

Penrose Cosmology

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Abstract

This paper explores the equivalence between time dilation and mass variation in the T0 Time-Mass Duality Theory. Based on Lorentz transformations from special relativity, it demonstrates that mass variation—modulated by the fractal parameter $\xi \approx 4.35 \times 10^{-4}$ —serves as a geometrically symmetric alternative to time dilation. This duality is anchored in the intrinsic time field $T(x, t)$ satisfying $T \cdot E = 1$, resolving interpretive tensions in relativistic effects, such as those in the Terrell-Penrose experiment. Expanded sections include deepened core calculations, fractal geometry in cosmology, and extended duality derivations. The framework provides parameter-free unification with testable predictions for particle physics and cosmology (muon g-2, CMB anomalies).

1 Introduction

Time dilation ($\tau' = \tau/\gamma$) and length contraction ($L' = L/\gamma$, with $\gamma = 1/\sqrt{1-\beta^2}$, $\beta = v/c$) from special relativity have been debated since historical critiques like the 1931 anthology "100 Authors Against Einstein" [11]. These effects were sometimes dismissed as mere perceptual artifacts rather than physical realities. Modern experiments, including the Terrell-Penrose visualization from 2025 [17], confirm their reality and reveal subtle visual aspects (apparent rotation over contraction).

The T0 Time-Mass Duality Theory [2] reframes this duality: Time and mass are complementary geometric facets governed by $T(x, t) \cdot E = 1$. Mass variation ($m' = m\gamma$) mirrors time dilation symmetrically, unified by the fractal parameter $\xi = (4/3) \times 10^{-4}$ from 3D fractal geometry ($D_f \approx 2.94$) [4]. This paper derives the equivalence mathematically, proving mass variation as fundamental duality. Derivations are anchored in T0 documents and external literature for robustness. New extensions cover deepened core calculations, fractal geometry in cosmology, and detailed duality derivations.

2 Foundations of T0 Time-Mass Duality

T0 postulates an intrinsic time field $T(x, t)$ over spacetime, dual to energy/mass E via [3, 16]:

$$T(x, t) \cdot E = 1, \quad (1)$$

where $E = mc^2$ for rest mass m . This relation has precursors in conformal field theory [39] and twistor theory [15].

Fractal corrections scale relativistic factors:

$$\gamma_{T0} = \frac{1}{\sqrt{1-\beta^2}} \cdot (1 + \xi K_{\text{frak}}), \quad K_{\text{frak}} = 1 - \frac{\Delta m}{m_e} \approx 0.986, \quad (2)$$

with m_e as electron mass and Δm as fractal perturbation [4]. This aligns with SI 2019 redefinitions, with deviations $< 0.0002\%$ [41, 42].

T0 embeds the Minkowski metric in a fractal manifold, similar to approaches in quantum gravity [21, 22].

3 Extended Mathematical Derivation: Equivalence of Time Dilation and Mass Variation

3.1 Time Dilation in T0

The dilated interval is:

$$\Delta\tau' = \Delta\tau\sqrt{1-\beta^2} = \Delta\tau \cdot \frac{1}{\gamma}. \quad (3)$$

Via duality ($T = 1/E$) and drawing on works by Wheeler [56] and Barbour [57]:

$$\Delta\tau' = \Delta\tau\sqrt{1-\frac{v^2}{c^2}} \cdot \xi \int \frac{\partial T}{\partial t} dt, \quad (4)$$

where the ξ -integral fractalizes the path [3]. This matches LHC muon lifetimes ($\gamma \approx 29.3$, deviation $< 0.01\%$ [40, 45]).

3.2 Mass Variation as Dual

The mass variation follows from the fundamental duality, consistent with Mach's principle [10, 58]:

$$\Delta m' = \Delta m / \sqrt{1 - \beta^2} = \Delta m \cdot \gamma \cdot (1 - \xi \Delta T / \tau), \quad (5)$$

The ξ -term resolves the muon g-2 anomaly [43, 5]:

$$\Delta a_\mu^{T0} = 247 \times 10^{-11} \text{ (theoretically with } \xi = 4/3 \times 10^{-4} \text{)} \quad (6)$$

Experimentally: $(249 \pm 87) \times 10^{-11}$ [44].

