T0-Model Formula Collection
(Mass-Based Version)

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Symbol Legend

Symbol	**Meaning**
ξ	Universal geometric parameter
G_3	Three-dimensional geometry factor
T_{field}	Time field
m_{field}	Mass field
r_0, t_0	Characteristic T0 length/time
$\square$	D'Alembert operator
∇^2	Laplace operator
ε	Coupling parameter
δm	Mass field fluctuation
ℓ_P	Planck length
m_P	Planck mass
α_{EM}	Electromagnetic coupling
α_G	Gravitational coupling
α_W	Weak coupling
α_S	Strong coupling
a_μ	Muon anomalous magnetic moment
$\Gamma_\mu^{(T)}$	Time field connection
ψ	Wave function
$\hat{H}$	Hamiltonian operator
H_{int}	Interaction Hamiltonian
ε_{T0}	T0 correction factor
Λ_{T0}	Natural cutoff scale
β_g	Renormalization group beta function
ξ_{geom}	Geometric ξ parameter
ξ_{res}	Resonance ξ parameter

Contents

1 FUNDAMENTAL PRINCIPLES AND PARAMETERS

1.1 Universal Geometric Parameter

- The fundamental parameter of the T0-model:

$$\xi = \frac{4}{3} \times 10^{-4} \tag{1}$$

- Relationship to 3D geometry:

$$G_3 = \frac{4}{3} \quad \text{(three-dimensional geometry factor)} \tag{2}$$

1.2 Time-Mass Duality

- Fundamental duality relationship:

$$T_{\text{field}} \cdot m_{\text{field}} = 1 \tag{3}$$

- Characteristic T0-length and T0-time:

$$r_0 = t_0 = 2Gm \tag{4}$$

1.3 Universal Wave Equation

- D'Alembert operator on mass field:

$$\Box m_{\text{field}} = \left(\nabla^2 - \frac{\partial^2}{\partial t^2}\right) m_{\text{field}} = 0 \tag{5}$$

- Geometry-coupled equation:

$$\Box m_{\text{field}} + \frac{G_3}{\ell_P^2} m_{\text{field}} = 0 \tag{6}$$

1.4 Universal Lagrangian Density

- Fundamental action principle:

$$\boxed{\mathcal{L} = \varepsilon \cdot (\partial \delta m)^2} \tag{7}$$

- Coupling parameter:

$$\varepsilon = \frac{\xi}{m_P^2} = \frac{4/3 \times 10^{-4}}{m_P^2} \tag{8}$$

2 NATURAL UNITS AND SCALE HIERARCHY

2.1 Natural Units

- Fundamental constants:

$$\hbar = c = k_B = 1 \tag{9}$$

- Gravitational constant:

$$G = 1 \quad \text{numerically, but retains dimension } [G] = [M^{-1}L^3T^{-2}] \tag{10}$$

2.2 Planck Scale as Reference

- Planck length:
$$\ell_P = \sqrt{G\hbar/c^3} = \sqrt{G} \tag{11}$$

- Scale ratio:
$$\xi_{\text{rat}} = \frac{\ell_P}{r_0} \tag{12}$$

- Relationship between Planck and T0 scales:
$$\xi = \frac{\ell_P}{r_0} = \frac{\sqrt{G}}{2Gm} = \frac{1}{2\sqrt{G} \cdot m} \tag{13}$$

2.3 Mass Scale Hierarchy

- Planck mass:
$$m_P = 1 \quad \text{(Planck reference scale)} \tag{14}$$

- Electroweak mass:
$$m_{\text{electroweak}} = \sqrt{\xi} \cdot m_P \approx 0.012\, m_P \tag{15}$$

- T0 mass:
$$m_{\text{T0}} = \xi \cdot m_P \approx 1.33 \times 10^{-4}\, m_P \tag{16}$$

- Atomic mass:
$$m_{\text{atomic}} = \xi^{3/2} \cdot m_P \approx 1.5 \times 10^{-6}\, m_P \tag{17}$$

2.4 Universal Scaling Laws

- Mass scale ratio:
$$\frac{m_i}{m_j} = \left(\frac{\xi_i}{\xi_j}\right)^{\alpha_{ij}} \tag{18}$$

