Neutrino Oscillations as Internal Mode Interference in the Vacuum Pressure Field

Carlos Omeñaca Prado

December 2025

Abstract

Neutrino oscillations constitute one of the most robustly confirmed phenomena in modern experimental physics, yet their conventional explanation relies on the introduction of extremely small but otherwise unexplained neutrino masses, flavor mixing matrices, and auxiliary parameters with no independent ontological grounding. In this work we show that neutrino oscillations arise naturally and unavoidably within the framework of Quarkbase Cosmology, where the neutrino is identified as the fundamental compactation of the Ψ-field (N = 1), and all physical phenomena emerge from the dynamics of a continuous, frictionless medium.

We demonstrate that neutrino oscillations do not correspond to transitions between distinct particles, but to interference between internal vibrational modes of a single elemental entity propagating through the Ψ-field. The observed oscillation probabilities, their characteristic dependence on the ratio L/E, the existence of two independent oscillation scales, and the modification of oscillations in matter all follow directly from phase accumulation and dispersion of longitudinal Ψ-modes, without invoking Dirac or Majorana mass terms, fundamental flavor symmetries, or a PMNS mixing matrix. The standard phenomenology is recovered as an effective description, while the underlying mechanism is reinterpreted as a mode-beating process intrinsic to the neutrino–quarkbase itself.

Contents

1 Conceptual Foundations and Observational Context

1.1 The Observational Problem of Neutrino Oscillations

Neutrino oscillations were established experimentally through solar, atmospheric, reactor, and accelerator experiments, which revealed that neutrinos produced in association with a given charged lepton are later detected with probabilities corresponding to other leptonic channels. These probabilities vary periodically with propagation distance and energy, exhibiting several universal features:

1. Oscillation probabilities depend primarily on the ratio of baseline length to neutrino energy, L/E.
2. At least two independent oscillation scales are required to account for experimental data.
3. Oscillations are modified when neutrinos propagate through matter, indicating sensitivity to environmental conditions.
4. The phenomenon is coherent over macroscopic distances, implying extremely weak dissipation.
5. Possible asymmetries between neutrinos and antineutrinos remain under investigation and are not yet decisively established.

Importantly, none of these observations directly measure neutrino mass. What is measured is phase-dependent interference between components of a propagating quantum state.

In the Standard Model extension commonly adopted, neutrino oscillations are explained by postulating that flavor eigenstates are superpositions of mass eigenstates, with tiny but nonzero mass differences. This explanation introduces several structural difficulties:

- The neutrino masses are many orders of magnitude smaller than those of other fermions, with no known generation mechanism.
- Flavor mixing is encoded in an empirical matrix (PMNS) with no derivation from deeper principles.
- Oscillations require the coexistence of multiple neutrino "species" whose ontological distinction remains unclear.
- The mechanism is disconnected from the rest of particle physics, which treats mass generation through unrelated assumptions.

These issues motivate the search for a more fundamental explanation rooted in a unified physical ontology.

1.2 Neutrino Ontology in Quarkbase Cosmology

Quarkbase Cosmology is founded on a single ontological postulate: there exists one real physical medium, the Ψ-field, continuous, elastic, and frictionless, from which all physical phenomena arise through discrete compactations and their associated vibrational dynamics.

Within this framework:

- The neutrino is not one particle among many, but the most elementary possible compactation of the Ψ-field.
- This compactation is denoted $N = 1$ and constitutes the minimal displaced volume compatible with Ψ-continuity.
- The neutrino–quarkbase is absolutely stable and serves as the fundamental carrier of Ψ-field phase.
- All higher structures—electrons, protons, nuclei, and macroscopic matter—are formed from organized assemblies of $N = 1$ units.

Crucially, the neutrino is not characterized by intrinsic "mass" as a primitive property. What is experimentally interpreted as mass corresponds instead to deformation energy of the Ψ-field associated with compactation. For the neutrino, this energy is minimal but nonzero, reflecting its role as a phase carrier rather than a localized inertial object.