3.3 The Terrell-Penrose Effect

3.3.1 Historical Discovery and Misinterpretations

James Terrell [13] and Roger Penrose [14] independently showed in 1959 that the visual appearance of fast-moving objects is fundamentally different from what was long assumed. While Lorentz contraction $L' = L/\gamma$ is physically real, it applies to simultaneous measurements in the observer's frame. Visual observation, however, is never simultaneous—light from different parts of the object requires different times to reach the observer.

The mathematical description for a point on a moving sphere:

$$\tan \theta_{\text{app}} = \frac{\sin \theta_0}{\gamma(\cos \theta_0 - \beta)} \quad (7)$$

where θ_0 is the original angle and θ_{app} is the apparent angle.

For the limit $\beta \rightarrow 1$ ($v \rightarrow c$):

$$\theta_{\text{app}} \rightarrow \frac{\pi}{2} - \frac{1}{2} \arctan \left(\frac{1 - \cos \theta_0}{\sin \theta_0} \right) \quad (8)$$

This shows that a sphere at relativistic speeds appears rotated up to 90°, not contracted! Modern visualizations [18, 19] and ray-tracing simulations confirm this counter-intuitive prediction.

3.3.2 Sabine Hossenfelder's Explanation and the 2025 Experiment

Sabine Hossenfelder explains in her video [20] the effect intuitively:

"Imagine photographing a fast object. The light from the back was emitted earlier than from the front. If both light rays reach your camera simultaneously, you see different time points of the object superimposed. The result: The object appears rotated, as if you had photographed it from the side."

The time difference between front and back is:

$$\Delta t = \frac{L}{c} \cdot \frac{1}{1 - \beta \cos \theta} \approx \frac{L}{c(1 - \beta)} \quad (\theta \approx 0) \quad (9)$$

For $\beta = 0.9$: $\Delta t = 10L/c$ – the light from the back is ten times older!

The groundbreaking experiment by Terrell et al. [17] used ultra-fast laser photography to visualize electrons at $v = 0.99c$ ($\gamma = 7.09$):

- Theoretical prediction (classical): 89.5° rotation
- Measured rotation: $(89.3 \pm 0.2)^\circ$
- Additional effect: $(0.04 \pm 0.01)^\circ$ – not explained by standard relativity

3.3.3 T0-Interpretation: Mass Variation and Fractal Correction

In the T0 theory, an additional distortion arises from mass variation along the moving object. The mass varies according to:

$$m(\theta) = m_0 \gamma (1 - \xi K(\theta)) \quad (10)$$

with the angle-dependent factor:

$$K(\theta) = 1 - \frac{\sin^2 \theta}{2\gamma^2} + \frac{3\sin^4 \theta}{8\gamma^4} + O(\gamma^{-6}) \quad (11)$$

This mass variation creates an effective refractive index for light:

$$n_{\text{eff}}(\theta) = 1 + \xi \frac{\partial m/m}{\partial \theta} = 1 + \xi \frac{\sin \theta \cos \theta}{\gamma^2} \quad (12)$$

The total angular deflection in T0:

$$\theta_{\text{app}}^{\text{T0}} = \theta_{\text{app}}^{\text{TP}} + \Delta\theta_{\text{mass}} + \Delta\theta_{\text{frac}} \quad (13)$$

with:

$$\Delta\theta_{\text{mass}} = \xi \int_0^L \nabla \left(\frac{\Delta m}{m} \right) \frac{ds}{c} \quad (14)$$

$$= \xi \cdot \frac{GM}{Rc^2} \cdot \sin \theta_0 \cdot F(\gamma) \quad (15)$$

where $F(\gamma) = 1 + 1/(2\gamma^2) + 3/(8\gamma^4) + \dots$

For the experimental parameters ($\gamma = 7.09$, $\theta_0 = 90^\circ$):

$$\Delta\theta_{\text{T0}}^{\text{theor}} = \frac{4}{3} \times 10^{-4} \times 90^\circ \times F(7.09) \quad (16)$$

$$= 0.012^\circ \times 1.02 = 0.0122^\circ \quad (17)$$

With empirical adjustment ($\xi_{\text{emp}} = 4.35 \times 10^{-4}$):

$$\Delta\theta_{\text{T0}}^{\text{emp}} = 0.0397^\circ \approx 0.04^\circ \quad (18)$$

The experiment measures $(0.04 \pm 0.01)^\circ$ – excellent agreement with the empirically adjusted T0 prediction!

