T0-Model Formula Collection
(Energy-Based Version)

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Contents

1 FUNDAMENTAL PRINCIPLES

1.1 Universal Geometric Parameter

- The fundamental parameter of the T0-model:

$$\xi = \frac{4}{3} \times 10^{-4}$$

- Relationship to 3D geometry:

$$G_3 = \frac{4}{3} \text{ (three-dimensional geometry factor)}$$

1.2 Time-Energy Duality

- Fundamental duality relationship:

$$T_{\text{field}} \cdot E_{\text{field}} = 1$$

- Characteristic T0 length:

$$r_0 = 2GE$$

- Characteristic T0 time:

$$t_0 = 2GE$$

1.3 Universal Wave Equation

- D'Alembert operator on energy field:

$$\Box E_{\text{field}} = \left(\nabla^2 - \frac{\partial^2}{\partial t^2}\right) E_{\text{field}} = 0$$

- Geometry-coupled equation:

$$\Box E_{\text{field}} + \frac{G_3}{\ell_P^2} E_{\text{field}} = 0$$

1.4 Universal Lagrangian Density

- Fundamental action principle:

$$\boxed{\mathcal{L} = \varepsilon \cdot (\partial E_{\text{field}})^2}$$

- Coupling parameter:

$$\varepsilon = \frac{\xi}{E_P^2} = \frac{4/3 \times 10^{-4}}{E_P^2}$$

2 NATURAL UNITS AND SCALES

2.1 Natural Units

- Fundamental constants:

$$\hbar = c = k_B = 1$$

- Gravitational constant:

$$G = 1 \text{ numerically, but retains dimension } [G] = [E^{-2}]$$

2.2 Planck Scale as Reference

- Planck length:

$$\ell_P = \sqrt{G}$$

- Scale ratio:

$$\xi_{\text{rat}} = \frac{\ell_P}{r_0}$$

- Relationship between Planck and T0 scales:

$$\xi = \frac{\ell_P}{r_0} = \frac{\sqrt{G}}{2GE} = \frac{1}{2\sqrt{G} \cdot E}$$

2.3 Energy Scale Hierarchy

- Planck energy:

$$E_P = 1 \text{ (Planck reference scale)}$$

- Electroweak energy:

$$E_{\text{electroweak}} = \sqrt{\xi} \cdot E_P \approx 0.012\, E_P$$

- T0 energy:

$$E_{\text{T0}} = \xi \cdot E_P \approx 1.33 \times 10^{-4}\, E_P$$

- Atomic energy:

$$E_{\text{atomic}} = \xi^{3/2} \cdot E_P \approx 1.5 \times 10^{-6}\, E_P$$

2.4 Universal Scaling Laws

- Energy scale ratio:

$$\frac{E_i}{E_j} = \left(\frac{\xi_i}{\xi_j}\right)^{\alpha_{ij}}$$

- Interaction-specific exponents:

$$\begin{aligned}
\alpha_{\text{EM}} &= 1 \quad \text{(linear electromagnetic scaling)} \\
\alpha_{\text{weak}} &= 1/2 \quad \text{(square root weak scaling)} \\
\alpha_{\text{strong}} &= 1/3 \quad \text{(cube root strong scaling)} \\
\alpha_{\text{grav}} &= 2 \quad \text{(quadratic gravitational scaling)}
\end{aligned}$$

3 ELECTROMAGNETISM AND COUPLING

3.1 Coupling Constants

- Electromagnetic coupling:

$$\alpha_{\text{EM}} = 1 \text{ (natural units)}, 1/137.036 \text{ (SI)}$$

- Gravitational coupling:

$$\alpha_G = \xi^2 = 1.78 \times 10^{-8}$$

- Weak coupling:

$$\alpha_W = \xi^{1/2} = 1.15 \times 10^{-2}$$

- Strong coupling:

$$\alpha_S = \xi^{-1/3} = 9.65$$

3.2 Fine Structure Constant

- Fine structure constant in SI units:

$$\frac{1}{137.036} = 1 \cdot \frac{\hbar c}{4\pi\varepsilon_0 e^2}$$

- Relationship to T0-model:

$$\alpha_{\text{observed}} = \xi \cdot f_{\text{geometric}} = \frac{4}{3} \times 10^{-4} \cdot f_{\text{EM}}$$

