The Dynamic Vacuum Substrate: Electrodynamic Radiation, Autowave Propagation, and Resonance Absorption in Discrete Bubble Media

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August 2026

Abstract

This paper expands the quaternionic field framework into the fully dynamic regime of electrodynamic radiation, autowave propagation, and resonance absorption by treating the physical vacuum as a deterministic, compressible elastic medium of sub-planckian vacuum bubbles (the Wheeler substrate). By deploying a non-linear second-order Verhulst–Van der Pol logistic regulator, we establish a rigorous four-fold taxonomy of substrate kinematics: laminar drift, collective macro-convection, pulse shocks, and high-frequency volumetric oscillations. We deconstruct the classical Maxwellian displacement current, mapping it as the literal velocity of elastic shape deformation within the bound bubble matrix under finite field viscosity. This hydrodynamic ontology eliminates the historical energy-divergence paradoxes and provides a transparent mechanical contrast between the closed, dissipative conduction currents of conventional technology and the open, non-local resonant autowave transfers observed in Tesla-Meyl single-wire topologies. Finally, the intra-atomic current of the hydrogen atom is reinterpreted as a closed, non-radiating toroidal self-circulation of the substrate under a 2:1 gyroscopic resonance condition. We define quantum transitions not as stochastic jumps, but as a causal two-stage process consisting of external acoustic pumping (vortex energy accumulation) followed by a non-linear quadratic boundary disruption that releases an isolated, indivisible longitudinal-transverse quaternionic electromagnetic wave packet with a strict pi/2 phase quadrature between the scalar potential S and the transverse vectors.

1 Introduction: The Transition to Pure Substrate Dynamics

In the previous foundational works of this research cycle [1], the structural completeness of electrodynamics was restored by reintroducing the Maxwellian field scalar potential $S = \text{Real}(\mathbb{DA}) \neq 0$, which had been arbitrarily expelled by the Heaviside–Gibbs vector reduction. This framework successfully modeled elementary charges as regular, singularity-free quaternionic field attractors in a state of rest. However, a complete description of physical reality requires a transition from electrostatics to pure electrodynamic propagation.

In this paper, we establish that free electromagnetic radiation—traditionally conceptualized via the contradictory wave-particle dualism—is an isolated, self-sustaining autowave packet (a quaternionic soliton of compression-torsion) propagating across a **deterministic elastic medium of vacuum bubbles**. Every individual vacuum bubble represents a sub-planckian

cellular entity capable of rapid volumetric pulsation and orientation precessional roll. Consequently, the dynamics of light emission, propagation, and absorption are stripped of probabilistic abstractions and mapped directly onto the continuous non-linear mechanics of a discrete compressible substrate.

2 The Four-Fold Taxonomy of Substrate Kinematics

To systematically categorize the dynamic behaviors of the bubble field under the governance of the generalized field evolution equation: we formulate an absolute four-fold taxonomy of substrate kinematics, which replaces the axiomatic constraints of relativistic kinematic postulates with local fluid mechanics:

1. **Laminar Drift (Type 1):** The slow, orderly translation of a macro-cavity (charge core) phase center along the screw-like incline of a deformed micro-bubble matrix. The surrounding substrate remains stationary, while the defect slides under a sub-critical velocity limit ($\mathbf{v} \ll c$).

2. **Macro-Convection (Type 2):** The macroscopic collective transport of entire ensembles and volumes of micro-bubbles driven by systemic gradients of thermal-like field density. This regular flow forms the hydrodynamic basis for free magnetic fields and cosmic jet structures.

3. **Pulse Shock Impact (Type 3):** An instantaneous disruption of the continuous field that occurs faster than the characteristic relaxation time of the micro-cells. The bubbles lock into an elastic clinch, generating a δ-shaped longitudinal-transverse disruption wavefront.

