Complex Formalism in Quarkbase Cosmology: Unified Description of Gravitational, Electromagnetic, and Quantum Interactions

Carlos Omeñaca Prado

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Abstract

This research extends the **QuarkBase Cosmology** into the complex domain, demonstrating that the mathematical representation through complex numbers does not alter the physical foundations of the theory but rather unifies, within a single analytical structure, the gravitational, electromagnetic, and quantum phenomena. The complex formalism allows one to express in a single function, $\Psi(x,t) = Ae^{i(\omega t - \mathbf{k}\cdot\mathbf{x})}$, the longitudinal (pressure) and transverse (vorticity) components of the etheric plasma, simplifying differential derivatives and revealing the intrinsic nature of the field oscillations. It is shown that Maxwell's equations can be reformulated as a complex wave equation of the etheric plasma, in which the real part represents electric pressure and the imaginary part magnetic vorticity, while the formalism strictly preserves Lorentz invariance. Finally, the framework is applied to the **nucleus–electron resonance in hydrogen**, deriving its coupling frequency directly from the phase conditions of the complex field and demonstrating the coherence of the QuarkBase model from the subatomic to the relativistic scale.

1 Introduction

The **QuarkBase Theory** describes the universe as a set of compact quarkbases immersed in a frictionless etheric plasma ($\mu = 0$), whose pressure deformations $\Psi(x,t)$ give rise to all known interactions. Previous developments—*Genesis Quarkbase*, *The Next Electromagnetic Revolution*, and *Reconfirmation of the Relativistic Invariance of the Theory of Quarkbase*—established the Lagrangian structure of the field, its equivalence with Maxwell's equations, and its full compatibility with special relativity. Within this framework, the next natural step is to **introduce complex notation** to represent the oscillations of the field Ψ, in the same manner used in classical wave theory, but without modifying the physical content of the model.

The use of complex numbers allows an elegant formulation of the harmonic modes of the ether, enabling the simultaneous treatment of longitudinal (pressure) and transverse (vorticity) vibrations, and defining phase and resonance conditions with algebraic precision. This extension does not imply any metaphysical reinterpretation of the field; it is a purely mathematical tool that enhances formal coherence and strengthens the bridge between the macroscopic expressions of pressure and the quantum-statistical descriptions of the same medium.

The present work develops this formalization, demonstrates its consistency with the original axioms of the QuarkBase model, and applies it to a representative case: the **constructive resonance between the nucleus and the electron in hydrogen**, where the phase condition of the field Ψ directly yields its fundamental coupling frequency.

2 Emergent Gravity from Quarkbase + Etheric Plasma in the Complex Formalism

Each quarkbase displaces a volume of the etheric plasma and generates pressure lines described by the complex field

$$\Psi(\mathbf{x},t) = Ae^{i(\omega t - \mathbf{k}\cdot\mathbf{x})}.$$

he real part of the field, $\Re[\Psi]$, corresponds to the measurable effective pressure, while the imaginary part, $\Im[\Psi]$, encodes the local phase of the ether deformation.

In the non-relativistic regime, the emergent force between two quarkbases separated by a distance r is expressed as

$$\mathbf{F} = -,\gamma v_q \nabla \Re[\Psi(r)] = -,\gamma v_q \Re[-i\mathbf{k}\Psi(r)], \tag{1}$$

where γ is the geometric coupling coefficient and v_q the volume displaced by each quarkbase.

If the complex pressure potential satisfies a Yukawa-type equation,

$$(\nabla^2 - \lambda^{-2})\Psi(r) = -\alpha\,\delta(\mathbf{r}),$$

the stationary complex solution is

$$\Psi(r) = \frac{\alpha}{4\pi r} e^{-(1+i)r/\lambda},$$

whose real part produces an attractive pressure of gravitational type:

$$\Re[\Psi(r)] = \frac{\alpha}{4\pi r} e^{-r/\lambda} \cos\left(\frac{r}{\lambda}\right).$$

For $r \ll \lambda$, the oscillatory term approaches unity, and the effective force reduces to

$$|\mathbf{F}| \approx \gamma v_q \frac{\partial}{\partial r} \Re[\Psi(r)] \simeq G, \frac{m_q^2}{r^2}, \tag{2}$$

thus reproducing the Newtonian gravitational behavior as a phase effect within the complex field.

Interpretation: Gravity arises as a constructive interference between the pressure waves emitted by quarkbases oscillating in coherent phase. The coupling is purely geometric and requires neither metric curvature nor attractive mass: the global phase of the complex field Ψ determines the orientation of the pressure lines within the ether, producing an emergent force indistinguishable from classical gravity at large distances.

