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Ulianov's Formulation of the Maxwell's Equations, from a Spherical-Shell Electron Model

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ABSTRACT

Ulianov String Theory (UST) proposes a non–pointlike electron: instead of an infinitesimal particle orbiting the proton, the electron is modeled as a thin spherical shell of negative charge whose radius is comparable to the size of its orbital. The shell rotates at high angular velocity and naturally generates a magnetic field. The negative charge is distributed over the entire membrane in a manner that parallels the quantum mechanical wave function; however, rather than representing a probability density of finding a point particle, the wave equation is interpreted here as a real charge density over a geometrical surface.

All of the rest mass of the electron is concentrated in a single point located at one pole of the shell-the *polar mass*. This point like mass determines a preferred direction of rotation, so that all electrons share the same intrinsic rotational sense. What quantum theory labels as "opposite spin" corresponds, in this model, merely to the shell being inverted, with the polar mass located at the opposite pole. Thus, the electron possesses an extended charge distribution but a localized point of inertia.

This microscopic structure allows for a natural and fully geometrical decomposition of macroscopic polarization **P** and magnetization **M**. From these fields, the usual conduction-current term $\mu_0\mathbf{J}$ in the Ampère–Maxwell law is not assumed but is instead *recovered as an emergent quantity*.

As a result, Maxwell's equations can be rewritten in a field-only form:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$
$$\nabla \cdot \mathbf{B} = 0,$$
$$\nabla \cdot \mathbf{D} = 0,$$
$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}.$$

with $\mathbf{D} = \varepsilon_0\mathbf{E} + \mathbf{P}$ and $\mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}$.

The central modification introduced by UST concerns the Amp`ere–Maxwell law. In its standard SI form,

$$\nabla \times \mathbf{B} = \mu_0\mathbf{J} + \mu_0\varepsilon_0\frac{\partial \mathbf{E}}{\partial t}.$$

the magnetic field has two distinct sources: electric current and the time derivative of the electric field. This two-term structure reflects the traditional belief that magnetism generated by permanent magnets and magnetism generated by electric currents are fundamentally different.

However, UST provides a unified microphysical explanation. Because every electron is a rotating spherical shell with a mass pole, both forms of magnetism arise from the same underlying mechanism: the alignment or misalignment of the rotation axes of many electrons. An electric current does not *create* a magnetic field; rather, the preexisting microscopic magnetic fields of the electrons become partially aligned as the shells move and the mass poles lag due to inertia. This alignment process parallels the way sailboats randomly oriented on a calm sea all turn in the same direction under a light wind.

Thus, the magnetic field surrounding a current-carrying wire is not produced but is the collective ordering of microscopic magnetization fields. This perspective removes the need for the explicit sum in the original Ampère–Maxwell law and yields a more uniform and elegant field structure without altering any experimentally verified predictions of classical electromagnetism.

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Introduction

Classical electromagnetism, as formulated by James Clerk Maxwell between 1861 and 1865, remains one of the most elegant and empirically successful theories in physics. Its four equations unify electricity, magnetism, and optics into a single coherent framework and continue to describe with remarkable accuracy the behavior of electromagnetic fields in matter and in vacuum. Modern textbooks typically present Maxwell's equations in a compact differential form, with the electric current density J introduced as a primitive source term in the Ampere-Maxwell law.

However, Maxwell's equations themselves do not specify-nor require-any particular microscopic structure for charges or currents. In standard physics, the electron is treated as a point-like particle, and the current density is simply postulated as an external input. This pragmatic stance has been enormously successful, yet it leaves open a deeper question: *what is the physical origin of the current density?*

Ulianov String Theory (UST) offers a different microscopic ontology. In this framework, electrons are not point particles but thin spherical membranes of Planck-scale thickness, created by the collapse of imaginary time from a single Ulianov Wormhole into NS identical copies arranged along a closed string. All of the rest mass of the electron resides in a small polar region-*the polar mass*-which fixes a unique intrinsic rotation sense. This extended geometry reproduces all known properties of the electron while providing new degrees of freedom for polarization and magnetization.

Building upon this geometry, the Ulianov formulation of Maxwell's equations proposes that the macroscopic electric current is not fundamental. Instead, the current density emerges from two collective effects of many electron shells:

- polarization arising from the displacement of the charged shells, and
- magnetization arising from the partial alignment of the spin axes fixed by the polar mass.

