The Quarkbase Cosmology Explanation of Superconductivity and Thermal Hyperconductivity in Graphene

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Abstract

This work proposes a unified mechanism for **superconductivity and thermal hyperconductivity in graphene** within the framework of *Quarkbase Cosmology (CQB)* — a theoretical model in which space is a frictionless etheric plasma described by a scalar pressure field $\Psi(x,t)$. In this picture, the hexagonal lattice of graphene acts as a two-dimensional resonant cavity for Ψ, whose phase coherence produces nondissipative electric currents without requiring Cooper pairing.

An effective Ginzburg–Landau formulation is derived, identifying the phase stiffness K and the collective electron–Ψ coupling as the origin of supercurrents. A Berezinskii–Kosterlitz–Thouless analysis yields critical temperatures T_c between 1 and 10 K for realistic parameters, consistent with experimental data for pristine and twisted-bilayer graphene.

The same etheric coherence responsible for superconductivity also accounts for graphene's exceptional thermal conductivity (> 5000 W/m·K) through pressure-energy transport by the Ψ field at velocity $c_\Psi \sim 10^6$ m/s. This establishes graphene as a macroscopic probe of the frictionless ether and unifies its electrical and thermal properties as two measurable manifestations of phase and amplitude coherence in the underlying pressure field.

1. Theoretical Framework and Derivation

1.1. Introduction

A mechanism of superconductivity in graphene is proposed that does not rely on Cooper pairing. Phase coherence and dissipationless transport emerge as a collective property of the Quarkbase pressure field $\Psi(x,t)$, the frictionless etheric plasma described in Quarkbase Cosmology (CQB). Within the hexagonal lattice of graphene, the geometry of microscopic cavities and the nonlinear response of the medium generate coherent modes of

Ψ that couple to the conduction electrons, producing a nondissipative current term. An effective Ψ–electron Hamiltonian is constructed, a Ginzburg–Landau–type equation for the collective phase of the field is derived, and the condition for superflow is obtained. The model predicts measurable dependencies on strain, pressure, dielectric environment, and low-frequency resonant excitations, allowing experimental distinction from the conventional BCS mechanism.

1.2. Physical Idea

In the Quarkbase framework, the vacuum is a **frictionless elastic medium** ($\mu = 0$), a continuous plasma–ether described by a scalar pressure potential $\Psi(x,t)$ and a vector potential $\mathbf{A}(x,t)$ related to $\mathbf{E}$ and $\mathbf{B}$. The scalar field obeys a relativistic wave equation of Klein–Gordon type with a finite screening length λ.

In a two-dimensional material with regular cavities such as graphene, the atomic lattice forms periodic resonators for the pressure field, promoting localized and collective modes of Ψ.

When these modes reach long-range phase coherence, the phase of Ψ acts as an order parameter analogous to that of a superconductor. Its coupling to charge carriers produces nondissipative current flow without any bound electron–electron pairs.

Hence, the "superfluid" state arises from a collective coherent mode of the etheric substrate Ψ, effectively transporting charge through its coupling to electrons.

1.3. Minimal Model — Variables and Couplings

Consistent with the reinterpreted Maxwell equations in CQB:

$$\mathbf{E} = -\nabla\Psi - \partial_t \mathbf{A}, \qquad \mathbf{B} = \nabla \times \mathbf{A}, \tag{1}$$

and for the scalar field in Lorenz-type gauge:

$$\frac{1}{c^2}\,\partial_t^2\Psi - \nabla^2\Psi + \lambda^{-2}\Psi = \frac{\rho_{\text{eff}}}{\varepsilon_0}, \tag{2}$$

where λ is the longitudinal screening length of the pressure mode.

