Maxwell Is All We Need

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Abstract

What if all of physics—space, matter, time, causality—could be derived from a single equation? In the Point–Not–Point (PNP) framework, Maxwell's equations are not just a description of electromagnetism—they are the *only* experimentally grounded starting point we need. By recasting them in a scalar, self-referential form, every observed structure emerges without additional postulates. Fields, quantization, inertia, thermodynamics, and even measurement collapse are deduced as consequences of topology and flow.

One-Sentence Summary

Space, time, matter, and measurement collapse arise naturally from Maxwell's equations when expressed as the self-referential scalar field U.

Keywords

Maxwell; scalar field; topology; causality; quantization; inertia; thermodynamics; time; relational physics

Introduction

Maxwell's equations, experimentally distilled in the 19th century, describe electric and magnetic fields with unmatched precision. Traditionally, they are written in vector form, on a background of space and time, with particles and charges as inputs. The PNP framework reverses this: there is no space to begin with, no separate particles—only a scalar energy field $U(x, t)$ whose self-referential oscillations and closures produce all observable structure.

This approach has **no postulates**. Maxwell's equations are already abstractions of experimental results; everything else is a logical unfolding from them.

Theory

Let $U : \mathbb{R}^3 \times \mathbb{R} \to \mathbb{R}$ be the fundamental scalar energy field. Define:

$$F = d(*dU)$$

Here:

- d is the exterior derivative, taking derivatives without coordinates.
- $*$ is the **Hodge dual operator**, mapping p-forms to $(n-p)$-forms in n dimensions, exchanging "flux" and "circulation" aspects of the field.

This definition produces the electromagnetic field tensor directly from U, with **no vector potential** A required.

In vacuum, Maxwell's equations emerge:

$$dF = 0, \quad d\star F = 0$$

These are the two homogeneous and two inhomogeneous Maxwell equations in one covariant statement. Gauge redundancy is eliminated—U is gauge-invariant by construction.

Why not a vector potential?

In the standard formalism, one writes $F = dA$, where A is a 1-form (the vector potential). This introduces unphysical degrees of freedom, removed by gauge fixing. In the scalar-first formalism, U already encodes all physical degrees of freedom; A is unnecessary. All measurable predictions match those of the A-formalism, but without the intermediate gauge structure.

This is more than aesthetic: removing A removes the *assumption* of a background geometry in which A lives. U generates both the fields and the relational structure that appears to us as "space."

Energy Flow and Conservation

From F, electric and magnetic fields appear in the usual way. The energy density u and Poynting vector $\mathbf{S}$ are:

$$u = \frac{\varepsilon_0}{2}(E^2 + c^2 B^2), \quad \mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$$

Poynting's theorem in vacuum:

$$\partial_t u + \nabla \cdot \mathbf{S} = 0$$

shows that **energy changes must be accompanied by flux**. This is not heuristic—it is enforced by the field equations themselves. Causality arises here: effects follow causes because flows must carry changes forward.

The Relational Chain

From these foundations, the physical hierarchy unfolds:

1. **Toroidal Modes → Quantization** Closed recurrence of U on two orthogonal loops (toroidal and poloidal) admits only discrete wavelengths, producing quantized energy levels.
2. **Mode Interaction → Inverse-Square Force** Standing-wave interactions decay $\propto 1/r$ in amplitude; energy conservation then yields a force $\propto -1/r^2$—without invoking charges or masses.
3. **Persistent Topology** (1) **→ Causality** The (1) mode (minimal closed oscillation) is self-inverting: inward flow flips phase to outward. This topological invariance defines causal ordering.
4. **Density-Dependent Flow → Cosmic Rotation Curves** Local energy density alters group velocity; Maxwell stresses from this variation explain flat galactic rotation curves—no dark matter required.
5. **Internal Momentum → Effective Mass** Circulating field momentum resists acceleration:
$$m_{\text{eff}} = \frac{1}{c^2} \int u \, dV \times \kappa$$
Mass is thus emergent, not fundamental.
6. **Thermodynamics → Non-Fundamental Arrow of Time** Microstates are full field configurations; coarse-graining yields entropy growth. Maxwell's dynamics remain reversible, but the arrow of time emerges statistically.
7. **Measurement → Reversible Collapse** In finite environments, measurement is reversible. Collapse is a controllable threshold in mode entanglement, not a universal law.

Master Relational Derivation

$$U \to \text{Maxwell} \to \text{Quantization} \to \frac{1}{r^2} \to \text{Causality} \to \text{Thermodynamics} \to \text{Measurement} \to m_{\text{eff}}$$

Higher-Order Relations

- **First order:** U defines E, B and thus "space."
- **Second order:** Space + fields define reversible time.
- **Third order:** Fields + directional flow define structured matter.
- **Higher:** Chemistry, biology, self-awareness—any self-sustaining causal loop.

Life itself is tied to Maxwell: any system that sustains its own causal loop in field flow meets the same topological persistence criteria.

Conclusion

Space is not a container for fields; it is a relation among them. Time is not fundamental; it is an emergent property of recurrence. Matter is not basic; it is structured, knotted energy flow. We believe it all happens because (1) happened—probably more than once.

WIP Note: Further expansion will include the explicit derivation of density-dependent $v_g(u)$, a full treatment of entropy production from mode statistics, and diagrams of the (1) mode topology for non-specialist audiences.