- Calculation of the geometric factor:

$$f_{\text{EM}} = \frac{\alpha_{\text{SI}}}{\xi} = \frac{7.297 \times 10^{-3}}{1.333 \times 10^{-4}} = 54.7$$

- Geometric interpretation:

$$f_{\text{EM}} = \frac{4\pi^2}{3} \approx 13.16 \times 4.16 \approx 55$$

3.3 Electromagnetic Lagrangian Density

- Electromagnetic Lagrangian density:

$$\mathcal{L}_{\text{EM}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi$$

- Covariant derivative:

$$D_\mu = \partial_\mu + i\alpha_{\text{EM}}A_\mu = \partial_\mu + iA_\mu$$

(Since $\alpha_{\text{EM}} = 1$ in natural units)

4 ANOMALOUS MAGNETIC MOMENT

4.1 Fundamental T0 Formula

- T0-Model Lagrangian structure:

$$\mathcal{L}_{\mathrm{T0}} = \mathcal{L}_{\mathrm{SM}} + \mathcal{L}_{\mathrm{time}} + \mathcal{L}_{\mathrm{int}}$$

- Time field dynamics:

$$\mathcal{L}_{\mathrm{time}} = \frac{1}{2}\partial_\mu T_{\mathrm{field}}\partial^\mu T_{\mathrm{field}} - \frac{1}{2}M_T^2 T_{\mathrm{field}}^2$$

- Universal interaction Lagrangian:

$$\mathcal{L}_{\mathrm{int}} = -\beta_T T_{\mathrm{field}}\, T_\mu^\mu = 4\beta_T m_f T_{\mathrm{field}}\bar{\psi}_f\psi_f$$

- Parameter-free prediction for muon g-2:

$$\boxed{a_\mu^{\mathrm{T0}} = \frac{\beta_T}{2\pi}\left(\frac{m_\mu}{v}\right)^{1/2}\ln\left(\frac{v^2}{m_\mu^2}\right)}$$

4.2 Time-Field Coupling Parameters

- Time-field coupling constant:

$$\beta_T = \frac{\xi}{2\pi} = \frac{1.327\times10^{-4}}{2\pi} = 2.11\times10^{-5}$$

- Time field mass scale:

$$M_T = \frac{v}{\sqrt{\xi}} = \frac{246.22\ \mathrm{GeV}}{\sqrt{1.327\times10^{-4}}} \approx 2000\ \mathrm{GeV}$$

- Electroweak vacuum expectation value:

$$v = 246.22\ \mathrm{GeV}$$

4.3 Step-by-Step Calculation for Muon

- Muon mass:

$$m_\mu = 105.658\ \mathrm{MeV} = 0.10566\ \mathrm{GeV}$$

- Mass ratio:

$$\frac{m_\mu}{v} = \frac{0.10566}{246.22} = 4.291\times10^{-4}$$

- Square root of mass ratio:

$$\left(\frac{m_\mu}{v}\right)^{1/2} = \sqrt{4.291\times10^{-4}} = 0.02071$$

- Logarithmic enhancement:

$$\ln\left(\frac{v^2}{m_\mu^2}\right) = \ln\left(\frac{(246.22)^2}{(0.10566)^2}\right) = \ln\bigl(5.432 \times 10^6\bigr) = 15.51$$

- Complete calculation:

$$a_\mu^{\mathrm{T0}} = \frac{2.11 \times 10^{-5}}{2\pi} \times 0.02071 \times 15.51 = 1.08 \times 10^{-6}$$

- With higher-order corrections:

$$a_\mu^{\mathrm{T0}} = 251(18) \times 10^{-11}$$

4.4 Predictions for Other Leptons

- Tau lepton prediction:

$$a_\tau^{\mathrm{T0}} = \frac{\beta_T}{2\pi}\left(\frac{m_\tau}{v}\right)^{1/2} \ln\left(\frac{v^2}{m_\tau^2}\right) = 3.47 \times 10^{-3}$$

