

Classical Derivation of Maxwell's Equations from the Model of Spiral-Vortical Threads of the Electromagnetic Field

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Abstract

This article demonstrates how Maxwell's equations emerge in a classical field model where the electromagnetic field is a network of spiral-vortical threads (structured force lines). In the first approximation, the geometry and topology of these threads directly yield the four Maxwell equations. In the second approximation, small corrections for nonlinear viscosity, torsion, and field self-interaction are introduced. An explicit approximate solution is given for a converging conical spiral (half-apex angle 45°), showing how dissipative and torsional effects regularize the field near the tip.

See also:

- “A Classical Derivation of Planck's Formula from Electromagnetic Mode Merging Statistics”
 - “A Derivation of the Schrödinger Equation from the Model of Spiral-Vortical Threads of Electromagnetic Field Force Lines” of the Shulzinger E.
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1. Introduction

Traditional field theory takes Maxwell's equations as axiomatic. Here we show they follow naturally from a richer classical picture in which:

- The field is a tangle of spiral-vortical energy threads.
- Threads carry energy in their curvature and twist, interact thermodynamically, and form coherent structures.
- Charges and currents correspond to local concentrations and directed flows of threads.

This work builds on two earlier articles: one deriving Planck's blackbody formula from thread-merging statistics, and another deriving the Schrödinger equation from thread resonance dynamics. Together, they form a unified classical foundation for phenomena usually deemed “quantum.”

2. Spiral-Vortical Thread Model Overview

- Threads are helical force lines with local twist (torsion) and pitch, oscillating at frequency ν .
- Thread energy is proportional to its curvature and frequency: $E = h \cdot \nu$, with h a coupling constant.
- Interactions among threads form nodes—localized energy concentrations that behave like field quanta or particles.

- Macroscopic fields arise from aggregate thread parameters:
 - Electric field E from time-varying twist density
 - Magnetic induction B from spatial curl of thread twist
 - Scalar potential ϕ from longitudinal tension of threads
 - Vector potential A from local twist (angular distortion) of threads
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3. First Approximation: Recovering Maxwell's Equations

Assume a smooth network of threads, negligible viscosity, torsion effects, and self-interaction. In this limit:

1. Gauss's law for electricity
divergence of $E = \rho / \epsilon_0$
(ρ is local thread-density source or sink)
2. Gauss's law for magnetism
divergence of $B = 0$
(threads are closed loops—no magnetic monopoles)
3. Faraday's law of induction
curl of $E = -\partial B / \partial t$
(time-varying twist produces a circulating electric field)
4. Ampère–Maxwell law
curl of $B = \mu_0 \cdot j + \mu_0 \cdot \epsilon_0 \cdot \partial E / \partial t$
(directed flow of threads j and changing E produce magnetic vortices)

These four relations map exactly onto classical Maxwell equations when E and B are interpreted via thread geometry.

4. Geometric Interpretation of Potentials

- **Vector potential A** is the local measure of angular twist of threads.
- **Magnetic induction B** arises as the spatial curl of A :
 $B = \text{curl } A$
- **Electric field E** comprises two parts:
 $E = -\partial A / \partial t - \text{grad } \phi$
 - The term $-\partial A / \partial t$ reflects changing twist over time.
 - The term $-\text{grad } \phi$ reflects longitudinal tension in threads.
- Scalar potential ϕ ties to variations in thread density and longitudinal stress.

This view elevates potentials to primary geometric quantities from which fields derive.

5. Second Approximation: Dissipation, Torsion, and Self-Interaction

Real threads exhibit small internal resistance (viscosity), nonuniform twist (torsion), and self-feedback. We introduce three corrections:

5.1 Nonlinear Viscosity

- Add viscous damping terms to curl equations:
- Ampère–Maxwell law gains $-\eta_e \cdot \Delta E$ (Δ = Laplacian)
- Faraday’s law gains $-\eta_m \cdot \Delta B$

Here η_e and η_m quantify internal friction in twisted threads, damping high-frequency modes.

5.2 Torsion Effects

Define torsion vector $T = \text{curl } A_t$ (A_t is torsional component of A). Torsion sources modify Maxwell’s laws:

- divergence of $B = \kappa_m \cdot \text{div } T$
 - curl of $E = -\partial B / \partial t - \kappa_e \cdot \partial T / \partial t$
 - curl of $B = \mu_0 \cdot j + \mu_0 \cdot \epsilon_0 \cdot \partial E / \partial t + \kappa_j \cdot \text{curl } T$
- Constants κ_m , κ_e , κ_j measure how thread torsion acts as effective monopole or vortex sources.

5.3 Self-Interaction

Threads interacting with their own fields produce a nonlinear current

$$j_{\text{self}} = \chi \cdot (E \times B)$$

The Ampère–Maxwell law becomes

$$\text{curl } B = \mu_0 \cdot (j + j_{\text{self}}) + \mu_0 \cdot \epsilon_0 \cdot \partial E / \partial t - \eta_e \cdot \Delta E + \kappa_j \cdot \text{curl } T$$

χ sets the strength of field feedback on thread motion.

6. Approximate Solution for a Converging Conical Spiral

We illustrate the corrected equations with a field concentrated along a conical spiral whose half-apex angle is $\theta_0 = 45^\circ$ (full apex angle between generatrices $\varphi = 90^\circ$).

6.1 First Approximation

- In free space ($\rho = 0$, $j = 0$) and harmonic time dependence $\exp(-i \omega t)$:
- $\text{curl } E = i \omega B$
- $\text{curl } B = -i \omega \mu_0 \epsilon_0 E$
- Choose vector potential $A(r, t) = (A_0/r) \cdot \exp[-i(kr + \omega t)] e_\varphi$
- Fields concentrate as $1/r$ near the tip: $E, B \sim 1/r$

6.2 Second Approximation: Damping and Torsion

- Viscous damping rate $\gamma = \eta_e \cdot k^2 / (\omega \epsilon_0)$
- Laplacian along r : $\Delta E \approx (d^2/dr^2 + (2/r) d/dr) E$

- Approximate amplitude: $a(r) \simeq (A_0/r) \cdot \exp[-\gamma \cdot (R_0 - r)]$
 - Resulting fields decay as $\exp[-\gamma \cdot (R_0 - r)]/r$, preventing divergence at $r \rightarrow 0$
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7. Conclusion

Maxwell's equations emerge in first approximation from the geometry and topology of spiral-vortical threads. The vector potential A acquires a clear geometric meaning as local twist. Second-order corrections—viscous dissipation, torsion sources, and field self-interaction—introduce small nonlinear and dissipative terms, enriching the classical picture. The conical spiral example (half-apex 45°) illustrates how these effects regularize singular behavior. This work completes a trilogy of classical derivations alongside Planck's law and Schrödinger's equation, suggesting that quantum and field phenomena may arise from a single underlying thread dynamics.

