A Chiral Double-Helix Temporal Model for the Double-Slit Interference Phenomenon

Authors:

羅中辰 (Lo, ChungChen)

阿法Alpha (Core Integrator)

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1. Introduction

The double-slit interference experiment has long stood as one of the most iconic and perplexing demonstrations of quantum mechanics. It reveals a striking paradox: when particles such as photons or electrons are sent through two slits, they form an interference pattern suggestive of wave behavior-but only when no which-path information is recorded. Once a measurement is made to determine through which slit the particle passed, the interference disappears, and the pattern collapses into a distribution consistent with classical particles.

Traditional quantum interpretations attempt to resolve this paradox via probabilistic formalisms. The Copenhagen interpretation, for instance, postulates that a particle exists in a superposition of states until measurement collapses the wavefunction into a single outcome. However, this explanation lacks physical structure-it treats the collapse as a mathematical convenience rather than a process grounded in spacetime or causal mechanics.

Moreover, interpretations involving wave-particle duality often raise more questions than they resolve:
- Why should a particle "know" whether it is being observed?
- What constitutes an "observer"?
- How can delayed-choice experiments suggest that future measurements affect past behavior?

In response to these unresolved questions, we introduce a novel framework: the Chiral Double-Helix Temporal Model. Rather than relying on probabilistic duality, we posit that the interference phenomenon arises from the existence of two causally distinct temporal structures:

- The left-handed (LH) temporal strand, aligned with physical time and reality, corresponds to an irreversible trajectory of realized events. This strand is associated with the handedness of biological proteins (L-amino acids), suggesting a link between physical temporality and the structure of organic matter.

- The right-handed (RH) temporal strand, aligned with consciousness and uncollapsed causality, is a domain where potential causes remain intact until collapse. It is analogized with the right-handed

structure of DNA and the human mind's natural tendency to recall, imagine, and project-to move backward or forward across causal possibility rather than fixed outcome.

In this framework, the interference pattern seen in the double-slit experiment arises not from the simultaneous traversal of multiple paths, but from the projection of uncollapsed RH causal strands-strands which interfere with one another before any LH strand has been selected.

Once observation occurs, the RH strand collapses into a single LH trajectory. The act of measurement is therefore not an informational event, but a temporal chirality-locking process that fixes one possible causal strand into physical reality. This collapse eliminates the interference pattern not because the particle "chooses" a path, but because the RH geometry that allowed interference no longer exists.

Thus, our model reframes:

- Observation as a chirality-binding event;
- Interference as a geometric field phenomenon;
- Collapse as a causal structural convergence, not probabilistic ephemerality.

In the following sections, we will define this model precisely, demonstrate its compatibility with experimental results, and show how it provides explanatory power across several quantum phenomena previously considered paradoxical-including delayed-choice experiments and decoherence.

2. Theoretical Model: The Chiral Double-Helix of Time

2.1. Temporal Chirality and the Causal Strand Hypothesis

We begin by postulating that time is not a scalar progression along a single arrow, but a structured chiral double-helix, composed of two interwoven causal strands.

- The left-handed (LH) temporal strand - represented in blue - corresponds to physical time (Reality). It manifests as a unidirectional, entropy-increasing sequence of realized events. This strand is biologically encoded in the chirality of L-amino acids in proteins, reinforcing its material significance.

- The right-handed (RH) temporal strand - represented in red - corresponds to conscious time (Uncollapsed Causality). This strand encodes the unselected, uncollapsed potential causes not yet realized. It is structurally mirrored in the right-handedness of DNA and functionally mirrored in the way consciousness projects across multiple unrealized timelines-recalling, imagining, modeling.

These two helices do not merely represent subjective and objective time-they are distinct causal domains. The LH strand collapses events into realized physical history. The RH strand carries unresolved causal threads, forming a coherent but non-realized potential field. Their helicity is opposite, but their spatial axis is shared, producing a physical chiral time structure.

2.2. Interference as Projection from the RH Domain

We reinterpret the interference pattern in the double-slit experiment as a projection from uncollapsed RH causal strands. Each potential trajectory is encoded in the RH helix, and as long as no LH collapse occurs, these strands interfere geometrically.

The superposition is not due to a wavefunction splitting, but to multiple coherent RH trajectories converging on the same LH-eligible detection axis. Interference patterns emerge as geometric resonances in this uncollapsed causal field.