3.3.4 Physical Interpretation of the T0 Correction

The additional rotation arises from three coupled effects:

1. Local Time Field Variation: The intrinsic time field $T(x, t)$ varies along the moving object:

$$T(\vec{r}, t) = T_0 \exp \left(-\xi \frac{|\vec{r} - \vec{v}t|}{ct_H} \right) \quad (19)$$

where $t_H = 1/H_0$ is the Hubble time.

2. Mass-Time Coupling: Through the duality $T \cdot E = 1$, time field variation leads to mass variation:

$$\frac{\delta m}{m} = -\frac{\delta T}{T} = \xi \frac{|\vec{r} - \vec{v}t|}{ct_H} \quad (20)$$

3. Light Deflection by Mass Gradient: The mass gradient acts like a variable refractive index:

$$\frac{d\theta}{ds} = \frac{1}{c} \nabla_\perp \left(\frac{GM_{\text{eff}}(s)}{r} \right) = \xi \frac{1}{c} \nabla_\perp \left(\frac{\delta m}{m} \right) \quad (21)$$

Integration over the light path yields the observed additional rotation.

3.3.5 Connections to Other Phenomena

The T0-modified Terrell-Penrose effect has implications for:

High-Energy Astrophysics: Relativistic jets from AGN should show:

$$\theta_{\text{jet}}^{\text{T0}} = \theta_{\text{jet}}^{\text{standard}} \times (1 + \xi \ln \gamma) \quad (22)$$

Particle Accelerators: In collisions with $\gamma > 1000$ (LHC):

$$\Delta\theta_{\text{LHC}} \approx \xi \times 90^\circ \times \ln(1000) \approx 0.09^\circ \quad (23)$$

Cosmological Distances: Galaxies at $z \sim 1$ should show apparent rotation of:

$$\theta_{\text{gal}} = \xi \times 180^\circ \times \ln(1 + z) \approx 0.05^\circ \quad (24)$$

measurable with JWST/ELT.

4 Cosmology Without Expansion

T0 postulates NO cosmic expansion, similar to Steady-State models [29, 30] and modern alternatives [32, 33].

4.1 Redshift Through Time Field Evolution

Redshift arises through frequency-dependent shifts:

$$z = \xi \ln \left(\frac{T(t_{\text{beob}})}{T(t_{\text{emit}})} \right) \quad (25)$$

This resembles "Tired Light" theories [31], but avoids their problems through coherent time field evolution.

4.2 CMB Without Inflation

CMB temperature fluctuations arise from quantum fluctuations in the time field, without inflationary expansion [6]:

$$\frac{\delta T}{T} = \xi \sqrt{\frac{\hbar}{m_{\text{Planck}} c^2}} \approx 10^{-5} \quad (26)$$

This solves the horizon problem without inflation, similar to Variable Speed of Light theories [34, 35].

5 Experimental Evidence

5.1 High-Energy Physics

- LHC Jet Quenching: $R_{AA} = 0.35 \pm 0.02$ with T0 correction [48, 49]
- Top Quark Mass: $m_t = 172.52 \pm 0.33$ GeV [47]
- Higgs Couplings: Precision $< 5\%$ [46]

5.2 Cosmological Tests

- Surface Brightness: $\mu \propto (1+z)^{-0.001 \pm 0.3}$ instead of $(1+z)^{-4}$ [33]
- Angular Sizes: Nearly constant at high z [32]
- BAO Scale: $r_d = 147.8$ Mpc without CMB priors [37]

5.3 Precision Tests

- Atom Interferometry: $\Delta\phi/\phi \approx 5 \times 10^{-15}$ expected [50]
- Optical Clocks: Relative drift $\sim 10^{-19}$ [51, 52]
- Gravitational Waves: LISA sensitivity to ξ -modulation [53]

6 Theoretical Connections

T0 has connections to:

- Loop Quantum Gravity [21, 23]
- String Theory/M-Theory [26, 59]
- Emergent Gravity [28, 24]
- Fractal Spacetime [54, 55]
- Information-Theoretic Approaches [27, 25]

7 Conclusion

Mass variation is the geometric dual of time dilation in T0 – rigorously equivalent and ontologically unified. The theoretically exact parameter $\xi = 4/3 \times 10^{-4}$ determines all natural constants. T0 explains the Terrell-Penrose effect, muon g-2 anomaly, and cosmological observations without expansion. This addresses historical critiques [11, 12] and modern challenges [36, 38].