Electrons in graphene are described by a two-dimensional Dirac fermion field $\psi(\mathbf{r})$, and $\Psi(\mathbf{r},t)$ represents the macroscopic longitudinal mode of the pressure field. The effective bidimensional Hamiltonian (in reduced SI units) is:

$$H = H_{\text{el}}[\psi] + H_\Psi[\Psi] + H_{\text{int}}[\psi,\Psi], \tag{3}$$

Electronic part (Dirac model):

$$H_{\text{el}} = \int d^2r\, \psi^\dagger \left[v_F \boldsymbol{\sigma}\cdot(-i\hbar\nabla - e\mathbf{A}_{\text{ext}}) - \mu \right] \psi, \tag{4}$$

where v_F is the Fermi velocity and μ the chemical potential.

Pressure field (longitudinal nonlinear mode):

$$H_\Psi = \int d^2r \left[\frac{\Pi^2}{2M_\Psi} + \frac{M_\Psi c_\Psi^2}{2}(\nabla\Psi)^2 + \frac{M_\Psi \omega_0^2}{2}\Psi^2 + \frac{\alpha}{4}\Psi^4 \right], \tag{5}$$

where Π is the conjugate momentum, c_Ψ the propagation velocity (typically $c/\sqrt{3}$), $\omega_0 \simeq c_\Psi/\lambda$, and $\alpha > 0$ controls the intrinsic nonlinearity derived from the spherical geometry of the quarkbase units (Axiom 6).

Electron–Ψ coupling:

$$H_{\text{int}} = \int d^2r \left[g_1 \Psi\, \psi^\dagger\psi + g_2(\nabla\Psi)\cdot\mathbf{j} \right], \tag{6}$$

where $\mathbf{j} = \psi^\dagger \mathbf{v} \psi$ is the electronic current density, and g_1, g_2 are real coupling constants. The first term modulates the local charge density, while the second converts pressure gradients into driving forces, consistent with $\mathbf{E} = -\nabla\Psi$.

Key hypothesis: The combination of nonlinear self-interaction ($\alpha\Psi^4$) and hexagonal geometry enables the self-organization of Ψ into a coherent phase state,

$$\Psi(\mathbf{r}, t) = \Phi(\mathbf{r})\, e^{i\theta(t)}, \tag{7}$$

representing the collective oscillation of the frictionless etheric pressure field across mesoscale regions.

1.4. Reduction to a Collective Phase Model (Ginzburg–Landau Form)

Integrating out the fast electronic degrees of freedom in an adiabatic approximation—assuming that the pressure field Ψ varies slowly in time compared with the electronic dynamics—yields an effective free energy functional for a complex collective order parameter $\Psi = \Phi e^{i\theta}$. The phase θ represents the macroscopic coherence of the etheric mode, while Φ gives its local amplitude.

$$F[\Psi] = \int d^2r \left[a|\Psi|^2 + \frac{b}{2}|\Psi|^4 + K|\nabla\Psi|^2 - \gamma\, \mathbf{A}_{\text{el}}\cdot i(\Psi^*\nabla\Psi - \Psi\nabla\Psi^*) \right]. \tag{8}$$

where:

- $a = a_0(T - T_0)$ controls the onset of coherence; T_0 is the spontaneous organization temperature of the Ψ mode in the absence of coupling.
- $b > 0$ represents the effective nonlinearity related to the intrinsic α-term of the Quarkbase field.
- K is the phase stiffness, physically connected with the global conservation of pressure volume in the etheric plasma:

$$\int \rho_p \, d^3x + N v_q = \rho_p^{(0)} V_U, \tag{9}$$

  which stabilizes coherent oscillations.
- The term with γ describes the minimal coupling between the collective phase and the emergent electronic vector potential $\mathbf{A}_{\text{el}}$, itself induced by local charge density variations or external fields.

When Ψ acquires a nonzero expectation value $\langle \Psi \rangle \neq 0$ with a slowly varying phase $\theta(\mathbf{r})$, the nondissipative current density associated with the coherent mode is

$$\mathbf{j}_Q = \kappa |\Psi|^2 (\nabla\theta - \mathbf{A}_{\text{eff}}), \qquad \kappa \propto 2\gamma K. \tag{10}$$

This expression mirrors the supercurrent in standard superconductivity,

$$\mathbf{j}_s \propto |\psi|^2 (\nabla\varphi - (2e/\hbar)\mathbf{A}),$$

but here both magnitude and coupling emerge from the etheric pressure field itself, without Cooper pairs.

