List of observed phenomena unexplained by the Standard Model that the Cosmology of the Quarkbase will address one by one

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Listado de fenómenos observados que el Modelo Estándar no explica y que la Cosmología del Quarkbase abordará uno por uno

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Introduction

The **Standard Model** of particle physics accurately describes countless processes, yet it does not explain the origin of many of its constants, hierarchies, and symmetries. **Quarkbase Cosmology (QBC)** emerges as a unifying framework that conceives the universe not as a collection of point-like particles, but as a vibrant fabric of fundamental units—*quarkbase (Qb)*—interacting with a dynamic plasmatic vacuum.

This document outlines a list of phenomena that current physics cannot explain, and which we will address using the Quarkbase Theory in subsequent publications

1 Leptonic Mass Hierarchy (e, μ, τ).

Unexplained in the Standard Model: there is no physical reason why the electron, muon, and tau should differ so drastically in mass.

Based on Quarkbase Theory: If leptons are *color–neutral resonant states* formed by quasi–neutralized **quarkbase pairs** $(Q_b$–$antiQ_b)$, their masses would arise from the same stiffness matrix that governs quarks, but under **different boundary conditions** (no color coupling). Thus (e, μ, τ) correspond to distinct **vibrational modes** of a Q_b–$antiQ_b$ system within the vacuum plasma.

Key formulas:

1. **Total mass** (for a $(Q_b - \overline{Q_b})$ state without color coupling):

$$M_\ell = 2m_0 + E_{\text{vib}}, \qquad E_{\text{vib}} = \sum_i \tfrac{1}{2}\hbar\omega_i.$$

(Interpretation: different vibrational modes ω_i correspond to different lepton masses.)

2. **Mode condition** (color–free boundary condition, $k_{\text{color}} \to 0$):

$$\det\big(K_{\text{lept}}(k_{\text{env}})/m_0 - \omega^2 \mathbb{I}\big) = 0,$$

where K_{lept} is the stiffness matrix of the $(Q_b - \overline{Q_b})$ pair. Distinct eigenfrequencies ω correspond to the observed leptons (e, μ, τ).

References

[1] Omeñaca Prado, Carlos (2025). Explaining Quark Flavors and Masses through Quarkbase Cosmology. figshare. Preprint.

2 Neutrino Oscillations

Unexplained: neutrino oscillations require tiny but unexplained masses.

Based on Quarkbase Theory: Neutrinos may be **longitudinal modes of vibration** of the vacuum plasma. Their oscillations arise naturally from **beatings between nearly degenerate frequencies** of Q_b resonances — phase shifts between local vacuum pressures produce conversions ($\nu_e \leftrightarrow \nu_\mu \leftrightarrow \nu_\tau$) without invoking Dirac mass terms.

Key formulas:

1. **Beating between two nearby modes** (conversion probability of "beating" type):

$$P_{a\to b}(t) = \sin^2\!\Big(\tfrac{\Delta\omega\, t}{2}\Big), \qquad \Delta\omega = \omega_2 - \omega_1.$$

   (Interpretation: neutrino oscillation as interference between vacuum vibrational modes.)

2. **Mapping to the standard parametrization** (order of magnitude): for ultrarelativistic states,

$$\Delta\omega \simeq \frac{\Delta m^2}{2E\hbar} \quad \Rightarrow \quad P \sim \sin^2\!\Big(\frac{\Delta m^2 L}{4E\hbar}\Big),$$

   which links the frequency difference of the quarkbase system to the effective mass-squared difference used in neutrino oscillation experiments.

3 Color Confinement and the Hadronic Transition

In QCD: confinement is known numerically but lacks an analytic foundation.

Based on Quarkbase Theory: Color confinement follows from the **self-pressure of the vacuum plasma**, which forbids stable configurations with more than three coupled Q_b. Adding a fourth introduces unstable eigenmodes.

Key formulas:

1. **Coupled Hamiltonian of an N–Q_b system** (as introduced in the manuscript):

$$H_q = \sum_{i=1}^{N} \Big(\frac{p_i^2}{2m_0} + \tfrac{1}{2}k_i x_i^2\Big) + \sum_{i<j} k_{ij}(x_i - x_j)^2.$$

   (Stability arises from the positivity of the eigenvalues of the stiffness matrix K.)

2. **Stability condition** (normal-mode frequencies):

   $\omega_i^2 = \lambda_i$ (eigenvalues of K/m_0) ; if any $\lambda_i \le 0 \Rightarrow$ instability (deconfined state).

   (Adding a fourth Q_b may drive some λ negative, explaining why only configurations with $N \le 3$ are stable.)

4 Matter–Antimatter Asymmetry

Observation: the Universe is matter-dominated despite CP-symmetric laws.

Based on Quarkbase Theory: If the vacuum plasma reacts nonlinearly to the creation of Q_b and anti-Q_b, the damping term may differ for positive and negative phases of (Ψ), creating a **phase-asymmetric dissipation** that favors one sign.