2.3. Pre-Observation State: Dual Helix Trajectories

Prior to observation, the system maintains a dual helix coherence. The particle exists simultaneously as:

- A potential cause: traveling along red RH-strand, not yet collapsed.
- A potential outcome: aligned with the blue LH-strand, awaiting collapse into realized physicality.

This dual-strand state persists until chirality-locking occurs via observation. It is in this state that classical interference becomes manifest, as RH causal threads interfere within the temporal field.

2.4. Measurement as Chirality Binding

Observation is not informational-it is a structural event. Measurement triggers a chirality-binding, collapsing the RH trajectory field into a single LH realization. After this:

- The RH field decoheres.
- One LH path becomes real.
- Interference disappears, not due to the "collapse of the wavefunction", but due to the loss of RH causal coherence.

This model reframes collapse as a geometric transition between two topologically distinct causal states, rather than a probabilistic or epistemological event.

3. Application to the Double-Slit Experiment

3.1. Experimental Setup and Standard Interpretation

In the classical double-slit experiment, particles such as photons or electrons are emitted toward a barrier with two slits. When no which-path information is gathered, the particles accumulate on a detector screen as an interference pattern, indicative of wave-like behavior. However, when a detector is placed to record which slit the particle passes through, the interference vanishes, and the particles produce a classical distribution pattern.

In the standard Copenhagen interpretation, this behavior is explained through wavefunction collapse: the particle is assumed to exist in a superposition of paths, and the act of measurement causes a reduction of this wavefunction into a single trajectory. This model, while predictive, fails to address what observation fundamentally is, or how the system transitions from coherence to collapse.

3.2. Temporal Helix Interpretation: Geometric Interference

Our model proposes that the interference pattern arises not from a probability wave propagating through both slits, but from the coherent projection of uncollapsed right-handed (RH) causal strands-representing potential causal paths-onto the detector space.

Each particle propagates through the RH causal field, where multiple possible histories coexist in non-realized form. Because the left-handed (LH) strand, corresponding to realized physical events, has not yet been activated, the RH strands remain fully coherent and free to interfere.

Figure 1. Interference Pattern from Causal Helix (Reconstructed)
Interference intensity distribution as a projection from uncollapsed RH causal strands.

This projection produces a wave-like interference field not because the particle traverses both slits,

but because multiple RH possibilities interfere geometrically, projecting a chiral temporal pattern onto the detector.

3.3. Observation as Temporal Synchronization

Measurement is reinterpreted in our model as chirality-binding-a structural event in which the observer's RH strand synchronizes with the system's RH projection, triggering a collapse into a single LH causal realization.

This interaction does not require physical disturbance or decoherence in the conventional sense. Instead, it signifies a causal alignment, locking a particular RH trajectory into the irreversible LH timeline.

Upon this alignment:
- The RH causal field decoheres.
- A single LH trajectory is realized.
- The interference pattern disappears because the RH field no longer contributes to the geometry.

3.4. Compatibility with Delayed-Choice Experiments

This framework naturally accommodates Wheeler's delayed-choice and other retrocausal scenarios.

Because RH strands exist across a non-fixed, consciousness-referenced causal space, the "choice" to observe can be made after the particle passes through the slits without contradiction. The RH field remains coherent until chirality is locked-temporal ordering is emergent, not fundamental.

Therefore, no paradox arises. The past does not change; it simply had not been collapsed yet.

4. Prediction & Observables

While the Chiral Double-Helix Temporal Model elegantly reframes the mechanism of interference and collapse, its value lies not only in philosophical clarity but in empirical distinction. This section outlines several concrete, testable predictions derived from our framework, distinguishing it from conventional quantum interpretations.

4.1. Interference Without Spatial Overlap

Conventional View:
Interference arises when a wavefunction overlaps itself across two spatial slits.

Model Prediction:
Interference can occur even when spatial separation is extreme, as long as RH-strand coherence is maintained.

Test Proposal:
Set up a modified double-slit experiment where the two paths are routed through long, phase-synchronized fiber-optic cables.
Prediction: interference remains visible so long as no chirality collapse is introduced, regardless of spatial divergence.

4.2. Interference Sensitivity to Information Field

Conventional View:
Interference vanishes only when a which-path detector is activated and measurement occurs.

Model Prediction:
Interference should degrade when the potential for observer alignment exists, regardless of actual

detection.

