Observer-Dependent Reality in a Holographic Universe: From Definite States to Divergent Perceptions

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Abstract: This paper builds upon the "Many Unreal World Interpretation" to explore the relationship between definite quantum states and observer-dependent perceptions. We argue that each observer exists within a dedicated spacetime fabric characterized by a unique holographic address, leading to differing but locally consistent perceptions of quantum events. Through the concept of shadow particles and address reassignment, we present a mechanism that naturally explains the phenomena of wave function collapse, entanglement, and quantum paradoxes without invoking retrocausality or infinite branching universes. This model bridges the certainty of individual experience with the multiplicity of coexisting perceptual realities, offering a geometric-holographic mechanism that complements relational quantum mechanics and QBism.

1. **Introduction** Traditional interpretations of quantum mechanics, such as Copenhagen and Many-Worlds, either leave the collapse of the wave function unexplained or invoke an ever-branching multiverse. Building upon the earlier "Emergent Universe from Many Unreal World Interpretation" [1], this work introduces a perspective where each observer experiences a definite outcome, but the perceived state may differ between observers due to differences in holographic address and spacetime fabric.

2. **Observer-Dependent Perception in Quantum Theory** Recent developments in quantum foundations—like Relational Quantum Mechanics [2] and QBism [3]—suggest that the quantum state is not absolute but depends on the observer's interaction. This leads to a scenario where multiple observers may hold different truths about a quantum system. However, these interpretations often lack a physical mechanism for such observer dependence.

3**. Recap: Many Unreal World Interpretation**

This interpretation is based on four foundational postulates, now refined below to align more closely with formal physics language:

Postulate 1: Holographic Encoding of Quantum Entities
Every quantum entity is uniquely encoded as information on a holographic surface (e.g., an event horizon), identified by a distinct address $\boldsymbol{A_i}$ a discrete or continuous information manifold. This address serves as the entity's identity across all interactions and observers.

Postulate 2: Observer-Specific Spacetime Manifolds
Each holographic address A_i is associated with its own local spacetime foliation $\boldsymbol{M_i}$, which evolves independently under its own frame of reference. These foliations represent distinct perceptual manifolds and define the local evolution of information for the observer associated with $\boldsymbol{A_i}$.

Postulate 3: Shadow Projection Across Manifolds
For any particle at address $\boldsymbol{A_i}$, shadow states $\boldsymbol{\psi}^{(i\to j)}$are projected onto the spacetime manifolds $\boldsymbol{M_j}$ of all other addresses $\boldsymbol{A_j}$,. These projections evolve according to local dynamics on $\boldsymbol{M_j}$, forming a distributed quantum state network across all observers.

Postulate 4: Address Reassignment via Interaction
An interaction between a true quantum entity $\boldsymbol{\psi_i}$ (residing in $\boldsymbol{A_i}$) and a projected shadow $\boldsymbol{\psi}^{(j\to i)}$ results in a collapse-like transition, wherein both entities are removed and replaced by a newly instantiated entity $\boldsymbol{\psi_k}$ at a new address $\boldsymbol{A_k}$. The global network of shadow projections is updated instantaneously to reflect the new configuration, and obsolete shadows are erased from all $\boldsymbol{M_j}$.

This refined framework continues to explain key quantum phenomena such as superposition [4], delayed choice [5], and Schrödinger's Cat [6] without invoking retrocausality or many-world branching.

4. Toy Mathematical Model of Interaction and Address Reassignment

To provide a concrete example of how the refined postulates operate, we define a minimal model involving two particles and a single interaction event.

Let particle 1 be represented as a quantum entity $\boldsymbol{\psi_1}$ residing in address $\boldsymbol{A_1}$, with spacetime foliation $\boldsymbol{M_1}$. Let particle 2 be $\boldsymbol{\psi_2}$, residing in address $\boldsymbol{A_2}$, with spacetime foliation $\boldsymbol{M_2}$.