4. **High-Frequency Oscillation (Type 4):** The cyclic, periodic volumetric pulsation (compression-rarefaction) and precessional spinning of the micro-bubble boundaries. This oscillatory mode constitutes the physical substance of free electromagnetic wave packets and spectral lines.

3 The Physics of Stationary Motion: Unifying Direct Current and Mechanical Equilibrium

3.1 The Stationary Verhulst Equilibrium and Energy Bifurcation

To establish a self-contained dynamical theory of the bubble substrate, we define the stationary regime of motion by contrasting it against the state of absolute rest ($\mathbf{v} = 0$) and free inertial flight. Under the influence of a continuous external scalar pressure gradient ∇S_{ext} (representing a macroscopic direct current electric field), the velocity evolution equation maps onto a strict localized balance of forces:

$$\alpha \cdot (\nabla S_{\text{ext}}) \cdot \mathbf{v}_{\max} \cdot \left(1 - \frac{\mathbf{v}_{\max}^2}{c^2}\right) = \mathbf{F}_{\text{vortex}}(B) + \nu_v \nabla^2 \mathbf{v}_{\max} \tag{1}$$

where $\dot{\mathbf{v}} = 0$, indicating that acceleration vanishes at the Verhulst logistic ceiling.

Unlike conventional vector treatments which assume all input energy is lost to resistive friction, the quaternionic convective operator $\mathbb{V}(\mathbb{D}\mathbb{V})$ forces a strict bifurcation of the incoming energy stream:

1. **The Dissipative Component:** A fraction of the spatial pressure gradient is consumed by the kinematic field viscosity $\nu_v \nabla^2 \mathbf{v}_{\max}$, dissipating into sub-planckian acoustic thermal noise, recorded macroscopically as Joule heating.

2. **The Reactive Component ($\mathbf{F}_{\mathbf{vortex}}$):** The remaining energy is mechanically directed into winding and sustaining a stable, macroscopic toroidal vortex of micro-bubbles around the conduction axis. This sustained angular precessional roll of the cell boundaries constitutes the static magnetic field ($\mathbf{B} = \text{Const}$).

3.2 Technical Isomorphism: Musk's Battery Blindness vs. Tesla's Open Vacuum Drive

This fundamental energetical split exposes the deep technological divergence between closed-loop conduction networks and open resonant bubble systems:

- **The Closed Conduction Limit (Elon Musk's "Tesla" EV):** Operates exclusively via Type 1 laminar macro-drift ($\mathbf{J}$). Energy is bounded by the chemical potential of heavy lithium-ion substrates. The closed circuit forces high viscous shear friction against the metallic lattice, maximizing dissipative thermal losses and bounding vehicle range strictly within Faraday-closed charge conservation.

- **The Open Resonant Drive (Nikola Tesla's 1931 Pierce-Arrow):** Utilized a high-frequency coaxial resonator acting as a localized hydrodynamic vacuum sink ("vacuum cleaner" mode). By inducing an interference hole of severe rarefaction (potential $-S$) via Kovalevski-type phase locking [3], the device tapped directly into the external hydrostatic pressure of the unperturbed Wheeler field. The resulting displacement current ($\partial_t \mathbf{E}$) sustained continuous autowave power extraction from the continuous elastic matrix without consuming an internal chemical resource [5, 6].

4 The Physical Nature of Displacement Current and Modified Continuity

The Maxwellian displacement current $\mathbf{J}_D = \varepsilon_0 \partial_t \mathbf{E}$ is stripped of its abstract "current-without-charge" definition. On the substrate level, it represents the literal velocity of elastic shape deformation of the bound micro-bubbles under a locked translation center ($\mathbf{v} = 0$). When a conduction current $\mathbf{J}$ hits a geometric boundary (e.g., a capacitor plate or single-wire termination), the cells flatten into thin lenses, storing potential energy. When the voltage is locked, $\partial_t \mathbf{E} = 0$, leading to topological jamming. By explicitly restoring the scalar potential term $S = -\nabla \cdot \mathbf{A} \neq 0$, we derive the **Quaternionic Continuity Equation of the Bubble Field**:

$$\frac{1}{\varepsilon_0} \left(\partial_t \rho + \nabla \cdot \mathbf{J} \right) = \frac{1}{c^2} \partial_t^2 S - \nabla^2 S \equiv \Box S \tag{2}$$