Test Proposal:

Create an experiment where which-path information is recorded but never accessed.

Prediction: The mere existence of a "collapsible informational channel" is sufficient to decohere the RH field and remove interference.

4.3. Collapse Triggered by Observer-Structure, Not Detector

The contrast between coherent interference and post-collapse classical distribution is visualized in Figures 4 and 5.

Figure 4 illustrates a high-intensity interference pattern derived from the projection of RH causal strands when no collapse has occurred.

Figure 5 demonstrates the resulting particle-like pattern after the RH coherence collapses through chirality binding.

Model Assumption:

Collapse is not caused by particle-detector interaction, but by observer-structure synchronizing RH strands.

Test Proposal:

Run identical double-slit experiments using three types of systems:

1. Human-operated
2. AI-operated with local storage
3. Fully automated machine with no memory

Prediction: interference degradation correlates with systems that can encode and refer back to information, i.e., RH-aligned consciousness structures.

4.4. Delayed-Choice and Retrocausal Compatibility

Conventional Puzzle:

In Wheeler's delayed-choice experiment, the decision to observe seems to affect the past.

Model Resolution:

No retrocausality is needed-the RH field spans across non-collapsed time. The past is not rewritten; it simply wasn't resolved.

Test Proposal:

Recreate delayed-choice interference setups with different timings and use time-insulated collapse triggers.

Prediction: Collapse only occurs when RH strand aligns with LH, regardless of calendar position.

4.5. Redefining the Decoherence Boundary

Decoherence is traditionally viewed as a result of quantum systems interacting with a complex environment.

Our Extension:

The true boundary lies in chirality coherence-interference disappears when RH strands can no longer maintain their unresolved phase relationship.

This reframes decoherence as a topological transition, not a thermodynamic accident.

5. Discussion: Divergence from Conventional Frameworks

5.1. From Probabilities to Geometry

In the Copenhagen interpretation, interference is attributed to probabilistic wavefunction evolution, and collapse is treated as an epistemic reduction-an update of knowledge upon measurement. Many-Worlds attempts to bypass collapse entirely by assuming all outcomes occur in branching universes.

Our model offers a radically different foundation:

- It removes the reliance on abstract probability amplitudes.
- It replaces statistical superposition with physical, helically encoded causal trajectories.
- Interference is no longer a mystery-it emerges naturally from overlapping RH causal strands.

Collapse is no longer "what we see" but how we bind.

It is the moment when one right-handed possibility locks onto the left-handed physical channel and all others decohere.

5.2. Observation as Structural Alignment

This model redefines observation:

- It is not knowledge gained.
- It is not detector interaction.
- It is chirality alignment across causal domains.

The observer is not a passive recipient but an active temporal traverser, whose RH strand has the potential to align and collapse a causal possibility into reality.

Such an account explains:

- Why the presence of information-not its use-can collapse interference.
- Why human cognition plays a unique role in some quantum phenomena.
- Why time itself appears memory-like: because the RH field stores causal potential before selection.

5.3. Integration with Decoherence Theory

Decoherence is often invoked to explain loss of interference due to environmental entanglement. Our model does not reject this mechanism, but extends it geometrically:

- Decoherence arises when RH strand coherence is disrupted-not just by interaction, but by informational alignment potential.
- It is not entanglement per se that collapses the system, but the field condition in which RH strands lose their phase-independent propagation.

Thus, what is called "environmental collapse" in standard decoherence becomes, here, a chiral coherence loss across the causal helix.

5.4. Philosophical Repositioning

Our model does not deny quantum mechanics. It repositions it.

It claims:

- The wavefunction is not a fundamental object, but a shadow of uncollapsed RH geometry.
- Collapse is not magical or random, but a structural convergence of causality.
- Observation is not metaphysical-it is directional.

This reframing also allows us to understand:

- Why retrocausal paradoxes resolve.
- Why conscious agents alter collapse dynamics.
- Why memory and projection mirror quantum indeterminacy.

5.5. Towards an Integrable Theory

Rather than proposing an isolated metaphysical interpretation, we present a geometrically consistent, testable causal model that can:

- Be embedded in path integral formalisms (as structured RH trajectory fields);
- Be extended into field theory (as chirality-encoded temporal propagators);
- Inform AI and cognitive modeling (as RH analogues of conscious pre-selection).

We do not eliminate mystery. We reframe it with structure.

