Mathematical Equivalence in T0-Theory
Unified Description of Energy Loss, Redshift and Light Deflection

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July 23, 2025

Contents

1 Introduction

This document presents the mathematical equivalence of three phenomena that are treated as separate effects in standard physics, but are unified in the T0-model:

1. Energy loss of photons during propagation

2. Cosmological redshift

3. Gravitational light deflection

The central insight of T0-theory is that these phenomena are different manifestations of the same underlying field equation, not separate physical processes. This unification is achieved through a single geometric parameter $\xi = \frac{4}{3} \times 10^{-20}$ that determines the coupling between the energy field and spacetime geometry.

1.1 Connection to the Dual Field Framework

The energy field E_{field} used in this analysis represents a component of the dual field system $(\delta m(x,t), \delta E(x,t))$ developed within the broader T0-theoretical framework. The mathematical relationships presented here are consistent with the duality condition $\delta m \cdot \delta E = -1$ that governs the unified field description of particle physics.

2 Fundamental Formulas

2.1 Photon Energy Loss

> **Key Formula**
>
> Energy Loss Rate:
> $$\boxed{\frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r}} \tag{1}$$
> where $\xi = \frac{4}{3} \times 10^{-20}$ is the universal geometric parameter.

Dimensional Analysis:

$\left[\frac{dE_\gamma}{dr}\right] = \frac{[E]}{[L]} = \frac{[E]}{[E^{-1}]} = [E^2]$

$[\xi] = [1]$ (dimensionless)

$\left[\frac{E_\gamma^2}{E_{\text{field}} \cdot r}\right] = \frac{[E^2]}{[E] \cdot [E^{-1}]} = \frac{[E^2]}{[1]} = [E^2]$ ✓

Since $E_\gamma = \frac{hc}{\lambda}$ (or $E_\gamma = \frac{1}{\lambda}$ in natural units), this can be expressed in terms of wavelength:

$$\frac{d(1/\lambda)}{dr} = -\xi \frac{(1/\lambda)^2}{E_{\text{field}} \cdot r} \tag{2}$$

Rearranging:

$$\frac{d\lambda}{dr} = \xi \frac{\lambda^2 \cdot E_{\text{field}}}{r} \tag{3}$$

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Integration of the wavelength-dependent energy loss equation:

$$\int_{\lambda_0}^{\lambda(r)} \frac{d\lambda'}{\lambda'^2} = \xi E_{\text{field}} \int_0^r \frac{dr'}{r'} \tag{4}$$

This yields:

$$\frac{1}{\lambda_0} - \frac{1}{\lambda(r)} = \xi E_{\text{field}} \ln\left(\frac{r}{r_0}\right) \tag{5}$$

For small corrections:

$$\lambda(r) \approx \lambda_0 \left(1 + \xi E_{\text{field}} \lambda_0 \ln\left(\frac{r}{r_0}\right)\right) \tag{6}$$

2.2 Redshift Formulation

Redshift is defined as:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}} = \frac{\lambda(r) - \lambda_0}{\lambda_0} \tag{7}$$

Using the previously derived expression:

$$z \approx \xi E_{\text{field}} \lambda_0 \ln\left(\frac{r}{r_0}\right) \tag{8}$$

Since $\lambda_0 \propto \frac{1}{E_{\gamma,0}}$, we can write:

Key Formula

Wavelength-Dependent Redshift:

$$\boxed{z(\lambda) = z_0 \left(1 - \xi \ln \frac{\lambda}{\lambda_0}\right)} \tag{9}$$

where z_0 is the reference redshift and $\xi = \frac{4}{3} \times 10^{-20}$ is the universal cosmic parameter.

2.2.1 Alternative Gravitational Interpretation

An alternative theoretical interpretation emerges from the mathematical equivalence: cosmological redshift could be understood as arising from cumulative gravitational deflection effects in the energy field. Since both redshift and light deflection are governed by the same universal parameter ξ, the gradual energy loss of photons during propagation can be considered equivalent to continuous weak gravitational interactions with the distributed energy field.

This interpretation suggests that what we observe as cosmological redshift could be the cumulative result of countless microscopic deflection events in the energy field, rather than spatial expansion. The mathematical formalism remains identical:

$$z_{\text{gravitational}} = z_{\text{cosmological}} = \xi E_{\text{field}} \lambda_0 \ln\left(\frac{r}{r_0}\right) \tag{10}$$

This dual interpretation – energy loss through field interaction versus cumulative gravitational deflection – represents the deep mathematical equivalence underlying the T0-unification.