2.1 Relativistic Covariance and Massive Field in the Complex Formalism

The pressure field $\Psi(x^\mu)$ is formulated as a complex scalar field with a covariant Lagrangian:

$$\mathcal{L}\Psi = -\frac{\beta}{2} \left(\partial\mu\Psi, \partial^\mu\Psi^* + m_\Psi^2, \Psi\Psi^*\right), \tag{3}$$

which yields the complex Klein–Gordon–type equation of motion:

$$\beta(\Box + m_\Psi^2)\Psi(x) = g \sum_i \int d\tau, \delta^{(4)}(x - x_i(\tau)). \tag{4}$$

- $m_\Psi = \hbar/(c_\Psi \lambda)$ represents the **effective mass of the pressure mode**, or the "quarkic photon."
- The complex expression $\Psi = |\Psi| e^{i\phi}$ allows amplitude and phase to be treated simultaneously as covariant magnitudes.
- The force acting on each quarkbase is given by

$$m_q \frac{Du^\mu}{d\tau} = -, g, P^{\mu\nu}, \Re[\partial_\nu \Psi] x = x_i, \tag{5}$$

  ensuring compatibility with the conservation of the energy–momentum tensor $T\mu\nu$.

Interpretation: Gravity emerges from the phase coherence of the complex field Ψ, which couples quarkbases through the pressure of the etheric plasma. The term m_Ψ introduces a natural etheric screening and guarantees exact relativistic covariance when $c_\Psi = c$.

2.2 Quantum Correspondence: Probability Wave in the Complex Representation

In the non-relativistic limit, the field Ψ acts as a pressure potential in the complex wave equation:

$$i\hbar, \partial_t \Phi = -\frac{\hbar^2}{2m_q}\nabla^2\Phi + g, \Psi, \Phi, \tag{6}$$

where Φ represents the state function of the deformed plasma.

Adopting the complex polar representation,

$$\Phi(\mathbf{x}, t) = \sqrt{\rho(\mathbf{x}, t)}\, e^{iS(\mathbf{x},t)/\hbar},$$

one obtains the hydrodynamic equations of the quarkic ether:

$$\text{(Continuity)} \qquad \partial_t \rho + \nabla \cdot (\rho \mathbf{v}) = 0, \quad \mathbf{v} = \frac{\nabla S}{m_q}. \tag{7}$$

$$\text{(Quantum Hamilton–Jacobi)} \qquad \partial_t S + \frac{(\nabla S)^2}{2m_q} + g\,\Re[\Psi] + Q = 0. \tag{8}$$

$$\text{(Quantum Potential)} \qquad Q = -\frac{\hbar^2}{2m_q}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}}. \tag{9}$$

Interpretation:

- The probability density $|\Phi|^2 = \rho$ represents the energy density of the oscillations of the complex field Ψ.
- The term Q reflects the phase curvature in complex space, which gives rise to the apparent quantum behavior.
- Quantum mechanics emerges as a statistical description of the etheric plasma operating in a regime of coherent interference.

3 Maxwell's Equations in the Complex Formalism of Quarkbase Cosmology

Within the framework of **Quarkbase Cosmology**, the electromagnetic vacuum is replaced by a continuous, frictionless medium —the *etheric plasma*. Maxwell's equations retain their canonical mathematical form but acquire a physical interpretation: they describe the reorganization of the ether's pressure and vorticity lines.

3.1 Complex Electromagnetic Field

The complex vector field is introduced as

$$\mathbf{F} = \mathbf{E} + i\, c_\Psi\, \mathbf{B},$$

where $\mathbf{E}$ represents the longitudinal pressure gradients of the plasma and $\mathbf{B}$ its transverse vorticity. In the absence of free charges, Maxwell's equations condense into the compact form:

$$\nabla \cdot \mathbf{F} = 0, \qquad \nabla \times \mathbf{F} = i\, \frac{1}{c_\Psi} \frac{\partial \mathbf{F}}{\partial t}.$$

These two expressions are simultaneously equivalent to the four real Maxwell equations.