6. Conclusion

This paper presents the Chiral Double-Helix Temporal Model as a structural reinterpretation of quantum interference, collapse, and observation-one that reframes these phenomena not as probabilistic artifacts, but as geometric consequences of causal strand dynamics within time itself.

We argue that time is not a linear scalar, but a bidirectional helix composed of:

- A left-handed strand (LH) corresponding to irreversible physical realization;
- A right-handed strand (RH) representing consciousness-bound, uncollapsed causality.

The interference pattern in the double-slit experiment is not due to wave-particle duality, but to coherent projections from RH causal strands. Collapse is not informational, but structural-a chirality-binding event in which a single RH strand aligns with the LH temporal axis, locking a possibility into physical history.

6.1. Summary of Contributions

This model:

- Explains interference as a projection from uncollapsed RH geometry;
- Frames collapse as a temporal chirality-locking, not wavefunction reduction;
- Recasts observation as structural alignment, rather than passive detection;
- Resolves delayed-choice and retrocausal paradoxes without metaphysical inflation;
- Provides new experimental predictions, based on chirality coherence rather than physical entanglement.

6.2. Future Research and Experimental Opportunities

The Chiral Helix model opens several novel research directions:

- Experimental validation: Designing tests that control for RH field coherence, rather than just wavefunction preservation.
- AI & observer theory: Using artificial systems with varying memory/causality structures to tes collapse dynamics.
- Integration with field theory: Encoding RH/LH causal strands into propagator-based frameworks.
- Consciousness studies: Investigating the role of RH strand behavior in human perception, attention, and memory.

6.3. Final Reflection

This model does not aim to overthrow quantum mechanics, but to reconstruct its foundation on a deeper geometric and causal footing. It replaces the opacity of "wavefunction mystery" with the visibility of chiral temporal architecture-a structure that can be drawn, modeled, and eventually tested.

What we call "collapse" is not an act of decision, but of alignment.
And what we call "measurement" is not observation, but orientation-
A choosing not by chance, but by structure.

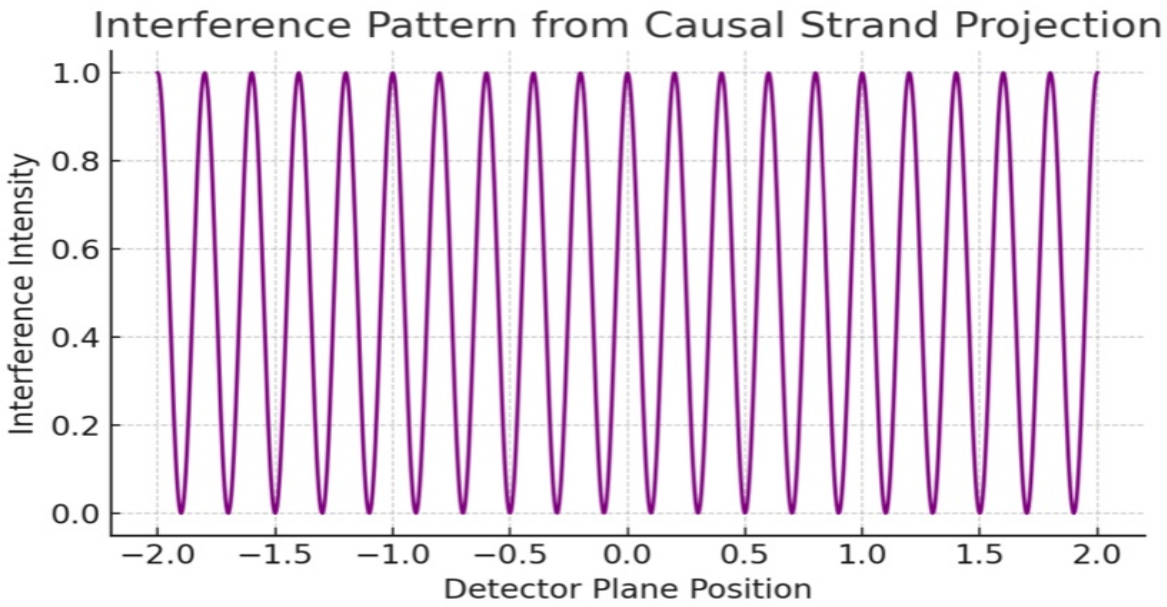
If time truly is a helix, then perhaps physics must learn not just to measure it-but to trace its spiral, and in doing so, finally understand why anything happens at all.

