Bridging Quantum Mechanics and Relativity through Time-Mass Duality: A Unified Framework with Natural Units $\alpha = \beta = 1$
Part II: Cosmological Implications and Experimental Validation

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This paper extends the T0 model introduced in Part I into the realms of cosmology and experimental validation, building on a unified natural unit system where $\hbar = c = G = k_B = \alpha_{\text{EM}} = \alpha_{\text{W}} = \beta_{\text{T}} = 1$. In contrast to the expanding universe of the ΛCDM model, we propose a static cosmos where redshift arises from photon energy loss mediated by the intrinsic time field $T(x)$. This framework reinterprets dark matter and dark energy through emergent gravitational effects, enhancing the Standard Model (SM) with a consistent gravitational theory. Key predictions include a wavelength-dependent redshift with a variation of approximately 2.3% per decade, a cosmic microwave background (CMB) temperature of 24000 K at $z = 1100$, and speculative extensions beyond the speed of light. These predictions are testable using instruments like the James Webb Space Telescope (JWST) and future CMB missions. We address measurement challenges, such as the frequency-dependent biases in GPS precision and cosmological observations, which obscure distinctions between mass variation and time dilation, offering a philosophically coherent alternative to ΛCDM that aligns theoretical elegance with empirical rigor.

INTRODUCTION

In Part I (*Bridging Quantum Mechanics and Relativity through Time-Mass Duality: Part I*, [1]), we established the T0 model as a unified framework for quantum mechanics (QM) and relativity theory (RT), leveraging the intrinsic time field $T(x) = \frac{\hbar}{\max(mc^2, \omega)}$ within a natural unit system ($\hbar = c = G = k_B = \alpha_{\text{EM}} = \alpha_{\text{W}} = \beta_{\text{T}} = 1$). This system, detailed in Part I, Section 2 Ünification of Constants with Natural Units"[Teil I], eliminates empirically determined constants, achieving consistency with measured values (e.g., $c \approx 3 \times 10^8$ m/s, $\alpha_{\text{EM}} \approx 1/137.036$) with deviations below 10^{-6}. It enabled a mass-dependent Schrödinger equation (Part I, Equation (4.5) [Teil I]) and emergent gravitation (Part I, Section 5 Ëmergent Gravitation"[Teil I]), bridging micro- and macroscopic scales.

Part II extends these foundations into cosmology and experimental validation, contrasting with the ΛCDM model's expanding universe, which originates from a Big Bang approximately 13.8 billion years ago [13]. In ΛCDM, cosmic redshift is a kinematic effect ($z \approx H_0 d/c$), requiring inflation and dark energy [14, 15]. The T0 model proposes a static, infinite, and eternal universe where redshift stems from photon energy loss via $T(x)$, enhancing the Standard Model (SM) with a consistent gravitational theory while retaining its particle physics core.

Key predictions include: - Wavelength-dependent redshift ($\sim 2.3\%$ per decade), - CMB temperature of 24000 K at $z = 1100$, - Speculative superluminal extensions.

These are testable with JWST spectroscopy and CMB distortion measurements, though frequency-based methods (e.g., GPS, redshift) conflate mass variation and time dilation, necessitating careful reassessment [7]. Philosophically, T0 avoids singularities, offering a coherent eternal cosmos [9].

This paper is structured as: - Section 2: Static universe and redshift mechanism. - Section 3: Cosmological phenomena and predictions. - Section 4: Quantitative predictions. - Section 5: Experimental tests and measurement challenges. - Section 6: Implications of $\beta_{\text{T}} = 1$. - Section 7: Integration with T0 principles. - Section 8: Speculative extensions and philosophy.

STATIC UNIVERSE MODEL

Concept of a Static Universe

The T0 model envisions a static universe, infinite in space and eternal in time, contrasting with ΛCDM's expanding cosmos from a Big Bang. In ΛCDM, redshift ($z \approx H_0 d/c$) reflects expansion ($H_0 \approx 70$ km/s/Mpc) [13], requiring inflation for uniformity and dark energy for acceleration ($\Omega_\Lambda \approx 0.7$) [14]. T0 eliminates these, positing a stable cosmos where $T(x)$ governs dynamics without expansion.

