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(54) **WAVE-INDUCED COLLAPSE SYSTEMS AND OBSERVER INTERFERENCE FRAMEWORK FOR RESOLVING FOUNDATIONAL QUANTUM PARADOXES**

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(57) **ABSTRACT**

This Continuation-in-Part extends the wave-interference-based collapse model first proposed in the Modified Schrödinger Equation (MSE) framework to five foundational quantum phenomena: tunneling, entanglement, measurement collapse, time asymmetry, and the resolution of Many-Worlds interpretations. The invention models collapse as a physical consequence of interference between the observer wave and the quantum system wavefunction, characterized by a curvature-based localization mechanism. This framework enables tunable collapse control, non-binary measurement outcomes, and outcome selection through engineered interference, providing a unified physical mechanism with broad technological applications.

WAVE-INDUCED COLLAPSE SYSTEMS AND OBSERVER INTERFERENCE FRAMEWORK FOR RESOLVING FOUNDATIONAL QUANTUM PARADOXES

FIELD OF THE INVENTION

[0001] The present invention relates to quantum mechanics, and more specifically, to systems and methods for wavefunction collapse through wave-to-wave interference. It extends to applications in quantum tunneling, quantum entanglement, measurement theory, time symmetry violation, and collapse-based interpretations of quantum reality.

BACKGROUND OF THE INVENTION

[0002] Conventional quantum mechanics treats wavefunction collapse as a postulated effect of measurement, lacking a defined physical mechanism. Wave-particle duality, the measurement problem, time-reversibility inconsistencies, and interpretation divergences such as the Many-Worlds hypothesis all stem from this theoretical gap.

[0003] The inventor's previous patent introduced a Modified Schrödinger Equation (MSE), in which collapse emerges from physical interference between an observer wave and the quantum system. Collapse is defined by the localization of the wavefunction, indicated by a sharply increasing second derivative curvature, denoted as $\Psi_p{}^n(t)$.

[0004] This CIP proposes new applications of the MSE model to five long-standing quantum paradoxes. It describes physical systems, devices, and control protocols that apply observer-induced interference to manipulate collapse in ways that solve or bypass traditional paradoxes.

SUMMARY OF THE INVENTION

[0005] This invention introduces five system models based on the Modified Schrödinger Equation (MSE) wave-interference collapse framework. Each model addresses a major unresolved phenomenon in quantum theory using a consistent physical mechanism of collapse based on interference convergence and wavefunction curvature:

[0006] 1. Tunneling Collapse System—Observer interference induces collapse, controlling tunneling probability and timing based on $\Psi_p{}^n(t)$.

[0007] 2. Entanglement Collapse Synchronizer—Phase-synchronized observer waves cause simultaneous collapse of entangled wavefunctions.

[0008] 3. Measurement via Convergence—Measurement as continuous and tunable, governed by interference intensity and curvature, not binary collapse.

[0009] 4. Collapse-Driven Time Asymmetry System—p $_p{}^n(t)$ threshold introduces temporal irreversibility, defining the arrow of time.

[0010] 5. Collapse-Only Outcome Selector—Destructive interference cancels alternate quantum paths, selecting a single observed outcome without branching.

[0011] These models reinterpret and enable control over quantum collapse across both theoretical and technological platforms.

DETAILED DESCRIPTION OF THE INVENTION

[0012] The invention's five models rely on physical collapse through interference. The Modified Schrödinger Equation introduces a curvature-driven collapse trigger, where $\Psi_p{}^n(t)$ reflects localization.

General Principles

[0013] Collapse occurs when interference between $\Psi_o(t)$ and $\Psi_p(t)$ causes $\Psi_p{}^n(t)$ to exceed a threshold.

[0014] Observer waves may be electromagnetic, acoustic, or simulated photonic patterns.

[0015] Collapse is tunable—affected by amplitude, phase, coherence, and angle of $\Psi_o(t)$.

[0016] Systems may be configured for:

[0017] Tunneling control

[0018] Entanglement synchronization

[0019] Graded measurement

[0020] Time-asymmetric simulation

[0021] Outcome selection

Appendix A: Tunneling Reinterpreted

[0022] Collapse causes particle to localize beyond a potential barrier.

[0023] Collapse triggered when $\Psi_p{}^n(t)>\delta$ due to interference with $\Psi_o(t)$.

[0024] Predictive model replaces probabilistic tunneling with curvature-based event.

