Quantum Reflection Across Multiple Fabrics of Spacetime: A Geometric Extension of the Path Integral Framework

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Abstract: We propose a novel interpretation of photon reflection grounded in Feynman's path integral formulation, enriched by a multi-fabric geometry of spacetime. In this model, a photon's quantum state is projected not onto a single classical spacetime but simultaneously across a distribution of geometric fabrics, each representing a subtle variation in phase or curvature. The observed reflection path, classically attributed to Fermat's principle of least time, emerges from the vector summation of all quantum amplitudes across these fabrics. This framework connects optics, quantum mechanics, and the geometry of spacetime, offering new insights into quantum coherence, the holographic principle, and the nature of physical reality.

Keywords:
Feynman path integral, photon reflection, holographic principle, emergent spacetime, quantum geometry, multiverse interference

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1. Introduction

Fermat's principle tells us that light takes the path of least time [2], a cornerstone of classical optics. In contrast, quantum electrodynamics, through Feynman's path integral formulation [1], describes photons as exploring all possible paths between source and detector. The classical path emerges not from exclusion of alternatives, but from constructive interference among nearby trajectories.

This paper proposes a geometric reinterpretation: the photon's quantum state is not only distributed over paths within one spacetime but also across multiple quasi-parallel geometries or "fabrics" of space. These fabrics can be interpreted as slight variations in geometry, curvature, or phase—akin to holographic sheets or multiversal projections.

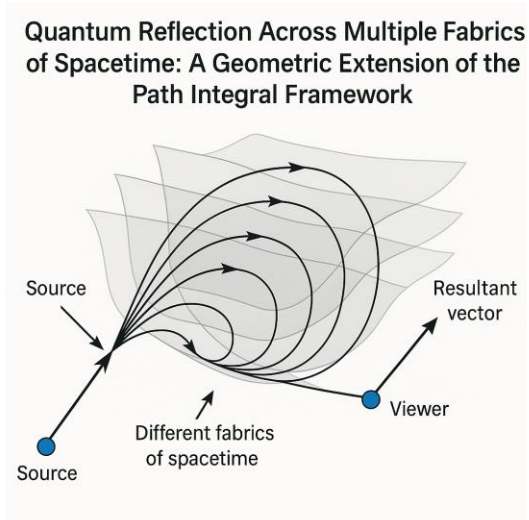

Figure 1: Photon paths reflected across multiple fabrics of spacetime. The observed path emerges from coherent interference among paths in different geometric layers

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2. The Classical and Quantum Views of Reflection

In classical optics: $\theta_i = \theta_r$ Light reflects at an angle equal to its angle of incidence, derived from Fermat's principle: $\delta T = 0 \Rightarrow$ stationary optical path time.

In quantum mechanics: A photon's amplitude to go from point A to B is given by [1]:

$$\psi(B) = \int D[x(t)]e^{iS[x(t)]/\hbar}$$

Where $S[x(t)]$ is the action along path $x(t)$.

Only paths near the classical trajectory contribute significantly due to constructive interference.

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3. Proposal: Projection Across Multiple Fabrics

We extend the traditional framework by assuming that the photon's state is also copied or projected into multiple nearby geometric configurations or fabrics:

Let $\boldsymbol{\mathcal{F}}$ be the space of fabric variations (geometries, phases, curvatures). Then:

$$\Psi(B) = \int_{\mathcal{F}} \int_{path\ in\ f} e^{iS_f[x(t)]/\hbar}\, Dx_f D_f$$

Here:

- $f \in \mathcal{F}$ is a specific geometric fabric.
- $S_f[x(t)]$ is the action evaluated in geometry ff.
- Dx_f is the path measure in that fabric.

Result: The observed outcome is a **coherent summation** of amplitudes not just over paths, but over geometrically distinct fabrics of spacetime.

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4. Physical Interpretation

- Each fabric represents a phase-shifted or curved spacetime layer.
- Photons do not "choose" a single fabric but exist as superpositions across all.
- The classical path of least time is the **net result** of coherent interference across these fabrics.

This interpretation aligns with:

- The holographic principle: each fabric may encode a boundary-variant of the bulk physics [4].
- Quantum decoherence: classicality arises when superpositions across fabrics collapse.

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5. Implications and Extensions

- **Reflection and Refraction:** Snell's law could be derived as a dominant contribution from fabric geometries that warp optical metrics.
- **Entanglement:** Correlated particles may project onto entangled fabrics, enforcing non-local coherence.
- **Quantum Gravity:** The geometry of these fabrics could reflect local spacetime fluctuations, linking this model to quantum gravitational effects [3].

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6. Experimental Speculations

- Could varying geometric phases (e.g., via metamaterials) affect interference from projected fabrics?
- Do photons in certain environments (e.g., near black holes) reveal multi-fabric interference patterns?

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7. Conclusion

We suggest that reflection, traditionally explained by the least-time principle or single-space path summation, may actually emerge from a deeper principle: quantum summation over geometrically distinct but subtly correlated fabrics of space. This view offers a bridge between quantum field theory, holography, and emergent geometry, inviting new ways to think about light, information, and reality itself.

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Author Contributions Bhushan Poojary conceived the idea, developed the mathematical framework, and wrote the manuscript.

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