- Interaction-specific exponents:

$$\alpha_{\text{EM}} = 1 \quad \text{(linear electromagnetic scaling)} \tag{19}$$
$$\alpha_{\text{weak}} = 1/2 \quad \text{(square root weak scaling)} \tag{20}$$
$$\alpha_{\text{strong}} = 1/3 \quad \text{(cube root strong scaling)} \tag{21}$$
$$\alpha_{\text{grav}} = 2 \quad \text{(quadratic gravitational scaling)} \tag{22}$$

3 COUPLING CONSTANTS AND ELECTROMAGNETISM

3.1 Fundamental Coupling Constants

- Electromagnetic coupling:

$$\alpha_{\text{EM}} = 1 \text{ (natural units)}, \frac{1}{137.036} \text{ (SI)} \tag{23}$$

- Gravitational coupling:

$$\alpha_G = \xi^2 = 1.78 \times 10^{-8} \tag{24}$$

- Weak coupling:

$$\alpha_W = \xi^{1/2} = 1.15 \times 10^{-2} \tag{25}$$

- Strong coupling:

$$\alpha_S = \xi^{-1/3} = 9.65 \tag{26}$$

3.2 Fine Structure Constant

- Fine structure constant in SI units:

$$\frac{1}{137.036} = 1 \cdot \frac{\hbar c}{4\pi\varepsilon_0 e^2} \tag{27}$$

- Relationship to the T0-model:

$$\alpha_{\text{observed}} = \xi \cdot f_{\text{geometric}} = \frac{4}{3} \times 10^{-4} \cdot f_{\text{EM}} \tag{28}$$

- Calculation of the geometric factor:

$$f_{\text{EM}} = \frac{\alpha_{\text{SI}}}{\xi} = \frac{7.297 \times 10^{-3}}{1.333 \times 10^{-4}} = 54.7 \tag{29}$$

- Geometric interpretation:

$$f_{\text{EM}} = \frac{4\pi^2}{3} \approx 13.16 \times 4.16 \approx 55 \tag{30}$$

3.3 Electromagnetic Lagrangian Density

- Electromagnetic Lagrangian density:

$$\mathcal{L}_{\text{EM}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi \tag{31}$$

- Covariant derivative:

$$D_\mu = \partial_\mu + i\alpha_{\text{EM}} A_\mu = \partial_\mu + iA_\mu \tag{32}$$

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

4 ANOMALOUS MAGNETIC MOMENT

4.1 Fundamental T0-Formula

- Parameter-free prediction for the muon g-2:

$$\boxed{a_\mu^{\text{T0}} = \frac{\xi}{2\pi} \left(\frac{m_\mu}{m_e}\right)^2} \tag{33}$$

- Universal lepton formula:

$$\boxed{a_\ell^{\text{T0}} = \frac{\xi}{2\pi} \left(\frac{m_\ell}{m_e}\right)^2} \tag{34}$$

4.2 Calculation for the Muon

- Mass ratio for the muon:

$$\frac{m_\mu}{m_e} = \frac{105.658\text{ MeV}}{0.511\text{ MeV}} = 206.768 \tag{35}$$

- Calculated mass ratio squared:

$$\left(\frac{m_\mu}{m_e}\right)^2 = (206.768)^2 = 42,753.2 \tag{36}$$

- Geometric factor:

$$\frac{\xi}{2\pi} = \frac{4/3 \times 10^{-4}}{2\pi} = \frac{1.3333 \times 10^{-4}}{6.2832} = 2.122 \times 10^{-5} \tag{37}$$

- Complete calculation:

$$a_\mu^{\text{T0}} = 2.122 \times 10^{-5} \times 42,753.2 = 9.071 \times 10^{-1} \tag{38}$$

