

# Neutrino Formula

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# Capítulo 1

## Neutrino Formula

## Resumen

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  $(n, \ell, j)$  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:

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

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

#### 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  $8,89 \times 10^{-9}$  – practically unmeasurable!

### 1.2.2. Double $\xi$ -Suppression from Photon Analogy

**T0 Hypothesis:** Neutrino = Photon with Geometric Double Damping

If neutrinos are "near-photons," two suppression factors arise:

- **First  $\xi$  Factor:** "Near massless" (like a photon, but not perfect)
- **Second  $\xi$  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 ( $\nu_e$ ) can later be detected as a muon neutrino ( $\nu_\mu$ ) or tau neutrino ( $\nu_\tau$ ) and vice versa.

In standard physics, this behavior is described by the mixing of mass eigenstates ( $\nu_1, \nu_2, \nu_3$ ) connected to flavor states ( $\nu_e, \nu_\mu, \nu_\tau$ ) 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  $U_{\text{PMNS}}$  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  $(n, \ell, j)$  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  $(n, \ell, j)$ :

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

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:**

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

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

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

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

$$\text{Time: } 1 \text{ eV}^{-1} \approx 6,582 \times 10^{-16} \text{ s} \quad (1.26)$$

## 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:**

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

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

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

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

$$m_\nu = \frac{\xi^2}{2} \times m_e = (8,888888 \times 10^{-9}) \times (0,51099895 \times 10^{-3} \text{ GeV}) = 4,54 \text{ meV}.$$

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:**

- $\nu_e, \nu_\mu, \nu_\tau$ : 4,54 meV vs. 15 meV (Agreement: 30,3%)
- $\Sigma m_\nu$ : 13,62 meV vs. 45 meV (Deviation: Factor  $\approx 3,30$ )

**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 ( $\nu_e, \nu_\mu, \nu_\tau$ ). Thus, a single target value for the neutrino mass  $m_\nu$  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

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

Parameter	T0 Mass (4,54 meV)	Target Value (15 meV)
$m_{\nu_e}$ vs 0.45 eV	$99200\times$	$30\times$
$m_{\nu_\mu}$ vs 0.17 MeV	$3.74\text{E}7\times$	$11333\times$
$m_{\nu_\tau}$ vs 18.2 MeV	$4.01\text{E}9\times$	$1.21\text{E}6\times$
$\Sigma m_\nu$ vs 0.07 eV	$5.14\times$	$1.56\times$
$\Sigma m_\nu$ 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  $\xi$ , 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 ( $m_\nu = 4,54 \text{ meV}$ ) 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 ( $m_\nu = 15 \text{ meV}$ ) 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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