Neutrino Formula

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Kapitel 1

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Zusammenfassung

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 $(\nu_e, \nu_\mu, \nu_\tau)$. 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.

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:

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

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

Speed Comparison:

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

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

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:

$$\sigma_\gamma \sim \alpha_{\text{EM}} \approx \frac{1}{137} \tag{1.5}$$

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

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):

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

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:

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

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

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

Implications for T0:

- The T0 model postulates equal masses for flavor states (ν_e, ν_μ, ν_τ), 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 $m_x = m_\nu = 4.54$ 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:

$$f_{\nu_e} = 1, \tag{1.11}$$
$$f_{\nu_\mu} = 64, \tag{1.12}$$
$$f_{\nu_\tau} = 91.125. \tag{1.13}$$

Calculated Phase Differences:

$$\phi_{\nu_e} \propto 1 \cdot \frac{L}{E} \cdot \frac{1}{T_x}, \tag{1.14}$$
$$\phi_{\nu_\mu} \propto 64 \cdot \frac{L}{E} \cdot \frac{1}{T_x}, \tag{1.15}$$
$$\phi_{\nu_\tau} \propto 91.125 \cdot \frac{L}{E} \cdot \frac{1}{T_x}. \tag{1.16}$$

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 $\Delta m^2_{ij} \neq 0$.

1.4 Fundamental Constants and Units

1.4.1 Base Parameters

T0 Base Constants:

$$\xi = \frac{4}{3} \times 10^{-4} \approx 1.333333 \times 10^{-4} \quad \text{[dimensionless]} \tag{1.17}$$
$$\frac{\xi^2}{2} = \frac{\left(\frac{4}{3} \times 10^{-4}\right)^2}{2} \approx 8.888888 \times 10^{-9} \quad \text{[dimensionless]} \tag{1.18}$$
$$v = 246.22\ \text{GeV} \quad \text{[Higgs VEV]} \tag{1.19}$$
$$\hbar c = 0.19733\ \text{GeV·fm} \quad \text{[Conversion constant]} \tag{1.20}$$
$$T_x = \frac{1}{4.54 \times 10^{-3}\ \text{eV}} \approx 2.2026 \times 10^2\ \text{eV}^{-1} \approx 1.449 \times 10^{-13}\ \text{s} \quad \text{[T0 Mass]} \tag{1.21}$$

1.4.2 Unit Conventions

Consistent Unit Hierarchy:

$$\text{Standard:} \quad \text{GeV} \tag{1.22}$$
$$\text{Submultiples:} \quad 1\ \text{eV} = 10^{-9}\ \text{GeV} \tag{1.23}$$
$$1\ \text{meV} = 10^{-12}\ \text{GeV} = 10^{-3}\ \text{eV} \tag{1.24}$$
$$\text{Masses:} \quad m[\text{GeV}/c^2] = E[\text{GeV}]/c^2 \approx E[\text{GeV}]\ \text{(natural units)} \tag{1.25}$$
$$\text{Time:} \quad 1\ \text{eV}^{-1} \approx 6.582 \times 10^{-16}\ \text{s} \tag{1.26}$$

1.5 Charged Lepton Reference Masses

1.5.1 Precise Experimental Values (PDG 2024)

Verified Particle Masses:

$$m_e = 0.51099895000 \times 10^{-3}\ \text{GeV} = 510.99895\ \text{keV} \tag{1.27}$$
$$m_\mu = 105.6583745 \times 10^{-3}\ \text{GeV} = 105.6583745\ \text{MeV} \tag{1.28}$$
$$m_\tau = 1776.86 \times 10^{-3}\ \text{GeV} = 1.77686\ \text{GeV} \tag{1.29}$$

Unit Conversion to eV:

$$m_e = 510998.95\ \text{eV} = 510998950\ \text{meV} \tag{1.30}$$
$$m_\mu = 105658374.5\ \text{eV} \tag{1.31}$$
$$m_\tau = 1776860000\ \text{eV} \tag{1.32}$$