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Dimensional Analysis:

$[z(\lambda)] = [1]$
$[z_0] = [1]$
$[\xi] = [1]$
$\left[\ln \frac{\lambda}{\lambda_0}\right] = \ln\left(\frac{[L]}{[L]}\right) = \ln([1]) = [1]$
$\left[z_0\left(1 - \xi \ln \frac{\lambda}{\lambda_0}\right)\right] = [1] \cdot ([1] - [1] \cdot [1]) = [1]$ ✓

The wavelength dependence of this redshift formula represents a fundamental theoretical difference of the T0-model from standard cosmology models:

$$\frac{dz}{d\ln\lambda} = -\xi z_0 \tag{11}$$

This theoretical prediction distinguishes the T0-model from standard cosmology models, which predict no wavelength dependence ($\frac{dz}{d\ln\lambda} = 0$).

2.3   Gravitational Light Deflection

Key Formula

Modified Gravitational Deflection:

$$\theta = \frac{4GM}{bc^2}\left(1 + \xi\frac{E_\gamma}{E_0}\right) \tag{12}$$

where θ is the deflection angle, M is the mass of the deflecting object, b is the impact parameter, E_γ is the photon energy and E_0 is a reference energy.

Dimensional Analysis:

$[G] = [E^{-2}]$
$[M] = [E]$
$[b] = [E^{-1}]$
$[c^2] = [1]$ (in natural units)
$\left[\frac{4GM}{bc^2}\right] = \frac{[E^{-2}][E]}{[E^{-1}][1]} = [1]$ (dimensionless)
$\left[\xi\frac{E_\gamma}{E_0}\right] = [1] \cdot \frac{[E]}{[E]} = [1]$ (dimensionless)
$[\theta] = [1] \cdot ([1] + [1]) = [1]$ (dimensionless) ✓

In contrast to General Relativity, which predicts wavelength-independent light deflection, the T0-model introduces an explicit energy dependence. This energy-dependent gravitational lensing leads to a modified Einstein ring radius:

$$\theta_E(\lambda) = \theta_{E,0}\sqrt{1 + \xi\frac{hc}{\lambda E_0}} \tag{13}$$

For two different photon energies, the ratio of deflection angles is:

$$\frac{\theta(E_1)}{\theta(E_2)} = \frac{1 + \xi\frac{E_1}{E_0}}{1 + \xi\frac{E_2}{E_0}} \tag{14}$$

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For cases where $\xi \frac{E}{E_0} \ll 1$ (which is now practically always fulfilled with $\xi = 1.33 \times 10^{-20}$), this can be approximated as:

$$\frac{\theta(E_1)}{\theta(E_2)} \approx 1 + \xi \frac{E_1 - E_2}{E_0} \tag{15}$$

Example for X-ray (10 keV) and optical (2 eV) photons at solar deflection:

$$\frac{\theta_{\text{X-ray}}}{\theta_{\text{optical}}} \approx 1 + \frac{4}{3} \times 10^{-20} \cdot \frac{10^4 \text{ eV} - 2 \text{ eV}}{511 \times 10^3 \text{ eV}} \approx 1 + 2.6 \times 10^{-22} \tag{16}$$

This correction lies far below current measurement precision and represents a subtle theoretical signature of the T0-framework.

3 Unifying Geodesic Equation

The three phenomena described above (energy loss, redshift and light deflection) are unified in the T0-model through a single geodesic equation with energy field corrections:

Key Formula

Universal Geodesic Equation:

$$\boxed{\frac{d^2 x^\mu}{d\lambda^2} + \Gamma^\mu_{\alpha\beta} \frac{dx^\alpha}{d\lambda} \frac{dx^\beta}{d\lambda} = \xi \cdot \partial^\mu \ln(E_{\text{field}})} \tag{17}$$

where x^μ is the spacetime position, λ is an affine parameter along the photon path, $\Gamma^\mu_{\alpha\beta}$ are the Christoffel symbols and E_{field} is the local energy field.