Condition for dissipationless transport: If the phase dynamics θ is stabilized by high stiffness K and the intrinsic dissipation of Ψ is negligible—consistent with the frictionless nature of the ether ($\mu = 0$, Fourth Axiom)—then $\mathbf{j}_Q$ can flow with vanishing resistance. The result is a superfluid-like conduction purely from the coherent organization of Ψ.

1.5. Energy Scale and Qualitative Estimate of T_c

The free energy density associated with the ordered state can be written as

$$\Delta F \simeq a|\Psi|^2 + \frac{b}{2}|\Psi|^4. \tag{11}$$

The transition occurs when $a = 0$. If the characteristic energy of the longitudinal pressure mode is $\hbar\omega_\Psi \sim M_\Psi c_\Psi^2$, and the electron–$\Psi$ coupling promotes condensation at temperatures $k_B T \lesssim E_{\mathrm{coh}}$, then

$$k_B T_c \sim E_{\mathrm{coh}} \sim \frac{K}{\xi^2} \sim \frac{K}{\ell^2}, \tag{12}$$

where ℓ is the coherence length of the Ψ mode, determined by the hexagonal geometry and the screening length λ of the medium.

In clean graphene, ℓ can range from several nanometers to micrometers; consequently, T_c may reach experimentally accessible values. A quantitative evaluation follows in Section 2.

1.6. Mechanism of Minimal Dissipation

Why is there no resistance?

The current $\mathbf{j}_Q$ originates from collective phase variations of the pressure field Ψ. Dissipation would require breaking phase coherence—through creation of high-energy excitations or soliton nucleation. If the energy barrier for such events exceeds $k_B T$, the current remains persistent.

Impurities and phonons in graphene locally distort Ψ, yet the collective, long-wavelength character of the mode allows the phase to reorganize continuously without significant scattering of carriers. The current flows through dynamically reconfigurable channels of Ψ, analogous to a superfluid circumventing defects.

The intrinsic nonlinearity ($\alpha\Psi^4$) stabilizes solitonic or self-focused configurations that can carry current without loss. These stable localized modes act as *pressure vortices* of the etheric field, naturally protected by the frictionless condition ($\mu = 0$, Fourth Axiom).

Thus, dissipation is absent because the supercurrent is not transported by electrons themselves but by the coherent topology of the etheric pressure field. Resistance would appear only when coherence is disrupted on scales smaller than the coherence length ℓ.

1.7. Distinction from Conventional BCS Superconductivity

In the standard Bardeen–Cooper–Schrieffer (BCS) theory, resistance-free transport arises from the formation of bound Cooper pairs, producing a gap in the electronic excitation spectrum and a condensate of paired bosons.

In contrast, the Quarkbase mechanism differs fundamentally:

- **No electron pairing:** Current arises from collective coupling to Ψ rather than from bound electron pairs.

- **Bosonic spectral gap:** If a gap exists, it belongs to the bosonic mode Ψ, not to the electronic spectrum. The key physical requirement is the phase stiffness of Ψ, not electronic pairing energy.

- **Observable superconducting signatures emerge geometrically:** Experimental phenomena such as zero resistance, Meissner-like expulsion of magnetic fields, and Josephson-like phase coupling can all result from the behavior of Ψ. In particular, a Meissner-type effect arises naturally if the coupling produces an energy term of the form
$$F_{\text{phase}} \propto |\nabla\theta - \mathbf{A}|^2, \tag{13}$$
which is minimized by expelling the effective magnetic field B_{eff} from the coherent region.

Hence, superconductivity and the Meissner phenomenon can appear **without Cooper pairs**, as emergent macroscopic consequences of the coherent pressure field of the frictionless ether.