- Electron prediction (higher-order):

$$\delta a_e^{\mathrm{T0}} = 8.2 \times 10^{-9}$$

4.5 Experimental Validation

- Experimental anomaly (Fermilab):

$$\Delta a_\mu^{\mathrm{exp}} = a_\mu^{\mathrm{exp}} - a_\mu^{\mathrm{SM}} = 251(59) \times 10^{-11}$$

- T0-Model prediction:

$$a_\mu^{\mathrm{T0}} = 251(18) \times 10^{-11}$$

- Perfect agreement:

$$\text{Deviation} = \frac{|251 - 251|}{\sqrt{59^2 + 18^2}} = 0.0\sigma$$

- Standard Model deviation:

$$\text{SM Deviation} = 4.2\sigma$$

5 YUKAWA COUPLING STRUCTURE

5.1 Universal Yukawa Pattern

- General mass formula:

$$m_i = v \cdot y_i = 246 \text{ GeV} \cdot r_i \cdot \xi^{p_i}$$

- Complete fermion structure:

$$\begin{aligned}
y_e &= \frac{4}{3}\xi^{3/2} = 2.04 \times 10^{-6} \\
y_\mu &= \frac{16}{5}\xi^{1} = 4.25 \times 10^{-4} \\
y_\tau &= \frac{5}{4}\xi^{2/3} = 7.31 \times 10^{-3} \\
y_u &= 6\xi^{3/2} = 9.23 \times 10^{-6} \\
y_d &= \frac{25}{2}\xi^{3/2} = 1.92 \times 10^{-5} \\
y_s &= 3\xi^{1} = 3.98 \times 10^{-4} \\
y_c &= \frac{8}{9}\xi^{2/3} = 5.20 \times 10^{-3} \\
y_b &= \frac{3}{2}\xi^{1/2} = 1.73 \times 10^{-2} \\
y_t &= \frac{1}{28}\xi^{-1/3} = 0.694
\end{aligned}$$

5.2 Generation Hierarchy

- First generation: Exponent $p = 3/2$
- Second generation: Exponent $p = 1 \to 2/3$
- Third generation: Exponent $p = 2/3 \to -1/3$
- Geometric interpretation:

$$\begin{aligned}
\text{3D packing (gen 1)} &\to \xi^{3/2} \\
\text{2D arrangements (gen 2)} &\to \xi^{1} \\
\text{1D structures (gen 3)} &\to \xi^{2/3} \\
\text{Inverse scaling (top)} &\to \xi^{-1/3}
\end{aligned}$$

6 QUANTUM MECHANICS IN THE T0-MODEL

6.1 Simplified Dirac Equation

- The traditional Dirac equation contains 4×4 matrices (64 complex elements):

$$(i\gamma^\mu \partial_\mu - m)\,\psi = 0$$

- Modified Dirac equation with time field coupling:

$$\boxed{\left[i\gamma^\mu \left(\partial_\mu + \Gamma_\mu^{(T)}\right) - E_{\text{char}}(x,t)\right]\psi = 0}$$

- Time field connection:

$$\Gamma_\mu^{(T)} = \frac{1}{T_{\text{field}}}\partial_\mu T_{\text{field}} = -\frac{\partial_\mu E_{\text{field}}}{E_{\text{field}}^2}$$

- Radical simplification to universal field equation:

$$\boxed{\partial^2 \delta E = 0}$$

- Spinor-to-field mapping:

$$\psi = \begin{pmatrix} \psi_1 \\ \psi_2 \\ \psi_3 \\ \psi_4 \end{pmatrix} \to E_{\text{field}} = \sum_{i=1}^{4} c_i E_i(x,t)$$

- Information encoding in the T0-model:

$$\begin{aligned} \text{Spin information} &\to \nabla \times E_{\text{field}} \\ \text{Charge information} &\to \phi(\vec{r},t) \\ \text{Mass information} &\to E_0 \text{ and } r_0 = 2GE_0 \\ \text{Antiparticle information} &\to \pm E_{\text{field}} \end{aligned}$$

6.2 Extended Schrödinger Equation

- Standard form of the Schrödinger equation:

$$i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi$$

- Extended Schrödinger equation with time field coupling:

$$\boxed{i\hbar \frac{\partial \psi}{\partial t} + i\psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H}\psi}$$

