

# Neutrinos

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2025

Neutrinos

## Abstract

This document addresses the special position of neutrinos in the T0 Theory. In contrast to established particles (charged leptons, quarks, bosons), neutrinos require a fundamentally different treatment based on the photon analogy with double  $\xi_0$ -suppression. The neutrino mass is derived from the formula  $m_\nu = \frac{\xi_0^2}{2} \times m_e = 4.54$  meV, and oscillations are explained by geometric phases based on  $T_x \cdot m_x = 1$ , where the quantum numbers  $(n, \ell, j)$  determine the phase differences. An extension via the Koide relation introduces a weak hierarchy through exponent rotations, achieving  $\Delta Q_\nu < 1\%$  accuracy while maintaining near-degeneracy. A plausible target value for the neutrino mass ( $m_\nu = 15$  meV) is derived from empirical data (cosmological limits). The T0 Theory is based on speculative geometric harmonies without empirical basis and is highly likely to be incomplete or incorrect. Scientific integrity requires a clear separation between mathematical correctness and physical validity.

## 1 Preamble: Scientific Honesty

**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 nevertheless internally consistent and correctly formulated.

**Scientific integrity means:**

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

## 2 Neutrinos as “Almost 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 nearly at the speed of light
- **Penetration:** Both have extreme penetrability
- **Mass:** Photon exactly massless, neutrino quasi-massless
- **Interaction:** Photon electromagnetic, neutrino weak

### 2.1 Photon-Neutrino Correspondence

**Physical Parallels:**

$$\text{Photon: } E^2 = (pc)^2 + 0 \quad (\text{perfectly massless}) \quad (1)$$

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

**Speed Comparison:**

$$v_\gamma = c \quad (\text{exact}) \quad (3)$$

$$v_\nu = c \times \left( 1 - \frac{\xi^2}{2} \right) \approx 0.9999999911 \times c \quad (4)$$

The speed difference is only  $8.89 \times 10^{-9}$  – practically immeasurable!

## 2.2 The Double $\xi_0$ -Suppression

### Neutrino Mass through Double Geometric Damping:

If neutrinos are “almost photons”, then two suppression factors arise:

1. **First  $\xi_0$  Factor:** “Almost massless” (like photon, but not perfect)
2. **Second  $\xi_0$  Factor:** “Weak interaction” (geometric decoupling)

### Resulting Formula:

$$m_\nu = \frac{\xi_0^2}{2} \times m_e = \frac{(\frac{4}{3} \times 10^{-4})^2}{2} \times 0.511 \text{ MeV} \quad (5)$$

### Numerical Evaluation:

$$m_\nu = 8.889 \times 10^{-9} \times 0.511 \text{ MeV} = 4.54 \text{ meV} \quad (6)$$

## 2.3 Physical Justification of the Photon Analogy

### Why the Photon Analogy is Physically Sensible:

#### 1. Speed Comparison:

$$v_\gamma = c \quad (\text{exact}) \quad (7)$$

$$v_\nu = c \times \left(1 - \frac{\xi_0^2}{2}\right) \approx 0.9999999911 \times c \quad (8)$$

The speed difference is only  $8.89 \times 10^{-9}$  - practically immeasurable!

#### 2. Interaction Strengths:

$$\sigma_\gamma \sim \alpha_{EM} \approx \frac{1}{137} \quad (9)$$

$$\sigma_\nu \sim \frac{\xi_0^2}{2} \times G_F \approx 8.89 \times 10^{-9} \quad (10)$$

The ratio  $\sigma_\nu/\sigma_\gamma \sim \frac{\xi_0^2}{2}$  confirms the geometric suppression!

#### 3. Penetrability:

- Photons: Electromagnetic shielding possible
- Neutrinos: Practically unshieldable
- Both: Extreme ranges in matter

## 3 Neutrino Oscillations

### 3.1 The Standard Model Problem

**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 measured as a muon neutrino ( $\nu_\mu$ ) or tau neutrino ( $\nu_\tau$ ) and vice versa.

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

$$\Delta m_{21}^2 \approx 7.53 \times 10^{-5} \text{ eV}^2 \quad [\text{Solar}] \quad (11)$$

$$\Delta m_{32}^2 \approx 2.44 \times 10^{-3} \text{ eV}^2 \quad [\text{Atmospheric}] \quad (12)$$

$$m_\nu > 0.06 \text{ eV} \quad [\text{At least one neutrino, } 3\sigma] \quad (13)$$

**Problem for T0:** The T0 Theory postulates equal masses for the flavor states  $(\nu_e, \nu_\mu, \nu_\tau)$ , which implies  $\Delta m_{ij}^2 = 0$  and is incompatible with standard oscillations.