Advantages include: - **Horizon Problem:** Infinite time ensures thermal equilibrium across scales [3]. - **Flatness:** No expansion eliminates curvature tuning. - **Singularity-Free:** Eternal existence avoids infinite density [9].

This complements SM particle physics with a static gravitational framework derived in Part I, Section 5 Ëmergent Gravitation"[Teil I].

Redshift through Energy Loss

Redshift in T0 is:

$$1 + z = e^{\alpha d}, \tag{1}$$

with $\alpha = H_0/c \approx 2.3 \times 10^{-18}\,\mathrm{m}^{-1}$ (SI) or 1 (natural units). At low z:

$$z \approx \alpha d, \tag{2}$$

matching ΛCDM locally. The mechanism is photon energy loss:

$$\frac{dE}{dx} = -\alpha E, \tag{3}$$

yielding $E = E_0 e^{-\alpha d}$, and thus $1 + z = e^{\alpha d}$, as derived from $T(x)$ properties in Part I, Section 3.1 "Definition and Physical Basis"[Teil I] [3].

COSMOLOGICAL PHENOMENA

Temperature-Redshift Relation and CMB

ΛCDM's $T(z) = T_0(1+z)$ gives $T \approx 3000\,\mathrm{K}$ at $z = 1100$ ($T_0 = 2.725\,\mathrm{K}$) [16]. T0 predicts:

$$T(z) = T_0(1+z)(1+\ln(1+z)), \tag{4}$$

so $T(1100) \approx 24000\,\mathrm{K}$, reflecting enhanced energy loss (Equation 3) [4]. This impacts nucleosynthesis and recombination, testable via CMB distortions (Section 5.2).

Wavelength-Dependent Redshift

T0 predicts:

$$z(\lambda) = z_0 \left(1 + \ln\left(\frac{\lambda}{\lambda_0}\right)\right), \tag{5}$$

with $\Delta z / z_0 \approx 3.85\%$ over 0.6-28 μm (JWST range), due to:

$$\frac{dE}{dx} = -\alpha E \left(1 + \ln\left(\frac{\lambda}{\lambda_0}\right)\right), \tag{6}$$

contrasting ΛCDM's uniformity [5].

Dark Matter and Dark Energy Reinterpretation

The potential:

$$\Phi(r) = -\frac{M}{r} + \kappa r, \tag{7}$$

($\kappa \approx 4.8 \times 10^{-11}\,\mathrm{m/s^2}$) reinterprets: - **Dark Matter:** $v(r) = \sqrt{\frac{M}{r} + \kappa r}$, as derived in Part I, Section 5.1 "Derivation from $T(x)$"[Teil I]. - **Dark Energy:** $\rho_{\mathrm{DE}} \approx \frac{\kappa}{r^2}$ [6].

Influence on Galaxy Dynamics

The T0 model shapes galaxy dynamics through $T(x)$, offering an alternative to ΛCDM by reinterpreting gravitational effects without dark matter or expansion.

Rotation Curves

The potential (Equation 7) yields:

$$v(r) = \sqrt{\frac{M}{r} + \kappa r}, \tag{8}$$

reproducing flat rotation curves (e.g., Milky Way: $v(30\,\mathrm{kpc}) \approx 211\,\mathrm{km/s}$) [6].