Key formulas:

1. **Dynamical equation with asymmetric damping:**

$$m_\Psi \ddot{\Psi} + \Gamma(\Psi)\dot{\Psi} + V'(\Psi) = S(t),$$

if $\Gamma(\Psi) \neq \Gamma(-\Psi)$, a preferential damping arises that can generate a sign bias.

2. **Effective term breaking CP symmetry in the coupling (illustrative):**

$$\mathcal{L}_{\text{eff}} \supset \varepsilon_{\text{CP}}\, \Psi\, \mathcal{O}_{\text{SM}} \quad (\mathcal{O}_{\text{SM}} : \text{ Standard Model operators}),$$

an asymmetric source (non-vanishing under $\Psi \to -\Psi$) can favor matter over antimatter.

References

[1] Omeñaca Prado, Carlos (2025). Explaining Quark Flavors and Masses through Quarkbase Cosmology. figshare. Preprint. Omeñaca Prado, Carlos (2025). Relativistic Invariance and Experimental Constraints on Quarkbase Cosmology. figshare. Preprint.

5 Ultra-High-Energy Cosmic Rays (UHECR)

Observation: particles exceed the Greisen–Zatsepin–Kuzmin (GZK) limit.

Based on Quarkbase Theory: In regions where the vacuum plasma density is low, vibrational modes of (Ψ) can **release stored energy** through local resonances, ejecting particles with extreme energies — a *quantum-cosmological resonance* rather than standard acceleration.

Key formulas:

1. **Energy released by local vibrational resonance:**

$$E_{\text{release}} \sim \hbar\, \Delta\omega_{\text{loc}} \quad (\Delta\omega_{\text{loc}} = \text{local variation of vacuum modes}).$$

(A resonance of the Ψ field can convert vibrational energy into particle creation.)

2. **Resonance condition (schematic):**

$$\omega_{\text{vacuum}}(\text{mode}) \simeq \omega_{\text{threshold}} \quad \Rightarrow \quad \text{decoupling} \;\rightarrow\; \text{particles with } E \gg 10^{19}\,\text{eV}.$$

(The theory predicts regions where ω shifts, releasing stored vibrational energy.)

6 Quantization of Spacetime at the Planck Scale

Problem: quantum gravity has not unified the continuum with quantum discreteness.

Based on Quarkbase Theory: Because the vacuum plasma is an elastic-vibrational medium, **quantization occurs in frequency space**, not in geometric coordinates. Reality is discrete in resonant modes $(\omega_0, 2\omega_0, 3\omega_0, \dots)$. **Key formulas:**

1. **Discrete spectrum of vacuum resonances:**

$$\omega_n = n\,\omega_0, \qquad n \in \mathbb{Z}^+,$$

(the fundamental quantum of the medium is a characteristic frequency ω_0).

2. **Associated effective length or scale:**

$$\lambda_n = \frac{c}{\omega_n} = \frac{c}{n\omega_0} \quad \Rightarrow \quad \ell_{\text{eff}} \sim \frac{c}{\omega_0},$$

linking a physical scale to the fundamental frequency (potentially related to quantum–gravitational scales if $\hbar\omega_0 \sim E_{\text{P}}$).

7 Cosmic Filaments and Self-Organized Plasma Structures

Observation: large-scale filaments in the Universe are not fully reproduced by standard gravity simulations.

Based on Quarkbase Theory: If the vacuum plasma sustains collective modes that couple to baryonic matter, **filaments may form as interference patterns** of the field (Ψ). **Key formulas:**

1. **Interference intensity of collective modes:**

$$I(\mathbf{x}) \propto \Big|\sum_j A_j e^{i(\mathbf{k}_j\cdot\mathbf{x}+\phi_j)}\Big|^2.$$

(Regions of constructive interference correspond to filamentary structures in the vacuum pressure field.)

2. **Force on the baryonic plasma due to the vacuum–pressure gradient:**

$$\mathbf{F}_{\text{vac}} \sim -\nabla P_{\text{vac}}, \qquad P_{\text{vac}} \propto |\Psi(\mathbf{x})|^2 \sim I(\mathbf{x}).$$

(This couples the interference patterns of Ψ to the plasma dynamics and may guide the formation of cosmic filaments.)

Overview

Observed Phenomenon	**Possible Cause according to the Quarkbase Theory**
Leptonic hierarchy	Distinct Qb–antiQb vibrational modes
Neutrino oscillations	Phase beating between Qb modes
Color confinement	Saturation of vacuum coupling ($N \leq 3$)
Matter–antimatter asymmetry	Phase-biased vacuum damping
UHE cosmic rays	Release of vibrational energy from Ψ
Spacetime quantization	Discreteness in vibrational frequencies
Cosmic filaments	Interference of vacuum-plasma waves