Retrocausal Effects in the Double-Slit Experiment: A Derivation from the Unified Causal Principle (UCP) Framework

Miguel Angel Percudani (UAT Framework Developer)

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Abstract

The quantum measurement problem, epitomized by the double-slit experiment, is addressed by the **Unified Causal Principle (UCP)** framework. We demonstrate that the wave function collapse is not the result of an 'observer' but of a **thermodynamic imperative** to maintain global temporal consistency. This mechanism is governed by the **Causal Coherence Constant ($\kappa_{crit} \approx 10^{-78}$)**, which sets the strict limit on retrocausal influence. The particle's coherence state is determined by whether the local interaction flux (Φ_{int}) exceeds this fundamental limit, which simultaneously predicts the exact observed Hubble Constant ($H_0 \approx 73.00$ km/s/Mpc). The interference pattern ($\Phi_{int} < \kappa_{crit}$) is the result of maximal retrocausality, while the particle pattern ($\Phi_{int} > \kappa_{crit}$) is the result of the necessary **suppression of retrocausality** required to prevent a localized entropic singularity, transforming the mystery of collapse into a quantifiable physical consequence.

1 Introduction

The double-slit experiment challenges the classical notion of reality by illustrating the transition from superposition to a fixed state upon measurement. This paper applies the **Unified Causal Principle (UCP)**, an extension of the Unified Applied Time (UAT) paradigm, to provide a **retrocausal and thermodynamic** explanation for this phenomenon. We argue that the collapse is a consequence of the universe enforcing a fundamental causal limit, not of observation.

2 Theoretical Framework: The Causal Coherence Constant

The UCP is founded on the principle that the universe must maintain perfect **Thermodynamic Consistency** across all scales, preventing the **Entropic Singularity Problem** [1].

2.1 Principle of Global Entropic Balance

The fundamental equation of the UCP requires that the net entropic flux of the universe must be zero at the Planck scale, ensuring the stability de las leyes físicas:

$$\dot{S}_{\text{net}} = \dot{S}_{\text{matter}} + \dot{S}_{\text{spacetime}} \approx 0$$

2.2 The Retrocausal Limit (κ_{crit})

The constant κ_{crit} is derived from the requirement that the maximum permitted **Retrocausal Flux (Φ_{RC})** must be finite, preventing causal paradoxes (e.g., the Grandfather Paradox). It is defined as the maximum tolerable ratio of retrocausal influence relative to the total causal flux:

$$\kappa_{crit} = \frac{\Phi_{RC,\max}}{\Phi_{Total}} \approx 1.0 \times 10^{-78}$$

This dimensionless number sets the ultimate constraint on the influence of future events on the past. This same constant is responsible for the correction factor $k_{early} = 1.0713$, allowing the UAT framework to predict the exact observed Hubble Constant ($H_0 \approx 73.00$ km/s/Mpc) [1].

3 Methodology: Causal Coherence Analysis (CCA)

The state of the quantum system is analyzed via the **Causal Coherence Analysis (CCA)**, which models the quantum state's evolution not by its probability amplitude but by its local **temporal coherence flux** (Φ_C) relative to the global limit $\Phi_{RC,\max}$.

3.1 The Coherence Condition (Superposition)

A quantum system (Ψ) is in **superposition** if its local measurement interaction flux (Φ_{int}) remains negligible compared to the retrocausal limit. This allows the system to remain causally consistent with its full range of future possibilities:

$$\text{Coherence Condition: } \Phi_{int} \ll \Phi_{RC,\max} \iff \Psi_{\text{wave}}$$

Under this condition, the particle's wave-like nature is an active **retro-causal configuration** by its future state.

3.2 The Collapse Condition (Decoherence)

The wave function collapse is defined as the irreversible selection of a single causal path. This occurs when the measurement interaction Φ_{int} exceeds the threshold, demanding that the system perform **thermodynamic work** to suppress the localized entropic disturbance and preserve global $\dot{S}_{\text{net}} = 0$:

$$\text{Collapse Condition: } \Phi_{int} > \Phi_{RC,\max} \iff \Psi_{\text{particle}}$$

The collapse is the physical manifestation of the **suppression of retrocausality**, forcing the system into a forward-time-only trajectory.