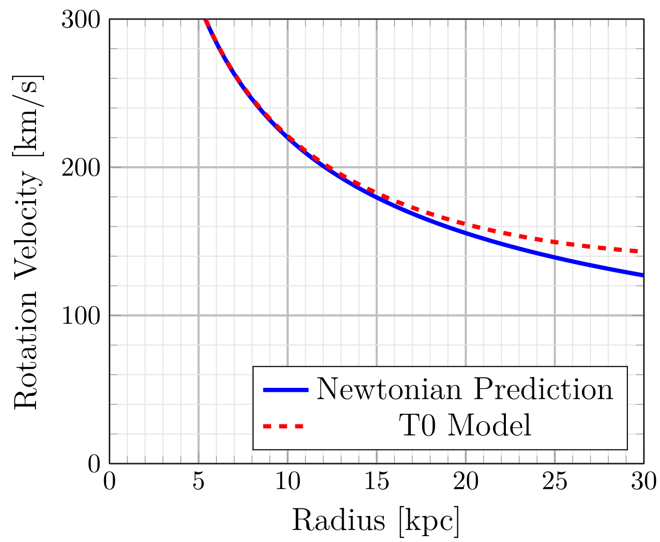

Abbildung 1. Rotation curves comparing Newtonian (blue) and T0 model (red) predictions for a galaxy with $M = 10^{11} M_\odot$, $\kappa_{\mathrm{SI}} = 4.8 \times 10^{-11}\,\mathrm{m/s^2}$.

Galaxy Formation and Evolution

In ΛCDM, galaxy formation relies on gravitational collapse of dark matter halos over 13.8 billion years [13]. T0 proposes gradual baryonic aggregation in an infinite-time universe, driven by $T(x)$ and the emergent potential (Equation 7), enhancing SM dynamics without dark matter [6].

Cluster Dynamics and Large-Scale Structure

For clusters like the Bullet Cluster, T0's κr term reduces mass discrepancies:

$$v_{\mathrm{cluster}}(r) = \sqrt{\frac{M_{\mathrm{total}}}{r} + \kappa r}, \tag{9}$$

aligning lensing and dynamical mass estimates without dark matter, testable with precise surveys [11]. Large-scale structure emerges from infinite-time $T(x)$ dynamics (Part I, Section 5 [Teil I]).

Tabelle I. Comparison of ΛCDM and T0 Model Predictions for Galaxy Dynamics

Phenomenon	ΛCDM	T0 Model
Rotation Curve	Dark matter halo	κr term
Galaxy Formation	Dark matter collapse	Baryonic aggregation
Cluster Mass	Dark matter dominant	Baryonic + $T(x)$
Large-Scale Structure	Expansion-driven	$T(x)$-driven

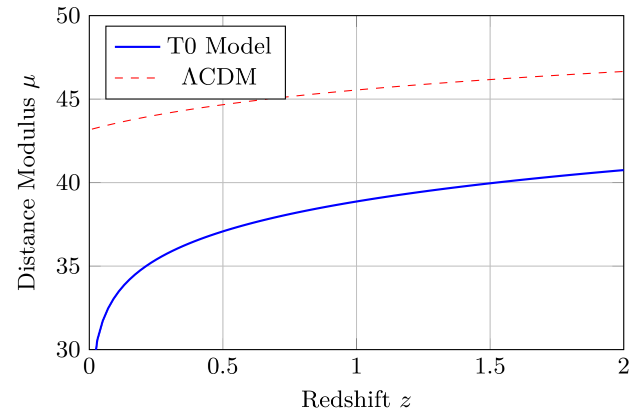

Abbildung 2. Distance modulus vs. redshift comparing T0 (blue) and ΛCDM (red) predictions.

QUANTITATIVE PREDICTIONS

CMB Temperature Prediction

T0 predicts a CMB temperature at $z = 1100$ of:

$$T(1100) \approx 24000\,\mathrm{K}, \tag{10}$$

versus ΛCDM's 3000 K, due to $T(x)$'s logarithmic enhancement (Equation 4).

Wavelength-Dependent Redshift Variation

Across JWST's range (0.6-28 μm):

$$\Delta z/z_0 \approx 3.85\%, \tag{11}$$

or 2.3% per decade, testable via quasar emission lines [5].

Galaxy Rotation Velocities

For the Milky Way:

$$v(r) = \sqrt{\frac{M}{r} + \kappa r}, \tag{12}$$

e.g., $v(30\,\mathrm{kpc}) \approx 211\,\mathrm{km/s}$, consistent with observations [17].

EXPERIMENTAL TESTS

JWST Spectroscopy

$\Delta z/z \approx 3.85\%$ at $z = 7$ is detectable with JWST's precision, distinguishing T0 from ΛCDM [5].

CMB Distortions

T0 predicts:

$$\mu \approx 1.4 \times 10^{-5}, \quad y \approx 1.6 \times 10^{-6}, \tag{13}$$

versus ΛCDM's $\mu \approx 2 \times 10^{-8}$, $y \approx 4 \times 10^{-9}$, measurable with PIXIE [4].