3.2 Potentials of the Complex Ether

The complex field is derived from a scalar potential Ψ (pressure) and a vector potential $\mathbf{A}$ (vorticity):

$$\mathbf{E} = -\nabla\Psi - \frac{\partial \mathbf{A}}{\partial t}, \qquad \mathbf{B} = \nabla \times \mathbf{A}.$$

In complex notation,

$$\mathbf{F} = -\nabla(\Psi + i c_\Psi\, \nabla \cdot \mathbf{A}) - \frac{\partial}{\partial t}(\mathbf{A} - i c_\Psi \nabla \times \mathbf{A}).$$

3.3 Complex Wave Equation of the Electromagnetic Field

By substituting the previous expressions into the ether equations, one obtains:

$$\frac{1}{c_\Psi^2} \frac{\partial^2 \mathbf{F}}{\partial t^2} - \nabla^2 \mathbf{F} + \lambda^{-2} \mathbf{F} = 0,$$

which is equivalent to a complex vector Klein–Gordon equation. The term λ^{-2} introduces an etheric screening or an effective mass of the quarkic photon:

$$m_{\text{ef}} = \frac{\hbar}{c_\Psi \lambda}.$$

In the limit $\lambda \to \infty$, the classical massless electromagnetic propagation is recovered.

3.4 Duality and Complex Polarization

The use of complex numbers allows the $\mathbf{E}/\mathbf{B}$ duality to be expressed as a phase rotation:

$$\mathbf{F}' = \mathbf{F}\, e^{i\theta} \quad \Rightarrow \quad \begin{cases} \mathbf{E}' = \mathbf{E}\cos\theta - c_\Psi \mathbf{B}\sin\theta, \\ \mathbf{B}' = \mathbf{B}\cos\theta + \frac{\mathbf{E}}{c_\Psi}\sin\theta. \end{cases}$$

Circular polarization is thus interpreted as a continuous phase rotation of the etheric pressure field.

3.5 Etheric Energy and Poynting Flow

The energy flux of the complex field is defined as:

$$\mathbf{S}_\Psi = \frac{1}{2}\Re[\mathbf{F}^* \times \mathbf{F}],$$

and its total energy density as:

$$U_\Psi = \frac{1}{2}(|\mathbf{E}|^2 + c_\Psi^2 |\mathbf{B}|^2),$$

which satisfy the continuity equation

$$\frac{\partial U_\Psi}{\partial t} + \nabla \cdot \mathbf{S}_\Psi = 0,$$

demonstrating that the complex ether conserves the total energy of electromagnetic oscillations.

3.6 Interpretation from the Quarkbase Theory

- The field $\mathbf{E}$ is the longitudinal manifestation of pressure gradients within the etheric plasma.
- The field $\mathbf{B}$ represents the transverse component, or vorticity, of the same medium.
- Electromagnetic propagation corresponds to a complex pressure–vorticity wave that remains phase-coherent due to the condition $\mu = 0$.
- Photons correspond to phase packets of $\mathbf{F}$, where the energy $E = \hbar\omega$ arises from the rotation of the complex vector in the $(\mathbf{E}, \mathbf{B})$ plane.

3.7 Conclusion

The complex formalism unifies Maxwell's electric and magnetic components into a single vectorial entity, analogous to the complex wave function in quantum mechanics. The Quarkbase Theory thus provides a physical interpretation of the electromagnetic vacuum: a frictionless etheric plasma in which Maxwell's equations describe the coherent dynamics of the medium's pressure and vorticity. The phase rotations of the field $\mathbf{F}$ replace the abstraction of "separate fields," integrating electromagnetism, gravity, and quantum phenomena within a single framework of complex pressure.

4 Nucleus–Electron Resonance Frequency at r_B in the Complex Formalism

Operational Hypothesis: In the nucleus–electron equilibrium, both components couple in phase through a **complex ether pressure wave** that propagates back and forth

between them. The pressure field can be expressed as

$$\Psi(x,t) = Ae^{i(\omega t - kx)} = A[\cos(\omega t - kx) + i\sin(\omega t - kx)],$$

where A is the real amplitude of the pressure gradient, ω the angular frequency, and k the wave number. The real part, $\Re[\Psi] = A\cos(\omega t - kx)$, represents the measurable physical pressure of the medium, while the imaginary part, $\Im[\Psi] = A\sin(\omega t - kx)$, encodes the phase of the displacement.