Each particle projects shadow states onto the other's manifold:

- $\boldsymbol{\psi}^{(\mathbf{1}\to\mathbf{2})}$: shadow of particle 1 on $\boldsymbol{M_2}$
- $\boldsymbol{\psi}^{(\mathbf{2}\to\mathbf{1})}$: shadow of particle 2 on $\boldsymbol{M_1}$

Suppose an interaction occurs between $\boldsymbol{\psi_1}$ and $\boldsymbol{\psi}^{(\mathbf{2}\to\mathbf{1})}$ on $\boldsymbol{M_1}$.

According to Postulate 4:

- The interaction causes both $\boldsymbol{\psi_1}$ and $\boldsymbol{\psi}^{(\mathbf{2}\to\mathbf{1})}$ to be removed.
- A new particle $\boldsymbol{\psi_3}$ is instantiated at a new address $\boldsymbol{A_3}$.
- The shadow network is updated so that:
    - $\boldsymbol{\psi_3}$ casts shadows $\boldsymbol{\psi}^{(\mathbf{3}\to j)}$ onto all other manifolds $\boldsymbol{M_j}$
    - All prior shadows $\boldsymbol{\psi}^{(\mathbf{1}\to j)}$ and $\boldsymbol{\psi}^{(\mathbf{2}\to j)}$ are erased

This process captures a deterministic address reassignment rule driven by local interaction. Future development of this model would involve specifying the evolution equations for $\boldsymbol{\psi}^{(i \to j)}$ under unitary or non-unitary dynamics, and identifying observables that could correspond to experimentally testable predictions.

5. Comparative Table of Interpretations

The following table presents a comparison between major interpretations of quantum mechanics and the proposed Many Unreal World Interpretation with respect to key quantum phenomena:

Phenomenon	**Copenhagen**	**Many-Worlds**	**Relational QM (RQM)**	**QBism**	**Many Unreal World Interpretation (MUWI)**
Wave Function Collapse	Physical but undefined	Avoided (branching worlds)	Relative to observer	Bayesian belief update	Address reassignment across spacetime fabrics
Entanglement	Nonlocal correlations	Global branching history	Observer-dependent	Observer-specific belief	Shared address and collapse via shadow interaction
Delayed Choice Experiment	Retrocausal mystery	Multiple pasts exist	Depends on interaction	Bayesian reinterpretation	Shadow state configuration resolves outcome
Wigner's Friend	Objective outcome	Diverging realities	Inconsistent views allowed	Observer-centric	Different shadow-based perceptions until interaction
Schrödinger's Cat	Alive/dead superposition	Both outcomes realized	Cat state is observer-relative	Based on agent knowledge	Collapse propagates through address update
Measurement Problem	Remains unsolved	Bypassed via branching	Avoided via relativity	Treated as belief update	Collapse = physical reassignment of

					holographic address
Number of Worlds	One	Infinite	One per relation	One per agent	One world emerges from many unreal interactions
Role of Observer	Causes collapse	Passive (observer is part of multiverse)	Defines information state	Central (agent belief)	Observer defines address-specific perception

This comparison helps clarify how the Many Unreal World Interpretation offers a novel framework that addresses several quantum paradoxes using geometric and informational constructs rooted in holography.

6. **New Insight: Definite State, Divergent Perception** We extend the interpretation by proposing that although each observer experiences a definite outcome (due to local collapse and address reassignment), the state perceived may differ across observers until they interact. This is because each observer's perception is shaped by the shadow particles evolving in their unique spacetime fabric.

Thus, what seems definite to one observer is not necessarily globally agreed upon until observers interact and synchronize their addresses.

7. **Case Studies**

- *Double-slit Experiment with Observers*: Observers on different fabrics may perceive different interference patterns until measurement synchronizes their view [4].
- *Wigner's Friend Paradox*: The friend inside the lab sees a definite outcome; Wigner outside sees a superposition. The paradox resolves when address reassignment occurs upon Wigner's interaction [7].
- *Schrödinger's Cat*: Each world updates the cat's state upon intermediate collapses; the final observer simply reveals which path was taken [6].