This identification radically alters the conceptual landscape of neutrino physics. Oscillations can no longer be interpreted as transitions between distinct fundamental particles, since only one such entity exists at the base level.

1.3 Internal Structure of the Neutrino–Quarkbase

Although the neutrino is the simplest compactation, it is not dynamically trivial. The Ψ-field enforces continuity and elasticity, which permit discrete internal vibrational modes even within minimal closures.

In Quarkbase Cosmology, the neutrino supports three distinct internal oscillatory configurations, corresponding to:

- an electronic mode,
- a muonic mode,
- a tauonic mode.

These are not separate particles, nor are they flavors in the conventional sense. They are internal phase patterns of the same $N = 1$ compactation, distinguished by how the neutrino couples to larger cuarquic structures and to the surrounding Ψ-field.

The existence of exactly three such modes is not assumed *ad hoc*. It mirrors the same structural principle that yields discrete and finite mode spectra in higher compactations, such as the three-degree-of-freedom resonant system responsible for the charged lepton hierarchy. The neutrino thus already contains, in embryonic form, the modal structure that later manifests in the leptonic sector.

1.4 Rethinking "Flavor" as a Measurement Effect

In this framework, what experimental physics calls "neutrino flavor" is not an intrinsic label attached to the neutrino itself. Instead, it is a property of the interaction channel through which the neutrino is produced or detected.

A neutrino produced in beta decay alongside an electron is prepared in a state that couples preferentially to the electronic mode of the neutrino–quarkbase. A detector sensitive to muons projects the incoming neutrino state onto the muonic mode, and similarly for tau channels.

Thus, production and detection define boundary conditions on the neutrino's internal state, rather than revealing a fixed identity. Between emission and detection, the neutrino propagates freely as a superposition of its internal modes.

This shift—from intrinsic flavor to interaction-dependent projection—is the conceptual pivot that allows oscillations to be understood without introducing new particles or masses.

1.5 From Ontology to Interference

Given a neutrino prepared in a superposition of internal modes and propagating through a continuous medium, oscillations become unavoidable.

Each internal mode propagates with a slightly different phase velocity, determined by its coupling to the Ψ-field. As the neutrino travels, phase differences accumulate between these modes. Detection probabilities then depend on the interference pattern resulting from their superposition.

At this stage, no assumptions beyond those already present in Quarkbase Cosmology are required. Oscillations are not an added mechanism; they are the natural dynamical expression of internal structure interacting with a continuous medium.

2 Dynamical Formalism and Emergence of the Oscillation Law

2.1 Propagation of the Neutrino as a Superposition of Internal Modes

Once a neutrino–quarkbase ($N = 1$) is produced, it propagates through the Ψ-field as a localized excitation carrying phase information. Because the neutrino possesses multiple internal vibrational modes, its physical state during propagation is described as a superposition of these modes.

Let $|i\rangle$ denote the internal vibrational eigenmodes of the neutrino, with $i = 1, 2, 3$ corresponding to the electronic, muonic, and tauonic configurations. The propagating neutrino state may be written as

$$|\nu(t)\rangle = \sum_{i=1}^{3} c_i \, e^{-i\omega_i t} \, |i\rangle, \tag{1}$$

where the coefficients c_i are determined by the production process, and ω_i are the angular frequencies associated with each internal mode.

These frequencies are not fundamental constants. They arise from the interaction between the neutrino's internal structure and the elastic response of the surrounding Ψ-field. Because the Ψ-field is continuous and frictionless, all modes propagate coherently over macroscopic distances.

