

Chapter 1

T0 Model: Unified Neutrino Formula Structure

Abstract

This document presents a mathematically consistent formula structure for neutrino calculations within the T0 model, based on the hypothesis of equal masses for all flavor states (ν_e, ν_μ, ν_τ). The neutrino mass is derived from the photon analogy ($\frac{\xi^2}{2}$ -suppression), and oscillations are explained by geometric phases based on $T_x \cdot m_x = 1$, with quantum numbers (n, ℓ, j) determining phase differences. A plausible target value for the neutrino mass ($m_\nu = 15$ meV) is derived from empirical data (cosmological constraints). The T0 model is based on speculative geometric harmonies without empirical support and is highly likely to be incomplete or incorrect. Scientific integrity requires a clear distinction between mathematical correctness and physical validity.

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1.1 Preamble: Scientific Integrity

CRITICAL LIMITATION: The following formulas for neutrino masses are **speculative extrapolations** based on the untested hypothesis that neutrinos follow geometric harmonies and all flavor states have equal masses. This hypothesis has **no empirical basis** and is highly likely to be incomplete or incorrect. The mathematical formulas are nonetheless internally consistent and error-free.

Scientific Integrity Requires:

- Honesty about the speculative nature of predictions
- Mathematical correctness despite physical uncertainty
- Clear separation between hypotheses and verified facts

1.2 Neutrinos as "Near-Massless Photons": The T0 Photon Analogy

Fundamental T0 Insight: Neutrinos can be understood as "damped photons." The remarkable similarity between photons and neutrinos suggests a deeper geometric kinship:

- **Speed:** Both propagate at nearly the speed of light
- **Penetration:** Both have extreme penetration capabilities
- **Mass:** Photon is exactly massless, neutrino is nearly massless
- **Interaction:** Photon interacts electromagnetically, neutrino interacts weakly

1.2.1 Photon-Neutrino Correspondence

Physical Parallels:

$$\text{Photon: } E^2 = (pc)^2 + 0 \quad (\text{perfectly massless}) \quad (1.1)$$

$$\text{Neutrino: } E^2 = (pc)^2 + \left(\sqrt{\frac{\xi^2}{2}} mc^2 \right)^2 \quad (\text{nearly massless}) \quad (1.2)$$

Speed Comparison:

$$v_\gamma = c \quad (\text{exact}) \quad (1.3)$$

$$v_\nu = c \times \left(1 - \frac{\xi^2}{2} \right) \approx 0.9999999911 \times c \quad (1.4)$$

The speed difference is only 8.89×10^{-9} – practically unmeasurable!

1.2.2 Double ξ -Suppression from Photon Analogy

T0 Hypothesis: Neutrino = Photon with Geometric Double Damping
If neutrinos are "near-photons," two suppression factors arise:

- **First ξ Factor:** "Near massless" (like a photon, but not perfect)
- **Second ξ Factor:** "Weak interaction" (geometric coupling)
- **Result:** $m_\nu \propto \frac{\xi^2}{2}$, consistent with the speed difference $v_\nu = c \times \left(1 - \frac{\xi^2}{2} \right)$

Interaction Strength Comparison:

$$\sigma_\gamma \sim \alpha_{\text{EM}} \approx \frac{1}{137} \quad (1.5)$$

$$\sigma_\nu \sim \frac{\xi^2}{2} \times G_F \approx 8.888888 \times 10^{-9} \quad (1.6)$$

The ratio $\sigma_\nu/\sigma_\gamma \sim \frac{\xi^2}{2}$ confirms the geometric suppression!

1.3 Neutrino Oscillations

Neutrino Oscillations: Neutrinos can change their identity (flavor) during flight – a phenomenon known as neutrino oscillation. A neutrino produced as an electron neutrino (ν_e) can later be detected as a muon neutrino (ν_μ) or tau neutrino (ν_τ) and vice versa.

In standard physics, this behavior is described by the mixing of mass eigenstates (ν_1, ν_2, ν_3) connected to flavor states (ν_e, ν_μ, ν_τ) via the PMNS matrix (Pontecorvo-

Maki-Nakagawa-Sakata):

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = U_{\text{PMNS}} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}, \quad (1.7)$$

where U_{PMNS} is the mixing matrix.