Equation (3) proves that a broken conduction circuit ($\partial_t \rho + \nabla \cdot \mathbf{J} \neq 0$) triggers a direct topological transition, converting localized drift into a longitudinal acoustic wave of scalar pressure S that propagates unhindered through Faraday cages. Due to finite field viscosity ν_v, this high-frequency displacement current inherently radiates a quantized thermal gradient into the matrix while remaining self-locked via gyroscopic auto-rotation.

5 The Physics of Pulse Shocks: Indivisible Longitudinal-Transverse Solitons

When the temporal gradient of the current front approaches a sharp limit ($\Delta t \to 0$), the substrate undergoes a non-linear acoustic shock modeled by a Dirac $\delta(t)$-distribution. This severe impulse input completely breaks the applicability of conventional Fourier spectral analysis. While a pulse can be mathematically decomposed into an infinite series of harmonic sine waves, physically separate longitudinal or transverse harmonics do not exist at the sub-planckian cell level. The pulse shock generates an **indivisible longitudinal-transverse quaternionic wave packet**. The longitudinal compression gradient ∇S acts as an internal engine pushing the wavefront forward, while the transverse magnetic rotor $\nabla \times \mathbf{B}$ acts as a gyroscopic stabilizer, preserving the non-spreading soliton form (Tesla's radiant energy packet) over macroscopic distances.

5.1 The Far-Field Wave Mathematics: Autowave Soliton Solutions

In the far-field zone, mathematically defined on macroscopic distances from the radiation boundary ($r \to \infty$), the structural substrate source density parameters vanish identically ($\rho = 0, \mathbf{J} = 0$). The modified dynamic field equations collapse into a source-free quaternionic continuum system [3]:

$$\frac{1}{c}\partial_t S + \nabla \cdot \mathbf{E} = 0, \quad \frac{1}{c}\partial_t \mathbf{E} - \nabla \times (c\mathbf{B}) = -\nabla S \tag{3}$$

Applying the d'Alembertian wave operator $\Box = \frac{1}{c^2}\partial_t^2 - \nabla^2$ combined with the second-order non-linear quadratic Verhulst regulator, we state the finalized non-linear evolution equation of free light propagation across the viscous bubble field [1]:

$$\left(\frac{1}{c^2}\partial_t^2 - \nabla^2\right)\mathbb{F} = \mu \cdot \mathbb{F} \cdot \left(1 - \frac{\mathbb{F}}{\mathbb{F}_0}\right) - \nu_v \nabla^2(\partial_t \mathbb{F}) \tag{4}$$

where $\mathbb{F} = [S, \mathbf{E} + c\mathbf{B}]$ is the total field quaternion, and $\mathbb{F}_0$ represents the structural elasticity ceiling of the micro-bubble walls.

The exact analytical solution of this non-linear framework mapping a localized wave packet (photon) traveling along the x-axis maps as an indivisible **longitudinal-transverse quaternionic envelope soliton** [4]:

$$S(x,t) = S_0 \cdot \operatorname{sech}(\omega t - kx) \cdot \sin(\omega t - kx) \tag{5}$$

$$\mathbf{E}(x,t) = \mathbf{E}_0 \cdot \operatorname{sech}(\omega t - kx) \cdot \cos(\omega t - kx) \tag{6}$$

$$c\mathbf{B}(x,t) = \mathbf{B}_0 \cdot \operatorname{sech}(\omega t - kx) \cdot \cos(\omega t - kx) \tag{7}$$

The trigonometric phase shift of $\pi/2$ between the longitudinal scalar tension S and the transverse vector profiles $\mathbf{E}, \mathbf{B}$ demonstrates the physical mechanism of free flight. The longitudinal pressure gradient ∇S acts as an internal continuous engine pushing the packet forward, while the transverse magnetic rotor locks the boundaries, preserving the non-spreading $\operatorname{sech}(z)$ geometric bullet shape over cosmological distances under finite field viscosity ν_v.

