Unification of the T0 Model: Foundations, Dark Energy and Galaxy Dynamics

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Abstract

This work presents a consistent unification of the T0 model and its applications to cosmological and astrophysical phenomena. The T0 model is based on the assumption of absolute time and variable mass, in contrast to relativity theory with relative time and constant mass. This fundamental reinterpretation leads to alternative explanations for cosmic redshift (through energy loss rather than expansion), dark energy (as a medium for energy exchange), and galaxy dynamics (through mass variation rather than dark matter). The present work ensures mathematical consistency between these different applications and provides a comprehensive theoretical framework that makes experimentally testable predictions.

Contents

1 Introduction to the T0 Model: Fundamental Concepts

1.1 Basic Assumptions of the T0 Model

The T0 model is based on the following central assumptions:

Basic Assumptions of the T0 Model

1. The time T_0 is absolute and universally constant. (1)
2. Mass varies according to $m = \gamma m_0$, where $\gamma = \frac{1}{\sqrt{1 - v^2/c_0^2}}$. (2)
3. Total energy is expressed by $E = \frac{\hbar}{T_0}$. (3)
4. Redshift arises from energy loss: $E_2 = E_1(1+z)^{-1}$. (4)

These basic assumptions lead to a complementary formulation of physics that provides mathematically equivalent predictions but conceptually differs from standard physics.

1.2 Intrinsic Time and Time-Mass Duality

An important concept of the extended T0 model is intrinsic time:

- The intrinsic time of a particle is defined as $T = \frac{\hbar}{mc^2}$. It is inversely proportional to the particle's mass.
- This intrinsic time leads to a duality in the description of physical phenomena:
  - **Standard model**: Time is relative (time dilation), mass is constant
  - **Complementary T0 model**: Time is absolute, mass varies

The time-mass duality enables an alternative interpretation of many phenomena traditionally explained by time dilation.

1.3 Unified Lagrangian Density

The Lagrangian density for the unified T0 model reads:

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{Gravitation}} + \mathcal{L}_{\text{SM}} + \mathcal{L}_{\text{Higgs}} + \mathcal{L}_{\text{intrinsic}} \tag{5}$$

where:

- $\mathcal{L}_{\text{Gravitation}}$ describes the Lagrangian density of gravitation,
- $\mathcal{L}_{\text{SM}}$ represents the Lagrangian density of the Standard Model (strong, electromagnetic and weak forces),
- $\mathcal{L}_{\text{Higgs}}$ is the Lagrangian density of the Higgs field,
- $\mathcal{L}_{\text{intrinsic}}$ is the new Lagrangian density that accounts for intrinsic time.

Gravitation can be expressed in two complementary forms:

$$\mathcal{L}_{\text{Gravitation}} = -\frac{1}{16\pi G}\sqrt{-g}R \tag{6}$$

in the Standard Model (with time dilation), and:

$$\mathcal{L}_{\text{Gravitation-T}} = -\frac{1}{16\pi G_T}\sqrt{-g_T}R_T \tag{7}$$

in the complementary model (with absolute time and mass variation), where $G_T = G \cdot \frac{T_0}{T}$ is a modified Newton constant that depends on the intrinsic time $T = \frac{\hbar}{mc^2}$, and T_0 is a reference time scale (e.g., the Planck time).

This unified Lagrangian density forms the mathematical basis for the application of the T0 model to cosmological and astrophysical phenomena.

2 Dark Energy in the T0 Model

2.1 Reinterpretation of Dark Energy

In the T0 model, dark energy is interpreted fundamentally differently than in the standard model of cosmology (ΛCDM):

- **Standard model (ΛCDM)**: Dark energy is a cosmological constant with negative pressure that drives the accelerated expansion of the universe.

- **T0 model**: Dark energy is a dynamic medium for energy exchange in a static universe.

Dark energy is modeled as a scalar field ϕ_{DE} that interacts with matter and radiation. The energy density of this field exhibits a spatial structure:

$$\rho_{DE}(r) = \frac{\kappa}{r^2} \tag{8}$$

where κ is a constant and r denotes the radial distance. This $1/r^2$ profile differs from the constant energy density ρ_Λ of the cosmological constant in the standard model.