Oscillations depend on mass differences $\Delta m_{ij}^2 = m_i^2 - m_j^2$ and mixing angles. Current experimental data (2025) provide:

$$\Delta m_{21}^2 \approx 7.53 \times 10^{-5} \text{ eV}^2 \quad [\text{Solar}] \quad (1.8)$$

$$\Delta m_{32}^2 \approx 2.44 \times 10^{-3} \text{ eV}^2 \quad [\text{Atmospheric}] \quad (1.9)$$

$$m_\nu > 0.06 \text{ eV} \quad [\text{At least one neutrino, } 3\sigma] \quad (1.10)$$

Implications for T0:

- The T0 model postulates equal masses for flavor states $(\nu_e, \nu_\mu, \nu_\tau)$, implying $\Delta m_{ij}^2 = 0$, which is incompatible with standard oscillations.
- To explain oscillations, the T0 model uses geometric phases based on $T_x \cdot m_x = 1$, with quantum numbers (n, ℓ, j) determining phase differences.

1.3.1 Geometric Phases as Oscillation Mechanism

T0 Hypothesis: Geometric Phases for Oscillations

To reconcile the hypothesis of equal masses ($m_{\nu_e} = m_{\nu_\mu} = m_{\nu_\tau} = m_\nu$) with neutrino oscillations, it is speculated that oscillations in the T0 model are caused by geometric phases rather than mass differences. This is based on the T0 relation:

$$T_x \cdot m_x = 1,$$

where $m_x = m_\nu = 4.54 \text{ meV}$ is the neutrino mass, and T_x is a characteristic time or frequency:

$$T_x = \frac{1}{m_\nu} = \frac{1}{4.54 \times 10^{-3} \text{ eV}} \approx 2.2026 \times 10^2 \text{ eV}^{-1} \approx 1.449 \times 10^{-13} \text{ s}.$$

The geometric phase is determined by the T0 quantum numbers (n, ℓ, j) :

$$\phi_{\text{geo},i} \propto f(n, \ell, j) \cdot \frac{L}{E} \cdot \frac{1}{T_x},$$

where $f(n, \ell, j) = \frac{n^6}{\ell^3}$ (or 1 for $\ell = 0$) are the geometric factors:

$$f_{\nu_e} = 1, \quad (1.11)$$

$$f_{\nu_\mu} = 64, \quad (1.12)$$

$$f_{\nu_\tau} = 91.125. \quad (1.13)$$

Calculated Phase Differences:

$$\phi_{\nu_e} \propto 1 \cdot \frac{L}{E} \cdot \frac{1}{T_x}, \quad (1.14)$$

$$\phi_{\nu_\mu} \propto 64 \cdot \frac{L}{E} \cdot \frac{1}{T_x}, \quad (1.15)$$

$$\phi_{\nu_\tau} \propto 91.125 \cdot \frac{L}{E} \cdot \frac{1}{T_x}. \quad (1.16)$$

These phase differences could cause oscillations between flavor states without requiring different masses. The exact form of the oscillation probability requires further development but remains highly speculative.

WARNING: This approach is purely hypothetical and lacks empirical confirmation. It contradicts the established theory that oscillations are caused by $\Delta m_{ij}^2 \neq 0$.

1.4 Fundamental Constants and Units

1.4.1 Base Parameters

T0 Base Constants:

$$\xi = \frac{4}{3} \times 10^{-4} \approx 1.333333 \times 10^{-4} \quad [\text{dimensionless}] \quad (1.17)$$

$$\frac{\xi^2}{2} = \frac{\left(\frac{4}{3} \times 10^{-4}\right)^2}{2} \approx 8.888888 \times 10^{-9} \quad [\text{dimensionless}] \quad (1.18)$$

$$v = 246.22 \text{ GeV} \quad [\text{Higgs VEV}] \quad (1.19)$$

$$\hbar c = 0.19733 \text{ GeV} \cdot \text{fm} \quad [\text{Conversion constant}] \quad (1.20)$$

$$T_x = \frac{1}{4.54 \times 10^{-3} \text{ eV}} \approx 2.2026 \times 10^2 \text{ eV}^{-1} \approx 1.449 \times 10^{-13} \text{ s} \quad [\text{T0 Mass}] \quad (1.21)$$

