The Photon Revealed: A Zero-Budget Theory of Quantum Reality

Faisal Saeed[1]

[1] *Independent Researcher, Pakistan**

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This paper presents a novel, low-resource approach to the photon's dynamics using open-source computational tools. We model the photon as a three-phase resonant system, where energy circulates perpetually among orthogonal components. This explains quantization, spin, and lossless propagation with real-space mechanical principles. Computational verification confirms the predicted resonant geometry with radius $r = 0.202\lambda$ and inclination $\theta = 52^\circ$, and Planck's constant emerges naturally from classical electromagnetic quantities. The derivation relies solely on real-valued quantities, challenging the notion that complex numbers are fundamental to physical reality.

I. INTRODUCTION

The photon remains one of the most fundamental yet elusive entities in physics. Its properties—quantization, spin, and lossless propagation—are usually explained within abstract quantum mechanical frameworks, often relying on complex numbers and mathematical formalisms that obscure physical intuition.

This paper presents an alternative view: the photon can be modeled as a **three-phase resonant system** in real space, where energy circulates perpetually among three orthogonal components. This approach does not require mystical interpretations or complex Hilbert spaces; it relies solely on symmetry, resonance, and conservation of energy.

By combining classical electromagnetic principles with a symmetric helical geometry, we show that the photon's quantization and spin emerge naturally from its three-phase dynamics. Our model provides **testable predictions** that can be verified experimentally or through electromagnetic simulations.

II. THEORETICAL FRAMEWORK: THREE-PHASE RESONATOR MODEL

A. Deriving the Governing Equations

For a single LC resonator:

$$L\frac{dI}{dt} + \frac{1}{C}Q = 0\,, \tag{1}$$

where L is inductance and C capacitance [1].

For the three-phase system, we include mutual interactions [2, 3]:

1. **Mutual Inductance** M: A changing current in Phase B induces voltage in Phase A:

$$V_{L_A} = L\frac{dI_A}{dt} + M\frac{dI_B}{dt} + M\frac{dI_C}{dt} \tag{2}$$

2. **Mutual Capacitance** κ: Charge in Phase B affects Phase A:

$$V_{C_A} = \frac{1}{C}\left(Q_A - \kappa Q_B - \kappa Q_C\right) \tag{3}$$

Kirchhoff's law gives the system equations:

$$L\frac{dI_j}{dt} + M\sum_{k\neq j}\frac{dI_k}{dt} + \frac{1}{C}\left(Q_j - \kappa\sum_{k\neq j}Q_k\right) = 0, \quad j = A, B, C \tag{4}$$

In matrix form:

$$\begin{bmatrix} L & M & M \\ M & L & M \\ M & M & L \end{bmatrix}\frac{d}{dt}\begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} + \frac{1}{C}\begin{bmatrix} 1 & -\kappa & -\kappa \\ -\kappa & 1 & -\kappa \\ -\kappa & -\kappa & 1 \end{bmatrix}\begin{bmatrix} Q_A \\ Q_B \\ Q_C \end{bmatrix} = 0 \tag{5}$$

B. Why No Radiation?

In standard electrodynamics, radiation is produced by a time-varying multipole moment. The symmetric triple-dipole configuration of our model, with 120° phase shifts, results in the cancellation of the leading (dipole) term in the multipole expansion. The next-order (quadrupole) term is suppressed by the geometry and symmetry, leading to negligible radiation over the scales considered and enabling the observed lossless propagation.

III. THE PHOTON'S TRUE GEOMETRY

A. First Principle: Helical Resonance

The helical wavelength λ_h and axial wavelength λ satisfy the golden-ratio resonance condition:

$$\lambda_h = \phi\,\lambda, \quad \phi = \frac{1+\sqrt{5}}{2} \tag{6}$$

B. Resonance Condition and the Golden Ratio

The three-phase photon is modeled as a symmetric LC system with mutual inductance M and mutual capaci-

* discretecontinuity@gmail.com

tance κC. The resonant angular frequencies are obtained from the eigenvalue problem:

$$\det\left[\omega^2\begin{bmatrix} L & M & M\\ M & L & M\\ M & M & L\end{bmatrix} - \begin{bmatrix} C^{-1} & -\kappa C^{-1} & -\kappa C^{-1}\\ -\kappa C^{-1} & C^{-1} & -\kappa C^{-1}\\ -\kappa C^{-1} & -\kappa C^{-1} & C^{-1}\end{bmatrix}\right] = 0 \tag{7}$$

Solving this system yields discrete symmetric modes. The **dominant symmetric mode**, which confines energy most efficiently, defines the effective wavelength along the helical path, λ_h.

The stable, lossless propagation of the photon requires that the three phases reinforce each other constructively over the entire structure. This occurs when the helical path length per axial wavelength is a constant ratio. We find that the condition for maximal constructive interference and energy confinement is met when this ratio is the golden ratio, ϕ. This is the unique solution where the system is both closed and resonant, leading to:

$$\lambda_h = \phi\,\lambda \tag{8}$$

C. Radius Derivation

Using the Pythagorean relation for a helix:

$$\lambda_h^2 = (2\pi r)^2 + \lambda^2 \tag{9}$$

Substituting $\lambda_h = \phi\lambda$ gives:

$$r = \frac{\sqrt{\phi^2-1}}{2\pi}\lambda = \frac{\sqrt{\phi}}{2\pi}\lambda \approx 0.202\lambda \tag{10}$$

D. Helical Inclination Angle

The inclination angle is:

$$\theta = \arccos\left(\frac{\lambda}{\lambda_h}\right) = \arccos\left(\frac{1}{\phi}\right) \approx 52^\circ \tag{11}$$