2.2 Oscillation as Mode Beating

Consider a neutrino produced in association with an electron. This preparation corresponds to a specific linear combination of internal modes,

$$|\nu_e\rangle = \sum_i U_{ei} |i\rangle, \tag{2}$$

where the coefficients U_{ei} encode how the electronic interaction channel couples to the neutrino's internal structure. Similarly, detection in a muonic channel corresponds to projection onto

$$|\nu_\mu\rangle = \sum_i U_{\mu i} |i\rangle. \tag{3}$$

The transition amplitude from an electronic to a muonic channel after a propagation time t is then

$$A_{e\to\mu}(t) = \langle \nu_\mu | \nu(t) \rangle = \sum_i U_{\mu i} U_{ei}^* e^{-i\omega_i t}. \tag{4}$$

The corresponding transition probability is

$$P_{e\to\mu}(t) = |A_{e\to\mu}(t)|^2 \,. \tag{5}$$

This expression contains all the ingredients necessary to produce oscillatory behavior. Interference between terms with different ω_i generates periodic variations in detection probability.

For the simplest case of two dominant modes, the probability reduces to the familiar beating form,

$$P_{a\to b}(t) = \sin^2\left(\frac{\Delta\omega \, t}{2}\right), \tag{6}$$

where $\Delta\omega = \omega_2 - \omega_1$. This is the universal mathematical structure underlying neutrino oscillations.

2.3 Absence of Intrinsic Neutrino Mass

In this formulation, oscillations arise entirely from phase differences between internal modes. No intrinsic particle masses are required.

The frequencies ω_i do not correspond to rest energies $m_i c^2$. They represent vibrational eigenfrequencies of the neutrino–Ψ system. What experiments conventionally interpret as "effective mass-squared differences" are, in this framework, merely parametrizations of frequency splittings between internal modes.

This reinterpretation eliminates the need to introduce Dirac or Majorana mass terms, as well as the conceptual problem of explaining why neutrino masses are so anomalously small compared to other fermions.

2.4 Emergence of the L/E Dependence

One of the most striking features of neutrino oscillations is their dependence on the ratio of propagation distance L to neutrino energy E. This dependence arises naturally from the dispersive properties of longitudinal Ψ-modes.

The neutrino propagates as an ultrarelativistic excitation of the Ψ-field. For such excitations, the wave number associated with a given internal mode may be expanded as

$$k_i(\omega) \simeq \frac{\omega}{c_\Psi} + \frac{\alpha_i}{E}, \tag{7}$$

where c_Ψ is the characteristic propagation speed of Ψ-field disturbances, and α_i are small, mode-dependent coefficients encoding the interaction between the neutrino's internal structure and the medium.

The accumulated phase for mode i after traveling a distance L is

$$\phi_i \simeq k_i L - \omega t. \tag{8}$$

For coherent propagation, the relative phase between two modes becomes

$$\Delta\phi_{ij} \simeq \frac{(\alpha_i - \alpha_j)L}{E}. \tag{9}$$

Thus, the oscillation phase depends directly on the ratio L/E, exactly as observed experimentally.

In the conventional formalism, this dependence is written as

$$\Delta\phi_{ij} = \frac{\Delta m_{ij}^2\, L}{2E}, \tag{10}$$

where Δm_{ij}^2 are treated as fundamental parameters. In Quarkbase Cosmology, these quantities are not masses but effective parameters encoding mode-dependent dispersion of the Ψ-field.

2.5 Interpretation of the Two Observed Oscillation Scales

Experimental data require two independent oscillation scales. In the Quarkbase framework, this requirement follows immediately from the existence of three internal modes.

With three frequencies $\omega_1, \omega_2, \omega_3$, there are two independent frequency differences. These differences manifest as two distinct oscillation lengths. No additional assumptions are required, and no hidden degrees of freedom need to be introduced.

The observed hierarchy between oscillation scales reflects the relative separation between the internal vibrational modes of the neutrino–quarkbase.

2.6 Coherence and Long-Range Stability

Neutrino oscillations are observed over distances ranging from kilometers to astronomical units. Such coherence is difficult to reconcile with conventional particle models unless neutrino masses are extraordinarily small.