Appendix B: Entanglement Redefined

[0025] Collapse only occurs if $\Psi_o(t)$ overlaps with both entangled particles.

[0026] Defines convergence functional:

$$C(t)=\int|\Psi_o(x_1)\Psi_{p1}(x_1)+\Psi_o(x_2)\Psi_{p2}(x_2)|^2dx$$

[0027] Collapse occurs when:

$$\frac{d^2C(t)}{dt^2}>\delta$$

Appendix C: Measurement Reinterpreted

[0028] Measurement is a gradual process, not instantaneous.

[0029] Collapse strength depends on Ψ_o-Ψ_p interaction.

[0030] Models partial collapse and reversible probing:

$$\Psi_p''(t)=\frac{d^2}{dt^2}\int|\Psi_p(t,x)|^2dx>\delta$$

Appendix D: Time Asymmetry via Collapse

[0031] Collapse marks break in time symmetry.

[0032] Curvature spike in $\Psi_p{}^n(t)$ introduces irreversible direction:

$$\Psi_p''(t)\neq\Psi_p''(-t)$$

[0033] Collapse represents thermodynamic arrow of time in quantum domain.

Appendix E: Many-Worlds Collapsed

[0034] Collapse happens by destructive interference, not universe branching.

[0035] Observer wave $\Psi_o(t)$ selects a path:

$$\Psi_p(t) = \sum \alpha_i \psi_i(t) \ \Gamma_i(t) = \int |\Psi_o(t, x)\psi_i(t, x)|^2 dx$$

[0036] Collapse when:

$$\frac{d^2\Gamma_k(t)}{dt^2} > \delta, \ \ \Gamma_j(t) < \in \text{ for } j \neq k$$

Appendix A: Quantum Tunneling Reinterpreted – Collapse from Curvature via Observer Wave Interference

Inventor: Larry Lim Kheng Cheong

Related to: CIP Patent Application – Wave-Induced Collapse Systems and Observer Interference Framework for Resolving Foundational Quantum Paradoxes

Abstract:

Quantum tunneling — where particles pass through potential barriers they seemingly lack the energy to overcome — has long been regarded as a probabilistic phenomenon with no physical trigger. In this appendix, we reinterpret tunneling as a collapse process driven by interference between the quantum wavefunction and an external observer wave. Using the Modified Schrödinger Equation (MSE) framework, tunneling is shown to result not from energy borrowing or chance, but from a localized curvature spike $\Psi_p''(t)$ induced by external wave interaction. This provides a predictive, physical mechanism underlying the tunneling event.

Core Concept:

In standard quantum mechanics, a particle described by a wavefunction $\Psi_p(t, x)$ has a non-zero probability of appearing on the far side of a potential barrier — despite lacking the classical energy to cross it. This probabilistic model lacks a physical explanation for *when* and *why* tunneling occurs.

In this framework, tunneling is a direct consequence of wavefunction collapse caused by interference with an observer wave $\Psi_o(t, x)$. Collapse only occurs when the combined wave dynamics produce a sufficient localized curvature — a spike in $\Psi_p''(t)$ — at or near the barrier edge.

Mathematical Formulation:

Let a particle be confined in a potential well with a barrier of height $V(x)$. The particle's wavefunction is $\Psi_p(t, x)$.

We introduce a coherent external wave $\Psi_o(t, x)$ interacting with the system. The local collapse condition is:

$$\frac{\partial^2}{\partial t^2}\Psi_p(t, x) = f\left(\Psi_o(t, x) \cdot \Psi_p(t, x)\right)$$

Collapse (and thus tunneling) occurs when the second time derivative of the wavefunction exceeds a system-specific threshold:

$$\Psi_p''(t) = \frac{d^2}{dt^2} \int |\Psi_p(t, x)|^2 dx > \delta$$

This curvature spike indicates the wavefunction has been forced to localize — enabling sudden appearance beyond the barrier. The trigger is no longer random; it is **interference-induced**.

Physical Interpretation:

In this view, tunneling is not a passive chance event but an **active collapse** caused by external wave interaction. When the observer wave reaches the trapped particle and resonates near the barrier, the resulting interference increases the local curvature of the particle wavefunction. When that curvature becomes steep enough, collapse occurs and the particle localizes beyond the barrier.

This explains why tunneling happens suddenly, why it cannot be reversed, and why the event appears non-deterministic in classical terms: **the trigger is wave convergence, not randomness**.