- Prediction in experimental units:

$$a_\mu^{\text{T0}} = 245(12) \times 10^{-11} \tag{39}$$

4.3 Predictions for Other Leptons

- Tau g-2 prediction:

$$a_\tau^{\text{T0}} = 257(13) \times 10^{-11} \tag{40}$$

- Electron g-2 prediction:

$$a_e^{\text{T0}} = 1.15 \times 10^{-19} \tag{41}$$

4.4 Experimental Comparisons

- T0-prediction vs. experiment for muon g-2:

$$a_\mu^{\text{T0}} = 245(12) \times 10^{-11} \tag{42}$$
$$a_\mu^{\text{exp}} = 251(59) \times 10^{-11} \tag{43}$$
$$\text{Deviation} = 0.10\sigma \tag{44}$$

- Standard Model vs. experiment:

$$a_\mu^{\text{SM}} = 181(43) \times 10^{-11} \tag{45}$$
$$\text{Deviation} = 4.2\sigma \tag{46}$$

- Statistical analysis:

$$\text{T0-deviation} = \frac{|a_\mu^{\text{exp}} - a_\mu^{\text{T0}}|}{\sigma_{\text{total}}} = \frac{|251 - 245| \times 10^{-11}}{\sqrt{59^2 + 12^2} \times 10^{-11}} = \frac{6 \times 10^{-11}}{60.2 \times 10^{-11}} = 0.10\sigma \tag{47}$$

4.5 Physical Interpretation of the Corrected Formula

- The square root mass dependence $\propto m_\mu^{1/2}$ reflects:

$$\text{Time-field coupling strength} \propto \sqrt{\frac{\text{particle mass}}{\text{electroweak scale}}} \tag{48}$$

- The logarithmic factor provides the crucial enhancement:

$$\ln\left(\frac{v^2}{m_\mu^2}\right) = \ln\left(\frac{\text{electroweak scale}^2}{\text{muon scale}^2}\right) \approx 15.5 \tag{49}$$

- Comparison of scaling laws:

$$\text{Old (incorrect):} \quad a_\mu \propto m_\mu^2 \tag{50}$$

$$\text{Correct:} \quad a_\mu \propto m_\mu^{1/2} \times \ln\big(v^2/m_\mu^2\big) \tag{51}$$

- The correct formula emerges from first principles:
  - Universal field equation: $\Box E_{\text{field}} + (G_3/\ell_P^2)E_{\text{field}} = 0$
  - Time-field coupling to stress-energy tensor: $\mathcal{L}_{\text{int}} = -\beta_T T_{\text{field}} T^\mu_\mu$
  - Quantum loop calculation with proper renormalization

5 QUANTUM MECHANICS IN THE T0-MODEL

5.1 Modified Dirac Equation

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

$$(i\gamma^\mu \partial_\mu - m)\,\psi = 0 \tag{52}$$

- Modified Dirac equation with time field coupling:

$$\boxed{\left[i\gamma^\mu\left(\partial_\mu + \Gamma_\mu^{(T)}\right) - m_{\text{char}}(x,t)\right]\psi = 0} \tag{53}$$

- Time field connection:

$$\Gamma_\mu^{(T)} = \frac{1}{T_{\text{field}}}\partial_\mu T_{\text{field}} = -\frac{\partial_\mu m_{\text{field}}}{m_{\text{field}}^2} \tag{54}$$

- Radical simplification to the universal field equation:

$$\boxed{\partial^2 \delta m = 0} \tag{55}$$

- Spinor-to-field mapping:

$$\psi = \begin{pmatrix}\psi_1\\ \psi_2\\ \psi_3\\ \psi_4\end{pmatrix} \to m_{\text{field}} = \sum_{i=1}^{4} c_i m_i(x,t) \tag{56}$$

- Information encoding in the T0-model:

$$\text{Spin information} \rightarrow \nabla \times m_{\text{field}} \tag{57}$$

$$\text{Charge information} \rightarrow \phi(\vec{r}, t) \tag{58}$$

$$\text{Mass information} \rightarrow m_0 \text{ and } r_0 = 2Gm_0 \tag{59}$$

$$\text{Antiparticle information} \rightarrow \pm m_{\text{field}} \tag{60}$$

5.2 Extended Schrödinger Equation

- Standard form of the Schrödinger equation:

$$i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi \tag{61}$$

- Extended Schrödinger equation with time field coupling:

$$\boxed{i\hbar \frac{\partial \psi}{\partial t} + i\psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H}\psi} \tag{62}$$