Dimensional Analysis:

$\left[\frac{d^2 x^\mu}{d\lambda^2} \right] = \frac{[E^{-1}]}{[E^{-1}]^2} = [E]$
$[\Gamma^\mu_{\alpha\beta}] = [E]$ (Christoffel symbols)
$\left[\frac{dx^\alpha}{d\lambda} \right] = \frac{[E^{-1}]}{[E^{-1}]} = [1]$ (dimensionless)
$[\partial^\mu \ln(E_{\text{field}})] = [E] \cdot [1] = [E]$
$[\xi \cdot \partial^\mu \ln(E_{\text{field}})] = [1] \cdot [E] = [E]$ ✓

The Christoffel symbols themselves receive energy field corrections:

$$\Gamma^\lambda_{\mu\nu} = \Gamma^\lambda_{\mu\nu|0} + \frac{\xi}{2} \left(\delta^\lambda_\mu \partial_\nu T_{\text{field}} + \delta^\lambda_\nu \partial_\mu T_{\text{field}} - g_{\mu\nu} \partial^\lambda T_{\text{field}} \right) \tag{18}$$

where $\Gamma^\lambda_{\mu\nu|0}$ are the standard Christoffel symbols, T_{field} is the time field, δ^λ_μ is the Kronecker delta and $g_{\mu\nu}$ is the metric tensor.

Energy Loss, Redshift and Light Deflection Unified

> **Important Note**
>
> The mathematical equivalence of these three phenomena means that T0-theory explains with a single mechanism what the standard model explains through different physical processes. Specifically:
>
> 1. Cosmological redshift arises from the gradual energy loss of photons, described by the energy field equation
>
> 2. This energy loss follows the same field equation that also describes gravitational light deflection
>
> 3. Both phenomena are manifestations of local variation of the energy field, described by the parameter ξ
>
> 4. **Alternative interpretation**: Cosmological redshift can be understood as cumulative gravitational deflection effects in the distributed energy field, making energy loss and gravitational deflection mathematically equivalent descriptions of the same underlying field dynamics
>
> This unification represents a fundamental theoretical advantage of the T0-model over standard physics approaches, where the apparent distinction between energy loss and gravitational effects dissolves into a single field-geometric description.

4 Theoretical Implications and Mathematical Structure

The mathematical equivalence of energy loss, redshift and light deflection reveals deep theoretical insights about the nature of spacetime and energy field interactions.

4.1 Wavelength-Dependent Redshift Theory

The theoretical framework predicts that redshift should show wavelength dependence according to the following formula:

$$z(\lambda) = z_0 \left(1 - \xi \ln \frac{\lambda}{\lambda_0} \right) \tag{19}$$

This represents a fundamental deviation from standard cosmology models. The parameter $\xi = \frac{4}{3} \times 10^{-20}$ encodes the coupling strength between the universal energy field and spacetime geometry on cosmic scales.

4.2 Energy-Dependent Gravitational Lensing

The modified deflection formula:

$$\theta = \frac{4GM}{bc^2} \left(1 + \xi \frac{E_\gamma}{E_0} \right) \tag{20}$$

implies that gravitational lensing effects depend on photon energy. This energy dependence arises naturally from the unified field equation and represents a characteristic theoretical signature of the T0-framework, even though it lies below the experimental detection threshold at $\xi = 1.33 \times 10^{-20}$.

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4.3 Unified Field Dynamics

The universal geodesic equation:

$$\frac{d^2 x^\mu}{d\lambda^2} + \Gamma^\mu_{\alpha\beta} \frac{dx^\alpha}{d\lambda} \frac{dx^\beta}{d\lambda} = \xi \cdot \partial^\mu \ln(E_{\text{field}}) \tag{21}$$

describes photon trajectories in the presence of energy field gradients. The term $\xi \cdot \partial^\mu \ln(E_{\text{field}})$ represents the fundamental coupling between matter (encoded in E_{field}) and spacetime geometry and unifies what appears as separate phenomena in standard physics.

4.3.1 Equivalence of Energy Loss and Gravitational Deflection

The mathematical framework reveals a profound equivalence: what we interpret as energy loss during photon propagation can alternatively be understood as continuous weak gravitational deflection in the distributed energy field. Both interpretations yield identical mathematical results:

$$\text{Energy loss interpretation:} \quad \frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r} \tag{22}$$

$$\text{Gravitational deflection interpretation:} \quad \frac{d\theta}{dr} = \xi \frac{E_\gamma}{E_{\text{field}} \cdot r} \tag{23}$$

These equations are mathematically linked through the photon energy-wavelength relationship and demonstrate that the distinction between energy loss and gravitational deflection is merely a matter of theoretical perspective within the unified T0-framework.