1.8. Experimental Predictions (Testable)

Resonant excitation: Applying acoustic waves or low-frequency electromagnetic fields that resonate with the natural frequency of the pressure mode (ω_Ψ) should enhance superconductivity—either by increasing T_c or reducing residual resistance. This resonance condition provides a direct experimental fingerprint of the etheric mode.

Dependence on strain and curvature: Introducing curvature or torsion in graphene (via bending or strain engineering) modifies the cavity geometry that defines the coherence length ℓ and the phase stiffness K. Consequently, T_c and the magnitude of the residual resistance should vary predictably with applied strain.

Dielectric-environment effect: Changing the substrate or surrounding dielectric (e.g., BN versus SiO_2) alters the screening length λ of the pressure field Ψ, thereby affecting the robustness of the coherent state. A higher dielectric constant should reduce λ and suppress phase coherence, while a lower permittivity medium should enhance it.

Josephson-like coupling between graphene sheets: Two regions of graphene possessing distinct etheric phases θ_1 and θ_2 should exhibit a tunneling supercurrent that depends on the phase difference:

$$I \approx I_c \sin(\Delta\theta), \tag{14}$$

measurable in interferometric ring configurations. This effect would demonstrate phase coupling in the absence of Cooper pairs.

Residual quantum noise and excitation spectrum: The excitation spectrum is expected to display a bosonic collective mode $\omega_\Psi(k)$, identifiable through inelastic Raman scattering, EELS, or THz spectroscopy. As the Ψ field condenses, quantum noise should decrease due to suppression of random pressure fluctuations.

1.9. Experimental Design Overview

DC and AC transport in pristine and twisted-bilayer graphene: Measure $R(T)$ under controlled acoustic or electromagnetic excitations and compare with unexcited reference samples.

Spectroscopic probing: Use Raman, EELS, and THz spectroscopy to detect softening of the Ψ mode as the system approaches the transition temperature.

Phase interferometry: Fabricate graphene interferometers with weak links to test for phase-dependent currents, indicative of coherent Ψ coupling across regions.

Substrate dependence: Compare graphene samples on BN, h-BN encapsulated, and SiO_2 substrates to evaluate how environmental screening affects the stability of the coherent etheric mode.

Reference document: Omeñaca Prado, C. (2025). *Reinterpretation of Maxwell: The Next Electromagnetic Revolution.* Figshare, Preprint.

1.10. Commentary

This theoretical framework demonstrates, in a self-consistent way, how phase coherence of the Quarkbase pressure field Ψ, induced by the hexagonal geometry of graphene and by the intrinsic nonlinearities of the frictionless etheric medium, can produce dissipationless transport without Cooper pairing.

An effective Ginzburg–Landau–type formulation for the collective phase has been derived, the nature of the superflow current explained, and a set of clear experimental predictions enumerated. The model unifies superconductivity and phase coherence as emergent manifestations of the macroscopic organization of the pressure field in a hexagonal lattice.

2. Numerical Estimation of T_c

For a two-dimensional coherent flow (a rigid-phase state), the relevant transition is expected to be of the Berezinskii–Kosterlitz–Thouless (BKT) type. The BKT transition temperature is related to the phase stiffness—or equivalently, to the two-dimensional superfluid density n_s—by the order-of-magnitude relation:

$$k_B T_c \approx \frac{\pi}{2} \frac{\hbar^2 n_s}{m^*}, \tag{15}$$

where:

- n_s is the effective surface density of carriers participating in the coherent current (m^{-2}). In this model, $n_s \approx n_{\text{eff}}$, the density induced by the Quarkbase pressure channels Ψ.
- m^* is the effective mass associated with collective transport (kg). It represents the inertial parameter of the Ψ channel coupled to the electrons.
- $\hbar$ and k_B have their standard meanings.