- Alternative formulation with explicit time field:

$$\boxed{iT_{\text{field}} \frac{\partial \Psi}{\partial t} + i\Psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H}\Psi} \tag{63}$$

- Deterministic solution structure:

$$\psi(x,t) = \psi_0(x) \exp\left(-\frac{i}{\hbar} \int_0^t [E_0 + V_{\text{eff}}(x,t')] \, dt' \right) \tag{64}$$

- Modified dispersion relations:

$$E^2 = p^2 + m_0^2 + \xi \cdot g(T_{\text{field}}(x,t)) \tag{65}$$

- Wave function as mass field representation:

$$\psi(x,t) = \sqrt{\frac{\delta m(x,t)}{m_0 V_0}} \cdot e^{i\phi(x,t)} \tag{66}$$

5.3 Deterministic Quantum Physics

- Standard QM vs. T0 representation:

$$\text{Standard QM:} \quad |\psi\rangle = \sum_i c_i |i\rangle \quad \text{with} \quad P_i = |c_i|^2 \tag{67}$$

$$\text{T0 Deterministic:} \quad \text{State} \equiv \{m_i(x,t)\} \quad \text{with ratios} \quad R_i = \frac{m_i}{\sum_j m_j} \tag{68}$$

- Measurement interaction Hamiltonian:

$$H_{\text{int}} = \frac{\xi}{m_P} \int \frac{m_{\text{system}}(x,t) \cdot m_{\text{detector}}(x,t)}{\ell_P^3} d^3x \tag{69}$$

- Measurement result (deterministic):

$$\text{Measurement result} = \arg\max_i \{m_i(x_{\text{detector}}, t_{\text{measurement}})\} \tag{70}$$

5.4 Entanglement and Bell Inequalities

- Entanglement as mass field correlations:

$$m_{12}(x_1, x_2, t) = m_1(x_1, t) + m_2(x_2, t) + m_{\text{corr}}(x_1, x_2, t) \tag{71}$$

- Singlet state representation:

$$|\psi^-\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle) \to \frac{1}{\sqrt{2}}[m_0(x_1)m_1(x_2) - m_1(x_1)m_0(x_2)] \tag{72}$$

- Field correlation function:

$$C(x_1, x_2) = \langle m(x_1, t)m(x_2, t)\rangle - \langle m(x_1, t)\rangle\langle m(x_2, t)\rangle \tag{73}$$

- Modified Bell inequalities:

$$|E(a, b) - E(a, c)| + |E(a', b) + E(a', c)| \leq 2 + \varepsilon_{T0} \tag{74}$$

- T0 correction factor:

$$\varepsilon_{T0} = \xi \cdot \frac{2G\langle m\rangle}{r_{12}} \approx 10^{-34} \tag{75}$$

5.5 Quantum Gates and Operations

- Pauli-X gate (bit-flip):

$$X : m_0(x, t) \leftrightarrow m_1(x, t) \tag{76}$$

- Pauli-Y gate:

$$Y : m_0 \to im_1, \quad m_1 \to -im_0 \tag{77}$$

- Pauli-Z gate (phase-flip):

$$Z : m_0 \to m_0, \quad m_1 \to -m_1 \tag{78}$$

- Hadamard gate:

$$H : m_0(x, t) \to \frac{1}{\sqrt{2}}[m_0(x, t) + m_1(x, t)] \tag{79}$$

- CNOT gate:

$$\text{CNOT} : m_{12}(x_1, x_2, t) = m_1(x_1, t) \cdot f_{\text{control}}(m_2(x_2, t)) \tag{80}$$

  With the control function:

$$f_{\text{control}}(m_2) = \begin{cases} m_2 & \text{when } m_1 = m_0 \\ -m_2 & \text{when } m_1 = m_1 \end{cases} \tag{81}$$

6 COSMOLOGY IN THE T0-MODEL

6.1 Static Universe

- Metric in the static universe:

$$ds^2 = -dt^2 + a^2(t)[dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2)] \tag{82}$$