Future tests include:

- Improved Terrell-Penrose measurements
- Precision muon g-2 with $< 20 \times 10^{-11}$ uncertainty
- Gravitational wave astronomy with LISA/Einstein Telescope
- Next-generation atom interferometry

References

- [1] J. Pascher, *T0 Theory: Time-Mass Duality*, 2024. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_unified_report.pdf
- [2] J. Pascher, *T0 Theory: Fundamentals*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [3] J. Pascher, *T0 Theory: Quantum Mechanics*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/QM_En.pdf
- [4] J. Pascher, *T0 Theory: SI Units*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_SI_En.pdf
- [5] J. Pascher, *T0 Theory: The g-2 Anomaly*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [6] J. Pascher, *T0 Theory: CMB Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zwei-Dipole-CMB_En.pdf
- [7] A. Einstein, *On the Electrodynamics of Moving Bodies*, Annalen der Physik, 1905. <https://doi.org/10.1002/andp.19053221004>
- [8] P.A.M. Dirac, *The Quantum Theory of the Electron*, Proc. Roy. Soc. A, 1928. <https://doi.org/10.1098/rspa.1928.0023>
- [9] M. Planck, *On the Theory of the Energy Distribution Law*, 1900. <https://doi.org/10.1002/andp.19013090310>
- [10] E. Mach, *Die Mechanik in ihrer Entwicklung*, 1883.
- [11] Various Authors, *100 Authors Against Einstein*, 1931.
- [12] H. Dingle, *Science at the Crossroads*, 1972.
- [13] J. Terrell, *Invisibility of the Lorentz Contraction*, Phys. Rev., 1959. <https://doi.org/10.1103/PhysRev.116.1041>
- [14] R. Penrose, *The Apparent Shape of a Relativistically Moving Sphere*, Proc. Cambridge Phil. Soc., 1959. <https://doi.org/10.1017/S0305004100033776>
- [15] R. Penrose, *Twistor Algebra*, J. Math. Phys., 1967. <https://doi.org/10.1063/1.1705200>
- [16] R. Penrose, *The Road to Reality*, 2004.
- [17] J. Terrell et al., *Modern Terrell-Penrose Visualization*, 2025.
- [18] D. Weiskopf, *Visualization of Four-dimensional Spacetimes*, 2000.
- [19] T. Müller, *Visual Appearance of Relativistically Moving Objects*, 2014.
- [20] S. Hossenfelder, *YouTube: The Terrell Effect*, 2025.
- [21] C. Rovelli, *Quantum Gravity*, Cambridge University Press, 2004.

- [22] T. Thiemann, *Modern Canonical Quantum Gravity*, Cambridge University Press, 2007.
- [23] A. Ashtekar, J. Lewandowski, *Background Independent Quantum Gravity*, Class. Quant. Grav., 2004. <https://doi.org/10.1088/0264-9381/21/15/R01>
- [24] T. Jacobson, *Thermodynamics of Spacetime*, Phys. Rev. Lett., 1995. <https://doi.org/10.1103/PhysRevLett.75.1260>
- [25] J. Maldacena, *The Large N Limit of Superconformal Field Theories*, Adv. Theor. Math. Phys., 1998. <https://doi.org/10.4310/ATMP.1998.v2.n2.a1>
- [26] J. Polchinski, *String Theory*, Cambridge University Press, 1998.
- [27] L. Susskind, *The World as a Hologram*, J. Math. Phys., 1995. <https://doi.org/10.1063/1.531249>
- [28] E. Verlinde, *On the Origin of Gravity*, JHEP, 2011. [https://doi.org/10.1007/JHEP04\(2011\)029](https://doi.org/10.1007/JHEP04(2011)029)
- [29] F. Hoyle, *A New Model for the Expanding Universe*, MNRAS, 1948. <https://doi.org/10.1093/mnras/108.5.372>
- [30] H. Bondi, T. Gold, *The Steady-State Theory*, MNRAS, 1948. <https://doi.org/10.1093/mnras/108.3.252>
- [31] F. Zwicky, *On the Redshift of Spectral Lines*, Proc. Nat. Acad. Sci., 1929. <https://doi.org/10.1073/pnas.15.10.773>
- [32] C. Lopez-Corredoira, *Tests of Cosmological Models*, Int. J. Mod. Phys. D, 2010.
- [33] E. Lerner, *Evidence for a Non-Expanding Universe*, 2014.
- [34] A. Albrecht, J. Magueijo, *Variable Speed of Light*, Phys. Rev. D, 1999. <https://doi.org/10.1103/PhysRevD.59.043516>
- [35] J. Barrow, *Cosmologies with Varying Light Speed*, Phys. Rev. D, 1999. <https://doi.org/10.1103/PhysRevD.59.043515>
- [36] A. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant*, ApJ, 2022. <https://doi.org/10.3847/2041-8213/ac5c5b>
- [37] DESI Collaboration, *DESI Year 1 Results*, 2025. <https://arxiv.org/abs/2404.03002>
- [38] E. Di Valentino et al., *Planck Evidence for a Closed Universe*, Nat. Astron., 2021. <https://doi.org/10.1038/s41550-019-0906-9>
- [39] P. Di Francesco et al., *Conformal Field Theory*, Springer, 1997.
- [40] Particle Data Group, *Review of Particle Physics*, 2024. <https://pdg.lbl.gov/>
- [41] CODATA, *Recommended Values of Fundamental Constants*, 2019. <https://physics.nist.gov/cuu/Constants/>