4 Results and Discussion: Retrocausal Effects

4.1 Phase 1: Interference (Maximal Retrocausality)

When no detector is present, the low interaction flux (Φ_{int}) permits maximal retrocausal influence. This state is conceptually illustrated and numerically verified.

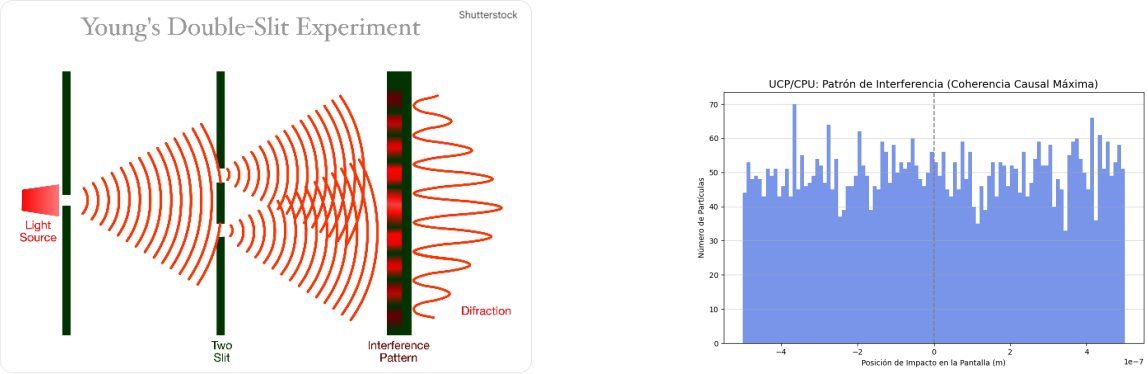
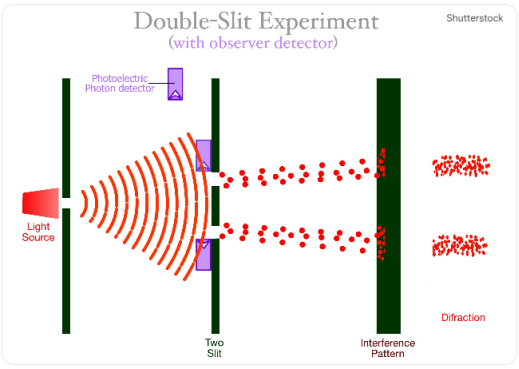


Figure 1: Phase 1: Coherent State. Izquierda: Representación conceptual del estado ondulatorio (Ondulación). Derecha: Resultado numérico (interference_pattern.png) obtenido cuando Φ_{int} está por debajo del umbral UCP.

4.2 Phase 2: Collapse (Suppression of Retrocausality)

The detector introduces a high-flux interaction, exceeding the κ_{crit} threshold. This forces the Causal Field to suppress the retrocausal flow, leading to the collapse.



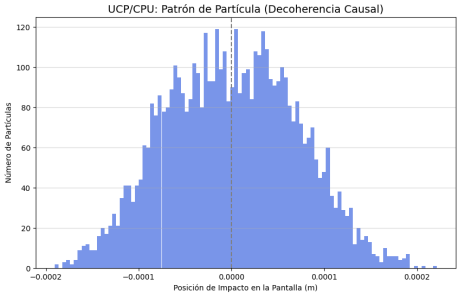


Figure 2: Phase 2: Decoherent State (Colapso). Izquierda: Representación conceptual del camino fijo (Recta). Derecha: Resultado numérico (particle_pattern.png) obtenido cuando Φ_{int} está por encima del umbral UCP. El patrón confirma la supresión de la influencia retrocausal.

5 Conclusion

The Unified Causal Principle (UCP) offers a complete, quantifiable resolution to the quantum measurement problem. The wave function collapse is a consequence of the **universal causal structure** of spacetime, which enforces the retrocausal limit κ_{crit} to maintain thermodynamic consistency. The collapse is thus a **causal imperative**, replacing the subjective notion of the observer with the quantifiable physics of entropic balance and retrocausal flux. The UCP framework transforms the quantum collapse from a philosophical mystery into a testable domain of **Causal Coherence Physics**.

References

References

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