In this formalism, differential derivatives transform into algebraic operators:

$$\frac{\partial \Psi}{\partial t} = i\omega\Psi, \qquad \nabla\Psi = -ik\Psi,$$

so that the longitudinal propagation equation of the ether,

$$\frac{1}{c_\Psi^2}\ddot{\Psi} - \nabla^2\Psi + \lambda^{-2}\Psi = 0$$

reduces to the dispersion relation

$$\omega^2 = c_\Psi^2 k^2 + c_\Psi^2 \lambda^{-2}.$$

Resonance between the nucleus and the electron occurs when the complex waves emitted by both are in **constructive phase** at their midpoint — that is, when the total phase difference over a complete round trip equals an integer multiple of 2π:

$$2kr_B = 2\pi n \quad \Rightarrow \quad k_n = \frac{n\pi}{r_B}.$$

The fundamental mode ($n = 1$) satisfies the condition

$$2r_B = \lambda_\Psi = \frac{2\pi}{k_1},$$

from which the resonance frequency is obtained:

$$\nu_0 = \frac{c_\Psi}{2r_B}.$$

The complex pressure field at equilibrium then takes the stationary form:

$$\Psi(x,t) = A\, e^{i\omega_0 t}\left(e^{-ik_1 x} + e^{ik_1 x}\right) = 2A\, e^{i\omega_0 t}\cos(k_1 x),$$

whose real part describes the standing-wave pattern of the ether between the nucleus and the electron.

If the medium transmits waves at a velocity $c_\Psi \simeq c$, the numerical result is:

- $c = 299,792,458$ m/s,
- $r_B = 5.291,772,10903 \times 10^{-11}$ m,

$$\nu_0 = \frac{c}{2r_B} = \frac{2.997\,924\,58 \times 10^8}{2 \times 5.291\,772\,10903 \times 10^{-11}} = 2.832\,628\,199 \times 10^{18}\ \text{Hz}.$$

The energy associated with the fundamental mode is:

$$E_0 = h\nu_0 = (6.626\,070\,15 \times 10^{-34})(2.832\,628\,199 \times 10^{18}) = 1.8769 \times 10^{-15}\ \text{J} \approx 11.7\ \text{keV}.$$

Physical interpretation:

- The electron and the nucleus behave as two reflectors sustaining a stationary complex pressure wave within the ether.
- The real part of the field represents the measurable pressure variations, while the imaginary part ensures phase continuity and allows the oscillations to be treated as rotations in the complex plane.
- The point $r = r_B$ corresponds to the stable node where convergent and divergent pressures balance.
- The described resonance is therefore a phenomenon of phase coherence of the complex field Ψ, rather than a pointwise attraction between particles.

5 Variant with λ^{-2} term (Yukawa-type potential) in the complex formalism

In the complex framework, the ether pressure field is written as

$$\Psi(x,t) = Ae^{i(\omega t - kx)},$$

so that time and spatial derivatives become algebraic operations:

$$\frac{\partial^2 \Psi}{\partial t^2} = -\omega^2 \Psi, \qquad \nabla^2 \Psi = -k^2 \Psi.$$

Substituting these relations into the generalized field equation,

$$\frac{1}{c_\Psi^2}\ddot{\Psi} - \nabla^2\Psi + \lambda^{-2}\Psi = 0,$$

yields the complex dispersion equation:

$$\left(-\frac{\omega^2}{c_\Psi^2} + k^2 + \lambda^{-2}\right)\Psi = 0.$$

Since $\Psi \neq 0$, the resonance condition implies

$$k = \sqrt{\frac{\omega^2}{c_\Psi^2} - \lambda^{-2}}.$$

For small deviations from the ideal vacuum ($\lambda \gg r_B$), one may expand in series:

$$k \approx \frac{\omega}{c_\Psi}\left(1 - \frac{1}{2}\left(\frac{c_\Psi}{\omega\lambda}\right)^2\right).$$

In the complex domain, this means that the wave phase

$$\phi(x,t) = \omega t - kx$$

accumulates an additional delay

$$\Delta\phi \approx \frac{1}{2}\left(\frac{r_B}{\lambda}\right)^2,$$

responsible for the slight frequency shift.

The adjusted resonance frequency then becomes:

$$\nu \approx \nu_0\left(1 - \frac{1}{2}\left(\frac{\lambda_0}{\lambda}\right)^2\right),$$

where $\lambda_0 = 2r_B$ is the wavelength of the fundamental mode in the unscreened case.

This complex treatment shows that the etheric screening described by the λ^{-2} term modifies not only the amplitude but also the **complex phase** of the field. The correction manifests as a slow rotation of the vector Ψ in the complex plane, whose effective angular velocity is slightly lower than in the ideal case:

$$\omega' = \omega\left(1 - \frac{1}{2}\left(\frac{\lambda_0}{\lambda}\right)^2\right).$$

The relative frequency shift $\Delta\nu/\nu_0 \approx -\frac{1}{2}(\lambda_0/\lambda)^2$ is on the order of 10^{-10} for $\lambda \sim 10^5 r_B$, making the effect practically undetectable under normal experimental conditions, although conceptually significant.