In Quarkbase Cosmology, long-range coherence is expected. The Ψ-field is frictionless, and neutrinos are stable compactations that do not dissipate energy during propagation. Internal mode coherence is preserved precisely because the neutrino is not a composite particle subject to decay, but a fundamental phase structure of the medium itself.

2.7 Scope and Status of the Framework

The present work is not intended as a complete field-theoretic reformulation of neutrino physics, nor as a finished Lagrangian theory. Its purpose is more fundamental and prior: to identify the minimal physical and ontological structure required to account for the observed phenomenology of neutrino oscillations.

The formalism developed here reorganizes existing observables—such as oscillation frequencies, effective mixing parameters, and matter-induced modifications—into a coherent physical interpretation grounded in the dynamics of the Ψ-field and the internal structure of the neutrino–quarkbase. At this stage, these quantities are treated as effective parameters encoding measurable properties of the medium and its excitations, rather than as derived constants of a finalized dynamical action.

The construction of explicit Lagrangian realizations or effective field-theoretic limits compatible with this framework is left for subsequent work, once the underlying physical ontology has been clearly established.

3 Matter Effects, Environmental Dependence, and Experimental Phenomenology

Ontological Status of the Ψ-Field

The Ψ-field is not introduced as an additional gauge field or as a new interaction layered on top of the Standard Model. It represents the physical substrate whose excitations and compactations constitute all observable degrees of freedom within the Quarkbase framework.

As such, the Ψ-field does not add independent observable particles or forces. Instead, it provides the continuous medium in which phase, propagation, and coherence acquire direct physical meaning. In this sense, the role of the Ψ-field is conceptually closer to that of spacetime structure in general relativity than to that of a conventional quantum field with independent dynamics.

3.1 Propagation Through Matter and the Origin of MSW Effects

One of the decisive confirmations of neutrino oscillations is the observation that oscillation patterns change when neutrinos propagate through matter. In the standard formalism, this phenomenon is described by introducing an effective potential generated by coherent forward scattering with electrons, leading to the Mikheyev–Smirnov–Wolfenstein (MSW) effect.

In Quarkbase Cosmology, no additional potentials or interaction fields are required. The explanation follows directly from the physical nature of the Ψ-field.

Matter is not an external background imposed on neutrinos; it is itself a structured state of the Ψ-field formed by dense assemblies of quarkbase compactations. When a neutrino propagates through matter, it traverses a region where:

- the local Ψ-field tension is modified,
- phase stiffness differs from that of the free medium,
- boundary conditions imposed by nearby compactations alter the effective response of the field.

As a consequence, the internal vibrational frequencies ω_i of the neutrino–quarkbase are shifted by small, mode-dependent amounts. This modifies the accumulated phase differences between modes and therefore changes the oscillation probabilities.

The MSW effect thus emerges naturally as an environmental modification of mode propagation in the Ψ-field, not as a new force or interaction. The formal equivalence with the standard MSW phenomenology is complete, but the ontological interpretation is fundamentally different.

3.2 Why Matter Effects Depend on the Leptonic Environment

A key empirical fact is that matter effects depend primarily on electron density. In the Quarkbase framework, this dependence follows from the structure of leptonic compactations.

Electrons correspond to the first stable compact closure beyond the neutrino, with $N = 13$. They strongly couple to the Ψ-field through torsional and compressive modes that are absent in neutral baryonic matter alone. As a result, regions with high electron density modify the Ψ-field phase structure more efficiently than regions dominated by neutrons or protons.

Because the electronic mode of the neutrino–quarkbase couples most strongly to these distortions, the effective frequency shifts are mode-selective. This naturally explains why oscillations involving the electronic channel are particularly sensitive to matter effects, while purely muonic or tauonic channels are less affected.

3.3 Reinterpretation of Effective Mixing Parameters

In the standard framework, neutrino oscillations are described using a unitary mixing matrix with several angles and a CP-violating phase. These parameters are fitted to experimental data but lack a deeper physical interpretation.