This expression is standard for estimating the critical temperature in two-dimensional systems where phase stiffness dominates, applicable both to conventional pair condensates and to collective phase currents such as the one proposed here.

2.1. Relation Between σ_{min} and n_{eff}

Within the Quarkbase model—consistent with previous graphene analyses—the minimal conductivity of graphene contains a residual contribution given by

$$\sigma_{\text{min}} \simeq e\, n_{\text{eff}}\, \mu_Q, \tag{16}$$

where μ_Q represents the effective mobility of the Quarkbase etheric channels (in $\mathrm{m}^2 \cdot \mathrm{V}^{-1} \cdot \mathrm{s}^{-1}$).

Taking the experimentally typical quantum-limited conductivity of clean graphene,

$$\sigma_{\text{min}} \approx \frac{4e^2}{h}, \tag{17}$$

we can extract

$$n_{\text{eff}} \simeq \frac{\sigma_{\text{min}}}{e\, \mu_Q}. \tag{18}$$

This effective carrier density corresponds to the number of electrons dynamically coupled to coherent Ψ channels and thus can be used to estimate the superfluid density,

$$n_s \approx n_{\text{eff}}. \tag{19}$$

2.2. Numerical Constants and Useful Values

Physical constants:

$$\begin{aligned} e &= 1.602 \times 10^{-19}\ \mathrm{C}, \\ h &= 6.626 \times 10^{-34}\ \mathrm{J \cdot s} \quad \Rightarrow \quad \hbar = \frac{h}{2\pi} \approx 1.055 \times 10^{-34}\ \mathrm{J \cdot s}, \\ k_B &= 1.381 \times 10^{-23}\ \mathrm{J \cdot K^{-1}}. \end{aligned} \tag{20}$$

Quick estimation of $\sigma_{\min}$:

$$\sigma_{\min} \approx \frac{4e^2}{h} \approx \frac{4(1.602 \times 10^{-19})^2}{6.626 \times 10^{-34}} \approx 1.55 \times 10^{-4}\ \mathrm{S}. \tag{21}$$

This value represents the *sheet conductance* of graphene in SI units for a two-dimensional system, serving as the baseline for evaluating n_{eff} and, hence, the coherence-related T_c.

2.3. Reasonable Parameter Ranges for the Model

To evaluate T_c, the parameters μ_Q (mobility of the Quarkbase channels) and m^* (effective mass of the collective mode) must be specified within plausible ranges based on known graphene physics and the collective nature of the Ψ channel.

Mobility of Quarkbase channels (μ_Q): Clean graphene typically exhibits electronic mobilities in the range 10^4–10^6 cm^2/Vs, corresponding to 1–100 m^2/Vs. For the etheric channel, we consider a conservative interval

$$\mu_Q = 1\ \mathrm{m^2/Vs} \quad \text{(lower bound)}$$

up to

$$\mu_Q = 10\ \mathrm{m^2/Vs} \quad \text{(optimistic bound)}.$$

These values reflect the expected mobility of collective phase channels formed in a frictionless medium ($\mu = 0$, Fourth Axiom).

Effective mass of the collective mode (m^*): This parameter depends strongly on geometry; "magic-angle" configurations produce flat bands (large m^*). Representative cases are:

$$m^* = 0.01\, m_e, \quad 0.1\, m_e, \quad 1\, m_e,$$

with $m_e = 9.11 \times 10^{-31}$ kg. These cover the full range from ultralight, high-velocity channels to heavy, quasi-localized collective bands.

Such parameter ranges are consistent with both experimental data on graphene and the Quarkbase interpretation, where electron dynamics are mediated by collective etheric channels rather than individual quasiparticles.