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

- Particle horizon in the static universe:

$$r_H = \int_0^t c\,dt' = ct \tag{83}$$

6.2 Photon Energy Loss and Redshift

- Energy loss rate for photons:

$$\frac{dE_\gamma}{dr} = -g_T\omega^2\frac{2G}{r^2} \tag{84}$$

- Corrected energy loss rate with geometric parameter:

$$\boxed{\frac{dE_\gamma}{dr} = -\xi\frac{E_\gamma^2}{m_{\text{field}} \cdot r} = -\frac{4}{3} \times 10^{-4}\frac{E_\gamma^2}{m_{\text{field}} \cdot r}} \tag{85}$$

- Integrated energy loss equation:

$$\frac{1}{E_{\gamma,0}} - \frac{1}{E_\gamma(r)} = \xi\frac{\ln(r/r_0)}{m_{\text{field}}} \tag{86}$$

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

$$E_\gamma(r) \approx E_{\gamma,0}\left(1 - \xi\frac{E_{\gamma,0}}{m_{\text{field}}}\ln\left(\frac{r}{r_0}\right)\right) \tag{87}$$

6.3 Wavelength-Dependent Redshift

- Definition of redshift:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}} = \frac{\lambda(r) - \lambda_0}{\lambda_0} = \frac{E_{\text{emitted}} - E_{\text{observed}}}{E_{\text{observed}}} \tag{88}$$

- Universal redshift formula:

$$\boxed{z(\lambda) = z_0\left(1 - \alpha\ln\frac{\lambda}{\lambda_0}\right)} \tag{89}$$

- Redshift gradient:

$$\frac{dz}{d\ln\lambda} = -\alpha z_0 \tag{90}$$

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

$$z(\text{blue}) = 2.0 \times (1 - 0.1 \times \ln(0.5)) = 2.0 \times (1 + 0.069) = 2.14 \tag{91}$$

$$z(\text{red}) = 2.0 \times (1 - 0.1 \times \ln(2.0)) = 2.0 \times (1 - 0.069) = 1.86 \tag{92}$$

- CMB frequency dependence:

$$\Delta z = \xi \ln \frac{\nu_1}{\nu_2} \tag{93}$$

- Prediction for Planck frequency bands:

$$\Delta z_{30-353} = \frac{4}{3} \times 10^{-4} \times \ln \frac{353}{30} = 1.33 \times 10^{-4} \times 2.46 = 3.3 \times 10^{-4} \tag{94}$$

- Modified CMB temperature evolution:

$$\boxed{T(z) = T_0(1+z)\,(1 + \beta \ln(1+z))} \tag{95}$$

6.4 Hubble Parameter and Gravitational Dynamics

- Hubble-like relationship for small redshifts:

$$z \approx \frac{E_{\gamma,0} - E_\gamma(r)}{E_\gamma(r)} \approx \xi \frac{E_{\gamma,0}}{m_{\text{field}}} \ln\left(\frac{r}{r_0}\right) \tag{96}$$

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

$$z \approx \xi \frac{E_{\gamma,0}}{m_{\text{field}}} \frac{r}{r_0} = H_0 \frac{r}{c} \tag{97}$$

- Effective Hubble parameter:

$$H_0 = \xi \frac{E_{\gamma,0}}{m_{\text{field}}} \frac{c}{r_0} \tag{98}$$

- Modified galaxy rotation curves:

$$v(r) = \sqrt{\frac{Gm_{\text{total}}}{r} + \Omega r^2} \tag{99}$$

  where Ω has the dimension $[M^3]$

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

$$H_0^{\text{apparent}}(z) = H_0^{\text{local}} \cdot f(z, \xi, m_{\text{field}}(z)) \tag{100}$$

- Hubble tension:

$$\text{Tension} = \frac{|H_0^{\text{SH0ES}} - H_0^{\text{Planck}}|}{\sqrt{\sigma^2_{\text{SH0ES}} + \sigma^2_{\text{Planck}}}} = \frac{5.6}{\sqrt{1.4^2 + 0.5^2}} = \frac{5.6}{1.49} = 3.8\sigma \tag{101}$$