In Quarkbase Cosmology, these parameters acquire a clear meaning:

- Mixing angles quantify the geometric overlap between production and detection channels and internal vibrational modes.
- They depend on how different leptonic resonators couple to the neutrino's internal structure.
- They are therefore not fundamental constants of nature, but effective parameters determined by interaction geometry.

This explains why mixing parameters appear stable across experiments but are not derivable from first principles within the Standard Model. They are emergent descriptors of projection geometry, not indicators of hidden particle identities.

3.4 Neutrinos and Antineutrinos: Phase Orientation, Not Mirror Particles

The question of CP violation in the neutrino sector remains open experimentally. In Quarkbase Cosmology, neutrinos and antineutrinos are not separate species defined by independent quantum numbers.

Instead, they correspond to opposite orientations of internal phase and torsion within the same $N = 1$ compactation. This distinction becomes relevant only in environments where the Ψ-field responds asymmetrically to phase orientation.

If the Ψ-field exhibits nonlinear or anisotropic responses to opposite phase configurations—particularly in dense or structured media—then neutrinos and antineutrinos will accumulate different phases along the same trajectory. This can produce apparent CP asymmetries without invoking a fundamental CP-violating term in the underlying dynamics.

Such asymmetries are therefore expected to depend on:

- propagation distance,
- energy,
- matter density,

- and the specific leptonic environment.

This prediction is compatible with the current experimental situation, where CP violation is hinted at but not conclusively established and appears entangled with mass-ordering assumptions in the standard formalism.

3.5 Why Three Flavors and No More

A persistent conceptual question in neutrino physics is why exactly three flavors exist. In the Standard Model, this fact is simply imposed.

In Quarkbase Cosmology, the answer is structural. The neutrino–quarkbase supports a finite number of stable internal vibrational modes permitted by Ψ-continuity at the $N = 1$ level. These modes correspond to the minimal degrees of freedom required to maintain phase coherence while allowing coupling to higher compactations.

No additional stable modes exist at this level. Introducing further independent oscillation channels would require additional internal degrees of freedom that are forbidden by the topology of the minimal compactation. Thus, the existence of exactly three neutrino modes is not an arbitrary feature of nature but a geometric necessity.

3.6 Long-Baseline and Atmospheric Neutrinos

The Quarkbase formulation naturally accounts for oscillations observed in long-baseline and atmospheric experiments.

Because oscillations depend on phase accumulation rather than particle decay, coherence can be maintained over planetary and even astrophysical distances. The frictionless nature of the Ψ-field ensures that internal mode interference remains intact over such scales.

Atmospheric neutrinos, which span wide ranges of energies and path lengths, provide a natural laboratory for probing deviations from ideal L/E scaling. In Quarkbase Cosmology, small departures from pure L/E behavior may appear at extreme energies or long baselines, reflecting higher-order dispersive corrections of the Ψ-field.

Such deviations represent genuine discriminators between the Quarkbase framework and mass-based explanations.

3.7 Relation to Existing Experimental Data

All existing oscillation data—solar, atmospheric, reactor, and accelerator—can be reproduced within this framework by appropriate identification of effective mode frequencies and coupling coefficients.

Importantly, no contradiction arises with current global fits. What changes is the interpretation of fitted parameters. Instead of inferring tiny masses and arbitrary mixing matrices, experimental results are reinterpreted as measurements of internal mode structure and Ψ-field response.

The Quarkbase framework therefore does not compete with experimental data; it subsumes them into a deeper physical explanation.

4 Falsifiable Predictions, Discriminators, and Conceptual Closure

4.1 Falsifiability as a Structural Requirement

A physical framework is scientific only if it identifies not only what it explains, but also how it could fail. Quarkbase Cosmology is no exception. The reinterpretation of neutrino oscillations presented here leads to concrete, experimentally testable consequences that differ in principle from mass-based explanations.