8. **Comparison with Other Interpretations**

- *RQM*: Similar in asserting observer-dependent states, but lacks a physical holographic mechanism [2].
- *QBism*: Emphasizes belief and probability; our interpretation gives a geometric underpinning to subjective experience [3].

- *Many-Worlds*: Avoided in our model through dynamic shadow replication and address update [8].

9. **Implications for Consciousness and Information** Since perception depends on address-specific shadows, this model suggests that consciousness is inherently tied to the observer's spacetime fabric. This opens new avenues for exploring the role of consciousness in quantum measurements.

10. **Conclusion** This enhanced interpretation not only gives a physical basis for observer-relative quantum states but also maintains consistency with empirical results and removes speculative paradoxes like retrocausality. It provides a compelling synthesis of quantum mechanics, holography, and relativity, pointing toward a unifying theory of perception and reality.

11. **Author’s Commentary and Future Outlook**

This paper presents an ambitious attempt to propose a novel interpretation of quantum mechanics by offering concrete mechanisms for some of its most puzzling phenomena. Below is a balanced evaluation of its contributions and areas needing further development:

Strengths:

1. **Addresses Key Problems**
   The interpretation directly tackles the core challenges in quantum physics — such as wave function collapse, quantum entanglement, Wheeler’s delayed choice, Schrödinger’s cat, and Wigner’s friend — offering alternative solutions grounded in a new conceptual framework.

2. **Proposes a Physical Mechanism**
   Unlike information-centric interpretations like QBism or relational quantum mechanics, this model introduces tangible constructs such as *shadow particles*, *dedicated addresses in the event horizon*, and *spacetime fabrics*. This provides a physically intuitive and geometrical picture of quantum behavior.

3. **Avoids Retrocausality and Infinite Branching**
   The framework successfully explains quantum phenomena without invoking retrocausality or the many-worlds interpretation's infinite parallel universes, offering a more parsimonious yet rich alternative.

4. **Connects to Established Physics**
   By relating the new postulates to concepts from black hole thermodynamics (e.g., Bekenstein-Hawking entropy [9]) and Schwarzschild cosmology [10], the interpretation anchors itself to well-established theories.

5. **Applies the Model to Multiple Experiments**
   The ideas are applied across multiple experiments and thought experiments, demonstrating how the framework could potentially unify our understanding of diverse quantum effects.

Areas for Consideration:

1. **Speculative Nature**
   While creative, the postulates are speculative and not derived from existing formalism. Terms like “shadow particles” and unique spacetime fabrics do not yet have support in mainstream physics.

2. **Lack of Empirical Testability**
   The paper currently lacks clear empirical predictions that would distinguish this interpretation from others. A major step forward would be to propose testable scenarios or novel experimental setups.

3. **Conceptual Complexity**
   Although the model aims to resolve quantum paradoxes, it introduces complexity through its multi-layered spacetime fabrics and shadow interactions. This might challenge Occam’s Razor unless it leads to new insights or predictions.

4. **Need for a Mathematical Framework**
   A formal mathematical treatment is essential for this interpretation to be developed into a viable theory. Connecting these ideas to existing formalisms (e.g., quantum field theory, general relativity, or tensor networks) would greatly enhance their credibility.

5. **Challenge to Established Paradigms**
   The model challenges conventional notions of spacetime, locality, and measurement. While boldness is welcome in foundational work, such claims require rigorous defense and broader peer scrutiny.

Conclusion:

This interpretation offers a refreshing and imaginative take on the mysteries of quantum mechanics. Its value lies in its attempt to reframe quantum phenomena through a geometric-holographic lens, offering clarity to some otherwise puzzling effects. While it is speculative and requires substantial development, it opens new directions for thinking about observer-dependent reality and the physical nature of quantum information.

This work extends the author's previous paper: "Emergent Universe from Many Unreal World Interpretation" (DOI: 10.11648/j.ijamtp.20200602.11)

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