With these ingredients, the usual current-density source term $\mu_0\mathbf{J}$ becomes an emergent functional,

$$\mathbf{J}_{\text{calc}} = \dot{\mathbf{P}} + \nabla \times \mathbf{M},$$

Maxwell's equations can be expressed in a **field-only** form closed solely by constitutive relations. This reformulation is mathematically equivalent to the classical Maxwell system, but it supplies a microphysical interpretation for the sources of electromagnetic fields.

Structure of the Paper

For clarity, this work proceeds through a sequence of conceptual steps. We begin by recalling the standard form of the Maxwell equations and the traditional role of the current density. We then summarize the essential elements of Ulianov String Theory relevant to electrodynamics, particularly the emergence of spherical-shell electrons from the collapse of imaginary time. Next, we present the UST Electron Model, emphasizing its geometry, polar mass, and its connection to quantum wave behavior. Building on this microscopic structure, we introduce the Ulianov formulation of Maxwell's equations, where polarization and magnetization arise directly from shell dynamics. Finally, we demonstrate the exact mathematical equivalence between this fields-only formulation and the classical Maxwell system, and we discuss its physical implications and potential experimental signatures.

Maxwell's Equations

Maxwell's Equations form the foundation of classical electrodynamics, unifying electricity, magnetism, and optics into a single coherent framework. Although they are now expressed in the compact vector notation shown below, their development was gradual and involved a sequence of major discoveries by several foundational figures in physics.

The story begins with Charles-Augustin de Coulomb, who in 1785 established the inverse–square law for electric forces using his torsion balance experiments [1]. Carl Friedrich Gauss later provided the mathematical formulation for electric flux and introduced what is now called Gauss's law, placing electrostatics on firm integral-grounded foundations [2].

In 1820-1823, Andre-Marie Ampere demonstrated that electric currents generate magnetic forces and derived the first integral law connecting current and magnetism [3]. Shortly thereafter, Michael Faraday discovered electromagnetic induction (1831-1832), revealing that time-varying magnetic fields generate electric fields [4]. Faraday's field concept was revolutionary, shifting physics from action-at-a-distance to continuous field descriptions.

Building on these pillars, James Clerk Maxwell published between 1861 and 1865 a sequence of papers that unified electricity and magnetism into a single dynamical system [5]. His key innovation was the introduction of the *displacement current* term, which completed the consistency of the theory and predicted the existence of electromagnetic waves-identifying light as an electromagnetic phenomenon. Maxwell later consolidated the theory in his monumental *Treatise on Electricity and Magnetism*, which established the modern field-based approach [6].

Today, Maxwell's equations in SI units (MKS) are written as:

$$\begin{aligned}
\nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t}, \\
\nabla \cdot \mathbf{E} &= \frac{\rho}{\varepsilon_0}, \\
\nabla \times \mathbf{B} &= \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}, \\
\nabla \cdot \mathbf{B} &= 0.
\end{aligned}$$

These equations, refined and standardized through modern expositions such as Jackson, describe all classical electromagnetic phenomena with remarkable accuracy and elegance [7].

These four equations have clear physical interpretations:

- **Faraday's Law** ($\nabla\times \mathbf{E} = -\partial\mathbf{B}/\partial t$): A changing magnetic field induces a circulating electric field.
- **Gauss's Law for Electricity** ($\nabla\cdot \mathbf{E} = \rho/\varepsilon_0$): Electric charges are sources (or sinks) of electric field.
- **Ampere-Maxwell Law** ($\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$ + μ_0 ε_0 ∂E/∂t): Magnetic fields arise from electric currents and from time-varying electric fields.
- **Gauss's Law for Magnetism** ($\nabla\cdot\mathbf{B} = 0$): There are no isolated magnetic monopoles; magnetic field lines always form closed loops.