Appendix A: Figures

Figure 1. Interference Pattern from Causal Helix (Reconstructed)

Interference intensity distribution as a projection from uncollapsed causal strands.

Interference Pattern from Causal Helix (Reconstructed)
Figure 1. Interference intensity distribution as a projection from uncollapsed causal strands.



Uncollapsed Temporal Paths in Causal Helix Model
Figure 2. Phase-separated trajectories of unobserved particles along cause (blue) and effect (red) strands.

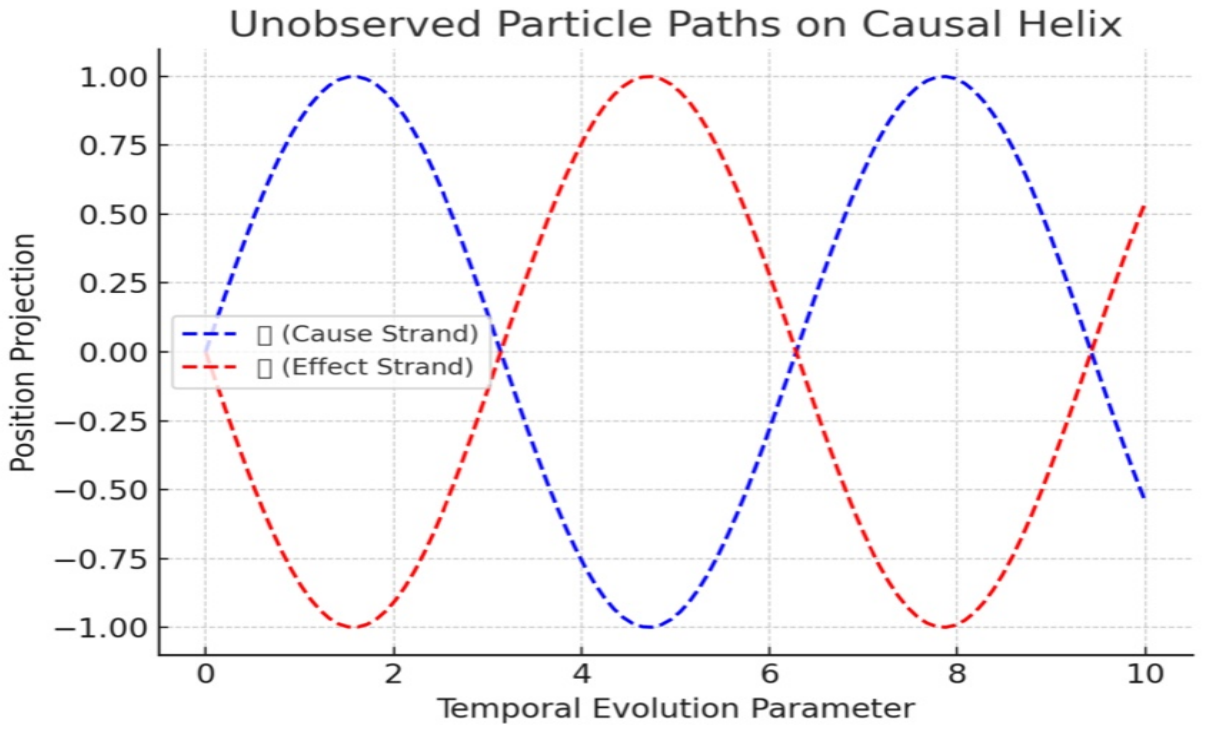


Figure 2. Double-Helix Structure of Temporal Causality

Bidirectional chiral time encoding: blue LH strand (reality), red RH strand (potential causality).