5.2 Historical Validation: The Convective Corrections of Hertz and the Scalar Fields of Tesla

The historical trajectory of electrodynamics reveals that both Heinrich Hertz and Nikola Tesla independently arrived at crucial physical modifications that directly validate our quaternionic

bubble framework, before being systematically erased by orthodox vector reductionism. Hertz vehemently rejected Maxwell's formulation for a complete void and explicitly rewrote the field equations by replacing the partial time derivative ∂_t with the complete Stokesian hydrodynamic convective derivative: $\frac{d}{dt} = \partial_t + (\mathbf{v} \cdot \nabla)$, effectively forcing the fields to be dynamic extensions of a moving physical medium [8]. Concurrently, Tesla experimentally demonstrated that the transverse "Hertzian" radiation was merely a dissipative losses byproduct of high-frequency spark discharges, proving that the true free transmission of energy across the substrate manifests as a non-damping, non-local **longitudinal acoustic wave of elastic vacuum compression** [6,7]. Our model seamlessly synthesizes these historical breakthroughs: the convective transport term of Hertz is structurally restored via the non-linear operator $\mathbb{V}(\mathbb{D}\mathbb{V})$, while Tesla's longitudinal radiant stream is mathematically mapped by the propagation of the dynamic scalar tension gradient $\nabla S \neq 0$.

6 Intra-Atomic Currents: Closed Autowave Self-Circulation in the Hydrogen Substrate

6.1 The Fifth Type of Current: Resonant Non-Radiating Loops

To complete the system of substrate electrodynamics, we introduce the **Fifth Type of Current: The Intra-Atomic Self-Circulating Current** ($\mathbf{J}_{\text{atom}}$). Unlike macro-currents bounded by wire geometries, the movement of the electronic macro-cavity around the proton-sink is an autonomous, closed autowave process governed by a non-linear quaternionic attractor [1]. In the ground state ($n = 1$), the orbital phase velocity and the micro-bubble precessional vorticity roll $\nabla \times \mathbf{A}$ establish a perfect 2:1 gyroscopic resonance (the Kovalevski top equivalent), ensuring that the time-averaged Poynting flux through the atomic boundary vanishes identically: $\oint \mathbf{S}_{\text{mod}} \cdot d\mathbf{S} = 0$. The exact analytical solution for the ground-state substrate velocity profile is regular and free of point-singularities:

$$\mathbb{V}_{\text{ground}}(r,t) = v_0 \cdot \text{sinc}\left(\frac{\omega_c r}{c}\right) \cdot e^{-i\omega_c t} \tag{8}$$

where $\omega_c = c/R_e$ is the Compton frequency, and the first stable spatial node of the cardinal sine naturally dictates the Bohr radius $a_0 = \pi c/\omega_c$ [1].

6.2 The Pumping Mechanism and Metastable Excited Solitons

The intra-atomic current transitions from the stable ground state into an excited configuration via a two-stage deterministic cycle: **Acoustic Pumping** followed by **Non-Linear Disruption**. Pumping occurs when an external high-frequency displacement current shock wave (Type 4) impacts the core, forcing the vortex to absorb the matrix deformation energy. The toroidal channel expands under centripetal expansion, shifting the system into a metastable saddle-focus mode governed by the integer quantum configurations ($n = 2, 3, \dots$):

$$\mathbb{V}_n(r,t) = v_0 \cdot \text{sinc}\left(\frac{\omega_c r}{nc}\right) \cdot e^{-\gamma_n t} \cdot e^{-i\left(\frac{\omega_c}{n}\right)t} \tag{9}$$