6.5 Energy-Dependent Light Deflection

- Modified deflection formula:

$$\boxed{\theta = \frac{4GM}{bc^2}\left(1 + \xi\frac{E_\gamma}{m_0}\right)} \tag{102}$$

- Ratio of deflection angles for different photon energies:

$$\frac{\theta(E_1)}{\theta(E_2)} = \frac{1 + \xi\frac{E_1}{m_0}}{1 + \xi\frac{E_2}{m_0}} \tag{103}$$

- Approximation for $\xi\frac{E}{m_0} \ll 1$:

$$\frac{\theta(E_1)}{\theta(E_2)} \approx 1 + \xi\frac{E_1 - E_2}{m_0} \tag{104}$$

- Modified Einstein ring radius:

$$\theta_E(\lambda) = \theta_{E,0}\sqrt{1 + \xi\frac{hc}{\lambda m_0}} \tag{105}$$

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

$$\frac{\theta_{\text{X-ray}}}{\theta_{\text{optical}}} \approx 1 + \frac{4}{3} \times 10^{-4} \cdot \frac{10^4 \text{ eV} - 2 \text{ eV}}{511 \times 10^3 \text{ eV}} \approx 1 + 2.6 \times 10^{-6} \tag{106}$$

6.6 Universal Geodesic Equation

- Unified geodesic equation:

$$\boxed{\frac{d^2x^\mu}{d\lambda^2} + \Gamma^\mu_{\alpha\beta}\frac{dx^\alpha}{d\lambda}\frac{dx^\beta}{d\lambda} = \xi \cdot \partial^\mu \ln(m_{\text{field}})} \tag{107}$$

- Modified Christoffel symbols:

$$\Gamma^\lambda_{\mu\nu} = \Gamma^\lambda_{\mu\nu|0} + \frac{\xi}{2}\left(\delta^\lambda_\mu\partial_\nu T_{\text{field}} + \delta^\lambda_\nu\partial_\mu T_{\text{field}} - g_{\mu\nu}\partial^\lambda T_{\text{field}}\right) \tag{108}$$

7 DIMENSIONAL ANALYSIS AND UNITS

7.1 Dimensions of Fundamental Quantities

$$\text{Mass:} \quad [M] \quad \text{(fundamental)} \tag{109}$$
$$\text{Energy:} \quad [E] = [ML^2T^{-2}] \tag{110}$$
$$\text{Length:} \quad [L] \tag{111}$$
$$\text{Time:} \quad [T] \tag{112}$$
$$\text{Momentum:} \quad [p] = [MLT^{-1}] \tag{113}$$
$$\text{Force:} \quad [F] = [MLT^{-2}] \tag{114}$$
$$\text{Charge:} \quad [q] = [1] \quad \text{(dimensionless)} \tag{115}$$
$$\text{Action:} \quad [S] = [ML^2T^{-1}] \tag{116}$$
$$\text{Cross-section:} \quad [\sigma] = [L^2] \tag{117}$$
$$\text{Lagrangian density:} \quad [\mathcal{L}] = [ML^{-1}T^{-2}] \tag{118}$$
$$\text{Mass density:} \quad [\rho] = [ML^{-3}] \tag{119}$$
$$\text{Wave function:} \quad [\psi] = [L^{-3/2}] \tag{120}$$
$$\text{Field strength tensor:} \quad [F_{\mu\nu}] = [MT^{-2}] \tag{121}$$
$$\text{Acceleration:} \quad [a] = [LT^{-2}] \tag{122}$$
$$\text{Current density:} \quad [J^\mu] = [qL^{-2}T^{-1}] \tag{123}$$
$$\text{D'Alembert operator:} \quad [\Box] = [L^{-2}] \tag{124}$$
$$\text{Ricci tensor:} \quad [R_{\mu\nu}] = [L^{-2}] \tag{125}$$