2.2 Field-Theoretical Description

The complete Lagrangian density for the dark energy field reads:

$$\mathcal{L}_{DE} = -\frac{1}{2}\partial_\mu\phi_{DE}\partial^\mu\phi_{DE} - V(\phi_{DE}) - \frac{\beta}{M_{Pl}}\phi_{DE}T^\mu_\mu - \frac{1}{2}\xi\phi_{DE}^2 R \tag{9}$$

where:

- $\partial_\mu\phi_{DE}\partial^\mu\phi_{DE}$ is the kinetic term,
- $V(\phi_{DE})$ is the self-interaction potential of the field,
- $\frac{\beta}{M_{Pl}}\phi_{DE}T^\mu_\mu$ is the coupling to matter and radiation,
- $\frac{1}{2}\xi\phi_{DE}^2 R$ is a non-minimal coupling to spacetime curvature R.

The field equation for the dark energy field reads:

$$\Box\phi_{DE} - \frac{dV}{d\phi_{DE}} - \frac{\beta}{M_{Pl}}T^\mu_\mu - \xi\phi_{DE}R = 0 \tag{10}$$

For a massless field ($V(\phi_{DE}) = 0$) and negligible curvature ($\xi R \approx 0$), the field equation simplifies to:

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\phi_{DE}}{dr}\right) = \frac{\beta}{M_{Pl}}T^\mu_\mu \tag{11}$$

2.3 Energy Exchange and Redshift

A central aspect of the T0 model is the interpretation of cosmic redshift as a consequence of photon energy loss to dark energy. The energy change of a photon is described by:

$$\frac{dE_\gamma}{dx} = -\alpha E_\gamma \tag{12}$$

with the solution:

$$E_\gamma(x) = E_{\gamma,0} e^{-\alpha x} \tag{13}$$

The redshift z is defined as:

$$1 + z = \frac{E_0}{E} = \frac{\lambda_{obs}}{\lambda_{emit}} = e^{\alpha d} \tag{14}$$

To ensure consistency with the observed Hubble relation $z \approx H_0 d/c$, the following must hold:

$$\alpha = \frac{H_0}{c} \approx 2.3 \times 10^{-28}\ \mathrm{m}^{-1} \tag{15}$$

This extremely small absorption rate explains why the energy loss of photons to dark energy is not measurable in laboratory experiments but becomes significant over cosmological distances.

3 Galaxy Dynamics in the T0 Model

3.1 Flat Rotation Curves Without Dark Matter

In the T0 model, the flat rotation curves of galaxies are explained not by dark matter but by an effective mass variation resulting from interaction with dark energy.

The effective mass of a particle in the T0 model can be considered as a dynamic quantity that interacts with the dark energy field:

$$m_{eff}(r) = m_0 \cdot f(\phi_{DE}(r)) \tag{16}$$

This coupling can be modeled by a Yukawa-like term in the Lagrangian density:

$$\mathcal{L}_{int} = -g\phi_{DE}\bar{\psi}\psi \tag{17}$$

In Newtonian mechanics, the rotation velocity $v(r)$ of an object in a circular orbit around a mass M is given by:

$$v^2(r) = \frac{GM(r)}{r} \tag{18}$$

In the T0 model, the rotation velocity is described by the modified equation:

$$\frac{G \cdot m_{eff}(r) \cdot M(r)}{r^2} = \frac{v^2(r)}{r} \cdot m_{eff}(r) \tag{19}$$

where $m_{eff}(r)$ is the effective mass of a test particle (e.g., a star) at position r.

3.2 Effective Gravitational Constant

An alternative approach is to introduce an effective gravitational constant that depends on the dark energy field:

$$G_{eff}(r) = G\left(1 + \beta\phi_{DE}(r)\right) = G\left(1 - \beta\frac{g\rho_0 r_0^2}{r}\right) \tag{20}$$

The rotation velocity then becomes:

$$v^2(r) = \frac{G_{eff}(r)M_{baryon}(r)}{r} \tag{21}$$

With a dark energy field with a density that is proportional to $1/r^2$ for large r:

$$\rho_{DE}(r) = \frac{\kappa}{r^2} \tag{22}$$

the rotation velocity becomes:

$$v^2(r) \approx \frac{GM_{baryon}}{r} + \frac{\kappa}{\rho_0} \tag{23}$$

For large r, the second term dominates, and we obtain:

$$v^2(r) \approx \frac{\kappa}{\rho_0} = \text{constant} \tag{24}$$

This exactly corresponds to the observed behavior of flat rotation curves.