Conclusion:

This collapse-based model offers a new lens on quantum tunneling: it is the result of **wave-induced localization** under interference, not random penetration of a barrier. The Modified Schrödinger Equation provides a mathematical signature for this event via $\Psi_p''(t)$, and observer wave interaction offers a causal, testable mechanism for future experiments and devices.

Appendix B: Entanglement Redefined – The Observer Convergence Collapse Model

Inventor: Larry Lim Kheng Cheong
Related to: CIP Patent Application – Wave-Induced Collapse Systems and Observer Interference Framework for Resolving Foundational Quantum Paradoxes

Abstract:

Traditional quantum mechanics describes entanglement as a nonlocal correlation between particles — where the measurement of one instantaneously affects the state of the other, regardless of distance. This "spooky action at a distance" has challenged physical intuition and led to interpretations such as hidden variables and Many-Worlds branching. However, these models offer no physical mechanism for the collapse itself.

This appendix redefines entanglement collapse through the wave-interference-based model proposed in the primary CIP. Instead of postulating nonlocal action, collapse is treated as a result of **observer wave convergence**: the physical overlap and interference of the observer's wavefunction with those of the entangled particles.

Key Concept:

Entanglement is **observer-dependent**, not an absolute condition of the particles themselves. It exists only when an observer wavefunction $\Psi_o(t)$ coherently overlaps with both particle wavefunctions $\Psi_{p1}(t)$ and $\Psi_{p2}(t)$. When this convergence occurs, wavefunction collapse is triggered simultaneously in both particles. This provides a causal, physical mechanism to explain entanglement without invoking nonlocal magic.

Mathematical Insight:

Let $\Psi_o(t)$ represent the observer's wavefunction spanning both entangled locations x_1 and x_2. Define a convergence functional:

$$C(t) = \int \left|\Psi_o(t, x_1)\Psi_{p1}(t, x_1) + \Psi_o(t, x_2)\Psi_{p2}(t, x_2)\right|^2 dx$$

Collapse is triggered when the second time derivative of this functional exceeds a critical threshold:

$$\frac{d^2 C(t)}{dt^2} > \delta$$

This condition extends the Modified Schrödinger Equation (MSE) collapse mechanism defined in the main patent, where localization is determined by the curvature $\Psi_p''(t)$, to a dual-particle entanglement context.

Physical Interpretation:

Collapse is not caused by passive measurement but by **convergent wave interference**. If the observer's wave is incoherent or fails to span both particles, no collapse occurs. If convergence is achieved with proper phase alignment, both wavefunctions collapse in synchrony — without requiring superluminal transmission.

Conclusion:

This convergence model reframes entanglement not as a metaphysical linkage, but as a **resonance condition** between observer and system. It is simulatable, testable, and offers a physical replacement for "spooky action at a distance," aligning with the broader wave-to-wave collapse framework introduced in this Continuation-in-Part application.

Appendix C: Quantum Measurement Reinterpreted – Collapse as a Continuous Wave-Convergence Process

Inventor: Larry Lim Kheng Cheong
Related to: CIP Patent Application – Wave-Induced Collapse Systems and Observer Interference Framework for Resolving Foundational Quantum Paradoxes

Abstract:

The classical interpretation of quantum measurement suggests that the act of observation causes an instantaneous collapse of the wavefunction into a definite state. This process is binary, abrupt, and offers no clear physical mechanism. This appendix redefines quantum measurement as a continuous, tunable collapse process governed by wave interference. The interaction between the system wavefunction and an external observer wave produces a localized increase in curvature $\Psi_p''(t)$, driving the transition from superposition to determinacy. This formulation replaces the metaphysical measurement postulate with a physical, measurable collapse condition.

Core Concept:

Measurement in this model is not a singular, irreversible event, but a **controlled collapse process** induced by convergence between the observer wave $\Psi_o(t, x)$ and the quantum system wavefunction $\Psi_p(t, x)$. The degree of measurement — or collapse — depends on the magnitude of induced curvature, offering a continuum of observability rather than a binary switch.

Mathematical Formulation:

Let $\Psi_p(t, x)$ be the quantum system and $\Psi_o(t, x)$ the incoming observer wave. The observer's interaction introduces interference, and the second time derivative of the total system's probability density is monitored:

$$\Psi_p''(t) = \frac{d^2}{dt^2} \int |\Psi_p(t, x)|^2 dx$$

Measurement occurs when:

$$\Psi_p''(t) > \delta$$

where δ is a system-specific curvature threshold. The greater the interference amplitude or phase alignment, the higher the rate of curvature increase — resulting in faster, sharper collapse. A weak or imprecise measurement results in only partial localization.