Although the compact vector form is modern, Maxwell's original work used much more cumbersome component-based expressions. For completeness, one can also express the same physics through the integral formulations:

$$\begin{aligned}
\oint_{\partial S} \mathbf{E} \cdot d\boldsymbol{\ell} &= -\frac{d}{dt} \int_S \mathbf{B} \cdot d\mathbf{A}, \\
\oint_{\partial S} \mathbf{B} \cdot d\boldsymbol{\ell} &= \mu_0 I_{\text{enc}} + \mu_0 \varepsilon_0 \frac{d}{dt} \int_S \mathbf{E} \cdot d\mathbf{A}, \\
\oint_{\partial V} \mathbf{E} \cdot d\mathbf{A} &= \frac{Q_{\text{enc}}}{\varepsilon_0}, \\
\oint_{\partial V} \mathbf{B} \cdot d\mathbf{A} &= 0.
\end{aligned}$$

Both the integral and differential notations describe the same underlying laws. The differential form is extremely compact and suitable for field theory, whereas the integral form is more directly tied to experimental measurements and physical intuition.

Maxwell's synthesis remains one of the greatest achievements in physics: it explains light, radio waves, electromagnetic radiation, the structure of atoms, and much modern technology.

Ulianov String Theory

The Ulianov Theory introduces a new type of string theory, called *Ulianov String Theory* (UST) [8,9]. UST is built upon a complex and discrete notion of time,

$$s = t + iq,$$

where the real time component t is an integer multiple of the Planck time t_P , and the imaginary time component q advances through a fixed number of "processing steps" equal to N_S (the number of Simoon, $N_S = 7.77 \times 10^{60}$). Each step corresponds to a fundamental "small sphere", and the full set of NS spheres forms a string-like structure analogous to a necklace of Planck-scale beads.

In this framework, each "small sphere" corresponds to an Einstein-Rosen-Ulianov bridge, a Ulianov wormhole (UWH). One mouth of the UWH appears as a Planck-diameter sphere that moves in imaginary time at imaginary light speed, advancing by one Planck length per unit of Ulianov imaginary time,

$$U_T = \frac{t_P}{N_S} = 6.9385 \times 10^{-105} \text{ imaginary seconds.}$$

Along its trajectory in imaginary time, the UWH can rotate in both space and time and can change its mass and electric charge. For any observer unable to access or perceive imaginary time (such as humans in real spacetime), the imaginary dimension collapses. As a consequence, the single 5D pointlike UWH manifests in real spacetime as a 4D *Ulianov String* composed of NS sequential copies of the same UWH state. The resulting object resembles a necklace of Planck-scale pearls, each capable of assuming positive or negative mass and electric charge.

This string can coil or fold into higher-dimensional structures, naturally forming 2D membranes, 3D shells, or even 4D hypersurfaces within spacetime.

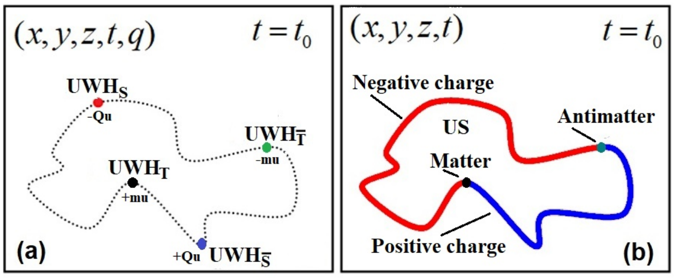

Figure 1: The foundation of Ulianov String Theory: the collapse of imaginary time transforms a single Ulianov Wormhole into an Ulianov String. (a) The UWH travels at imaginary light speed and may change its type along the path. (b) The resulting Ulianov String (US) is obtained after the collapse of imaginary time

Within this model, all known particles in our universe, including leptons, baryons, quarks, and photons, are constructed from specific combinations of UWHs that fold into characteristic strings and membranes. These structures determine the observed mass, charge, spin, and interaction properties of each particle species [10].

The UST Electron Model

In the Ulianov Atomic Model (UAM), a framework built upon Ulianov String Theory, electrons are not point-like particles but extended membranes formed by the collapse of imaginary time [11]. Before observation, an electron consists of a single Ulianov wormhole (UWH) propagating through complex time. After the collapse of the imaginary-time dimension, its N_S UWH copies appear simultaneously, forming a closed string of fixed length $N_S L_P$, which folds into a thin Planck thickness spherical shell.