Conclusion of the variant:

- The λ^{-2} term introduces an **etheric screening** or "effective mass of the quarkic photon," manifested as a slower rotation of the complex field Ψ in phase space.
- In the limit $\lambda \to \infty$, the phase argument $\phi = \omega t - kx$ is fully restored, recovering the ideal resonance with $\nu_0 = c_\Psi/(2r_B)$.
- The complex formalism expresses this phenomenon as a simple phase shift in the exponential function $e^{i(\omega t - kx)}$, without requiring any modification of the real differential equations of the theory.

6 Compatibility with Relativistic Invariance in the Complex Formalism

The complex formalism strictly preserves the **Lorentz invariance** established in *Reconfirmation of the Relativistic Invariance of the Theory of Quarkbase*. The ether pressure field is expressed as a complex function:

$$\Psi(x,t) = Ae^{i(\omega t - \mathbf{k}\cdot\mathbf{x})}.$$

Substituting this form into the general ether propagation equation,

$$\frac{1}{c_\Psi^2}\ddot{\Psi} - \nabla^2\Psi + \lambda^{-2}\Psi = 0,$$

directly yields the **complex dispersion relation**:

$$\left(-\frac{\omega^2}{c_\Psi^2} + k^2 + \lambda^{-2}\right)\Psi = 0 \quad \Rightarrow \quad \omega^2 = c_\Psi^2\left(k^2 + \lambda^{-2}\right).$$

This equation has a form identical to the relativistic energy–momentum relation for a particle with an effective mass $m_{\text{ef}} = \hbar/(c_\Psi\lambda)$, since it can be rewritten as

$$\frac{\omega^2}{c_\Psi^2} - k^2 = \lambda^{-2} \quad \Longleftrightarrow \quad E^2 = p^2c_\Psi^2 + m_{\text{ef}}^2c_\Psi^4.$$

Lorentz symmetry is preserved because the complex phase $\phi = \omega t - \mathbf{k}\cdot\mathbf{x}$ is a *Lorentz invariant*:

$$\phi' = \omega' t' - \mathbf{k}'\cdot\mathbf{x}' = \phi.$$

This implies that the complex wave function $\Psi = Ae^{i\phi}$ retains its form in all inertial reference frames.

The complex representation is not a mere mathematical artifact: it allows Lorentz invariance to be expressed as a **phase rotation** in the complex plane. Lorentz transformations act on $(\omega, \mathbf{k})$ as a hyperbolic rotation in space–time, and on Ψ as an ordinary rotation in the complex plane—both preserving their invariant modulus:

$$|\Psi'| = |\Psi|, \qquad |\phi'| = |\phi|.$$

In this way, the covariance of the solutions is expressed in a more compact and visually intuitive form.

Possible anisotropies introduced by the quarkbase medium produce deviations smaller than

$$|\Delta c/c| < 10^{-15},$$

in full agreement with astrophysical observations from Fermi–LAT and GRB data.

7 General Conclusion

The introduction of complex numbers into Quarkbase Cosmology formally unifies all domains of the theory:

- **Gravity** emerges as constructive interference between coherent phase pressure waves.
- **Electromagnetism** is reinterpreted as a complex rotation of the ether's pressure–vorticity field, represented compactly through Maxwell's equations.
- **Quantum mechanics** arises as the statistical description of the etheric plasma under phase coherence, where the wave function Φ constitutes a macroscopic representation of the same field Ψ.
- **Special relativity** remains strictly preserved, since the phase $\phi = \omega t - \mathbf{k} \cdot \mathbf{x}$ is a Lorentz invariant.

Taken together, the complex formalism reveals that all physical interactions —gravitational, electromagnetic, and quantum— are expressions of a single wave phenomenon: the coherent oscillation of the etheric pressure field. This formulation introduces no new entities; rather, it reorganizes existing ones within a single-phase mathematical framework, in which rotations in the complex plane directly represent energy–momentum exchanges in the frictionless ether. Within this context, the use of complex numbers is not a mere formal device but the algebraic manifestation of the ether's deep symmetry: all physical reality is a phase rotation within the complex space of the Quarkbase.

Thus, **Quarkbase Cosmology** is established as a universal, invariant, and unified field theory, where matter, radiation, and gravity emerge as modulations of a single complex pressure function.

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