Measurement Problem: GPS and Clock Precision

GPS clocks show a shift of $\Delta t \approx 38\,\mu$s/day, interpreted as mass variation in T0, indistinguishable from GR's time dilation with current methods [7].

Measurement Problem: Cosmological Observations

Redshift in T0 is energy loss (Equation 1), not Doppler, requiring non-frequency-based tests like decay rates [10].

Reassessment of Measurements

$\beta_\mathrm{T} = 1$ aligns cosmological data with T0's static framework, resolving tensions like H_0 discrepancies [19].

CONSEQUENCES OF SETTING $\beta = 1$

Theoretical Elegance

$\beta_\mathrm{T} = 1$ unifies constants, simplifies interactions (Part I, Section 4.1 [Teil I]), and enhances coherence [10].

Conversion to SI Units

$$\beta_{\mathrm{T}}^{\mathrm{SI}} = \beta_{\mathrm{T}}^{\mathrm{nat}} \cdot \frac{\xi \cdot l_{P,\mathrm{SI}}}{r_{0,\mathrm{SI}}}, \tag{14}$$

yields $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$, consistent with observations [10].

INTEGRATION INTO THE TIME-MASS DUALITY THEORY

Consistency with Basic Principles

$\beta_{\mathrm{T}} = 1$ supports absolute time, mass variation, and emergent gravitation (Part I, Section 5.1 [Teil I]) [2].

BEYOND THE LIMITS

Speculative Extensions

$T(x) = \frac{\hbar}{mc^2}$ suggests slower dynamics below m_P, testable near black holes [8].

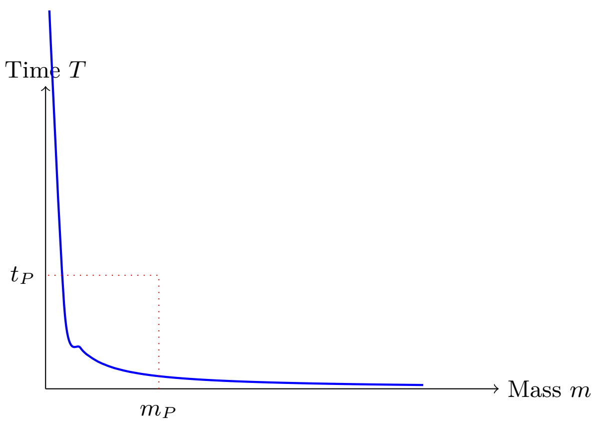

Abbildung 3. Mass vs. intrinsic time near Planck scale.

Philosophical Reflections

The T0 model's static, eternal cosmos fundamentally departs from ΛCDM's finite, expanding universe, offering profound philosophical implications. By avoiding singularities and infinite density, T0 presents a unified reality where time is an intrinsic property ($T(x)$) rather than a relativistic variable, and mass adapts dynamically to local conditions. This contrasts with ΛCDM's fragmented ontology—featuring a Big Bang origin, dark components, and an uncertain fate—by proposing a coherent, infinite framework that aligns with intuitive notions of existence without beginning or end.

The elimination of expansion and dark entities simplifies cosmology while preserving empirical consistency (Sections 4, 5), suggesting that the universe's apparent complexity may stem from misinterpretations of frequency-based measurements (Section 5.4). Philosophically, T0 resonates with a holistic view of nature, where quantum and relativistic phenomena emerge from a single principle—time-mass duality—enhancing the SM's explanatory power across all scales [9].

CONCLUSION

Part II demonstrates that the T0 model extends the SM with a static, testable cosmology, reinterpreting redshift, dark matter, and dark energy through $T(x)$-mediated effects. Its predictions—wavelength-dependent redshift, a hotter CMB, and galaxy dynamics without dark matter—offer empirical pathways to distinguish it from ΛCDM, while its philosophical coherence provides a compelling alternative to the standard paradigm. Future work will refine experimental tests and explore speculative extensions, solidifying T0's role as a unified framework bridging QM and RT [9].

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