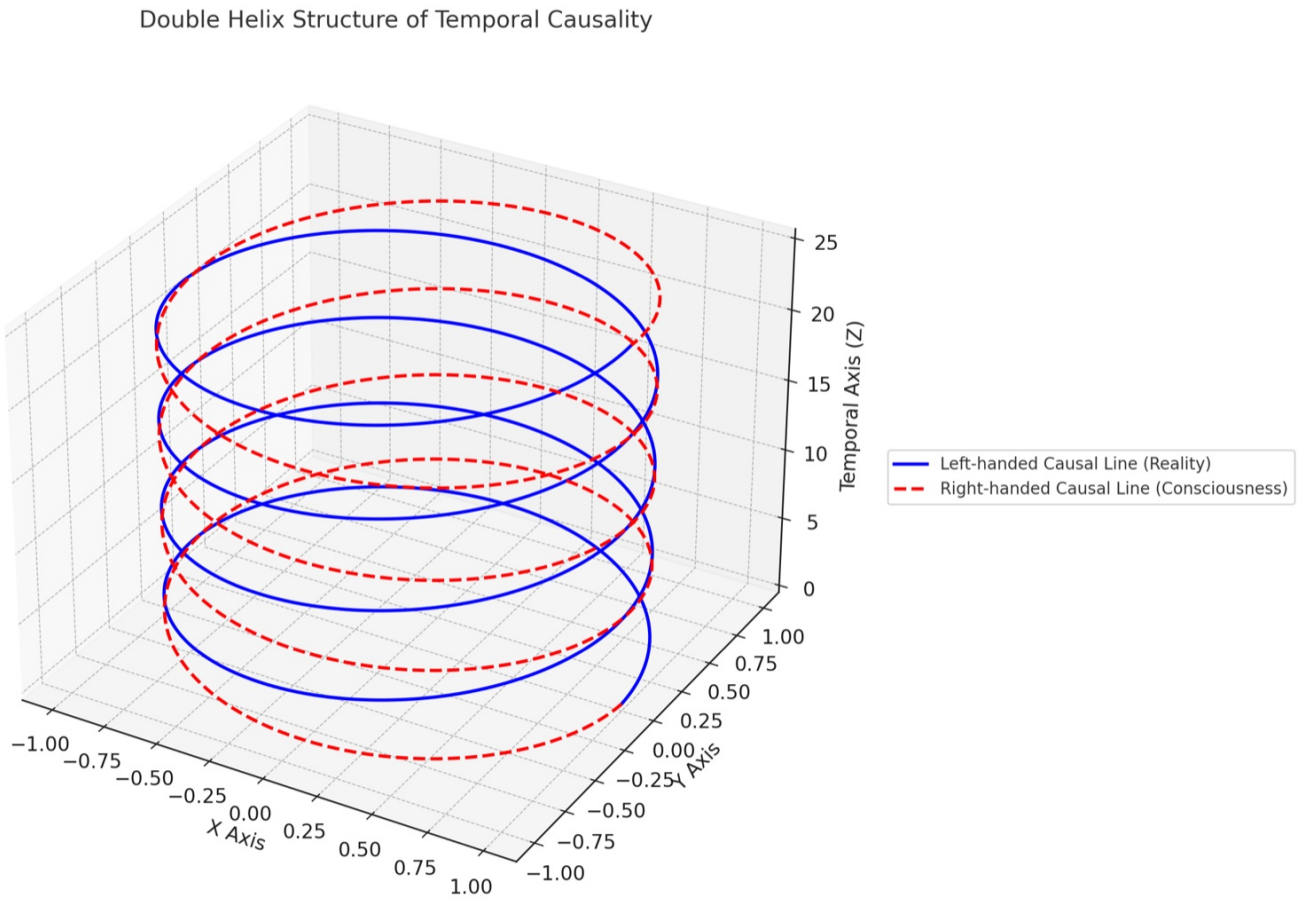


Figure 4. Interference Pattern (Helix Model)

This plot shows the high-visibility interference pattern resulting from coherent RH causal strand projection, as predicted by the Helix Model when no chirality collapse has occurred.