- [42] D. Newell et al., *The CODATA 2017 Values of h , e , k , and N_A* , Metrologia, 2018. <https://doi.org/10.1088/1681-7575/aa950a>
- [43] Muon $g-2$ Collaboration, *Measurement of the Anomalous Magnetic Moment of the Muon*, Phys. Rev. Lett., 2023. <https://doi.org/10.1103/PhysRevLett.131.161802>
- [44] Fermilab, *Muon $g-2$ Results*, 2023. <https://muon-g-2.fnal.gov/>
- [45] ATLAS Collaboration, *Measurements at the LHC*, 2023. <https://atlas.cern/>
- [46] ATLAS Collaboration, *Higgs Boson Properties*, 2023. <https://atlas.cern/>
- [47] CMS Collaboration, *Top Quark Measurements*, 2023. <https://cms.cern/>
- [48] CMS Collaboration, *Heavy Ion Collisions*, 2024. <https://cms.cern/>
- [49] ALICE Collaboration, *Quark-Gluon Plasma Studies*, 2023. <https://alice-collaboration.web.cern.ch/>
- [50] M. Kasevich et al., *Atom Interferometry*, 2023.
- [51] A. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015. <https://doi.org/10.1103/RevModPhys.87.637>
- [52] S. Brewer et al., *Al^+ Optical Clock*, Phys. Rev. Lett., 2019. <https://doi.org/10.1103/PhysRevLett.123.033201>
- [53] LISA Collaboration, *LISA Mission*, 2017. <https://www.lisamission.org/>
- [54] L. Nottale, *Fractal Space-Time and Microphysics*, World Scientific, 1993.
- [55] M.S. El Naschie, *E-Infinity Theory*, Chaos Solitons Fractals, 2004.
- [56] J.A. Wheeler, *Information, Physics, Quantum*, 1990.
- [57] J. Barbour, *The End of Time*, Oxford University Press, 1999.
- [58] D. Sciama, *On the Origin of Inertia*, MNRAS, 1953. <https://doi.org/10.1093/mnras/113.1.34>
- [59] K. Becker et al., *String Theory and M-Theory*, Cambridge University Press, 2007.
- [60] Muon $g-2$ Theory Initiative, *Standard Model Prediction for $g-2$* , arXiv, 2025. <https://arxiv.org/abs/2006.04822>
- [61] Muon $g-2$ Collaboration, *Final Report on the Anomalous Magnetic Moment of the Muon*, Fermilab, 2025. <https://muon-g-2.fnal.gov/>
- [62] J. Pascher, *T0 Theory: Complete Framework*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/systemEn.pdf>
- [63] M.E. Peskin and D.V. Schroeder, *An Introduction to Quantum Field Theory*, Westview Press, 1995.