3.3 Parameter Values from Observations

For a typical spiral galaxy like the Milky Way with a rotation velocity of about $v \approx 220$ km/s, we obtain:

$$\kappa = v^2 \rho_0 \approx (220 \text{ km/s})^2 \cdot \rho_0 \approx 4.8 \times 10^{-7} \text{ GeV/cm} \cdot \text{s}^{-2} \tag{25}$$

The dimensionless coupling constant is approximately:

$$\hat{\beta} \approx 10^{-3} \tag{26}$$

These values are consistent with the parameters of the dark energy field derived from cosmological observations.

4 Unified Mathematical Formulation

4.1 Common Field Equations

The complete unified theory can be described by the following action:

$$S_{\text{unified}} = \int (\mathcal{L}_{\text{standard}} + \mathcal{L}_{\text{complementary}} + \mathcal{L}_{\text{coupling}}) \, d^4x \tag{27}$$

where:

$$\mathcal{L}_{\text{standard}} = -\frac{1}{16\pi G}\sqrt{-g}R + \mathcal{L}_{\text{SM}} + (D_\mu \phi)^\dagger (D^\mu \phi) - V(\phi) \tag{28}$$

$$\mathcal{L}_{\text{complementary}} = -\frac{1}{16\pi G_T}\sqrt{-g_T}R_T + \mathcal{L}_{\text{SM-T}} + (D_{T\mu} \phi_T)^\dagger (D_T^\mu \phi_T) - V_T(\phi_T) \tag{29}$$

$$\mathcal{L}_{\text{coupling}} = \int \mathcal{D}[\Psi] \, \Psi^* \left(i\hbar \frac{\partial}{\partial t} - i\hbar \frac{\partial}{\partial (t/T)} \right) \Psi \tag{30}$$

This unified formulation connects the foundations of the T0 model with its applications to dark energy and galaxy dynamics.

On cosmological scales, the Friedmann equations in the T0 model can be reinterpreted. In the standard model, they describe the expansion of the universe:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho \tag{31}$$

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho + 3p) \tag{32}$$

In the T0 model, they instead describe an effective mass variation in a static universe:

$$\left(\frac{\dot{m}}{m}\right)^2 = \frac{8\pi G}{3}\rho_{eff} \tag{33}$$

$$\frac{\ddot{m}}{m} = -\frac{4\pi G}{3}(\rho_{eff} + 3p_{eff}) \tag{34}$$

4.2 Consistent Parameterization

To ensure consistency between the different applications of the T0 model, the various parameters can be related as follows:

- The absorption coefficient $\alpha = H_0/c \approx 2.3 \times 10^{-28}$ m^{-1} determines the rate of photon energy loss.
- The parameter $\kappa \approx 4.8 \times 10^{-7}$ GeV/cm·s^{-2} determines the strength of the dark energy field for galaxy dynamics.
- The dimensionless coupling constant $\beta \approx 10^{-3}$ characterizes the interaction between the dark energy field and baryonic matter.

These parameters are connected by the following relation:

$$\kappa = \frac{\beta^2 H_0^2 M_{Pl}^2}{c^2 \rho_0} \tag{35}$$

where M_{Pl} is the Planck mass and ρ_0 is a reference density.
For photons, the intrinsic time can be defined as:

$$T = \frac{\hbar}{E_\gamma} e^{\alpha x} \tag{36}$$

where $\alpha = \frac{H_0}{c} \approx 2.3 \times 10^{-28}$ m^{-1} accounts for the energy loss over distance x, consistent with the T0 model.

5 Experimental Tests of the T0 Model

5.1 Common Predictions

The T0 model leads to several experimentally verifiable predictions that could distinguish it from the standard model:

1. **Mass-dependent time evolution in quantum systems**, measurable as different coherence times.

2. **Differences in entanglement speed** for particles of different mass.

3. **Scale-dependent gravitational constant**, correlated with intrinsic time.

4. **Modified energy-momentum relation** for very massive particles.

5. **Measurable deviations in high-precision experiments** typically explained by time dilation.