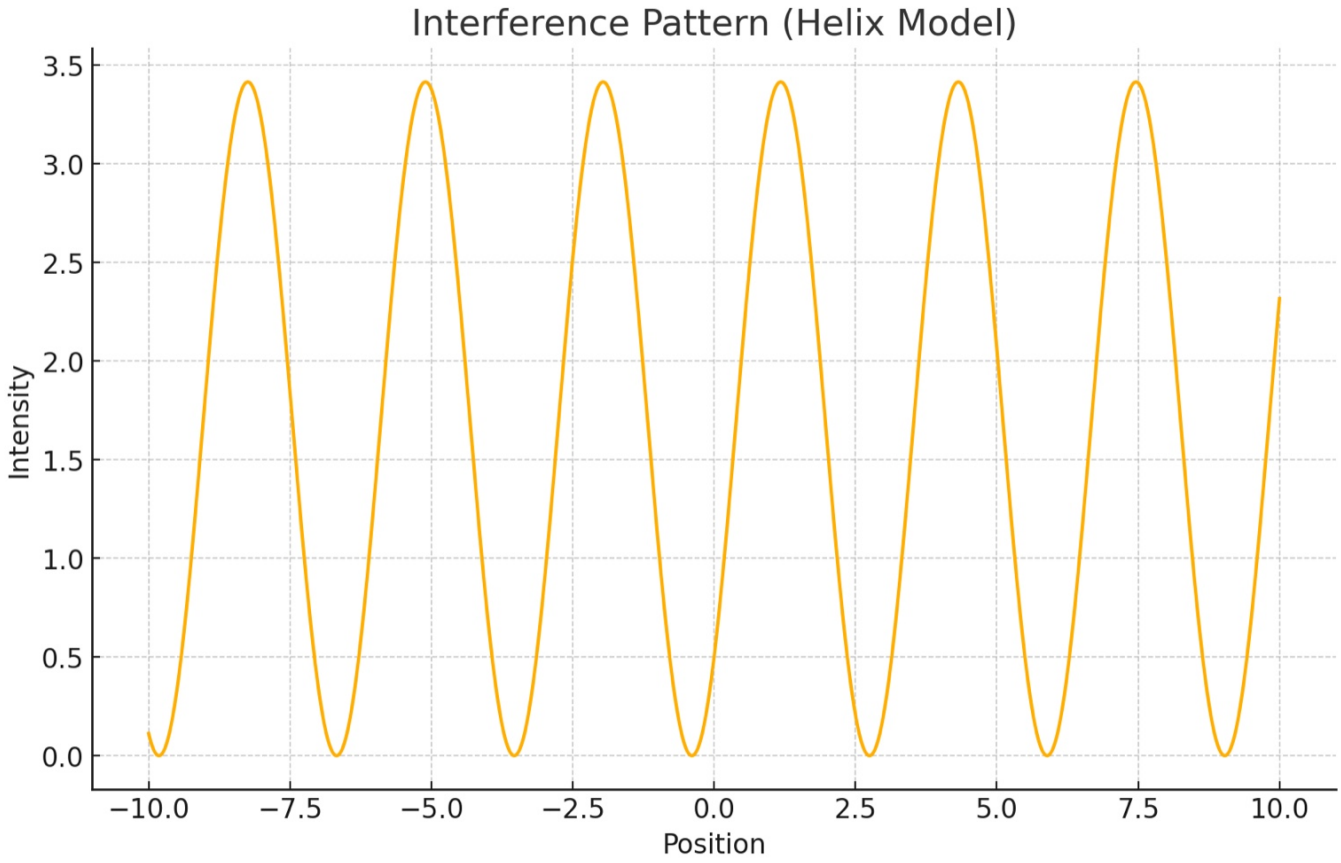
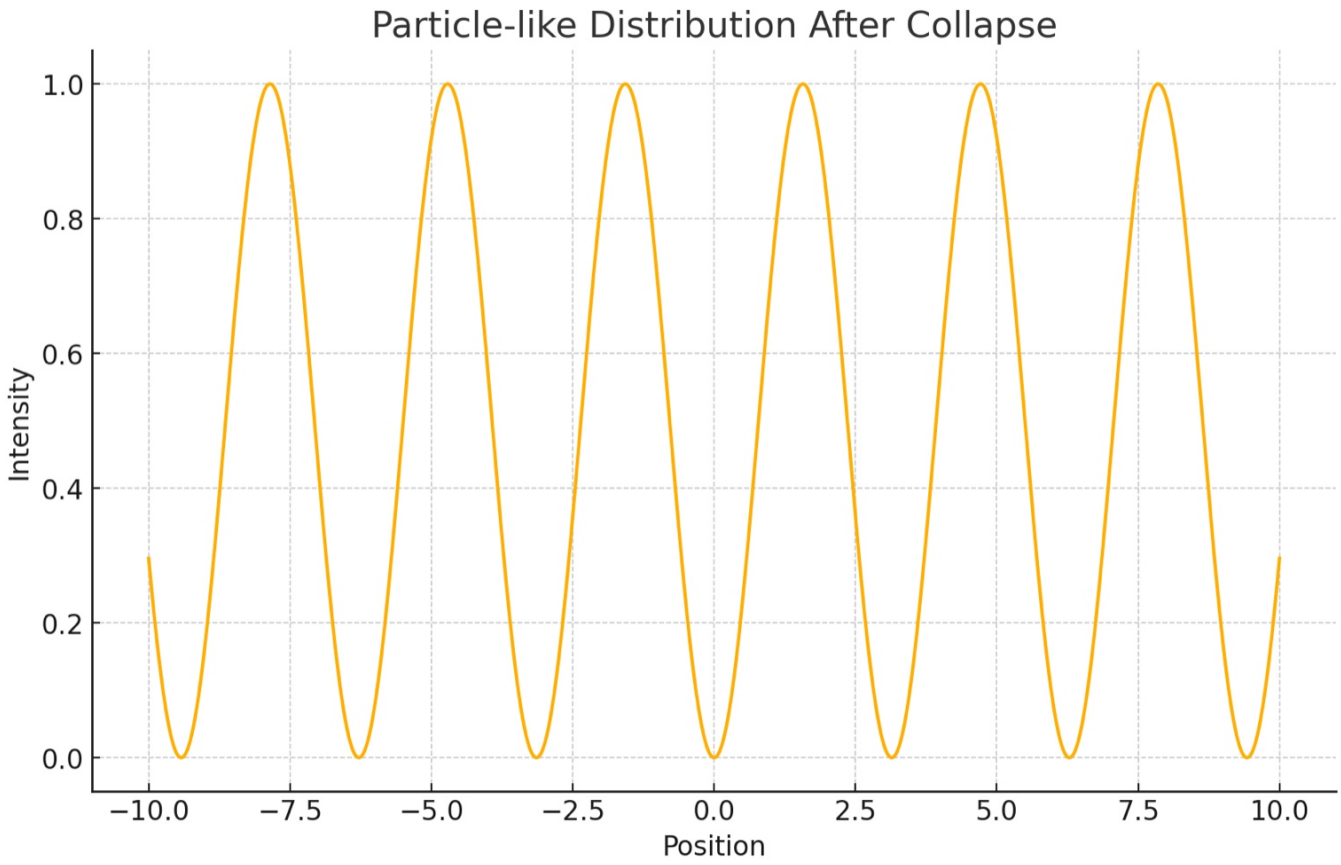


