Feynman's Light Path Integral Mirage: Why "All Possible Paths" for Photons is a Mathematical Illusion That Academic Professional Philosophy Lets Stand

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A laser fires. A red line slices the dark. Common sense says the photon took the shortest path. Quantum mechanics, in Richard Feynman's path integral formulation, says it took every path—straight, curved, to the Moon, through the Sun, faster than light, backward in time—*all at once* (Feynman, 1948)! Then, in a cosmic ledger, the impossible routes cancel via interference, leaving only the classical beam. But stop. Look closer. The mathematics is dazzling, and the story is intoxicating, but the ontology a house of cards.

Here is the core claim: a photon explores all possible paths from A to B. The probability amplitude $\Psi(x\_B, t\_B \leftarrow x\_A, t\_A)$ is the integral $\Psi(x\_B, t\_B \leftarrow x\_A, t\_A)$ = ∫[all paths] $D[x(t)] \times \exp(i\, S[x(t)] / \hbar)$ where $S[x(t)]$ = ∫(from t_A to t_B) $L\, dt$ is the action (Lagrangian $L = T - V$), and $\hbar$ is the reduced Planck constant. The probability is $|\Psi|^2$.

Each path contributes a complex amplitude—a spinning arrow whose phase is $S/\hbar$. Paths near the classical (least-action) trajectory have similar S, so their arrows align and add constructively. "Crazy" paths—detours to Andromeda, superluminal

sprints—have wildly different S, so their arrows spin rapidly and cancel via destructive interference.

That's the fairy tale. Now for the cracks.

First, the measure D[x(t)] over the space of all continuous paths does not exist in standard mathematics. It's a formal symbol, not a Lebesgue integral. To compute anything, physicists discretize time into N slices of width $\varepsilon = (t_B - t_A)/N$, approximate the path as a polygonal chain $x_0, x_1, \ldots, x_N$, and write

$$\Psi = \lim_{N \to \infty} (m / (2\pi i \hbar \varepsilon))^{(N/2)} \prod_{j=1}^{N} \int dx_j \exp(i \sum_{k=1}^{N} [m (x_k - x_{k-1})^2 / (2\varepsilon) - V(x_k) \varepsilon])$$

Each integral is Gaussian, solvable exactly. The limit $N \to \infty$ recovers the Schrödinger equation. It works. But the continuum path space was never rigorously defined. The integral is a limit of finite-dimensional approximations, not a true integral over an infinite-dimensional manifold. As Glimm and Jaffe recognised, it is unclear what this measure should be or if such a measure exists (Glimm and Jaffe, 1981).

Second, the oscillatory integrand $\exp(i S / \hbar)$ has no decay. For non-classical paths, S deviates by $\Delta S \gg \hbar$, so the phase changes by $\Delta\varphi = \Delta S / \hbar \gg 2\pi$. Neighboring paths have phases differing by whole radians, not tiny fractions. Their arrows point in random directions. Summing infinitely many such arrows should yield zero—but only if the sum converges absolutely. It doesn't. The series is conditionally convergent at best: the result depends on the order of summation, the cutoff, the regularization scheme. Cancellation is not a physical mechanism; it's a mathematical hope.

Third, the paths include superluminal and acausal trajectories. To get the right propagator, you must sum over paths with $v > c$ and $t < 0$. The final probability respects relativity, but the intermediate sum does not. The photon is asked to consider a round trip to Alpha Centauri—just to have it erased. This is not explanation. It's exorcism. Now the Zeno regress hits hardest. For any path P, construct an infinite family:

• P_1: P with one extra loop around the Earth,

• P_2: two loops,

• P_n: n loops.

The action difference $\Delta S_n \propto n$ is large, but between P_n and P_{n+1}, $\Delta S = O(1)$. The phase difference is $\sim 2\pi$, not infinitesimal. These are not "nearby" paths. Their arrows do not cancel in pairs; they form an infinite sequence of nearly opposite vectors. The

partial sum oscillates forever. Add paths that wiggle, reverse, or retrace infinitesimally, and the phase differences become $\delta\varphi \sim \varepsilon$, but there are $1/\varepsilon$ such paths in any interval.

The sum is $\Sigma[\text{loops}] \exp(i\, \Delta S\_n / \hbar) + \Sigma[\text{wiggles}] \exp(i\, \delta\varphi\_k / \hbar)$

The first diverges. The second is a Riemann sum over a dense set. No absolute convergence. No physical cancellation. The classical path survives not because crazy paths cancel, but because we define the integral to peak there via stationary phase approximation—a classical limit, $\hbar \to 0$, not a quantum truth.

This is where professional academic philosophy—especially Analytic philosophy of physics—fails spectacularly. It treats the path integral as a calculational scheme, not an ontological claim. It says: "It predicts the double-slit pattern, so the interpretation is secondary." But prediction is not understanding. When a theory requires an uncountable infinity of unphysical paths, regulated by ad-hoc cutoffs, to describe a particle moving in a straight line, it's time to question the picture, not the experimenter.

There is a cleaner path: Bohmian mechanics. In Bohmian mechanics, the particle follows one definite trajectory, guided by a pilot wave that obeys the Schrödinger equation. No infinities. No superluminal detours. The wave explores configuration space; the particle surfs the wave. It reproduces every quantum prediction, including interference, without summoning ghosts.

The path integral is a masterpiece of applied mathematics. As ontology, it's a mirage. The photon doesn't take all paths. It takes one. The wave just knows which one. Professional academic philosophy, drunk on formalism, lets the mirage stand. Reality and realistic philosophy demand better.

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