where $\gamma_n = \nu_v/(n^2 R_e^2)$ represents the micro-structural field damping factor driven by the vacuum viscosity [1]. This excited mode is inherently unstable; as the relaxation window closes, the attractor experiences an Arnold-type boundary disruption, collapsing back to the ground cycle. The function of light emission is embedded directly into the differential phase mapping:

$$\mathbb{V}_{\text{radiation}}(r,t) = \mathbb{V}_n(r,t) - \mathbb{V}_{\text{ground}}(r,t) = \mathbf{A}_0 \cdot \left[\text{sinc}\left(\frac{\omega_{\text{rad}} r}{c}\right)\right] \cdot \cos(\omega_{\text{rad}} t - \mathbf{k} \cdot \mathbf{r}) \tag{10}$$

where the emitted light frequency ω_{rad} emerges as a direct arithmetic difference of the two substrate modes, satisfying the Ritz-Rydberg combination principle without Bohr's postulates:

$$\omega_{\text{rad}} = \omega_c \left(\frac{1}{1} - \frac{1}{n} \right) \implies \omega_{m \to n} = \omega_c \left(\frac{1}{n} - \frac{1}{m} \right) \tag{11}$$

6.3 Topological Mapping of the Intra-Atomic Vortex

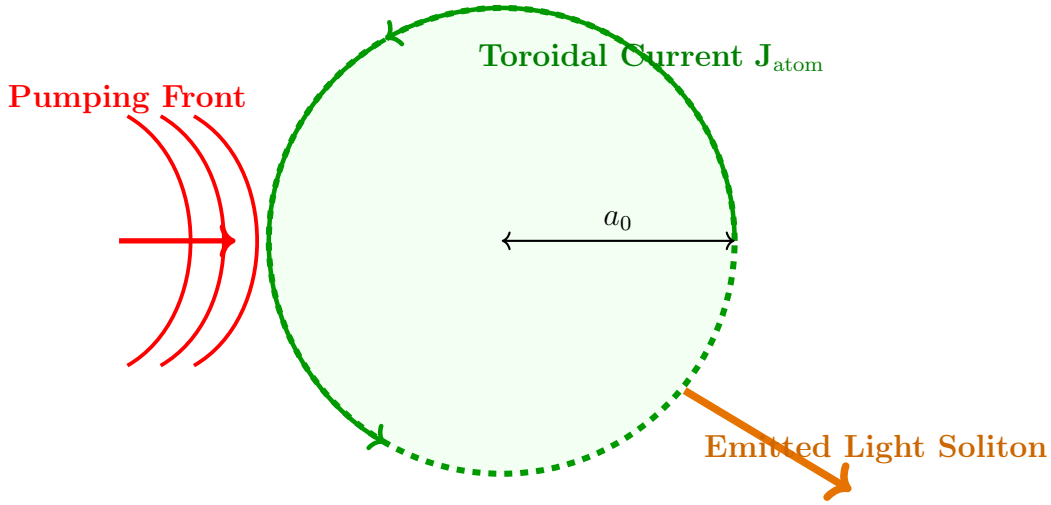

Figure 1: The dynamic topology of the intra-atomic current: The central proton maps as a continuous cavitational sink, maintaining the closed, non-radiating green toroidal autowave channel of the electron core. The incoming red front drives the structural pumping, while the outgoing orange path vectors the released quaternionic light packet.

6.4 Holographic Comparison of Light Paradigms

7 Conclusion

The dynamic extension of the quaternionic field framework achieved in this paper establishes a deterministic, purely mechanical foundation for electrodynamic radiation, breaking both the vector limitations of the Heaviside-Lorentz school and the probabilistic dualisms of the Planck-Einstein quantum paradigm. By explicitly restoring the original Maxwellian field scalar potential $S = -\nabla \cdot \mathbf{A} \neq 0$, we eliminate the historical energy-pulsation paradoxes that plague orthodox field theory.