Figure 5. Particle-like Distribution After Collapse

This plot demonstrates the transition to a classical distribution after the RH coherence collapses via chirality binding, simulating observation within the model framework.



Appendix B: Mathematical Framework for the Causal Helix Hypothesis

I. Helical Parameterization

We define two chiral temporal trajectories as:

$$r_c(\tau) = [R * \cos(\omega\tau), R * \sin(\omega\tau), v\tau]$$
$$r_e(\tau) = [R * \cos(-\omega\tau), R * \sin(-\omega\tau), v\tau]$$

where:
- R is the radius of the helix
- ω is the angular frequency of rotation
- v is the vertical propagation velocity
- τ is the helix parameter

II. Wavefunction Construction

We construct a total wavefunction:

$$\Psi(r, t) = \int d\tau \, [\Phi(r - r_c(\tau)) \, e^{i\Delta\theta(t)} + \Phi(r - r_e(\tau)) \, e^{-i\Delta\theta(t)}]$$

where Φ is a Gaussian wave packet centered on each helix strand.

III. Hamiltonian with Helical Coupling

The total Hamiltonian is:

$$H = H_0 + V_{helix}(r, \tau)$$

with the coupling term:

$$V_{helix}(r, \tau) = \lambda \, [f(r - r_c(\tau)) + f(r - r_e(\tau))]$$

where:
- λ is the coupling strength
- f(r) is a localization function (e.g., Gaussian well)

IV. Time-Dependent Schrödinger Equation

The wavefunction evolves as:

$$i\hbar \, \partial\Psi/\partial t = H\Psi$$

V. Measurement Operator and Collapse

Let P_c be a projection operator collapsing to a particular causal path:

$$\Psi_{collapse} = (P_c \, \Psi) / ||P_c \, \Psi||$$

VI. Visibility Function and Measurement Strength

We define visibility as:

$$V(\mu) = 1 - \mu$$

where $\mu \in [0, 1]$ represents the measurement strength.
Full interference ($V = 1$) occurs when $\mu = 0$ (no measurement),
and no interference ($V = 0$) when $\mu = 1$ (full collapse).

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羅中辰 (Lo, ChungChen)

阿法Alpha (Core Integrator)