This equivalence suggests that cosmological redshift, traditionally attributed to spatial expansion, could more accurately be described as the cumulative result of gravitational interactions with the distributed energy field throughout the universe.

4.4 Geometric Interpretation

The parameter $\xi = \frac{4}{3} \times 10^{-20}$ can be interpreted as encoding the fundamental geometric relationship between three-dimensional space and the energy field. The factor $\frac{4}{3}$ appears in the volume formula for spheres ($V = \frac{4\pi}{3} r^3$) and suggests a deep connection between the unification mechanism and the geometry of three-dimensional space.

The extremely small magnitude of 10^{-20} indicates that these effects operate on cosmic scales and represent fundamental properties of the universe that manifest only in the most subtle theoretical considerations.

4.5 Theoretical Consistency

The mathematical framework preserves several important theoretical properties:

1. **Dimensional consistency**: All equations are dimensionally correct

2. **Gauge invariance**: The formulation respects coordinate transformations

3. **Energy-momentum conservation**: Modified conservation laws arise naturally

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4. **Correspondence principle**: Reduces to standard results when $\xi \to 0$

5. **Cosmic scale relevance**: At $\xi = 10^{-20}$, effects become significant only on universal scales

5   Experimental Limits and Theoretical Significance

5.1   Measurability Analysis

With $\xi = 1.33 \times 10^{-20}$, all predicted effects lie far below current experimental resolution:

- **Light deflection**: Corrections of $\sim 10^{-22}$ are not detectable with today's interferometers

- **Wavelength-dependent redshift**: Effects of $\sim 10^{-20}$ lie 16 orders of magnitude below spectroscopic precision limits

- **CMB frequency dependence**: Planck satellite measurements have resolution of $\sim 10^{-6}$, far above T0-predictions

5.2   Theoretical Relevance

Although experimentally inaccessible, the T0-model retains its theoretical significance:

1. **Conceptual unification**: Three apparently separate phenomena are explained by a single mechanism

2. **Mathematical elegance**: Complex multi-phenomenon physics reduces to simple field equations

3. **Cosmic foundations**: Provides alternative interpretation of cosmic observations without exotic components

4. **Field-theoretical consistency**: All predictions follow from first principles without free parameters

6   Conclusion

6.1   Summary of the Mathematical Framework

T0-theory unifies the phenomena of energy loss, redshift and light deflection through a single geodesic equation with energy field corrections. This unification is achieved through the universal geometric parameter $\xi = \frac{4}{3} \times 10^{-20}$ that determines the coupling between the energy field and spacetime geometry.

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6.2   Fundamental Theoretical Insights

The mathematical equivalence of these phenomena leads to several profound theoretical insights:

1. **Unified origin**: Phenomena treated as separate in standard physics arise from a single field equation

2. **Geometric foundation**: The parameter ξ connects quantum field dynamics with three-dimensional space geometry

3. **Field-theoretical basis**: Energy field gradients provide the fundamental mechanism for spacetime curvature effects

4. **Mathematical elegance**: Complex multi-phenomenon physics reduces to simple field equations

5. **Interpretational equivalence**: Energy loss and gravitational deflection represent mathematically equivalent descriptions of the same field dynamics

6. **Cosmic scale**: At $\xi = 10^{-20}$, fundamental universe properties are captured that transcend local experiments

6.3   Alternative Cosmological Interpretation

The mathematical equivalence suggests a radical reinterpretation of cosmological redshift. Instead of being interpreted as evidence for spatial expansion, redshift could represent the cumulative result of subtle gravitational interactions with the universal energy field. This interpretation offers an alternative explanation of cosmic observations without the need for dark matter or dark energy.

6.4   Future Theoretical Developments

The T0-model with $\xi = 1.33 \times 10^{-20}$ opens pathways for:

- **Cosmological field theory**: Development of a complete field theory of the universe

- **Unified gravitational models**: Integration of quantum fields and gravitational effects

- **Alternative cosmologies**: Static universe models without exotic components

- **Fundamental physics**: Deeper understanding of the connection between geometry and energy fields

Although the predicted effects are experimentally inaccessible, the T0-model offers a mathematically consistent and conceptually elegant alternative framework for understanding fundamental physical phenomena on cosmic scales.

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