto \lambda$ relationship holds
4. Compare with standard cosmology prediction ($z =$ 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 $\xi = \frac{4}{3} \times 10^{-4}$:

$$\frac{\Delta z}{z} = \frac{\lambda_1 - \lambda_2}{\lambda_{\text{avg}}} \times \xi \approx 10^{-4} \text{ to } 10^{-5} \tag{24}$$

Key Insight

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

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

7 Advantages Over Standard Cosmology

7.1 Model-Independent Approach

Table 2: T0-Theory vs. Standard Cosmology

Aspect	**Standard Cosmology**	**T0-Theory**
Distance Requirement	$z \to d$ (via Hubble)	Direct spectroscopic test
Wavelength Dependence	$\frac{dz}{d\lambda} = 0$	$\frac{dz}{d\lambda} \propto \xi$
Free Parameters	$\Omega_m, \Omega_\Lambda, H_0, \ldots$	Single parameter ξ
Exotic Components	Dark Energy (69%)	Only ξ-field
Testability	Indirect (via distance ladder)	Direct (spectroscopy)

7.2 Testable Predictions

T0-Prediction

Distinguishing Test:

$$\text{Standard:} \quad z_{\text{blue}} = z_{\text{red}} \tag{25}$$

$$\text{T0:} \quad \frac{z_{\text{blue}}}{z_{\text{red}}} = \frac{\lambda_{\text{blue}}}{\lambda_{\text{red}}} < 1 \tag{26}$$

8 Observational Strategy

8.1 Target Selection

Focus on objects with:

1. **Strong spectral lines** across wide wavelength range
2. **Well-determined masses** from stellar/galactic dynamics
3. **High signal-to-noise** spectra available

Ideal targets:

- Bright quasars with broad spectral coverage
- Nearby galaxies with multiple emission lines
- Binary star systems with precise mass determinations

8.2 Data Analysis Protocol

Experimental Test

Analysis Steps:

1. Measure redshifts from multiple spectral lines
2. Plot z vs. λ for each object
3. Fit linear relationship: $z = \alpha \cdot \lambda + \beta$
4. Compare slope α with T0-prediction: $\alpha = \frac{\xi x}{E_\xi}$
5. Test against standard cosmology: $\alpha = 0$

8.3 Required Precision

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

- **Minimum precision needed**: $\frac{\Delta z}{z} \approx 10^{-5}$
- **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 Conclusion

9.1 Summary of T0-Redshift Mechanism

The T0-theory provides a **distance-independent** mechanism for cosmological redshift through ξ-field energy loss. The key features are:

1. **Universal constant**: $\xi = \frac{4}{3} \times 10^{-4}$ determines all redshift effects
2. **Wavelength dependence**: $z \propto \lambda$ (fundamental prediction)
3. **Mass-based calibration**: Uses measured cosmic object masses
4. **Model-independent tests**: Direct spectroscopic verification

9.2 Experimental Accessibility

The theory provides concrete, testable predictions:

T0-Prediction

Key Experimental Signature:

$$\boxed{\frac{z_{\text{blue}}}{z_{\text{red}}} = \frac{\lambda_{\text{blue}}}{\lambda_{\text{red}}} \neq 1} \tag{27}$$

This prediction can be tested with:

- Multi-wavelength spectroscopy of the same objects
- Radio vs. optical redshift comparisons
- High-precision measurements of spectral line ratios

9.3 Revolutionary Implications

Key Insight

If confirmed, wavelength-dependent redshift would revolutionize our understanding of:

- **Cosmic redshift origin**: Energy loss vs. spatial expansion
- **Distance measurements**: Model-independent spectroscopic distances
- **Dark energy**: No longer required to explain cosmic acceleration
- **Fundamental physics**: New field interactions on cosmic scales

The T0-redshift mechanism offers a **testable alternative** to standard cosmology that can be verified through spectroscopic observations, making it experimentally accessible with current or near-future astronomical instruments.

References

[1] Pascher, J. (2024). *T0-Theory: Mathematical Equivalence Formulation.* HTL Leonding, Department of Communications Engineering.

[2] Planck Collaboration (2020). *Planck 2018 results. VI. Cosmological parameters.* Astron. Astrophys. 641, A6.

[3] SDSS Collaboration (2020). *The Sloan Digital Sky Survey: Technical Summary.* Astron. J. 120, 1579.

[4] ALFALFA Team (2018). *The Arecibo Legacy Fast ALFA Survey.* Astrophys. J. Suppl. 232, 21.