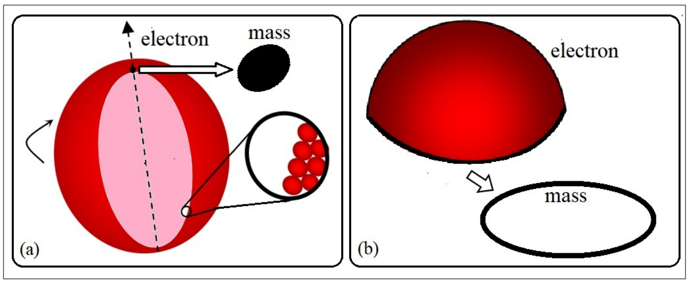

Figure 2: Electron geometries in UST: (a) a thin spherical shell with a polar mass that fixes the common spin sense; (b) a hemispherical cap where the mass relocates coherently along the equatorial rim in bound states

This shell model differs from the standard wave-particle duality, but remains fully compatible with the successful predictions of modern quantum mechanics. In the conventional interpretation, the wave function ψ encodes a probability distribution to locate a point-like electron. In UST, the same Schrödinger equation instead describes a *real* charge-density field (units of C/m^3) distributed over the spherical membrane. The familiar "electron cloud" becomes a physical, oscillating membrane rather than a statistical abstraction.

A central feature of **UST** is that **all the rest of the electron is concentrated in a tiny polar region** of the shell, a "polar mass" which behaves as a point-like corpuscle without electric charge. This localized mass rotates at the speed of light around the symmetry axis, fixing *a unique intrinsic rotation sense* for all electrons. What physicists call "opposite spin" simply corresponds to the same rotating shell viewed upside down, with the polar mass located at the opposite pole. This picture removes spin paradoxes while preserving all measurable spin phenomena.

As illustrated in Figure 2, UST admits two geometric realizations for the electron membrane:

- a **thin spherical shell** of negative charge, with Planck-length thickness and a radius ranging from tens of picometers to several nanometers, depending on the energy level, and hosting a small polar mass at the North pole;
- a **hemispherical-cap configuration** that appears only inside atoms, where two caps join to form a complete shell and the polar mass relocates along the equatorial rim.

These two shapes differ only in geometry, not in the underlying microstructure. In bound states, the cap geometry arises because two electrons in the same orbital come into mass-contact along the equatorial line. The distance between their polar-mass points becomes one Planck length, generating a strong gravitational contact force, enhanced by a factor of $1/L_P^2$, which exceeds their electrostatic repulsion by several orders of magnitude [12]. Because the two electrons touch their mass points, one shell is necessarily upside down relative to the other; although both maintain the same absolute rotation sense, they appear to have opposite spins. This provides a natural explanation for why atomic orbitals require electron pairs with opposite spins, without invoking the Pauli exclusion as a purely abstract rule.

Within this geometry, electric and magnetic phenomena acquire a unified microscopic origin. A rotating charged shell naturally produces a magnetic dipole moment, and because all electrons share the same intrinsic rotation sense, large groups of them can align under very small external fields. What is usually interpreted as "electric currents generating magnetic fields" becomes, in this view, the collective ordering of many preexisting microscopic magnetic fields carried by each electron.

A crucial prediction of UST is that a free electron maintains its spherical-shell form with a radius of roughly $Re \approx 5.1$ nm. This large radius appears only for an electron essentially at rest (spinning but with small translational velocity). As the electron accelerates, its relativistic mass increases, and the shell radius decreases, approaching values compatible with the de Broglie wavelength of the moving electron.

In particular, a 5nm shell radius coincides with:
- the Bohr radius for highly excited hydrogen states (n ∼ 10);
- the de Broglie wavelength of a very low-energy electron accelerated by ∼ 0.1 V.

Thus, free-electron diffraction, double-slit interference, and electron-microscope wave behavior arise naturally from extended-shell geometry, which explains the electron wave–particle duality: the polar mass behaves as a particle, while the oscillating shell behaves as a wave.