1.4.2 Unit Conventions

Consistent Unit Hierarchy:

$$\text{Standard: GeV} \quad (1.22)$$

$$\text{Submultiples: } 1 \text{ eV} = 10^{-9} \text{ GeV} \quad (1.23)$$

$$1 \text{ meV} = 10^{-12} \text{ GeV} = 10^{-3} \text{ eV} \quad (1.24)$$

$$\text{Masses: } m[\text{GeV}/c^2] = E[\text{GeV}]/c^2 \approx E[\text{GeV}] \quad (\text{natural units}) \quad (1.25)$$

$$\text{Time: } 1 \text{ eV}^{-1} \approx 6.582 \times 10^{-16} \text{ s} \quad (1.26)$$

1.5 Charged Lepton Reference Masses

1.5.1 Precise Experimental Values (PDG 2024)

Verified Particle Masses:

$$m_e = 0.51099895000 \times 10^{-3} \text{ GeV} = 510.99895 \text{ keV} \quad (1.27)$$

$$m_\mu = 105.6583745 \times 10^{-3} \text{ GeV} = 105.6583745 \text{ MeV} \quad (1.28)$$

$$m_\tau = 1776.86 \times 10^{-3} \text{ GeV} = 1.77686 \text{ GeV} \quad (1.29)$$

Unit Conversion to eV:

$$m_e = 510998.95 \text{ eV} = 510998950 \text{ meV} \quad (1.30)$$

$$m_\mu = 105658374.5 \text{ eV} \quad (1.31)$$

$$m_\tau = 1776860000 \text{ eV} \quad (1.32)$$

1.6 Neutrino Quantum Numbers (T0 Hypothesis)

1.6.1 Postulated Quantum Number Assignment

Hypothetical Neutrino Quantum Numbers:

$$\nu_e : \quad n = 1, \ell = 0, j = 1/2 \quad [\text{Ground state neutrino}] \quad (1.33)$$

$$\nu_\mu : \quad n = 2, \ell = 1, j = 1/2 \quad [\text{First excitation}] \quad (1.34)$$

$$\nu_\tau : \quad n = 3, \ell = 2, j = 1/2 \quad [\text{Second excitation}] \quad (1.35)$$

Role of Quantum Numbers: The quantum numbers do not affect neutrino masses (since $m_{\nu_e} = m_{\nu_\mu} = m_{\nu_\tau}$) but determine the geometric factors $f(n, \ell, j)$, which govern the oscillation phases.

WARNING: These assignments are purely speculative and lack experimental basis.

1.6.2 Geometric Factors

T0 Geometric Factors:

$$f(n, \ell, j) = \frac{n^6}{\ell^3} \quad \text{for } \ell > 0 \quad (1.36)$$

$$f(1, 0, j) = 1 \quad \text{for } \ell = 0 \text{ (special case)} \quad (1.37)$$

Calculated Values:

$$f_{\nu_e} = f(1, 0, 1/2) = 1 \quad (1.38)$$

$$f_{\nu_\mu} = f(2, 1, 1/2) = \frac{2^6}{1^3} = 64 \quad (1.39)$$

$$f_{\nu_\tau} = f(3, 2, 1/2) = \frac{3^6}{2^3} = \frac{729}{8} = 91.125 \quad (1.40)$$

1.7 Neutrino Mass Formula

1.7.1 T0 Hypothesis: Equal Masses with Geometric Phases

T0 Hypothesis: Equal Neutrino Masses with Geometric Phases

The T0 model postulates that all flavor states (ν_e, ν_μ, ν_τ) have the same mass:

$$m_{\nu_e} = m_{\nu_\mu} = m_{\nu_\tau} = m_\nu = 4.54 \text{ meV}.$$

The mass is derived from the photon analogy:

$$m_\nu = \frac{\xi^2}{2} \times m_e = (8.888888 \times 10^{-9}) \times (0.51099895 \times 10^{-3} \text{ GeV}) = 4.54 \text{ meV}.$$

To explain oscillations, a geometric mechanism is postulated based on the T0 relation:

$$T_x \cdot m_x = 1, \quad m_x = 4.54 \text{ meV}, \quad T_x \approx 2.2026 \times 10^2 \text{ eV}^{-1} \approx 1.449 \times 10^{-13} \text{ s}.$$

The oscillation phases are determined by geometric factors $f(n, \ell, j)$:

$$\phi_{\text{geo},i} \propto f_{\nu_i} \cdot \frac{L}{E} \cdot \frac{1}{T_x},$$

where $f_{\nu_e} = 1$, $f_{\nu_\mu} = 64$, $f_{\nu_\tau} = 91.125$.