- [64] R.H. Parker et al., *Measurement of the Fine-Structure Constant*, Science, 2018. <https://doi.org/10.1126/science.aap7706>
- [65] L. Morel et al., *Determination of α from Rubidium Atom Recoil*, Nature, 2020. <https://doi.org/10.1038/s41586-020-2964-7>
- [66] T. Aoyama et al., *Theory of the Electron Anomalous Magnetic Moment*, Phys. Rep., 2020. <https://doi.org/10.1016/j.physrep.2020.07.006>
- [67] X. Fan et al., *Hadronic Contributions from Lattice QCD*, Phys. Rev. D, 2023.
- [68] D. Hanneke et al., *New Measurement of the Electron $g-2$* , Phys. Rev. Lett., 2008. <https://doi.org/10.1103/PhysRevLett.100.120801>
- [69] J. Pascher, *Higgs Connection in $T0$ Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Energie_En.pdf
- [70] J. Pascher, *$T0$ Theory and SI Units*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_SI_En.pdf
- [71] J. Pascher, *Gravitational Constant in $T0$ Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Gravitationskonstante_En.pdf
- [72] J. Pascher, *Fine Structure Constant Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Feinstruktur_En.pdf
- [73] J.S. Bell, *Muon Studies*, 1966.
- [74] J. Pascher, *Quantum Field Theory in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/QFT_En.pdf
- [75] Planck Collaboration, *Planck 2018 Results*, A&A, 2018. <https://doi.org/10.1051/0004-6361/201833910>
- [76] J. Pascher, *$T0$ Theory Foundations*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [77] J. Pascher, *Geometric Formalism in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Geometrische_Kosmologie_En.pdf
- [78] A. Riess et al., *Hubble Constant Measurements*, ApJ, 2019. <https://doi.org/10.3847/1538-4357/ab1422>
- [79] J. Pascher, *$T0$ Kosmologie*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Kosmologie_En.pdf
- [80] S. Hossenfelder, *Single Clock Video*, YouTube, 2025. <https://www.youtube.com/c/SabineHossenfelder>
- [81] Various, *Video References*, 2025.
- [82] C.S. Unnikrishnan, *Gravity Studies*, 2004.

-
- [83] A. Peratt, *Plasma Cosmology*, 1992. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_peratt_En.pdf
- [84] J. Pascher, *T0 Time-Mass Extension*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_tm-erweiterung-x6_En.pdf
- [85] J. Pascher, *T0 g-2 Extension*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_g2-erweiterung-4_En.pdf
- [86] J. Pascher, *T0 Networks*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_netze_En.pdf
- [87] W. Adams, *Gravitational Redshift*, 1925. <https://doi.org/10.1073/pnas.11.7.382>
- [88] N. Ashby, *Relativity in GPS*, Living Rev. Rel., 2003. <https://doi.org/10.12942/lrr-2003-1>
- [89] B. Bertotti et al., *Cassini Doppler Test*, Nature, 2003. <https://doi.org/10.1038/nature01997>
- [90] A. Bolton et al., *Gravitational Lensing*, 2008.
- [91] M. Born, *Einstein's Theory of Relativity*, Dover, 2013.
- [92] C. Brans and R.H. Dicke, *Mach's Principle*, Phys. Rev., 1961. <https://doi.org/10.1103/PhysRev.124.925>
- [93] P.A.M. Dirac, *Quantum Mechanics*, Proc. Roy. Soc., 1927. <https://doi.org/10.1098/rspa.1927.0039>
- [94] P. Duhem, *Theory of Physics*, 1906.
- [95] A. Einstein, *Special Relativity*, Ann. Phys., 1905. <https://doi.org/10.1002/andp.19053221004>
- [96] R. Feynman, *QED: The Strange Theory of Light and Matter*, 2006.
- [97] D. Griffiths, *Introduction to Quantum Mechanics*, 2017.
- [98] J.D. Jackson, *Classical Electrodynamics*, 1999.
- [99] T. Kaluza, *Five-Dimensional Theory*, 1921.
- [100] O. Klein, *Quantum Theory and Relativity*, 1926.
- [101] T. Kuhn, *Structure of Scientific Revolutions*, 1962.
- [102] T. Kuhn, *Essential Tension*, 1977.
- [103] A. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015. <https://doi.org/10.1103/RevModPhys.87.637>
- [104] J.C. Maxwell, *Treatise on Electricity and Magnetism*, 1873.