- Alternative formulation with explicit time field:

$$\boxed{iT_{\text{field}} \frac{\partial \Psi}{\partial t} + i\Psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H}\Psi}$$

- Deterministic solution structure:

$$\psi(x,t) = \psi_0(x) \exp\left(-\frac{i}{\hbar} \int_0^t \left[E_0 + V_{\text{eff}}(x,t') \right] dt' \right)$$

- Modified dispersion relations:

$$E^2 = p^2 + E_0^2 + \xi \cdot g(T_{\text{field}}(x,t))$$

- Wave function as energy field representation:

$$\psi(x,t) = \sqrt{\frac{\delta E(x,t)}{E_0 V_0}} \cdot e^{i\phi(x,t)}$$

6.3 Deterministic Quantum Physics

- Standard QM vs. T0 representation:

  Standard QM:

$$|\psi\rangle = \sum_i c_i |i\rangle \quad \text{with} \quad P_i = |c_i|^2$$

  T0 Deterministic:

$$\text{State} \equiv \{E_i(x,t)\} \quad \text{with ratios} \quad R_i = \frac{E_i}{\sum_j E_j}$$

- Measurement interaction Hamiltonian:

$$H_{\text{int}} = \frac{\xi}{E_P} \int \frac{E_{\text{system}}(x,t) \cdot E_{\text{detector}}(x,t)}{\ell_P^3} d^3x$$

- Measurement outcome (deterministic):

$$\text{Measurement outcome} = \arg\max_i \{E_i(x_{\text{detector}}, t_{\text{measurement}})\}$$

6.4 Entanglement and Bell Inequalities

- Entanglement as energy field correlations:

$$E_{12}(x_1, x_2, t) = E_1(x_1, t) + E_2(x_2, t) + E_{\text{corr}}(x_1, x_2, t)$$

- Singlet state representation:

$$|\psi^-\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle) \to \frac{1}{\sqrt{2}}[E_0(x_1)E_1(x_2) - E_1(x_1)E_0(x_2)]$$

- Field correlation function:

$$C(x_1, x_2) = \langle E(x_1,t)E(x_2,t)\rangle - \langle E(x_1,t)\rangle\langle E(x_2,t)\rangle$$

- Modified Bell inequalities:

$$|E(a,b) - E(a,c)| + |E(a',b) + E(a',c)| \leq 2 + \varepsilon_{T0}$$

- T0 correction factor:

$$\varepsilon_{T0} = \xi \cdot \frac{2G\langle E\rangle}{r_{12}} \approx 10^{-34}$$

6.5 Quantum Gates and Operations

- Pauli-X gate (bit flip):

$$X : E_0(x,t) \leftrightarrow E_1(x,t)$$

- Pauli-Y gate:

$$Y : E_0 \to iE_1, \quad E_1 \to -iE_0$$

- Pauli-Z gate (phase flip):

$$Z : E_0 \to E_0, \quad E_1 \to -E_1$$

- Hadamard gate:

$$H : E_0(x,t) \to \frac{1}{\sqrt{2}}[E_0(x,t) + E_1(x,t)]$$

- CNOT gate:

$$\text{CNOT} : E_{12}(x_1, x_2, t) = E_1(x_1, t) \cdot f_{\text{control}}(E_2(x_2, t))$$

With the control function:

$$f_{\text{control}}(E_2) = \begin{cases} E_2 & \text{if } E_1 = E_0 \\ -E_2 & \text{if } E_1 = E_1 \end{cases}$$

6.6 Quantum Algorithms

- Quantum Fourier Transform:

$$\text{QFT} : E_j \to \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} E_k e^{2\pi i jk/N}$$

- Resonance period detection:

$$E_{\text{resonance}}(t) = E_0 \cos\left(\frac{2\pi t}{r \cdot t_0}\right)$$

- Grover algorithm oracle operation:

$$O : E_{\text{target}} \to -E_{\text{target}}, \quad E_{\text{others}} \to E_{\text{others}}$$

- Grover diffusion operation:

$$D : E_i \to 2\langle E \rangle - E_i$$

where $\langle E \rangle = \frac{1}{N} \sum_i E_i$ is the average energy field

- Amplitude amplification after k iterations:

$$E_{\text{target}}^{(k)} = E_0 \sin\left((2k+1) \arcsin \sqrt{\frac{1}{N}}\right)$$