This leads to the prediction that Bell tests with particles of different masses or photons of different frequencies could show measurable delays in correlations, proportional to the mass ratio $\frac{m_1}{m_2}$ or energy ratio $\frac{E_1}{E_2}$.

5.2 Tests in the Cosmological Context

Specific tests of the T0 model in the cosmological context include:

1. **Temporal variation of the fine structure constant**:

$$\frac{d\alpha_{fs}}{dt} \approx \alpha_{fs} \cdot \alpha \cdot c \approx 10^{-18} \text{ year}^{-1} \tag{37}$$

2. **Environment dependence of redshift**:

$$\frac{z_{cluster}}{z_{void}} \approx 1 + \delta \frac{\rho_{cluster} - \rho_{void}}{\rho_0} \tag{38}$$

3. **Anomalous light propagation in strong gravitational fields** with an effective refractive index:

$$n_{eff}(r) = 1 + \epsilon \frac{\phi_{DE}(r)}{M_{Pl}} \tag{39}$$

4. **Differential redshift**:

$$\frac{z(\lambda_1)}{z(\lambda_2)} \approx 1 + \eta \frac{\lambda_1 - \lambda_2}{\lambda_0} \tag{40}$$

5.3 Tests for Galaxy Dynamics

Specific tests of the T0 model in the area of galaxy dynamics include:

1. **Modification of the Tully-Fisher relation**:

$$L \propto v_{max}^{4+\epsilon} \tag{41}$$

where ϵ is a small correction term that depends on the coupling constant β:

$$\epsilon \approx \frac{\beta^2 \rho_0 r_0^2}{m_0 G} \tag{42}$$

2. **Mass-dependent gravitational lensing effects**:

$$\alpha_{lens} \propto \int \nabla(\Phi_{Newton} + \beta\phi_{DE})dz \tag{43}$$

3. **Differences between gas-rich and gas-poor galaxies**:

$$\frac{v_{gas-rich}^2(r)}{v_{gas-poor}^2(r)} = 1 + \delta(r) \tag{44}$$

4. **Dwarf galaxy dynamics** with systematically lower velocity dispersion:

$$\sigma_{v,T_0} \approx \sigma_{v,\Lambda CDM} \times \left(1 - \gamma\frac{M_{gas}}{M_{star}}\right) \tag{45}$$

6 Comparison with the ΛCDM Standard Model

Model Comparison

ΛCDM Model	T0 Model
Dark matter as separate particle species	No separate dark matter, but effective mass variation
NFW density profile: $\rho_{DM}(r) = \frac{\rho_0}{\frac{r}{r_s}(1+\frac{r}{r_s})^2}$	Effective density profile: $\rho_{eff}(r) \approx \rho_{baryon}(r) + \frac{\kappa}{r^2}$
Time is relative (time dilation), rest mass constant	Time is absolute, mass varies with energy
Dark energy as driver of cosmic expansion	Dark energy as medium for energy exchange
Redshift from expansion	Redshift from energy loss
Expanding universe	Static universe

In the ΛCDM model, the constant energy density of dark energy leads to accelerated expansion that becomes increasingly faster. The future of the universe is a "Big Rip" or eternal expansion, depending on the exact equation of state of dark energy.

In the T0 model, there is no real expansion of the universe but a continuous conversion of matter and radiation energy into dark energy. The energy densities evolve according to:

$$\rho_{matter}(t) = \rho_{matter,0}e^{-\alpha ct} \tag{46}$$

$$\rho_{\gamma}(t) = \rho_{\gamma,0}e^{-\alpha ct} \tag{47}$$

$$\rho_{DE}(t) = \rho_{DE,0} + (\rho_{matter,0} + \rho_{\gamma,0})(1 - e^{-\alpha ct}) \tag{48}$$

In the long term, the universe approaches a state where all energy is in the form of dark energy - a "heat death", but without expansion of space.

7 Summary

The T0 model represents a comprehensive alternative theoretical framework to standard physics, based on the assumption of absolute time and variable mass. This reinterpretation leads to:

1. An alternative explanation for cosmic redshift through energy loss rather than expansion

2. A new interpretation of dark energy as a dynamic medium for energy exchange

3. An explanation for flat rotation curves in galaxies without dark matter

The mathematical consistency between the fundamental principles of the T0 model, its application to dark energy, and the explanation of galaxy dynamics is ensured by a unified field theory. This theory encompasses both the standard and complementary formulations of physics and provides specific experimental predictions that could distinguish between the T0 model and the standard model.