In the quantum-wave model, the act of observation collapses a probability distribution into a localized electron. In the UST framework, imaginary time exists continuously, but an observer (who cannot perceive this dimension) induces a collapse of the imaginary time coordinate. However, in **UST** an electron does not collapse into a point containing all of its mass and charge. Instead, it manifests as a rotating spherical shell with a large radius, with electric charge distributed across the membrane and the rest mass concentrated at a single polar region. A stationary electron shell (only rotating) may have a radius of approximately 5 nm, however, when inserted into atomic hydrogen, the shell interacts elastically with the proton, shrinks, acquires additional mass through **UWH** clustering, and reproduces Bohr-like radii and energy levels with excellent numerical accuracy.

Likewise, when the electron shell is accelerated to high velocities, its relativistic mass increases and the radius contracts to a scale comparable to the de Broglie wavelength of the moving electron. In this way, the UST electron model connects smoothly to the UAM nuclear structure while providing the geometric and dynamical elements required for the fields-only reformulation of Maxwell's equations developed in the following sections.

Ulianov's Formulation of Maxwell's Equations

Modern electrodynamics successfully describes how electric and magnetic fields propagate, but it remains deliberately agnostic with respect to the internal structure of the electron. In the standard picture, the electron is point-like, and the current density $\mathbf{j}(r, t)$ is inserted as a primitive source term into the Ampere-Maxwell's law.

In Ulianov String Theory (UST), the electron is not a point object but a *thin rotating spherical shell* that transports charge-e and hosts a tiny *polar mass* that fixes a unique spin sense for all electrons.

Two electron geometries are relevant in the UST: a spherical shell and a hemispherical cap. The cap configuration occurs only when two electrons share an orbital in mass-contact, rotating in opposite directions (because one shell is upside down with respect to the other, thus reversing the spin sense). However, when an electron is expelled from an atom, it always takes the form of a spherical shell, and its radius may increase considerably at low translational velocity. This extended geometry allows a free electron to pass through metallic lattices in a manner reminiscent of how a soap bubble can slip through a grid of thin wires.

This spherical-shell structure provides concrete degrees of freedom absent in a point-electron model:
- **Rotational Magnetic Moment.** A circulating negative charge produces a magnetic dipole μe, while the polar mass enforces a universal rotation sense for all electrons.
- **Collective Alignment in an Electric Field.** In a conductor, an applied field displaces shell centers and slightly biases their spin axes. This "sail-in-the-wind" mechanism produces macroscopic polarization **P** and magnetization **M**.
- **Current Density as an Emergent Functional.** At the continuum level,

$$\mathbf{J}_{\text{calc}} = \dot{\mathbf{P}} + \nabla \times \mathbf{M},$$

recovering the familiar Ampere–Maxwell source term without postulating primitive conduction currents.

Figure 3 illustrates the central idea: electrons in a metal behave like sailboats with randomly oriented masts. In the absence of an applied field, each electron already carries its own microscopic magnetic field-but the ensemble of spin axes points in all possible directions, so the vector sum of these micro-magnetic fields is essentially zero.

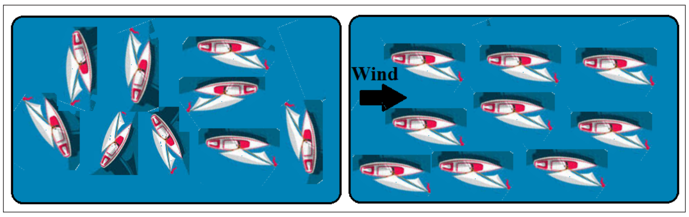

Figure 3: Sailboats analogy for electron-shell alignment. Left: as sailboats adrift point their masts in random directions, free electrons in a metal also have random spin orientations whose magnetic moments cancel statistically. Right: a light breeze aligns the sails and the boats; analogously, an electric field exerts forces on the spherical shell, causing the polar mass to lag slightly and aligning all electron spin axes, which strengthens the net magnetic field

A weak electric field plays the role of a gentle breeze: it shifts the centers of the spherical shells and causes their polar masses to lag slightly behind the drift direction. This bias aligns the spin axes of the electrons. The important point is that the magnetic field is *not created* by the current density; rather, it *pre-exists* at the microscopic level and becomes visible only when billions of electron dipoles become partially aligned. The macroscopic magnetic field observed around a current-carrying wire is simply the coherent sum of these previously hidden micromagnetic fields.