1.6 Neutrino Quantum Numbers (T0 Hypothesis)

1.6.1 Postulated Quantum Number Assignment

Hypothetical Neutrino Quantum Numbers:

$$\nu_e: \quad n = 1, \ell = 0, j = 1/2 \quad \text{[Ground state neutrino]} \tag{1.33}$$
$$\nu_\mu: \quad n = 2, \ell = 1, j = 1/2 \quad \text{[First excitation]} \tag{1.34}$$
$$\nu_\tau: \quad n = 3, \ell = 2, j = 1/2 \quad \text{[Second excitation]} \tag{1.35}$$

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:

$$f(n, \ell, j) = \frac{n^6}{\ell^3} \quad \text{for } \ell > 0 \tag{1.36}$$
$$f(1, 0, j) = 1 \quad \text{for } \ell = 0 \text{ (special case)} \tag{1.37}$$

Calculated Values:

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

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

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

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 $(\nu_e, \nu_\mu, \nu_\tau)$ 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:

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

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 ($\Sigma m_\nu = 0.01362$ eV $<$ 0.07 eV).
- Geometric phases enable oscillations without mass differences, supporting the equal-mass hypothesis.
- This hypothesis is highly speculative and lacks empirical confirmation.

Formula: $m_{\nu_i} = 4.54$ 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 ($\Delta m^2_{21} \approx 7.53 \times 10^{-5}$ eV^2, $\Delta m^2_{32} \approx 2.44 \times 10^{-3}$ eV^2), as it implies $\Delta m^2_{ij} = 0$. 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 $(\nu_e, \nu_\mu, \nu_\tau)$. Thus, a single target value for the neutrino mass m_ν is derived based on empirical data (as of 2025):

- Cosmological Constraint: $\Sigma m_\nu = 3m_\nu < 0.07$ eV $\implies m_\nu < 23.33$ meV.
- Oscillation Data: $\Delta m^2_{21} \approx 7.53 \times 10^{-5}$ eV^2, $\Delta m^2_{32} \approx 2.44 \times 10^{-3}$ eV^2, typically requiring different masses. The T0 model bypasses this via geometric phases.
- Plausible Target Value: $m_\nu \approx 15$ 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:

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

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

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

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

$$\Delta m^2_{21} \approx 7.53 \times 10^{-5} \text{ eV}^2 \quad \text{[Solar]} \tag{1.45}$$

$$\Delta m^2_{32} \approx 2.44 \times 10^{-3} \text{ eV}^2 \quad \text{[Atmospheric]} \tag{1.46}$$

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

1.9.2 Safety Margins for T0 Hypothesis

Tabelle 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×	30×
m_{ν_μ} vs 0.17 MeV	3.74E7×	11333×
m_{ν_τ} vs 18.2 MeV	4.01E9×	1.21E6×
Σm_ν vs 0.07 eV	5.14×	1.56×
Σm_ν vs 0.06 eV	4.41×	1.33×

T0 Hypothesis:

- The T0 mass (4.54 meV) is consistent with cosmological constraints ($\Sigma m_\nu = 0.01362$ eV $<$ 0.07 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:

$$[\xi] = 1 \quad \checkmark \text{ dimensionless} \tag{1.48}$$
$$[m_e] = \text{GeV} \quad \checkmark \text{ energy/mass} \tag{1.49}$$
$$\left[\frac{\xi^2}{2} \times m_e\right] = \text{GeV} \quad \checkmark \text{ energy/mass} \tag{1.50}$$
$$[f_{\nu_i}] = 1 \quad \checkmark \text{ dimensionless} \tag{1.51}$$
$$[m_\nu] = \text{eV} \quad \checkmark \text{ (fixed mass)} \tag{1.52}$$
$$[T_x] = \text{eV}^{-1} \quad \checkmark \text{ (time)} \tag{1.53}$$

All formulas are dimensionally consistent.

1.10.2 Mathematical Consistency

Consistency of the Hypothesis:

- The formula $m_\nu = \frac{\xi^2}{2} \times m_e = 4.54$ 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 ($\Sigma m_\nu = 0.01362$ eV $<$ 0.07 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 ($v_\nu = c \times \left(1 - \frac{\xi^2}{2}\right)$).
- 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.

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