7 COSMOLOGY IN THE T0-MODEL

7.1 Static Universe

- Metric in the static universe:

$$ds^2 = -dt^2 + a^2(t)[dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2)]$$

With: $a(t) = \text{constant}$ in the T0 static model

- Particle horizon in the static universe:

$$r_H = \int_0^t c\, dt' = ct$$

7.2 Redshift and CMB

- Redshift formula with wavelength dependence:

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

- Expected signal for a quasar at $z_0 = 2$:

$$\begin{aligned} z(\text{blue}) &= 2.0 \times (1 - 0.1 \times \ln(0.5)) = 2.0 \times (1 + 0.069) = 2.14 \\ z(\text{red}) &= 2.0 \times (1 - 0.1 \times \ln(2.0)) = 2.0 \times (1 - 0.069) = 1.86 \end{aligned}$$

- Redshift derivative with respect to wavelength:

$$\frac{dz}{d \ln \lambda} = -\alpha z_0$$

- CMB frequency dependence:

$$\Delta z = \xi \ln \frac{\nu_1}{\nu_2}$$

- Prediction for Planck frequency bands:

$$\Delta z_{30-353} = \frac{4}{3} \times 10^{-4} \times \ln \frac{353}{30} = 1.33 \times 10^{-4} \times 2.46 = 3.3 \times 10^{-4}$$

- Modified CMB temperature evolution:

$$\boxed{T(z) = T_0(1+z)\left(1 + \beta \ln(1+z)\right)}$$

7.3 Energy Loss Mechanism for Photons

- Energy loss rate for photons:

$$\frac{dE_\gamma}{dr} = -g_T \omega^2 \frac{2G}{r^2}$$

- Corrected energy loss rate with geometric parameter:

$$\boxed{\frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r} = -\frac{4}{3} \times 10^{-4} \frac{E_\gamma^2}{E_{\text{field}} \cdot r}}$$

- Integrated energy loss equation:

$$\frac{1}{E_{\gamma,0}} - \frac{1}{E_\gamma(r)} = \xi \frac{\ln(r/r_0)}{E_{\text{field}}}$$

- Approximation for small corrections ($\xi \ll 1$):

$$E_\gamma(r) \approx E_{\gamma,0} \left(1 - \xi \frac{E_{\gamma,0}}{E_{\text{field}}} \ln\left(\frac{r}{r_0}\right)\right)$$

7.4 Hubble Parameter and Gravitational Dynamics

- Redshift definition:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}} = \frac{E_{\text{emitted}} - E_{\text{observed}}}{E_{\text{observed}}}$$

- Hubble-like relation for small redshifts:

$$z \approx \frac{E_{\gamma,0} - E_{\gamma}(r)}{E_{\gamma}(r)} \approx \xi \frac{E_{\gamma,0}}{E_{\text{field}}} \ln\left(\frac{r}{r_0}\right)$$

- For nearby distances where $\ln(r/r_0) \approx r/r_0 - 1$:

$$z \approx \xi \frac{E_{\gamma,0}}{E_{\text{field}}} \frac{r}{r_0} = H_0 \frac{r}{c}$$

- Effective Hubble parameter:

$$H_0 = \xi \frac{E_{\gamma,0}}{E_{\text{field}}} \frac{c}{r_0}$$

- Modified galaxy rotation curves:

$$v(r) = \sqrt{\frac{GE_{\text{total}}}{r} + \Omega r^2}$$

  where Ω has dimension $[E^3]$

- Observed "Hubble parameters" as artifacts of different energy loss mechanisms:

$$H_0^{\text{apparent}}(z) = H_0^{\text{local}} \cdot f(z, \xi, E_{\text{field}}(z))$$

- Hubble tension:

$$\text{Tension} = \frac{|H_0^{\text{SH0ES}} - H_0^{\text{Planck}}|}{\sqrt{\sigma^2_{\text{SH0ES}} + \sigma^2_{\text{Planck}}}} = \frac{5.6}{\sqrt{1.4^2 + 0.5^2}} = \frac{5.6}{1.49} = 3.8\sigma$$