This microscopic ontology naturally generates electric polarization (via shell-center displacement) and magnetic response (via spin-axis alignment). With this structure, the macroscopic current density becomes an *emerging* quantity rather than a primitive axiom, and Maxwell's equations take the form of clean fields-only. In SI units, we can write:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$
$$\nabla \cdot \mathbf{B} = 0,$$
$$\nabla \cdot \mathbf{D} = 0,$$
$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t},$$

closed by the constitutive relations

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}, \qquad \mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}. \tag{1}$$

From a Single Shell Electron to Macroscopic Electrodynamics

The spherical-shell electron described in the previous section supplies two microscopic degrees of freedom that are absent from the point–particle ontology: (i) displacement of the negative shell center with respect to the ionic background, and (ii) alignment of the electron's spin axis, fixed by the polar mass. These two collective variables generate the macroscopic polarization and magnetization fields.

Polarization and Magnetization from Shell Dynamics

For a number density ne of electrons with centers at R$i(t)$ and spin axes $\hat{\mathbf{s}}_i(t)$ we define

$$\mathbf{P}(t) = -e\, n_e\, \mathbf{u}(t), \qquad \mathbf{M}(t) = n_e\, \mu_e\, \mathbf{s}(t),$$

where u(t) is the displacement averaged by the ensemble of the center shell and $s(t)$ is the spin direction averaged by the ensemble. At thermal equilibrium, we have s ≈ 0, but an applied electric field induces partial alignment because the polar mass biases the rotation axis ("sails-in-the-wind" effect). This provides a natural microscopic interpretation for the macroscopic fields **P** and **M** used in standard electrodynamics.

Fields-Only Maxwell Base

In macroscopic electrodynamics (SI units), the Maxwell equations in matter are written as

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$
$$\nabla \cdot \mathbf{B} = 0,$$
$$\nabla \cdot \mathbf{D} = \rho_{\text{free}},$$
$$\nabla \times \mathbf{H} = \mathbf{J}_{\text{free}} + \frac{\partial \mathbf{D}}{\partial t},$$

where ρ_{free} and $\mathbf{J}_{\text{free}}$ denote the free charge and current densities, i.e., sources not accounted for by polarization and magnetization (bound response).

We close the system with the constitutive definitions

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}, \qquad \mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}.$$

In this work we focus on electrically neutral bulk conductors in steady operating conditions, for which

$$\rho_{\text{free}} \approx 0 \text{ in the bulk,}$$

so that ∇·D = 0 holds away from surface-charge layers. In the Ulianov shell ontology, the macroscopic conduction process is attributed to the collective dynamics that build **P** and **M**, and the effective current is defined as

$$\mathbf{J}_{\text{calc}} = \dot{\mathbf{P}} + \nabla \times \mathbf{M}.$$

Note that $\dot{\mathbf{P}}$ and ∇ ×**M** both have SI units of A/m^2.

Under the source-free bulk condition ($\rho_{\text{free}} = 0$ and $\mathbf{J}_{\text{free}} = 0$), the macroscopic Maxwell equations can be written in the following fields-only base form:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$
$$\nabla \cdot \mathbf{B} = 0,$$
$$\nabla \cdot \mathbf{D} = 0,$$
$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t},$$

Substituting $\mathbf{J}_{\text{calc}}$ into the standard Ampere-Maxwell law reproduces the usual SI expression identically:

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0\, \mathbf{J}_{\text{calc}}.$$

Thus, the Ulianov formulation is not a modification of Maxwell's theory, but an *interpretation* in which the microscopic origins of **P** and **M** arise from the shell-electron geometry, and the current density is treated as an emergent macroscopic functional.

Physical Picture for Conductors

In a conductor subjected to an electric field:

- The shell centers drift, producing $\dot{\mathbf{P}} \neq 0$,
- The spin axes are partially aligned, producing $\mathbf{M} \neq 0$.

The magnetic field around a current-carrying wire is then superposed on (i) the magnetization generated by aligned shell electrons and (ii) the displacement current associated with the drifting shells. No primitive "bare" current density is required.

Observable Consequences

This reinterpretation suggests measurable signatures:

- a transient magnetization **M**(t) following a purely electric step,
- temperature- and history-dependent magnetic noise in conducting wires,
- spin polarization by current even in weak spin-orbit media.