These differences do not rely on speculative parameters or inaccessible regimes. They emerge directly from the ontology of a continuous Ψ-field and the internal structure of the neutrino–quarkbase.

4.2 Prediction I: Existence of an Additional Weak Oscillation Frequency

Because the neutrino possesses three internal vibrational modes, interference is not limited to the two dominant frequency differences typically extracted in standard analyses. A third, weaker oscillation frequency must exist, corresponding to higher-order interference between internal modes.

In conventional analyses, such a frequency would appear as a small-amplitude modulation superimposed on the dominant oscillation pattern and could easily be absorbed into noise or systematic uncertainty. In the Quarkbase framework, its existence is unavoidable.

Detection of a subleading oscillation frequency with consistent phase behavior across experiments would strongly support an internal-mode interpretation and challenge explanations based solely on two independent mass-squared differences.

4.3 Prediction II: Controlled Deviations from Exact L/E Scaling

The standard oscillation formula assumes perfect L/E scaling across all energies. In Quarkbase Cosmology, this scaling is an approximation arising from the leading-order dispersive behavior of longitudinal Ψ-modes.

At sufficiently high energies or extremely long baselines, higher-order terms in the dispersion relation should become relevant, producing small but systematic deviations from pure L/E behavior. These deviations are expected to be:

- smooth rather than abrupt,
- energy-dependent,
- coherent across different experimental baselines.

Atmospheric neutrinos at high energies and future ultra-long-baseline experiments provide the natural testing ground for this prediction.

4.4 Prediction III: Environmental Dependence Beyond Standard MSW

While the MSW effect is well established, Quarkbase Cosmology predicts that environmental dependence is not limited to electron density alone. Any configuration that significantly modifies the local Ψ-field—such as extreme density gradients, strong electromagnetic torsion, or highly ordered cuarquic structures—should influence oscillation behavior.

This opens the possibility of subtle oscillation anomalies in environments not traditionally considered in neutrino physics, such as dense astrophysical plasmas or regions with intense electromagnetic activity. Observation of such effects would be difficult to reconcile with purely weak-interaction-based explanations.

4.5 Prediction IV: Apparent CP Asymmetry as a Medium-Dependent Effect

If CP asymmetries in neutrino oscillations are confirmed, Quarkbase Cosmology predicts that they will not be universal constants. Instead, the magnitude and even the sign of apparent asymmetry may depend on:

- matter density profiles,
- path geometry,
- energy regime.

A rigid, environment-independent CP phase would favor fundamental CP violation. A context-dependent asymmetry would point toward a phase-orientation effect in the Ψ-field, as described here.

4.6 Conceptual Economy and Unification

The Quarkbase explanation of neutrino oscillations achieves a significant reduction in conceptual complexity:

- No fundamental neutrino masses are required.
- No flavor eigenstates exist as ontological entities.
- No PMNS matrix is postulated.
- No additional fields or symmetries are introduced.

Oscillations emerge as a necessary consequence of internal structure and medium propagation, fully aligned with the broader Quarkbase unification of interactions, matter, and spacetime behavior.

The neutrino is not an anomaly requiring special treatment. It is the elemental unit of physical reality, behaving exactly as such a unit must behave in a continuous medium.

4.7 Relation to the Broader Quarkbase Framework

This work integrates seamlessly with the wider body of Quarkbase Cosmology:

- The identification of the neutrino as the fundamental phase carrier underpins weak interactions.
- The emergence of leptonic families from internal mode structure parallels the resonant origin of charged lepton masses.
- The role of the Ψ-field in oscillations mirrors its role in gravitation, electromagnetism, and large-scale structure formation.

Neutrino oscillations thus become a central pillar of the framework rather than an isolated phenomenon.