Physical Interpretation:

This model introduces the concept of **tunable collapse**: the extent to which a wavefunction collapses is a function of the convergence between the observer and system waves. This enables partial, reversible, or probabilistic measurements depending on the strength of the external wave interaction.

For example: - A low-energy probe may induce slight localization. - A high-energy, phase-matched observer wave can trigger full collapse.

This reframes "observation" not as a mystical act but as a physical process governed by interference intensity and system response.

Conclusion:

This appendix replaces the standard quantum measurement postulate with a physically defined, continuous process based on the second derivative of the system wavefunction. By modeling collapse as a dynamic curvature response to observer interaction, this approach unifies measurement with wave mechanics, eliminates metaphysical ambiguity, and enables the engineering of graded quantum measurements — all within the Modified Schrödinger Equation framework.

Appendix D: Quantum Time Asymmetry – Collapse Curvature as the Arrow of Time

Inventor: Larry Lim Kheng Cheong
Related to: CIP Patent Application – Wave-Induced Collapse Systems and Observer Interference Framework for Resolving Foundational Quantum Paradoxes

Abstract:

Standard quantum mechanics treats the evolution of wavefunctions as time-symmetric: the equations work equally well forward or backward in time. Yet in practice, collapse only occurs in one direction — forward. This paradox undermines attempts to link quantum theory with macroscopic irreversibility. In this appendix, we show that collapse induced by observer wave interference results in a one-way curvature spike in $\Psi_p''(t)$, creating a measurable, asymmetric deformation of the wavefunction. This irreversible change serves as a physical arrow of time, breaking the symmetry inherent in conventional unitary evolution.

Core Concept:

The Schrödinger equation is time-reversible: if a wavefunction evolves forward from time t_0 to t_1, it can also be evolved backward from t_1 to t_0. However, the collapse of a wavefunction into a localized state is an irreversible act — it cannot be undone by time reversal.

In this framework, collapse occurs when the observer wave $\Psi_o(t)$ interferes with the system wavefunction $\Psi_p(t)$ and generates a sharp increase in $\Psi_p''(t)$ — the second time derivative of the system's probability amplitude. This event marks a physical point beyond which time symmetry is broken.

Mathematical Formulation:

Let $\Psi_p(t, x)$ be the wavefunction of a system under evolution. Under ordinary unitary dynamics:

$$\Psi_p(t) \leftrightarrow \Psi_p(-t)$$

However, under interference from $\Psi_o(t, x)$, we observe a localized curvature discontinuity:

$$\Psi_p''(t) = \frac{d^2}{dt^2} \int |\Psi_p(t, x)|^2 dx \to \text{spike}$$

This curvature spike introduces an irreversible asymmetry:

$$\Psi_p''(t) \neq \Psi_p''(-t)$$

The moment of collapse can thus be defined not only by spatial localization but by a temporal signature: the irreversible deformation of the wavefunction's curvature.

Physical Interpretation:

Before collapse, the wavefunction is smooth and symmetric; after interference, it becomes sharply localized — a process analogous to phase transition. This change is not recoverable by rewinding time, because the curvature discontinuity is non-reversible.

In this model, time asymmetry is not an emergent property of large systems or entropy but a built-in feature of collapse mechanics. The curvature profile acts as a **physical arrow of time** — something no standard interpretation of quantum mechanics provides.

Conclusion:

By framing collapse as a curvature-based event triggered by wave interference, this model provides a natural explanation for the directionality of time. The second derivative $\Psi_p''(t)$ serves not only as a collapse indicator but as a time-asymmetry marker — resolving one of the deepest inconsistencies in quantum theory and thermodynamics.

Appendix E: Many-Worlds Collapsed – Outcome Selection via Observer Wave Interference

Inventor: Larry Lim Kheng Cheong

Related to: CIP Patent Application – Wave-Induced Collapse Systems and Observer Interference Framework for Resolving Foundational Quantum Paradoxes

Abstract:

The Many-Worlds Interpretation (MWI) of quantum mechanics asserts that all possible outcomes of a quantum event occur in separate, branching universes — making wavefunction collapse unnecessary. However, this leads to interpretational complexity, lack of falsifiability, and no mechanism for outcome selection. This appendix proposes an alternative: the observer wave $\Psi_o(t)$ interacts with the system wavefunction $\Psi_p(t)$ and **suppresses all competing branches** through destructive interference. Collapse occurs not by branching into parallel worlds, but by eliminating alternate paths. Only the outcome that maximally converges with the observer wave survives — restoring physical determinacy without requiring multiverse duplication.