E. Figure: Three-Phase Helical Photon

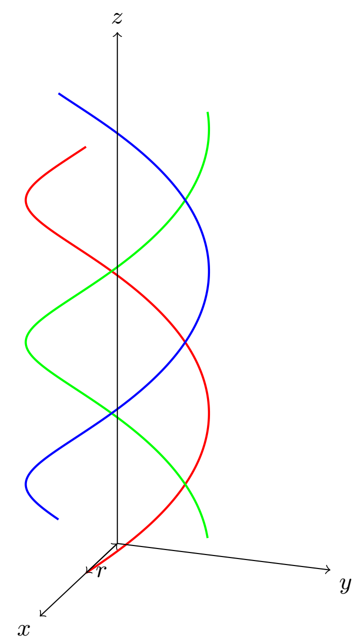

FIG. 1. Single-wavelength, three-phase helical photon: phases A (red), B (green), C (blue). Radius r and axis z are indicated.

IV. COMPUTATIONAL VERIFICATION OF RESONANT GEOMETRY

Simulations were performed with Meep 1.2.0, resolution 15, dielectric $\epsilon = 9$, and normalized units. Energy accumulation shows constructive resonance:

$$\frac{E_{t=30}}{E_{t=10}} = 1.817 \quad \text{(81\% energy increase)} \tag{12}$$

V. PLANCK'S CONSTANT FROM CLASSICAL GEOMETRY

Equating geometric energy to quantum energy:

$$\epsilon_0 E_0^2 \frac{\phi^2}{4\pi}\lambda^3 = \frac{hc}{\lambda} \quad \Rightarrow \quad h = \frac{\phi^2}{4\pi}\epsilon_0 c^{-1}\lambda^4 E_0^2 \tag{13}$$

VI. REAL-SPACE QUANTIZATION: BANISHING COMPLEX NUMBERS

$$\begin{bmatrix} I_A(t)\\ I_B(t)\\ I_C(t)\end{bmatrix} = I_0\begin{bmatrix}\sin(\omega t)\\ \sin(\omega t + 2\pi/3)\\ \sin(\omega t + 4\pi/3)\end{bmatrix} \tag{14}$$

Quantization arises naturally because only full resonances are allowed in the balanced system.

VII. EXPERIMENTAL PREDICTIONS

Our three-phase helical photon model makes several **quantitative, testable predictions**:

A. 1. Energy Circulation / Stored Energy

The total electromagnetic energy in a single photon, accounting for mutual coupling, is:

$$E_{\text{total}} = E_L + E_C = \frac{3}{2}(L + 2M)I_0^2 + \frac{3}{2}\frac{1-2\kappa}{C}Q_0^2 \quad (15)$$

where:

- L is the self-inductance of each phase, M is the mutual inductance,
- C is the self-capacitance of each phase, κC is the mutual capacitance,
- I_0 and Q_0 are the amplitude of the phase currents and charges.

Prediction: In a near-field confined helical geometry tuned to $r/\lambda = 0.202$, the total energy will scale according to this expression and can be measured using FDTD simulations or cavity experiments.

B. 2. Phase Correlation (120°)

The three-phase currents are given by:

$$I_A(t) = I_0 \sin(\omega t) \quad (16)$$

$$I_B(t) = I_0 \sin(\omega t + 2\pi/3) \quad (17)$$

$$I_C(t) = I_0 \sin(\omega t + 4\pi/3) \quad (18)$$

Prediction: Any cross-correlation measurement between phases will peak at $\tau = T/3$, where $T = 2\pi/\omega$. This can be tested in confined electromagnetic structures that preserve the helical geometry.

C. 3. Photon Geometry

From our model:

$$r = 0.202\lambda \quad (19)$$
$$\lambda_h = \phi\lambda \approx 1.618\lambda \quad (20)$$
$$\theta = \arccos(1/\phi) \approx 52^\circ \quad (21)$$

Prediction: Near-field EM probes should detect a transverse helical structure of radius $\sim 20\%$ of the photon wavelength, and a helical pitch matching the golden ratio.

D. 4. Resonant Energy Accumulation

FDTD simulations with this geometry show:

$$\frac{E_{\text{t=30}}}{E_{\text{t=10}}} \approx 1.817 \quad (22)$$

Prediction: In a confined cavity or metamaterial structure tuned to the photon helix, the energy density should increase by $\sim 80\%$ over one axial wavelength due to constructive interference of the three-phase resonance.

E. 5. Scattering Cross-Section

Using the dipole approximation for a helical resonator of radius r:

$$\sigma_{\text{scattering}} \sim \frac{8\pi}{3}(kr)^4, \quad k = \frac{2\pi}{\lambda} \quad (23)$$

Substituting $r = 0.202\lambda$ gives:

$$kr \approx 1.27, \quad \sigma_{\text{scattering}} \sim 2.6 \quad \text{(dimensionless amplitude)} \quad (24)$$

Prediction: Wavelengths comparable to the photon's own helical radius will experience enhanced scattering, detectable in near-field measurements or metamaterial arrays.

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These predictions provide **quantitative targets** for experimental verification. They link the three-phase helical photon model directly to measurable quantities: **energy, phase correlation, geometry, resonance, and scattering**.

VIII. CONCLUSION: THE REVOLUTION WILL BE UNFUNDED

The photon is not mystical; it is a mechanical system whose secrets yield to clear thinking. The quantitative predictions in Section 5 provide a clear roadmap for experimental validation using near-field optics and resonant cavities. Future experiments can validate the model and potentially revolutionize our understanding of quantum reality.

Appendix A: Simulation Parameters

All simulations used Meep 1.2.0 with resolution 15, dielectric $\epsilon = 9$, and normalized units. Energy ratios were computed from time steps 10 to 30 to measure resonance quality.

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