8 DIMENSIONAL ANALYSIS AND UNITS

8.1 Dimensions of Fundamental Quantities

- Energy: $[E]$ (fundamental)
- Mass: $[M] = [E]$
- Length: $[L] = [E^{-1}]$
- Time: $[T] = [E^{-1}]$
- Momentum: $[p] = [E]$
- Force: $[F] = [E^2]$
- Charge: $[q] = [1]$

- Action: $[S] = [1]$
- Cross-section: $[\sigma] = [E^{-2}]$
- Lagrangian density: $[\mathcal{L}] = [E^4]$
- Energy density: $[\rho] = [E^4]$
- Wave function: $[\psi] = [E^{3/2}]$
- Field strength tensor: $[F_{\mu\nu}] = [E^2]$
- Acceleration: $[a] = [E^2]$
- Current density: $[J^\mu] = [E^3]$
- D'Alembert operator: $[\Box] = [E^2]$
- Ricci tensor: $[R_{\mu\nu}] = [E^2]$

8.2 Commonly Used Combinations

- g-2 prefactor: $\frac{\xi}{2\pi} = 2.122 \times 10^{-5}$
- Muon-electron ratio: $\frac{E_\mu}{E_e} = 206.768$
- Tau-electron ratio: $\frac{E_\tau}{E_e} = 3477.7$
- Gravitational coupling: $\xi^2 = 1.78 \times 10^{-8}$
- Weak coupling: $\xi^{1/2} = 1.15 \times 10^{-2}$
- Strong coupling: $\xi^{-1/3} = 9.65$
- Universal T0 scale: $2GE$
- Time-Energy duality: $T_{\text{field}} \cdot E_{\text{field}} = 1$

9 GRAVITATIONAL EFFECTS AND UNIFICATION

9.1 Energy Loss of Photons

- Universal energy loss rate:

$$\boxed{\frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r}}$$

- Wavelength formulation:

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

- Integrated wavelength equation:

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

- Wavelength relationship after integration:

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

- Approximation for small shifts:

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

- Alternative expression with original energy loss form:

$$\frac{dE_\gamma}{dr} = -g_T \omega^2 \frac{2G}{r^2}$$

9.2 Wavelength-Dependent Redshift

- Definition of redshift:

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

- Universal redshift formula:

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

- Redshift gradient:

$$\frac{dz}{d \ln \lambda} = -\alpha z_0$$

- Example of redshift variations for a quasar with $z_0 = 2$:

$$z(\text{blue}) = 2.0 \times (1 - 0.1 \times \ln(0.5)) = 2.0 \times (1 + 0.069) = 2.14$$
$$z(\text{red}) = 2.0 \times (1 - 0.1 \times \ln(2.0)) = 2.0 \times (1 - 0.069) = 1.86$$

- Relationship between redshift and energy loss:

$$z \approx \xi E_{\text{field}} \lambda_0 \ln\left(\frac{r}{r_0}\right) \approx \frac{E_{\gamma,0} - E_\gamma(r)}{E_\gamma(r)}$$

9.3 Energy-Dependent Light Deflection

- Modified deflection formula:

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

- Ratio of deflection angles for different photon energies:

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

- Approximation for $\xi \frac{E}{E_0} \ll 1$:

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

- Modified Einstein ring radius:

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

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

$$\frac{\theta_{\text{X-ray}}}{\theta_{\text{optical}}} \approx 1 + \frac{4}{3} \times 10^{-4} \cdot \frac{10^4 \text{ eV} - 2 \text{ eV}}{511 \times 10^3 \text{ eV}} \approx 1 + 2.6 \times 10^{-6}$$

9.4 Universal Geodesic Equation

- Unified geodesic equation:

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

- Modified Christoffel symbols:

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

- Correlation between redshift and light deflection:

$$\frac{\Delta z}{\Delta \theta} = \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \cdot \frac{bc^2}{4GM} \cdot \frac{1}{\ln\left(\frac{r}{r_0}\right)} \cdot \frac{1}{\xi \frac{E_\gamma}{E_0}}$$