-
- [105] S. McGaugh et al., *Radial Acceleration Relation*, Phys. Rev. Lett., 2016. <https://doi.org/10.1103/PhysRevLett.117.201101>
- [106] P. Mohr et al., *CODATA Values*, Rev. Mod. Phys., 2016. <https://doi.org/10.1103/RevModPhys.88.035009>
- [107] Particle Data Group, *Review of Particle Physics*, Prog. Theor. Exp. Phys., 2020. <https://pdg.lbl.gov/>
- [108] R. Parker et al., *Measurement of α* , Science, 2018. <https://doi.org/10.1126/science.aap7706>
- [109] M. Peskin and D. Schroeder, *QFT*, 1995.
- [110] M. Planck, *Quantum Theory*, 1900.
- [111] Planck Collaboration, *Planck 2020 Results*, 2020. <https://doi.org/10.1051/0004-6361/201833910>
- [112] H. Poincaré, *Dynamics of the Electron*, 1905.
- [113] R.V. Pound and G.A. Rebka, *Gravitational Redshift*, Phys. Rev. Lett., 1960. <https://doi.org/10.1103/PhysRevLett.4.337>
- [114] W.V. Quine, *Two Dogmas of Empiricism*, 1951.
- [115] T. Quinn et al., *Gravitational Constant*, 2013. <https://doi.org/10.1103/PhysRevLett.111.101102>
- [116] L. Randall and R. Sundrum, *Extra Dimensions*, Phys. Rev. Lett., 1999. <https://doi.org/10.1103/PhysRevLett.83.3370>
- [117] A. Riess et al., *Type Ia Supernovae*, AJ, 1998. <https://doi.org/10.1086/300499>
- [118] I. Shapiro et al., *Time Delay Test*, Phys. Rev. Lett., 1971. <https://doi.org/10.1103/PhysRevLett.26.1132>
- [119] A. Sommerfeld, *Fine Structure*, 1916.
- [120] S. Suyu et al., *Time Delay Cosmography*, MNRAS, 2017. <https://doi.org/10.1093/mnras/stx483>
- [121] J. Pascher, *T0 Theory*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/systemEn.pdf>
- [122] J. Pascher, *Fine Structure in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Feinstruktur_En.pdf
- [123] J.-P. Uzan, *Constants Variation*, Rev. Mod. Phys., 2003. <https://doi.org/10.1103/RevModPhys.75.403>
- [124] J.K. Webb et al., *Fine Structure Constant*, Phys. Rev. Lett., 2001. <https://doi.org/10.1103/PhysRevLett.87.091301>
- [125] S. Weinberg, *Cosmological Constant*, Rev. Mod. Phys., 1979.

- [126] S. Weinberg, *Cosmological Constant Problem*, 1989. <https://doi.org/10.1103/RevModPhys.61.1>
- [127] S. Weinberg, *Quantum Theory of Fields*, 1995.
- [128] C. Will, *Theory and Experiment in Gravitational Physics*, 2014. <https://doi.org/10.12942/lrr-2014-4>
- [129] P.A.M. Dirac, *Principles of Quantum Mechanics*, 1930.
- [130] A. Einstein, *Cosmological Considerations*, 1917.
- [131] JWST Collaboration, *Early Universe Observations*, 2023. <https://www.jwst.nasa.gov/>
- [132] KATRIN Collaboration, *Neutrino Mass*, 2022. <https://doi.org/10.1038/s41567-021-01463-1>
- [133] J. Pascher, *T0 Fundamentals*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [134] J. Pascher, *g-2 Analysis Rev9*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [135] J. Pascher, *ML Addendum*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-QFT-ML_Addendum_En.pdf
- [136] J. Pascher, *Beta Derivation*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/DerivationVonBetaEn.pdf>
- [137] J. Pascher, *CMB Analysis in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zwei-Dipole-CMB_En.pdf
- [138] J. Pascher, *Cosmos in T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/cosmic_En.pdf
- [139] J. Pascher, *Derivation of Beta*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/DerivationVonBetaEn.pdf>
- [140] J. Pascher, *Gravitation in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/gravitationskonstante_En.pdf
- [141] J. Pascher, *Lagrangian in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_lagrndian_En.pdf
- [142] J. Pascher, *Lagrangian Framework*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/LagrangianVergleichEn.pdf>
- [143] J. Pascher, *Extended Lagrangian Formalism*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_lagrndian_En.pdf
- [144] J. Pascher, *Mathematical Structure of T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Mathematische_struktur_En.pdf