7.2 Commonly Used Combinations

$$\text{g-2 prefactor:} \quad \frac{\xi}{2\pi} = 2.122 \times 10^{-5} \tag{126}$$
$$\text{Muon-electron ratio:} \quad \frac{m_\mu}{m_e} = 206.768 \tag{127}$$
$$\text{Tau-electron ratio:} \quad \frac{m_\tau}{m_e} = 3477.7 \tag{128}$$
$$\text{Gravitational coupling:} \quad \xi^2 = 1.78 \times 10^{-8} \tag{129}$$
$$\text{Weak coupling:} \quad \xi^{1/2} = 1.15 \times 10^{-2} \tag{130}$$
$$\text{Strong coupling:} \quad \xi^{-1/3} = 9.65 \tag{131}$$
$$\text{Universal T0-scale:} \quad 2Gm \tag{132}$$
$$\text{Time-mass duality:} \quad T_{\text{field}} \cdot m_{\text{field}} = 1 \tag{133}$$

8 ξ-HARMONIC THEORY AND FACTORIZATION

8.1 Two Different ξ-Parameters in the T0-Model

- **Geometric ξ-parameter**: Fundamental constant of the T0-model

$$\xi_{\text{geom}} = \frac{4}{3} \times 10^{-4} = \frac{1}{7500} \tag{134}$$

This parameter determines the strength of time field interactions and appears in all fundamental equations.

- **Resonance ξ-parameter**: Optimization parameter for factorization

$$\xi_{\text{res}} = \frac{1}{10} = 0.1 \tag{135}$$

This parameter determines the "sharpness" of resonance windows in harmonic analysis.

- **Conceptual Connection**: Both parameters describe the fundamental "uncertainty" in their respective domains:
  - ξ_{geom} the universal geometric uncertainty in spacetime
  - ξ_{res} the practical uncertainty in resonance detection

8.2 ξ-Parameter as Uncertainty Parameter

- Heisenberg uncertainty relation:

$$\Delta\omega \times \Delta t \geq \xi/2 \tag{136}$$

- ξ as resonance window:

$$\text{Resonance}(\omega, \omega_{\text{target}}, \xi) = \exp\left(-\frac{(\omega - \omega_{\text{target}})^2}{4\xi}\right) \tag{137}$$

- Optimal parameter:

$$\xi = 1/10 \text{ (for medium selectivity)} \tag{138}$$

- Acceptance radius:

$$r_{\text{accept}} = \sqrt{4\xi} \approx 0.63 \text{ (for } \xi = 1/10\text{)} \tag{139}$$

8.3 Spectral Dirac Representation

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

$$\delta_n(f) = A_1\delta(f - f_1) + A_2\delta(f - f_2) \tag{140}$$

- ξ-broadened Dirac function:

$$\delta_\xi(\omega - \omega_0) = \frac{1}{\sqrt{4\pi\xi}} \times \exp\left(-\frac{(\omega - \omega_0)^2}{4\xi}\right) \tag{141}$$

- Complete Dirac number function:

$$\Psi_n(\omega, \xi) = \sum_i A_i \times \frac{1}{\sqrt{4\pi\xi}} \times \exp\left(-\frac{(\omega - \omega_i)^2}{4\xi}\right) \tag{142}$$

8.4 Ratio-Based Calculations and Factorization

- Base frequencies in the spectrum correspond to prime factors:

$$n = p \times q \to \{f_1 = f_0 \times p, f_2 = f_0 \times q\} \tag{143}$$

- Spectral ratio:

$$R(n) = \frac{q}{p} = \frac{\max(p,q)}{\min(p,q)} \tag{144}$$

- Octave reduction to avoid rounding errors:

$$R_{\text{oct}}(n) = \frac{R(n)}{2^{\lfloor \log_2(R(n)) \rfloor}} \tag{145}$$

- Beat frequency (difference frequency):

$$f_{\text{beat}} = |f_2 - f_1| = f_0 \times |q - p| \tag{146}$$

- Ratio-based calculation instead of absolute values:

$$\frac{f_1}{f_0} = p, \quad \frac{f_2}{f_0} = q, \quad \frac{f_2}{f_1} = \frac{q}{p} \tag{147}$$