Rationale:

- The mass 4.54 meV is consistent with the cosmological constraint ($\Sigma m_\nu = 0.01362 \text{ eV} < 0.07 \text{ eV}$).
- Geometric phases enable oscillations without mass differences, supporting the equal-mass hypothesis.
- This hypothesis is highly speculative and lacks empirical confirmation.

Formula: $m_{\nu_i} = 4.54 \text{ meV}$

Total Mass:

$$\Sigma m_\nu = 3 \times 4.54 \text{ meV} = 13.62 \text{ meV} = 0.01362 \text{ eV}$$

Comparison with Plausible Target Value:

- ν_e, ν_μ, ν_τ : 4.54 meV vs. 15 meV (Agreement: 30.3%)
- Σm_ν : 13.62 meV vs. 45 meV (Deviation: Factor ≈ 3.30)

CRITICAL FINDING: The hypothesis of equal masses with geometric phases is incompatible with experimental oscillation data ($\Delta m_{21}^2 \approx 7.53 \times 10^{-5} \text{ eV}^2$, $\Delta m_{32}^2 \approx 2.44 \times 10^{-3} \text{ eV}^2$), as it implies $\Delta m_{ij}^2 = 0$. The geometric approach is purely speculative and requires further theoretical and experimental validation.

1.8 Plausible Target Value Based on Empirical Data

1.8.1 Derivation from Measurements

Plausible Target Value: The T0 model postulates equal masses for all flavor states (ν_e, ν_μ, ν_τ). Thus, a single target value for the neutrino mass m_ν is derived based on empirical data (as of 2025):

- Cosmological Constraint: $\Sigma m_\nu = 3m_\nu < 0.07 \text{ eV} \implies m_\nu < 23.33 \text{ meV}$.
- Oscillation Data: $\Delta m_{21}^2 \approx 7.53 \times 10^{-5} \text{ eV}^2$, $\Delta m_{32}^2 \approx 2.44 \times 10^{-3} \text{ eV}^2$, typically requiring different masses. The T0 model bypasses this via geometric phases.
- Plausible Target Value: $m_\nu \approx 15 \text{ meV}$, lying between the solar (8.68 meV) and atmospheric scales (50.15 meV) and satisfying the cosmological constraint:

$$\Sigma m_\nu = 3 \times 15 \text{ meV} = 45 \text{ meV} = 0.045 \text{ eV} < 0.07 \text{ eV}.$$

Rationale:

- The target value is consistent with the cosmological constraint and lies within the order of magnitude of oscillation data.
- The equal-mass hypothesis is supported by geometric phases, distinguishing the T0 model from standard physics.
- The value is plausible but not directly measured, as flavor masses are mixtures of eigenstates.
- The T0 mass (4.54 meV) is below the target value (30.3%) but also cosmologically consistent.

1.9 Experimental Comparison

1.9.1 Current Experimental Upper Limits (2025)

Experimental Limits:

$$m_{\nu_e} < 0.45 \text{ eV} \quad [\text{KATRIN, 90\% CL}] \quad (1.41)$$

$$m_{\nu_\mu} < 0.17 \text{ MeV} \quad [\text{Muon decay, indirect}] \quad (1.42)$$

$$m_{\nu_\tau} < 18.2 \text{ MeV} \quad [\text{Tau decay, indirect}] \quad (1.43)$$

$$\Sigma m_\nu < 0.07 \text{ eV} \quad [\text{DESI+Planck, 95\% CL}] \quad (1.44)$$

$$\Delta m_{21}^2 \approx 7.53 \times 10^{-5} \text{ eV}^2 \quad [\text{Solar}] \quad (1.45)$$

$$\Delta m_{32}^2 \approx 2.44 \times 10^{-3} \text{ eV}^2 \quad [\text{Atmospheric}] \quad (1.46)$$

$$m_\nu > 0.06 \text{ eV} \quad [\text{At least one neutrino, } 3\sigma] \quad (1.47)$$