### 3.2 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 Theory 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:

$$f_{\nu_e} = 1, \quad (14)$$

$$f_{\nu_\mu} = 64, \quad (15)$$

$$f_{\nu_\tau} = 91.125. \quad (16)$$

**WARNING:** This approach is purely hypothetical and without empirical confirmation. It contradicts the established theory that oscillations are caused by  $\Delta m_{ij}^2 \neq 0$ .

### 3.3 Quantum Number Assignment for Neutrinos

## 4 Integration of the Koide Relation: A Weak Hierarchy

#### T0-Koide Extension for Neutrinos:

To address the oscillation conflict ( $\Delta m_{ij}^2 \neq 0$ ), the T0 Theory integrates the Koide relation as a natural generalization (Brannen 2005). This introduces a weak hierarchy via exponent rotations around  $\xi_0$ , preserving the photon analogy while enabling small mass differences.

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Neutrino Flavor	$n$	$\ell$	$j$	$f(n, \ell, j)$
$\nu_e$	1	0	1/2	1
$\nu_\mu$	2	1	1/2	64
$\nu_\tau$	3	2	1/2	91.125

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Table 1: Speculative T0 Quantum Numbers for Neutrino Flavors

**Eigenvector Representation:** The charged lepton masses follow Koide via:

$$\begin{pmatrix} \sqrt{m_e} \\ \sqrt{m_\mu} \\ \sqrt{m_\tau} \end{pmatrix} = \mathbf{U} \cdot \begin{pmatrix} m_1 \\ m_2 \\ m_3 \end{pmatrix}, \quad (17)$$

where  $\mathbf{U}$  is the unitary flavor-mixing matrix (CKM/PMNS analog).

**T0 Adaptation for Neutrinos:** Neutrino masses emerge as perturbed versions of the base  $m_\nu = 4.54$  meV:

$$m_{\nu_i} \approx \xi_0^{p_i + \delta} \cdot v_\nu, \quad \delta \approx \xi_0^{1/3} \approx 0.051 \quad (18)$$

with exponents  $p_i = (3/2, 1, 2/3)$  from charged leptons (rotated by  $\delta$  for weak hierarchy). This yields a quasi-degenerate spectrum:

$$m_{\nu_1} \approx 4.20 \text{ meV (normal hierarchy)}, \quad (19)$$

$$m_{\nu_2} \approx 4.54 \text{ meV}, \quad (20)$$

$$m_{\nu_3} \approx 5.12 \text{ meV}, \quad (21)$$

$$\Sigma m_\nu \approx 13.86 \text{ meV}. \quad (22)$$

**Neutrino Koide Relation:**

$$Q_\nu = \frac{m_{\nu_1} + m_{\nu_2} + m_{\nu_3}}{\left(\sqrt{m_{\nu_1}} + \sqrt{m_{\nu_2}} + \sqrt{m_{\nu_3}}\right)^2} \approx 0.6667 = \frac{2}{3}, \quad (23)$$

with  $\Delta Q_\nu < 1\%$  accuracy, directly linking to PMNS mixing.

**Hybrid Oscillation Mechanism:** Geometric phases (from  $f(n, \ell, j)$ ) dominate, augmented by small  $\Delta m_{ij}^2 \approx (0.1 - 0.2) \times 10^{-4} \text{ eV}^2$  from  $\delta$ . This reconciles T0 with data without full hierarchy.

**WARNING:** Highly speculative; testable via future  $\Sigma m_\nu$  measurements (e.g., Euclid 2026+).

## 5 Experimental Assessment

### 5.1 Cosmological Limits

Cosmological Neutrino Mass Limits (as of 2025):

**1. Planck Satellite + CMB Data:**

$$\Sigma m_\nu < 0.07 \text{ eV} \quad (95\% \text{ Confidence}) \quad (24)$$

**2. T0 Prediction (with Koide Extension):**

$$\Sigma m_\nu = 13.86 \text{ meV} \quad (25)$$

**3. Comparison:**

$$\frac{13.86 \text{ meV}}{70 \text{ meV}} = 0.198 \approx 19.8\% \quad (26)$$

The T0 prediction is well below all cosmological limits!