None of these contradicts classical electromagnetism; instead, they refine its microscopic interpretation.

Macroscopic Consistency

The electromagnetic energy density and the Poynting vector retain the standard SI forms,

$$u = \frac{1}{2}\left(\mathbf{E}\cdot\mathbf{D} + \mathbf{B}\cdot\mathbf{H}\right), \qquad \mathbf{S} = \mathbf{E} \times \mathbf{H},$$

and Poynting's theorem holds with $\mathbf{J}_{\text{calc}}$ serving as the work channel. Thus, the field-only base is fully compatible with classical limits while providing a concrete physical origin for **P**, **M** and the emergent current density.

Demonstrating that the Ulianov Formulation of Maxwell's Equations is Mathematically Exact

In this section, we show that the Ulianov reformulation of Maxwell's equations is fully consistent with the classical Maxwell system. The key idea is to remove the electric current density **J** as a primitive quantity and replace it with a physical expression derived from the polarization and magnetization fields. This approach preserves all vector identities, ensures charge conservation, and leads to a formulation that is mathematically equivalent to Maxwell's original equations.

Starting Point: Redefinition of the Current Density

In SI units the standard Ampere-Maxwell law is

$$\nabla \times \mathbf{B} = \mu_0 \, \mathbf{J} + \mu_0 \varepsilon_0 \, \frac{\partial \mathbf{E}}{\partial t}. \tag{2}$$

In the Ulianov formulation, we introduce the constitutive definitions

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}, \tag{3}$$

$$\mathbf{H} = \frac{1}{\mu_0} \mathbf{B} - \mathbf{M}, \tag{4}$$

and postulate the fundamental relation (for the fields-only base)

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}. \tag{5}$$

Substituting these definitions gives:

$$\nabla \times \left(\frac{1}{\mu_0} \mathbf{B} - \mathbf{M} \right) = \frac{\partial}{\partial t} \left(\varepsilon_0 \mathbf{E} + \mathbf{P} \right). \tag{6}$$

Rearranging terms yields:

$$\frac{1}{\mu_0} \, \nabla \times \mathbf{B} = \varepsilon_0 \, \frac{\partial \mathbf{E}}{\partial t} + \left(\dot{\mathbf{P}} + \nabla \times \mathbf{M} \right). \tag{7}$$

Thus, the Ulianov model identifies the effective current as

$$\mathbf{J}_{\mathrm{calc}} = \dot{\mathbf{P}} + \nabla \times \mathbf{M}. \tag{8}$$

Equivalence to Maxwell's Original Form

Multiplying the previous relation by μ_0 gives:

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \, \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \, \mathbf{J}_{\mathrm{calc}}, \tag{9}$$

which is algebraically identical to the standard Ampere–Maxwell equation with $\mathbf{J}_{\mathrm{calc}}$ replaced by $\mathbf{J}_{\mathrm{calc}}$. Furthermore, since in the fields-only base we also impose

$$\nabla \cdot \mathbf{B} = 0, \qquad \nabla \cdot \mathbf{D} = 0,$$

the continuity equation,

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{J}_{\mathrm{calc}} = 0, \tag{10}$$

follows automatically. This guarantees that the Ulianov replacement for **J** does not violate charge conservation and maintains full compatibility with the Maxwell structure.

Preservation of Symmetries

The Reformulated System Preserves:

- rotational symmetry (because the curl and divergence operators are unchanged),
- gauge symmetry (because Jcalc satisfies continuity),
- the possibility of Lorentz covariance (the model can be rewritten using electromagnetic tensors without contradiction).

Thus, the Ulianov formulation is not an alteration of Maxwell's theory but a reinterpretation of the microscopic origin of the current density.

Observing the Ulianov formulation of Maxwell's equations, we can conclude that this new framework is mathematically exact:

- it reproduces the Maxwell equations without residual terms,
- it preserves the required vector identities,
- it satisfies charge conservation automatically,
- it provides a physical microstructure for the effective current density in terms of polarization and magnetization dynamics.

This ensures full equivalence with classical electrodynamics while offering a deeper physical interpretation of the sources of electric and magnetic fields.