The T0 model offers a conceptually elegant alternative to the standard model of cosmology by reinterpreting fundamental assumptions about time and mass. The proposed tests, particularly the analysis of galaxies with different gas-to-star ratios and the detailed measurement of gravitational lensing profiles, offer promising opportunities to distinguish between the models.

Regardless of the outcome of these tests, the mathematical formulation of the T0 model contributes to a deeper understanding of the fundamental concepts of time, mass, and energy in modern physics and opens new perspectives for the interpretation of cosmic phenomena.

8 Bibliography

References

[1] Pascher, J. (2025). Complementary Extensions of Physics: Absolute Time and Intrinsic Time.

[2] Pascher, J. (2025). A Model with Absolute Time and Variable Energy: A Comprehensive Investigation of the Foundations.

[3] Pascher, J. (2025). Extensions of Quantum Mechanics through Intrinsic Time.

[4] Pascher, J. (2025). Integration of Time-Mass Duality into Quantum Field Theory.

[5] Pascher, J. (2025). Dynamic Mass of Photons and Their Implications for Nonlocality.

[6] Pascher, J. (2025). Fundamental Constants and Their Derivation from Natural Units.

[7] Pascher, J. (2025). Real Consequences of Reformulating Time and Mass in Physics: Beyond the Planck Scale.

[8] Rubin, V. C., Ford, W. K. (1970). Rotation of the Andromeda Nebula from a Spectroscopic Survey of Emission Regions. The Astrophysical Journal, 159, 379.

[9] Navarro, J. F., Frenk, C. S., White, S. D. M. (1996). The Structure of Cold Dark Matter Halos. The Astrophysical Journal, 462, 563.

[10] Tully, R. B., Fisher, J. R. (1977). A new method of determining distances to galaxies. Astronomy and Astrophysics, 54, 661.

[11] Clowe, D., Bradač, M., Gonzalez, A. H., et al. (2006). A Direct Empirical Proof of the Existence of Dark Matter. The Astrophysical Journal, 648, L109.

[12] Perlmutter, S., et al. (1999). Measurements of Ω and Λ from 42 High-Redshift Supernovae. The Astrophysical Journal, 517, 565.

[13] Riess, A. G., et al. (1998). Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant. The Astronomical Journal, 116, 1009.

[14] Planck Collaboration. (2020). Planck 2018 results. VI. Cosmological parameters. Astronomy & Astrophysics, 641, A6.

[15] Bennett, C. L., et al. (2013). Nine-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Final Maps and Results. The Astrophysical Journal Supplement Series, 208, 20.

[16] Eisenstein, D. J., et al. (2005). Detection of the Baryon Acoustic Peak in the Large-Scale Correlation Function of SDSS Luminous Red Galaxies. The Astrophysical Journal, 633, 560.

[17] Eisenstein, D. J., et al. (2005). Detection of the Baryon Acoustic Peak in the Large-Scale Correlation Function of SDSS Luminous Red Galaxies. The Astrophysical Journal, 633, 560.

[18] Caldwell, R. R., Dave, R., Steinhardt, P. J. (1998). Cosmological Imprint of an Energy Component with General Equation of State. Physical Review Letters, 80, 1582.

[19] Laureijs, R., et al. (2011). Euclid Definition Study Report. ESA/SRE(2011)12.

[20] Zwicky, F. (1929). On the Red Shift of Spectral Lines through Interstellar Space. Proceedings of the National Academy of Sciences, 15, 773.

[21] Webb, J. K., et al. (2011). Indications of a Spatial Variation of the Fine Structure Constant. Physical Review Letters, 107, 191101.

[22] Weinberg, S. (1989). The Cosmological Constant Problem. Reviews of Modern Physics, 61, 1.

[23] Fujii, Y., Maeda, K. (2003). The Scalar-Tensor Theory of Gravitation. Cambridge University Press.

[24] Carroll, S. M. (2001). The Cosmological Constant. Living Reviews in Relativity, 4, 1.