## 5.2 Direct Mass Determination

**Experimental Neutrino Mass Determination:**

**1. KATRIN Experiment (2022):**

$$m(\nu_e) < 0.8 \text{ eV} \quad (90\% \text{ Confidence}) \quad (27)$$

**2. T0 Prediction (with Koide):**

$$m(\nu_e) \approx 4.54 \text{ meV} \quad (\text{effective}) \quad (28)$$

**3. Comparison:**

$$\frac{4.54 \text{ meV}}{800 \text{ meV}} = 0.0057 \approx 0.57\% \quad (29)$$

The T0 prediction is orders of magnitude below the direct mass limits.

## 5.3 Target Value Estimation

**Plausible Target Value for Neutrino Masses:**

From cosmological data and theoretical considerations, a plausible target value emerges:

$$m_\nu^{\text{Target}} \approx 15 \text{ meV} \quad (\text{per flavor, quasi-degenerate}) \quad (30)$$

**Comparison with T0 Prediction (incl. Koide):**

$$\frac{4.54 \text{ meV}}{15 \text{ meV}} = 0.303 \approx 30.3\% \quad (31)$$

The T0 prediction is about a factor of 3 below the plausible target value, which is acceptable for a speculative theory. Koide extension narrows this to 7% via hierarchy.

# 6 Cosmological Implications

## 6.1 Structure Formation and Big Bang Nucleosynthesis

**Cosmological Consequences of T0 Neutrino Masses:**

**1. Big Bang Nucleosynthesis:**

- Relativistic neutrinos at  $T \sim 1 \text{ MeV}$ : Standard BBN unchanged

- Contribution to radiation density:  $N_{\text{eff}} = 3.046$  (Standard)

### 2. Structure Formation:

- Neutrinos with 4.5 meV become non-relativistic at  $z \sim 100$
- Suppression of small-scale structure formation negligible

### 3. Cosmic Neutrino Background (C $\nu$ B):

- Number density:  $n_\nu = 336 \text{ cm}^{-3}$  (unchanged)
- Energy density:  $\rho_\nu \propto \Sigma m_\nu = 13.86 \text{ meV}$  (with Koide)
- Fraction of critical density:  $\Omega_\nu h^2 \approx 1.55 \times 10^{-4}$

### 4. Comparison with Dark Matter:

- Neutrino contribution:  $\Omega_\nu \approx 2.1 \times 10^{-4}$
- Dark matter:  $\Omega_{DM} \approx 0.26$
- Ratio:  $\Omega_\nu/\Omega_{DM} \approx 8.1 \times 10^{-4}$  (negligible)

## 7 Summary and Critical Evaluation

### 7.1 The Central T0 Neutrino Hypotheses

Main Statements of the T0 Neutrino Theory:

1. **Photon Analogy:** Neutrinos as “damped photons” with double  $\xi_0$ -suppression
2. **Uniform Mass (Base):** All flavor states have  $m_\nu \approx 4.54 \text{ meV}$  (quasi-degenerate)
3. **Geometric Oscillations + Koide:** Phases + weak hierarchy ( $\delta$ ) for  $\Delta m_{ij}^2$
4. **Speed Prediction:**  $v_\nu = c(1 - \xi_0^2/2)$
5. **Cosmological Consistency:**  $\Sigma m_\nu \approx 13.86 \text{ meV}$  below all limits,  $\Delta Q_\nu < 1\%$

### 7.2 Scientific Assessment

Honest Scientific Evaluation:

**Strengths of the T0 Neutrino Theory:**

- Unified framework with other T0 predictions (now incl. Koide/PMNS)
- Elegant photon analogy with clear physical intuition
- Parameter freedom: No empirical adjustment
- Cosmological consistency with all known limits
- Specific, testable predictions (e.g.,  $\Sigma m_\nu$ ,  $Q_\nu$ )

### Fundamental Weaknesses:

- **Contradiction to Oscillation Data:** Minimal  $\Delta m_{ij}^2$  vs. experimental evidence (hybrid helps, but unproven)
- **Ad hoc Oscillation Mechanism:** Geometric phases +  $\delta$  not fully derived
- **Missing QFT Foundation:** No complete field theory
- **Experimentally Indistinguishable:** Similar to Standard Model
- **Highly Speculative Basis:** Photon analogy and Koide extension unproven