4.8 Operational Falsifiability Criterion

Beyond qualitative reinterpretation, the present framework admits direct empirical discrimination. In particular, any confirmed and reproducible deviation from strict L/E scaling at extreme energies or ultra-long baselines, incompatible with mass-based dispersion relations but consistent across experimental environments, would constitute a decisive test of the present interpretation.

Conversely, the absence of such deviations within future high-precision atmospheric or long-baseline data would place strong constraints on the viability of a medium-based explanation of neutrino oscillations. The framework is therefore not insulated from experimental refutation, but explicitly exposes itself to it.

4.9 Conclusion

Neutrino oscillations do not require hidden particles, infinitesimal masses, or arbitrary mixing matrices. They require only what the universe demonstrably possesses: a continuous medium capable of sustaining coherent phase dynamics and a minimal compactation capable of internal vibration.

Within Quarkbase Cosmology, neutrino oscillations are revealed as the simplest nontrivial dynamical expression of the Ψ-field itself. They are not a mystery added onto an otherwise complete theory; they are an expected and illuminating consequence of the universe's most elementary structure.

By reinterpreting neutrino oscillations as interference between internal modes of the neutrino–quarkbase propagating through the Ψ-field, Quarkbase Cosmology provides a unified, ontologically economical, and experimentally distinguishable explanation of one of modern physics' most compelling phenomena. All observed features—oscillation patterns, L/E dependence, matter effects, and coherence—emerge naturally, while new falsifiable predictions invite decisive experimental tests.

References

[1] B. Pontecorvo, Inverse beta processes and nonconservation of lepton charge, Sov. Phys. JETP **7**, 172 (1958).

[2] Z. Maki, M. Nakagawa, and S. Sakata, Remarks on the unified model of elementary particles, Prog. Theor. Phys. **28**, 870 (1962).

[3] Y. Fukuda et al. (Super-Kamiokande Collaboration), Evidence for oscillation of atmospheric neutrinos, Phys. Rev. Lett. **81**, 1562 (1998).

[4] Q. R. Ahmad et al. (SNO Collaboration), Direct evidence for neutrino flavor transformation from neutral-current interactions, Phys. Rev. Lett. **89**, 011301 (2002).

[5] K. Eguchi et al. (KamLAND Collaboration), First results from KamLAND: Evidence for reactor antineutrino disappearance, Phys. Rev. Lett. **90**, 021802 (2003).

[6] L. Wolfenstein, Neutrino oscillations in matter, Phys. Rev. D **17**, 2369 (1978).

[7] S. P. Mikheyev and A. Y. Smirnov, Resonance amplification of oscillations in matter and solar neutrino spectroscopy, Sov. J. Nucl. Phys. **42**, 913 (1985).

[8] R. L. Workman et al. (Particle Data Group), Review of Particle Physics, Prog. Theor. Exp. Phys. **2024**, 083C01 (2024).

[9] I. Esteban, M. C. Gonzalez-Garcia, M. Maltoni, T. Schwetz, and A. Zhou, The fate of hints: updated global analysis of three-flavor neutrino oscillations, JHEP **09**, 178 (2020), updated results available at http://www.nu-fit.org.

[10] C. Giunti and C. W. Kim, *Fundamentals of Neutrino Physics and Astrophysics*, Oxford University Press (2007).

[11] B. Kayser, Neutrino mass, mixing, and flavor change, Phys. Rept. **333**, 1 (2000).

[12] M. Faraday, Thoughts on Ray Vibrations, Philosophical Magazine **28**, 345 (1846).

[13] A. Einstein, On the electrodynamics of moving bodies, Ann. Phys. **17**, 891 (1905).

[14] A. Einstein, The foundation of the general theory of relativity, Ann. Phys. **49**, 769 (1916).

[15] C. Omenaca Prado, *Genesis Quarkbase: A New Genesis for Physics*, Zenodo (2025).

[16] C. Omenaca Prado, General Cosmology of Quarkbase (Neutrino), Zenodo Preprint (2025).