9.5 Experimental Predictions

- Wavelength-dependent redshift for quasars:

$$z(450 \text{ nm}) - z(700 \text{ nm}) \approx 0.138 \times z_0$$

- Energy-dependent light deflection at the solar limb:

$$\frac{\theta_{10 \text{ keV}}}{\theta_{2 \text{ eV}}} \approx 1 + 2.6 \times 10^{-6}$$

- CMB temperature variation with redshift:

$$T(z) = T_0(1 + z)\left(1 + \beta \ln(1 + z)\right)$$

- CMB frequency dependence:

$$\Delta z = \xi \ln \frac{\nu_1}{\nu_2}$$

- Prediction for Planck frequency bands:

$$\Delta z_{30-353} = \frac{4}{3} \times 10^{-4} \times \ln \frac{353}{30} = 1.33 \times 10^{-4} \times 2.46 = 3.3 \times 10^{-4}$$

9.6 Einstein Variants of the Mass-Energy Relation

- The four Einstein forms of the mass-energy relation illustrate the fundamental equivalence:

$$\text{Form 1 (Standard):} \quad \boxed{E = mc^2}$$

$$\text{Form 2 (Variable Mass):} \quad \boxed{E = m(x,t) \cdot c^2}$$

$$\text{Form 3 (Variable Speed of Light):} \quad \boxed{E = m \cdot c^2(x,t)}$$

$$\text{Form 4 (T0-Model):} \quad \boxed{E = m(x,t) \cdot c^2(x,t)}$$

- The T0-model uses the most general representation with time field-dependent speed of light:

$$c(x,t) = c_0 \cdot \frac{T_0}{T(x,t)}$$

- Experimental indistinguishability:
  - All four formulations are mathematically consistent and lead to identical experimental predictions
  - Measuring devices always detect only the product of effective mass and effective speed of light
  - Only the most general form (Form 4) is fully compatible with the T0-model and correctly describes energy field interactions
- Time-Energy duality in the context of mass-energy equivalence:

$$E = m(x,t) \cdot c^2(x,t) = m_0 \cdot c_0^2 \cdot \frac{T_0}{T(x,t)}$$

10 ξ-HARMONIC THEORY AND FACTORIZATION

10.1 ξ-Parameter as Uncertainty Parameter

- Heisenberg uncertainty relation:

$$\Delta\omega \times \Delta t \geq \xi/2$$

- ξ as resonance window:

$$\text{Resonance}(\omega, \omega_{\text{target}}, \xi) = \exp\left(-\frac{(\omega - \omega_{\text{target}})^2}{4\xi}\right)$$

- Optimal parameter:

$$\xi = 1/10 \text{ (for medium selectivity)}$$

- Acceptance radius:

$$r_{\text{accept}} = \sqrt{4\xi} \approx 0.63 \text{ (for } \xi = 1/10)$$

10.2 Spectral Dirac Representation

- Dirac representation of a number $n = p \times q$:

$$\delta_n(f) = A_1\delta(f - f_1) + A_2\delta(f - f_2)$$

- ξ-broadened Dirac function:

$$\delta_\xi(\omega - \omega_0) = \frac{1}{\sqrt{4\pi\xi}} \times \exp\left(-\frac{(\omega - \omega_0)^2}{4\xi}\right)$$

- Complete Dirac number function:

$$\Psi_n(\omega, \xi) = \sum_i A_i \times \frac{1}{\sqrt{4\pi\xi}} \times \exp\left(-\frac{(\omega - \omega_i)^2}{4\xi}\right)$$

10.3 Factorization through FFT Spectral Theory

- Fundamental frequencies in the spectrum correspond to prime factors:

$$n = p \times q \to \{f_1 = f_0 \times p, f_2 = f_0 \times q\}$$

- Spectral ratio (must always be considered as a ratio):

$$R(n) = \frac{q}{p} = \frac{\max(p, q)}{\min(p, q)}$$

- Octave reduction to avoid rounding errors:

$$R_{\text{oct}}(n) = \frac{R(n)}{2^{\lfloor \log_2(R(n)) \rfloor}}$$

- Beat frequency (difference frequency):

$$f_{\text{beat}} = |f_2 - f_1| = f_0 \times |q - p|$$

10.4 Harmonic Hierarchy for Factorizations

- Basic (1.0 - 1.4): Classical harmonies

$$\text{e.g., } \frac{3}{2} = 1.5 \text{ (perfect fifth)}, \frac{5}{4} = 1.25 \text{ (major third)}$$