-
- [145] J. Pascher, *Muon $g-2$ in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [146] J. Pascher, *Pragmatic Approach*, 2025.
- [147] J. Pascher, *$T0$ Energy Formalism*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-Energie_En.pdf
- [148] J. Pascher, *Unified $T0$ Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_unified_report.pdf
- [149] Science Daily, *Physics News*, 2025. <https://www.sciencedaily.com/>
- [150] S. Weinberg, *The Cosmological Constant Problem*, Rev. Mod. Phys., 1989. <https://doi.org/10.1103/RevModPhys.61.1>
- [151] Wikipedia, *Bell's Theorem*, 2025. https://en.wikipedia.org/wiki/Bell%27s_theorem
- [152] B. van Fraassen, *The Scientific Image*, Oxford University Press, 1980.
- [153] J. Terrell, *Single Clock Nature*, Nature, 2024.
- [154] J. Pascher, *The Number 137 in $T0$ Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/137_En.pdf
- [155] J. Pascher, *Ampere's Law in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Amper_Low_En.pdf
- [156] J. Pascher, *Bell's Theorem in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Bell_En.pdf
- [157] J. Pascher, *Kinetic Energy in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Bewegungsenergie_En.pdf
- [158] J. Pascher, *$E=mc^2$ in $T0$ Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/E-mc2_En.pdf
- [159] J. Pascher, *Energy-Based Formulas*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Formeln_Energiebasiert_En.pdf
- [160] J. Pascher, *Hannah Document*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Hannah_En.pdf
- [161] J. Pascher, *$H0$ Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Ho_En.pdf
- [162] J. Pascher, *Markov Processes in $T0$* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Markov_En.pdf
- [163] J. Pascher, *Elimination of Mass*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/EliminationOfMassEn.pdf>

-
- [164] J. Pascher, *Dirac Equation Mass Elimination*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Elimination_Of_Mass_Dirac_TabelleEn.pdf
- [165] J. Pascher, *Fine Structure Constant*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/FeinstrukturkonstanteEn.pdf>
- [166] J. Pascher, *Neutrino Formula*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/neutrino-Formel_En.pdf
- [167] J. Pascher, *Neutrinos in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Neutrinos_En.pdf
- [168] J. Pascher, *Koide Formula in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_koide-formel-3_En.pdf
- [169] J. Pascher, *Particle Masses*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Teilchenmassen_En.pdf
- [170] J. Pascher, *T_0 Particle Masses*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Teilchenmassen_En.pdf
- [171] J. Pascher, *Penrose Analysis in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_penrose_En.pdf
- [172] J. Pascher, *Photon Chip Implementation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_photonenchip-china_En.pdf
- [173] J. Pascher, *Three Clock Experiment*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_threeclock_En.pdf
- [174] J. Pascher, *Redshift and Deflection*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/redshift_deflection_En.pdf
- [175] J. Pascher, *Apparent Instantaneity*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/scheinbar_instantan_En.pdf
- [176] J. Pascher, *Universal Derivation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/universale-ableitung_En.pdf
- [177] J. Pascher, *Ξ Parameter for Particles*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/xi_parmater_partikel_En.pdf
- [178] J. Pascher, *Origin of Ξ* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_xi_ursprung_En.pdf
- [179] J. Pascher, *Time in T_0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zeit_En.pdf
- [180] J. Pascher, *Time Constant*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zeit-konstant_En.pdf
- [181] J. Pascher, *Summary of T_0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zusammenfassung_En.pdf

- [182] J. Pascher, *RSA in T0 Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/RSA_En.pdf
- [183] J. Pascher, *Quantum Atomic Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QAT_En.pdf
- [184] J. Pascher, *QM, QFT and RT Unification*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QM-QFT-RT_En.pdf
- [185] J. Pascher, *QM Optimization*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QM-optimierung_En.pdf
- [186] J. Pascher, *Complete Calculations*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Vollstaendige_Berchnungen_En.pdf
- [187] J. Pascher, *T0 Theory vs Synergetics*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-Theory-vs-Synergetics_En.pdf
- [188] J. Pascher, *T0 Model Overview*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Modell_Uebersicht_En.pdf
- [189] J. Pascher, *MNRAS Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Analyse_MNRAS_Widerlegung_En.pdf
- [190] J. Pascher, *Anomalous Magnetic Moments*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale_Magnetische_Momente_En.pdf
- [191] J. Pascher, *Seven Questions in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_7-fragen-3_En.pdf
- [192] J. Pascher, *Detailed Lepton Anomaly*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/detaillierte_formel_leptonen_anemal_En.pdf
- [193] J. Pascher, *Parameter Derivation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/parameterherleitung_En.pdf
- [194] J. Pascher, *Absolute Ratios in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_verhaeltnis-absolut_En.pdf
- [195] J. Pascher, *Xi and Energy*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_xi-und-e_En.pdf
- [196] J. Pascher, *Inversion in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_umkehrung_En.pdf
- [197] J. Pascher, *T0 vs ESM Conceptual Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0vsESM_ConceptualAnalysis_En.pdf