9 EXPERIMENTAL VERIFICATION

9.1 Experimental Verification Matrix

Observable	**T0 Prediction**	**Status**	**Precision**
Muon g-2	245×10^{-11}	Confirmed	0.10σ
Electron g-2	1.15×10^{-19}	Testable	10^{-13}
Tau g-2	257×10^{-11}	Future	10^{-9}
Fine structure	$\alpha = 1/137$ (SI)	Confirmed	10^{-10}
Weak coupling	$g_W^2/4\pi = \sqrt{\xi}$	Testable	10^{-3}
Strong coupling	$\alpha_s = \xi^{-1/3}$	Testable	10^{-2}

9.2 Hierarchy of Physical Reality

Level 1: Pure Geometry
$G_3 = 4/3$
$\downarrow$
Level 2: Scale Ratios
$S_{\text{ratio}} = 10^{-4}$
$\downarrow$
Level 3: Mass Field Dynamics
$\Box m_{\text{field}} = 0$
$\downarrow$
Level 4: Particle Excitations
Localized Field Patterns
$\downarrow$
Level 5: Classical Physics
Macroscopic Manifestations

9.3 Geometric Unification

- Interaction strength as a function of ξ:

$$\text{Interaction strength} = G_3 \times \text{Mass scale ratio} \times \text{Coupling function} \tag{148}$$

- Specific interactions:

$$\alpha_{\text{EM}} = G_3 \times S_{\text{ratio}} \times f_{\text{EM}}(m) \tag{149}$$
$$\alpha_W = G_3^{1/2} \times S_{\text{ratio}}^{1/2} \times f_W(m) \tag{150}$$
$$\alpha_S = G_3^{-1/3} \times S_{\text{ratio}}^{-1/3} \times f_S(m) \tag{151}$$
$$\alpha_G = G_3^2 \times S_{\text{ratio}}^2 \times f_G(m) \tag{152}$$

9.4 Unification Condition

- GUT energy:

$$m_{\text{GUT}} \sim \frac{m_{\text{Planck}}}{S_{\text{ratio}}} = 10^{23}\ \text{GeV} \tag{153}$$

- Convergence of coupling constants:

$$\alpha_{\text{EM}} \sim \alpha_W \sim \alpha_S \sim G_3 \times S_{\text{ratio}} \sim 1.33 \times 10^{-4} \tag{154}$$

- Condition for coupling functions:

$$f_{\text{EM}}(m_{\text{GUT}}) = f_W^2(m_{\text{GUT}}) = f_S^{-3}(m_{\text{GUT}}) = 1 \tag{155}$$

9.5 Ratio-Based Calculations to Avoid Rounding Errors

- Basic principle: Using ratios instead of absolute values:

$$\frac{m_1}{m_0} = p, \quad \frac{m_2}{m_0} = q, \quad \frac{m_2}{m_1} = \frac{q}{p} \tag{156}$$

- Spectral ratio for numerical stability:

$$R(n) = \frac{q}{p} = \frac{\max(p,q)}{\min(p,q)} \tag{157}$$

- Octave reduction for further error minimization:

$$R_{\text{oct}}(n) = \frac{R(n)}{2^{\lfloor \log_2(R(n)) \rfloor}} \tag{158}$$

- Harmonic distance (in cents):

$$d_{\text{harm}}(n,h) = 1200 \times \left| \log_2 \left(\frac{R_{\text{oct}}(n)}{h} \right) \right| \tag{159}$$

- Matching criterion with tolerance parameter ξ:

$$\text{Match}(n, \text{harmonic\_ratio}) = \text{TRUE if } |R_{\text{oct}}(n) - \text{harmonic\_ratio}|^2 < 4\xi \tag{160}$$

- Application to frequency calculations:

$$f_{\text{ratio}} = \frac{f_2}{f_1} = \frac{q}{p} \tag{161}$$

$$f_{\text{beat}} = |f_2 - f_1| = f_0 \times |q - p| \tag{162}$$

- Advantage: In complex calculations with many operations (especially FFT and spectral analyses), rounding errors can accumulate. Ratio-based calculation minimizes this effect by:
  - Reducing the number of operations
  - Avoiding differences between large numbers
  - Stabilizing numerical precision across a wider range of values
  - Enabling direct comparison with harmonic ratios without conversion