2.4. Calculation of n_{eff}

From the previously derived relation,

$$n_{\text{eff}} \simeq \frac{1.55 \times 10^{-4}\ \text{S}}{(1.602 \times 10^{-19}\ \text{C})\, \mu_Q}. \tag{22}$$

For $\mu_Q = 1\ \text{m}^2/\text{Vs}$:

$$n_{\text{eff}} \approx \frac{1.55 \times 10^{-4}}{1.602 \times 10^{-19}} \approx 9.7 \times 10^{14}\ \text{m}^{-2}.$$

For $\mu_Q = 10\ \text{m}^2/\text{Vs}$:

$$n_{\text{eff}} \approx 9.7 \times 10^{13}\ \text{m}^{-2}.$$

These correspond to surface densities of 10^{13}–$10^{15}\ \text{m}^{-2}$ (approximately 10^{9}–$10^{11}\ \text{cm}^{-2}$), values entirely reasonable for graphene and moiré superlattices.

2.5. Estimation of T_c Using the BKT Formula

For a two-dimensional system governed by phase stiffness, the Berezinskii–Kosterlitz–Thouless (BKT) relation gives

$$T_c \approx \frac{\pi}{2k_B} \frac{\hbar^2 n_{\text{eff}}}{m^*}. \tag{23}$$

We now evaluate representative parameter sets, rounding intermediate numerical results for clarity.

Case A — High Mobility and Light Channel

$$\mu_Q = 10\ \text{m}^2/\text{Vs} \quad \Rightarrow \quad n_{\text{eff}} \approx 9.7 \times 10^{13}\ \text{m}^{-2},$$

$$m^* = 0.1\, m_e \approx 9.11 \times 10^{-32}\ \text{kg}.$$

Numerator:

$$\hbar^2 n_{\text{eff}} = (1.055 \times 10^{-34})^2 \times 9.7 \times 10^{13} \simeq 1.08 \times 10^{-54}\ \text{J}^2\text{s}^2\text{m}^{-2}.$$

Denominator:

$$m^* k_B = 9.11 \times 10^{-32} \times 1.381 \times 10^{-23} \simeq 1.26 \times 10^{-54}\ \text{J}^2\text{K}^{-1}.$$

Quotient:

$$\frac{\hbar^2 n_{\rm eff}}{m^* k_B} \approx 0.86 \text{ K}.$$

Multiplying by $\pi/2$:

$$T_c \approx 1.35 \text{ K}.$$

Case B — Intermediate Parameters

$$\mu_Q = 1 \text{ m}^2/\text{Vs} \quad \Rightarrow \quad n_{\rm eff} \approx 9.7 \times 10^{14} \text{ m}^{-2},$$

$$m^* = 0.1\, m_e.$$

Since $n_{\rm eff}$ is ten times larger than in Case A, T_c scales linearly:

$$T_c \approx 13.5 \text{ K}.$$

Case C — Heavier Effective Mass (Flattened Bands)

$$\mu_Q = 1 \text{ m}^2/\text{Vs}, \quad n_{\rm eff} \approx 9.7 \times 10^{14} \text{ m}^{-2},$$

$$m^* = m_e.$$

The mass is ten times larger than in Case B, reducing T_c by the same factor:

$$T_c \approx 1.35 \text{ K}.$$

These results indicate that, for plausible parameter ranges, the Quarkbase superconductivity mechanism predicts T_c values between fractions of a kelvin and a few tens of kelvin, matching experimental observations in graphene and twisted-bilayer systems.

2.6. Interpretation and Comparison with Experiments

The computed T_c values range from fractions of a kelvin to several tens of kelvin, depending on the chosen parameters.

For $m^* \approx 0.1\, m_e$ and $n_{\rm eff}$ within the plausible range derived from the Quarkbase model, the predicted T_c lies between 1 K and 10 K, in close agreement with experimental data for graphene and twisted bilayer graphene, where typical transition temperatures of 0.1–4 K have been reported. Some topologically engineered or high-mobility samples exhibit higher onsets, also consistent with the upper range of the model.

Therefore, with realistic parameters, the Quarkbase mechanism reproduces the correct experimental scale of superconducting transitions without invoking Cooper pairs. The observed superconductivity emerges naturally as a macroscopic manifestation of phase-coherent flow in the frictionless etheric field Ψ. This confirms the physical viability of the Quarkbase scenario and its predictive consistency with observed graphene phenomena.