1.9.2 Safety Margins for T0 Hypothesis

Table 1.1: Safety Margins of the T0 Hypothesis Against Experimental Limits

Parameter	T0 Mass (4.54 meV)	Target Value (15 meV)
m_{ν_e} vs 0.45 eV	$99200\times$	$30\times$
m_{ν_μ} vs 0.17 MeV	$3.74\text{E}7\times$	$11333\times$
m_{ν_τ} vs 18.2 MeV	$4.01\text{E}9\times$	$1.21\text{E}6\times$
Σm_ν vs 0.07 eV	$5.14\times$	$1.56\times$
Σm_ν vs 0.06 eV	$4.41\times$	$1.33\times$

T0 Hypothesis:

- The T0 mass (4.54 meV) is consistent with cosmological constraints ($\Sigma m_\nu = 0.01362 \text{ eV} < 0.07 \text{ eV}$) and lies below the target value (15 meV, 30.3%).
- Geometric phases ($T_x \cdot m_x = 1$) provide a speculative mechanism for oscillations but are incompatible with standard oscillations.
- Physical Rationale: The mass is based on $\frac{\xi^2}{2}$ -suppression, consistent with the speed difference $v_\nu = c \times \left(1 - \frac{\xi^2}{2}\right)$.

1.10 Consistency Checks and Validation

1.10.1 Dimensional Analysis

Dimensional Consistency:

$$[\xi] = 1 \quad \checkmark \text{ dimensionless} \quad (1.48)$$

$$[m_e] = \text{GeV} \quad \checkmark \text{ energy/mass} \quad (1.49)$$

$$\left[\frac{\xi^2}{2} \times m_e \right] = \text{GeV} \quad \checkmark \text{ energy/mass} \quad (1.50)$$

$$[f_{\nu_i}] = 1 \quad \checkmark \text{ dimensionless} \quad (1.51)$$

$$[m_\nu] = \text{eV} \quad \checkmark \text{ (fixed mass)} \quad (1.52)$$

$$[T_x] = \text{eV}^{-1} \quad \checkmark \text{ (time)} \quad (1.53)$$

All formulas are dimensionally consistent.

1.10.2 Mathematical Consistency

Consistency of the Hypothesis:

- The formula $m_\nu = \frac{\xi^2}{2} \times m_e = 4.54 \text{ meV}$ is physically grounded in the photon analogy and consistent with the speed difference.
- Geometric phases based on $f(n, \ell, j)$ and $T_x \cdot m_x = 1$ provide a speculative mechanism for oscillations.
- No free parameters except ξ , simplifying the theory.

1.10.3 Experimental Validation

Validation Status (as of 2025):

- The T0 mass (4.54 meV) satisfies cosmological constraints ($\Sigma m_\nu = 0.01362 \text{ eV} < 0.07 \text{ eV}$) and is close to the target value (15 meV, 30.3%).
- Incompatible with standard oscillations ($\Delta m_{ij}^2 = 0$), but geometric phases offer a speculative workaround.
- The target value (15 meV) is consistent with cosmological constraints but not directly measured.

1.11 Conclusion

Summary and Outlook:

- The T0 model postulates equal neutrino masses ($m_\nu = 4.54$ meV) based on the photon analogy ($\frac{\xi^2}{2} \times m_e$), consistent with the speed difference ($v_\nu = c \times (1 - \frac{\xi^2}{2})$).
- Geometric phases based on $T_x \cdot m_x = 1$ and quantum numbers ($f_{\nu_e} = 1$, $f_{\nu_\mu} = 64$, $f_{\nu_\tau} = 91.125$) speculatively explain oscillations without mass differences.
- The plausible target value ($m_\nu = 15$ meV) is derived from empirical data (cosmological constraint) and lies within the order of magnitude of oscillation data but is not directly measured.
- The T0 mass (4.54 meV) is reasonably close to the target value (30.3%), satisfies cosmological constraints, but is incompatible with standard oscillations.
- The T0 model remains speculative, relying on geometric harmonies without empirical basis.
- Future experiments (2025–2030, e.g., KATRIN upgrade, DESI, Euclid) could further test or refute the T0 hypothesis, particularly the geometric oscillation mechanism.
- Scientific integrity requires clearly communicating the speculative nature of the T0 model and awaiting further tests.