In stark contrast to Heaviside's reduction, which forces the transverse vectors $\mathbf{E}$ and $\mathbf{B}$ to oscillate in perfect spatial in-phase synchronicity—leaving the spatial nodes completely void of localized energy—our regular quaternionic envelope soliton solution ($\text{sech}(z)$) establishes a strict $\pi/2$ trigonometric phase quadrature between the longitudinal scalar tension S and the transverse field metrics. When the transverse rotational vorticity of the micro-bubbles vanishes, the local potential energy is completely preserved and transferred into the longitudinal pressure gradient ∇S. This longitudinal component acts as a continuous internal mechanical engine pushing the wavefront forward at the speed of substrate compression c, while the transverse components act as a gyroscopic self-locking stabilizer.

Ultimately, this framework unifies macro-scale resonant power dynamics (Tesla-Meyl single-wire lines) and sub-atomic quantum states under a single continuous mechanical ledger. The intra-atomic current of the hydrogen atom is revealed not as a probabilistic cloud, but as a

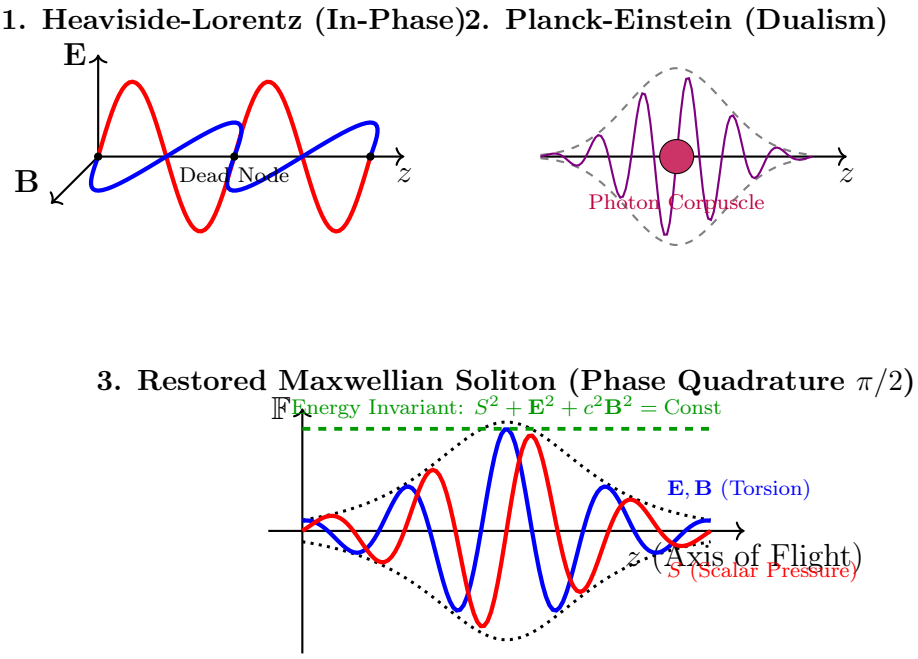

Figure 2: Comparative analysis of light representations: 1. The classical Heaviside framework with problematic zero-energy nodes. 2. The standard quantum mechanical corpuscle-wave packaging. 3. Our proposed restored Maxwellian quaternionic model, demonstrating how the $\pi/2$ phase shift between the longitudinal scalar pressure S and the transverse vector fields locks the total localized energy into a non-spreading soliton.

stable, non-radiating fluid attractor. Quantum transitions are cleared of stochastic mysticism, mapped instead as a causal two-stage loop where discrete structural pumping (vortex energy accumulation) triggers a deterministic quadratic Verhulst boundary disruption, releasing an indivisible, energy-invariant longitudinal-transverse wave packet into the elastic matrix of the physical vacuum.

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