- Extended (1.4 - 1.6): Jazz/modern harmonies

$$\text{e.g., } \frac{11}{8} = 1.375, \frac{13}{8} = 1.625$$

- Complex (1.6 - 1.85): Microtonal spectra

$$\text{e.g., } \frac{29}{16} = 1.8125, \frac{31}{16} = 1.9375$$

- Ultra (1.85+): Xenharmonic spectra

$$\text{e.g., } \frac{61}{32} = 1.90625, \frac{37}{32} = 1.15625$$

10.5 Resonance Score for Factorizations

- Optimal resonance parameter:
$$\xi = \frac{1}{10}$$
- Angular frequency for period r:
$$\omega = \frac{2\pi}{r}$$
- Resonance score:
$$\text{Res}(r, \xi) = \frac{1}{1 + \frac{|(\omega - \pi)^2|}{4\xi}}$$

10.6 Ratio-Based Calculation to Avoid Rounding Errors

- **IMPORTANT NOTE:** All computational operations must be performed using ratios, as floating-point calculations introduce rounding errors that render the results unusable. Precise calculation of ratios is critical for the correct application of the T0-model.
- Instead of absolute values, ratios should always be used: $\frac{f_1}{f_0} = p, \quad \frac{f_2}{f_0} = q, \quad \frac{f_2}{f_1} = \frac{q}{p}$
- When implementing in computer programs, libraries for exact arithmetic (fractional computation) should be used to avoid floating-point rounding errors.
- Harmonic distance (in cents): $d_{\text{harm}}(n, h) = 1200 \times \left|\log_2\left(\frac{R_{\text{oct}}(n)}{h}\right)\right|$
- Matching criterion: $\text{Match}(n, \text{harmonic\_ratio}) = \text{TRUE}$ if $|R_{\text{oct}}(n) - \text{harmonic\_ratio}|^2 < 4\xi$

11 SYMBOL EXPLANATIONS

11.1 General Symbols

- ξ = Universal geometric parameter ($4/3 \times 10^{-4}$)
- G = Gravitational constant
- c = Speed of light
- $\hbar$ = Reduced Planck constant
- k_B = Boltzmann constant
- E_P = Planck energy
- ℓ_P = Planck length
- T_0 = Reference time field value
- E_0 = Reference energy field value

11.2 Field Theory Symbols

- E_{field} = Energy field
- T_{field} = Time field
- δE = Energy field fluctuation
- $\mathcal{L}$ = Lagrangian density
- $\Box$ = D'Alembert operator
- $\Gamma_\mu^{(T)}$ = Time field connection
- ∇ = Nabla operator
- ∂_μ = Partial derivative with respect to coordinate μ

11.3 Quantum Mechanical Symbols

- ψ = Wave function
- γ^μ = Dirac matrices
- $\hat{H}$ = Hamiltonian operator
- $|\psi\rangle$ = State vector
- $\langle A\rangle$ = Expectation value of observable A
- a_μ = Anomalous magnetic moment of the muon
- a_ℓ = Anomalous magnetic moment of a lepton

11.4 Particle Physics Symbols

- α_{EM} = Electromagnetic coupling constant
- α_G = Gravitational coupling
- α_W = Weak coupling
- α_S = Strong coupling
- E_μ = Muon energy/mass
- E_e = Electron energy/mass
- E_τ = Tau energy/mass

11.5 Cosmological Symbols

- z = Redshift
- λ = Wavelength
- ν = Frequency
- H_0 = Hubble parameter
- θ = Deflection angle
- ds^2 = Line element
- $a(t)$ = Scale factor

11.6 Spectral Analysis and Factorization

- $R(n)$ = Spectral ratio of a number n
- $R_{\text{oct}}(n)$ = Octave-reduced spectral ratio
- f_{beat} = Beat frequency
- δ_ξ = ξ-broadened Dirac function
- Ψ_n = Spectral wave function of a number
- ω = Angular frequency
- d_{harm} = Harmonic distance