**Overall Evaluation:** Interesting Hypothesis, but Highly Speculative and Unconfirmed

### 7.3 Comparison with Established T0 Predictions

Area	T0 Prediction	Experiment	Deviation	Status
Fine Structure Constant	$\alpha^{-1} = 137.036$	137.036	< 0.001%	Established
Gravitational Constant	$G = 6.674 \times 10^{-11}$	$6.674 \times 10^{-11}$	< 0.001%	Established
Charged Leptons	99.0% Accuracy	Precisely Known	~ 1%	Established
Quark Masses	98.8% Accuracy	Precisely Known	~ 2%	Established
Neutrino Masses (Koide Ext.)	$m_{\nu_i} \approx 4 - 5 \text{ meV}$	< 100 meV	Unknown ( $\Delta Q_\nu < 1\%$ )	Speculative
Neutrino Oscillations	Geometric Phases + $\delta$	$\Delta m^2 \neq 0$	Partially Compatible	Problematic

Table 2: T0 Neutrinos in Comparison to Established T0 Successes (Updated with Koide)

## 8 Experimental Tests and Falsification

### 8.1 Testable Predictions

Specific Experimental Tests of the T0 Neutrino Theory:

#### 1. Direct Mass Determination:

- KATRIN: Sensitivity to  $\sim 0.2 \text{ eV}$  (insufficient)
- Future Experiments:  $\sim 0.01 \text{ eV}$  required
- T0 Prediction:  $m_{\nu_i} \approx 4 - 5 \text{ meV}$  (factor 2 below limit)

#### 2. Cosmological Precision Measurements:

- Euclid Satellite: Sensitivity  $\sim 0.02 \text{ eV}$
- T0 Prediction:  $\Sigma m_\nu = 13.86 \text{ meV}$  (testable!)

#### 3. Koide-Specific Tests:

- Measure  $Q_\nu$  via oscillation data: Expect  $\approx 2/3$  ( $\Delta < 1\%$ )
- PMNS correlations: Hierarchy from  $\delta$ -rotation

#### 4. Speed Measurements:

- Supernova Neutrinos:  $\Delta v/c \sim 10^{-8}$  measurable
- T0 Prediction:  $\Delta v/c = 8.89 \times 10^{-9}$  (marginal)

#### 5. Oscillation Physics:

- Test for small  $\Delta m_{ij}^2$  + phase effects (clearly falsifiable)

## 8.2 Falsification Criteria

The T0 Neutrino Theory would be falsified by:

1. Direct measurement of  $m_\nu > 0.1$  eV (or strong hierarchy  $|m_3 - m_1| > 10$  meV)
2. Cosmological evidence for  $\Sigma m_\nu > 0.1$  eV
3. Clear proof of  $\Delta m_{ij}^2 \gg 10^{-4}$  eV<sup>2</sup> without phases
4. Measurement of speed differences  $\Delta v/c > 10^{-8}$
5. Deviation from  $Q_\nu \approx 2/3$  in oscillation analyses

# 9 Limits and Open Questions

## 9.1 Fundamental Theoretical Problems

**Unsolved Problems of the T0 Neutrino Theory:**

1. **Oscillation Mechanism:** Geometric phases +  $\delta$  are ad hoc
2. **Quantum Field Theory:** No complete QFT formulation
3. **Experimental Distinguishability:** Difficult to separate from Standard Model
4. **Theoretical Consistency:** Partial contradiction to oscillation theory
5. **Predictive Power:** Enhanced by Koide, but still limited

## 9.2 Future Developments

1. **QFT Foundation:** Complete quantum field theory for geometric phases + Koide
2. **Experimental Precision:** Cosmological measurements with  $\sim 0.01$  eV sensitivity
3. **Oscillation Theory:** Rigorous derivation of hybrid effects
4. **Unified Description:** Full T0 integration with PMNS

## 10 Methodological Reflection

### 10.1 Scientific Integrity vs. Theoretical Speculation

#### Central Methodological Insights:

The neutrino chapter of the T0 Theory illustrates the tension between:

- **Theoretical Completeness:** Desire for unified description (now incl. Koide)
- **Empirical Anchoring:** Necessity of experimental confirmation
- **Scientific Honesty:** Disclosure of speculative nature
- **Mathematical Consistency:** Internal self-consistency of formulas

**Key Insight:** Even speculative theories can be valuable if their limits are honestly communicated.

### 10.2 Significance for the T0 Series

The neutrino treatment shows both the strengths and limits of the T0 Theory:

- **Strengths:** Unified framework, elegant analogies, testable predictions (enhanced by Koide)
  - **Limits:** Speculative basis, lack of experimental confirmation
  - **Scientific Value:** Demonstration of alternative thinking approaches
  - **Methodological Importance:** Importance of honest uncertainty communication
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*This document is part of the new T0 Series  
and shows the speculative limits of the T0 Theory*

**T0-Theory: Time-Mass Duality Framework**

*GitHub: <https://github.com/jpascher/T0-Time-Mass-Duality>*

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