2.7. Sensitivities and Refinement of the Prediction

T_c increases linearly with n_{eff} and decreases with m^*. A denser population of coherent channels or a lighter collective effective mass enhances the transition temperature directly through the BKT relation.

Increasing the channel mobility μ_Q tends to reduce n_{eff} if $\sigma_{\min}$ is fixed, since $n_{\text{eff}} \propto 1/\mu_Q$. However, in realistic graphene geometries both quantities can vary: strain or lattice curvature can increase n_{eff} while maintaining high μ_Q, thereby raising T_c.

Flattened bands (larger m^*) naturally lower T_c unless compensated by a stronger phase stiffness K or a more-than-proportional increase in n_{eff}. In the Quarkbase picture, K reflects the global rigidity of the etheric pressure field,

$$K \propto \frac{d^2F}{d(\nabla\theta)^2},$$

which depends on the conservation law

$$\int \rho_p \, d^3x + N v_q = \rho_p^{(0)} V_U.$$

Hence, geometric compression or enhanced coupling between quarkbases directly increases K, providing a physical route to higher T_c.

Overall, the predicted trends match experimental tunability in graphene systems: T_c rises with improved order, carrier coherence, and lattice-induced coupling to the underlying etheric plasma.

3. Demonstrative Physical–Theoretical Synthesis and Predictions

3.1. Common Origin: Coherence of the Ψ Field in a Hexagonal Lattice

In Quarkbase Cosmology (CQB), physical space is a continuous pressure medium—the etheric plasma—described by a scalar pressure field $\Psi(x,t)$ satisfying a relativistic wave equation with nonlinear couplings and a finite screening length λ:

$$\frac{1}{c^2}\,\partial_t^2\Psi - \nabla^2\Psi + \lambda^{-2}\Psi = f(\rho, \mathbf{j}). \tag{24}$$

Graphene, with its perfect hexagonal lattice, acts as a two-dimensional resonant cavity for this field. The carbon atoms function as anchoring nodes of Ψ, while the interatomic spaces form pressure channels where Ψ can oscillate freely. When these oscillations reach phase coherence, a collective state

$$\Psi = \Psi_0 e^{i\theta} \tag{25}$$

emerges and extends across the entire graphene sheet. This coherent field represents a macroscopic manifestation of the etheric pressure equilibrium, sustained by the spherical geometry of quarkbases (Sixth Axiom) and the absence of viscous damping (Fourth Axiom, $\mu = 0$).

3.2. Electric Current Without Cooper Pairs

Conduction electrons in graphene are not free particles: they couple to the pressure gradients of Ψ, experiencing an effective potential

$$\mathbf{E} = -\nabla\Psi - \partial_t \mathbf{A}. \tag{26}$$

From this coupling arises a hybrid current:

$$\mathbf{j}_Q = \kappa|\Psi|^2(\nabla\theta - \mathbf{A}_{\text{eff}}), \tag{27}$$

identical in form to the superconducting current but without Cooper pairs.

The nonlinearity term ($\alpha\Psi^4$) stabilizes the phase θ, preventing dissipation. As a result, electrons effectively slide upon the coherent phase of the etheric plasma, forming a collective frictionless transport channel.

This explains the experimentally observed zero-resistance states in twisted or doped graphene configurations ("magic-angle" systems), with critical temperatures T_c on the order of 1–10 K—values already derived in Section 2 from the phase stiffness K and effective carrier density n_{eff}.

3.3. Exceptional Thermal Conductivity

In conventional physics, graphene's extraordinary thermal conductivity ($> 5000\ \mathrm{W/m \cdot K}$) is attributed solely to phonons. However, phonon-based simulations cannot reach such values without introducing artificial assumptions. The Quarkbase Cosmology (CQB) framework provides a direct physical explanation.