Finally, it is important to mention that, as discussed in Section 2, the next logical step is to express the same formulation in a manifestly Lorentz-covariant way using the electromagnetic field tensor $F^{\mu v}$ and the polarization-magnetization tensor $M^{\mu v}$, which further strengthens the theoretical foundations of the Ulianov model.

Conclusion

We have presented a microscopic framework in which the electron is not a point particle but a thin rotating spherical shell (or, in bound configurations, a hemispherical cap) containing a localized polar mass that fixes a universal spin sense. When many such shells interact within a material, their collective displacement and partial spin alignment generate the macroscopic fields **P** and **M** directly from first principles.

Within this ontology, the density of the electric current is no longer a primitive external input to the Ampere-Maxwell's law. Instead, it is an *emergent quantity*,

$$\mathbf{J}_{\mathrm{calc}} = \dot{\mathbf{P}} + \nabla \times \mathbf{M},$$

arising from the real-time dynamics of shell centers and spin axes. Substituting this expression into the fields-only Maxwell base presented in this article reproduces *exactly* the classical Maxwell system. No approximation is involved; all vector identities, Gauss constraints, and the continuity equation follow identically.

This shows that the Ulianov formulation is not a modification of electromagnetism but a reorganization that accesses a more fundamental micro-physical layer. What previously appeared as the sum of two qualitatively different magnetic sources (currents and time-varying electric fields) now emerges from a single microscopic mechanism rooted in the geometry and rotation of the electron shell. Thus, the traditional conceptual divide between permanent magnets and electromagnets is removed: in UST both phenomena arise from the ordering or disordering of the same preexisting microscopic magnetic fields.

This unification also sheds light on superconductivity. Because current in the UST picture does not require energy to "create" magnetic fields but only to *align* preexisting ones, a coherent two-shell masscontact pairing can drift without dissipation once alignment is achieved. The macroscopic magnetic field of a superconductor (which can be very large despite the minimal driving power applied) appears naturally as the collective alignment of millions of identical rotating shells whose spin axes remain locked by pairing, providing an intuitive mechanistic picture behind the Meissner effect and persistent currents.

The framework yields concrete, falsifiable predictions, including: (i) transient magnetization induced solely by a step in the electric field; (ii) specific temperature, and history, dependent features in the near-field magnetic noise of conducting wires; and (iii) current-induced spin polarization even in weak spin-orbit materials. These signatures allow direct experimental adjudication of the model.

In summary, the spherical-shell electron provides a unified description for polarization, magnetization, conduction, and magnetic-field generation. The resulting field-only Maxwell base is mathematically exact, conceptually simpler, and physically richer. Its deeper value lies not merely in elegance but in opening a path toward quantitative tests capable of confirming or refuting the underlying ontology.

Large paradigm shifts are rarely accepted at once. Normally, progress follows a sequence of experimental dominoes, but the present work places the first one with clarity and precision. What matters is that each next domino is placed with clear predictions and clean comparisons with experiment.

Future work will fit the constitutive parameters to transient magnetometry data, extend the dynamics to superconductors and to nuclear-scale phenomena, and explore device-level implications where the emergent-current viewpoint simplifies modeling and suggests new control knobs.

The fields-only Maxwell base derived from the shell ontology cannot be immediately useful, but its deeper value lies in a new way to see the electrons that leads to a new Maxwell equation, a more basic formulation that is more symmetrical and a mathematical form that is obviously more elegant, which is something so powerful that it can be noticed even by someone unfamiliar with the subject that observes the two formulations in a side-side panel, as presented in figure (4).

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \cdot \mathbf{D} = 0$$
$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}$$

Figure 4: Maxwell's equations in the standard format with the new Ulianov's formulation of Maxwell equations. A side-by-side comparison makes immediate the increased symmetry, compactness, and conceptual unity of the new Ulianov formulation relative to the standard one

It should be noted that this work is part of a much broader framework known as Ulianov Theory [13]. This framework encompasses not only particle physics but also new atomic models and a new formulation of string theory, grounded on the notion of complex time [9,14-16]

Ulianov Theory further extends into cosmology, including the Small Bang scenario, Ulianov, Ulianov, and introduces new insights into black holes, antimatter-dominated galaxies, and a reformulation of gravitational behavior itself, Ulianov [17-24]. Together, these works establish a coherent theoretical ecosystem within which the present model naturally belongs.

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