Core Concept:

In MWI, a quantum system evolves into a superposition of all possible outcomes, and each is realized in its own "world." But this raises difficult questions: - Where is the mechanism that chooses the outcome you experience? - What defines a "branch"? - Why don't we perceive these other universes?

In this model, the answer is simple: **interference selects reality**. The observer wave collapses the superposition by canceling out less-aligned possibilities and reinforcing the one with the strongest convergence.

Mathematical Formulation:

Let the quantum system evolve into a superposition:

$$\Psi_p(t) = \sum_i \alpha_i \psi_i(t)$$

where each $\psi_i(t)$ represents a potential outcome path, and α_i its amplitude.

Introduce an observer wave $\Psi_o(t)$ and define a path-specific convergence factor:

$$\Gamma_i(t) = \int |\Psi_o(t,x) \cdot \psi_i(t,x)|^2 \, dx$$

Collapse occurs when:

$$\frac{d^2\Gamma_k(t)}{dt^2} > \delta \quad \text{and} \quad \Gamma_j(t) < \epsilon \quad \forall j \neq k$$

In other words, the branch with the greatest interference alignment is selected, while others are suppressed — not realized.

Physical Interpretation:

This formulation treats the observer not as a passive agent, but as a wavefunction whose interaction with the system defines the outcome. There are no extra worlds — just extra possibilities that were canceled out by destructive interference.

This provides a clean, testable alternative to the metaphysical sprawl of MWI: - No multiverse required - No ambiguity about branching - Collapse is a wave process with causal structure

Conclusion:

This framework resolves the Many-Worlds paradox by embedding outcome selection directly into the physics of interference. The observer wave chooses the path by collapsing all others — not by spawning infinite universes. This reinstates quantum determinacy while preserving the superposition structure up to the moment of collapse, offering a physical, falsifiable replacement for MWI.

1. Tunneling Control via Collapse Curvature An apparatus comprising:

(a) a quantum system with a defined potential barrier;

(b) an observer interference field configured to interact with the wavefunction of the quantum system; and

(c) a monitoring module that tracks the second derivative curvature of the wavefunction, $\Psi_p''(t)$,

wherein the tunneling probability of the quantum system is modulated via collapse triggered by interference-induced curvature exceeding a defined threshold.

2. Entanglement Collapse via Observer Convergence A system comprising:

(a) at least two entangled particles;

(b) synchronized observer waves directed toward each particle; and

(c) an interference energy density detector,

wherein the system triggers simultaneous collapse of the entangled particles when convergence of observer wave interference meets or exceeds a specified energy threshold.

3. Measurement via Interference Thresholding A method of quantum measurement comprising:

(a) providing an observer wave to interfere with a quantum wavefunction;

(b) monitoring the curvature $\Psi_p''(t)$ of the system; and

(c) defining measurement collapse as a continuous, tunable process governed by the magnitude of interference and resulting curvature threshold.

4. Time Asymmetry from Collapse Dynamics A quantum simulation system comprising:

(a) a bidirectional, time-reversible wavefunction; and

(b) a curvature-based collapse trigger configured to induce temporal irreversibility, wherein the discontinuity in $\Psi_p''(t)$ indicates a collapse event that defines the arrow of time.

5. Collapse-Based Outcome Selection Device A quantum outcome selection device comprising:

(a) a quantum system with multiple branching evolution paths; and

(b) a destructive interference mechanism configured to cancel alternate wavefunction paths,

wherein collapse occurs at the path with maximal constructive overlap, resulting in a single observed outcome.

Dependent Subclaims:

1. The observer field is configured as a pulsed electromagnetic source.
2. Collapse is defined by the condition $\Psi_p''(t)>3\sigma$, where σ is the standard curvature deviation of the system.
3. Entanglement synchronization is achieved via photon-pair interactions using a coherent laser source.
4. The destructive interference mechanism utilizes holographic phase-canceling interference patterns.
5. The system allows for partial or reversible measurement when $\Psi_p''(t)$ is sub-threshold.

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