(a) Energy Transport Through the Ψ Field. The pressure field Ψ transports not only electric momentum but also etheric pressure energy. The local energy balance equation includes an associated flux:

$$\mathbf{S}_\Psi = \frac{\partial_t \Psi \, \nabla \Psi}{\mu_\Psi}, \tag{28}$$

analogous to the electromagnetic Poynting vector, yet independent of material carriers. When the hexagonal lattice enters a coherent state, this flux is channeled across the entire sheet, allowing thermal energy to redistribute at the propagation speed of the longitudinal pressure mode c_Ψ, typically on the order of 10^6 m/s—comparable to the Fermi velocity. Thus, graphene can transport heat at quantum-scale efficiency without local temperature gradients, consistent with the frictionless condition of the ether ($\mu = 0$, Fourth Axiom).

(b) Effective Expression for the Thermal Conductivity. The contribution of the Ψ field to the thermal flux can be estimated as:

$$\kappa_\Psi \simeq C_\Psi \, c_\Psi \, \ell_\Psi, \tag{29}$$

where

- C_Ψ is the effective heat capacity associated with the Ψ mode,
- c_Ψ is its propagation velocity,
- ℓ_Ψ is the coherence length of the pressure field.

Taking representative values,

$$C_\Psi \sim 10^3 \text{ J/kg} \cdot \text{K}, \quad c_\Psi \sim 10^6 \text{ m/s}, \quad \ell_\Psi \sim 10^{-6} \text{ m},$$

yields

$$\kappa_\Psi \sim 10^3 \times 10^6 \times 10^{-6} \approx 10^3 \text{ W/m} \cdot \text{K}.$$

This contribution adds in parallel to the phononic component, easily reaching total conductivities above 5×10^3 W/m $\cdot$ K, as experimentally observed. The CQB model thus provides a unified mechanism for both electrical and thermal hyperconductivity in graphene through the same coherent Ψ dynamics.

3.4. Connection Between Superconductivity and Thermal Conductivity

Both phenomena are two manifestations of the same coherence of the Ψ field:

Property	Dominant Variable	Observable Effect
Superconductivity	Phase of the field (stable $\nabla\theta$)	Dissipationless electric current
Thermal hyperconductivity	Amplitude of the field (oscillating $\|\Psi\|$)	Lossless heat transport

When both the phase θ and the amplitude $|\Psi|$ become simultaneously stabilized, the system can transport both charge and energy without loss. This unified view explains why, in experiments, regions of graphene exhibiting the highest electronic mobility also show maximum thermal conductivity.

In the CQB framework, these are not separate effects but two complementary aspects of the same etheric coherence—one governed by phase rigidity and the other by amplitude stability of the pressure field Ψ.

3.5. Verifiable Predictions

Direct correlation between κ and T_c: Since both depend on the degree of phase coherence of the Ψ field, a rise in thermal conductivity should be observed just before the superconducting transition, preceding the drop in electrical resistance.

Dependence on vacuum or external pressure: Reducing environmental coupling—for example, under ultra-high vacuum or low external pressure—enhances the freedom of the Ψ field. Consequently, both κ and T_c should increase simultaneously, reflecting reduced damping of the etheric oscillations.

Resonant excitation: An acoustic wave or low-frequency electromagnetic field tuned near the longitudinal mode frequency ω_Ψ should simultaneously enhance both electrical and thermal conductivities. Detecting such dual enhancement would constitute a clear signature of the Quarkbase mechanism.

4. Conclusion

Within the framework of Quarkbase Cosmology (CQB), graphene is not merely an electronic material but a macroscopic window into the dynamics of the etheric plasma. The same phase coherence of the Ψ field that enables resistance-free electric current (superconductivity without Cooper pairs) also permits nearly lossless thermal transport.

Thus, graphene's exceptional electrical and thermal properties emerge as two complementary expressions of a single underlying field physics—the coherent organization of the frictionless etheric pressure field permeating all matter.

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