Parity-Driven Quantum Mechanics: A Framework for Superposition, Collapse, and the Gravity-Quantum Divide

Karel John Murdoch[*]

Independent Researcher

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Abstract

We propose a new interpretive framework for quantum mechanics in which the binary parity (odd or even) of a universe's total particle count acts as the fundamental switch governing quantum and classical behavior. In this model, particles transit between parallel universes in pairs; unpaired particles remain uncommitted to any single universe and exhibit quantum behavior (superposition, tunneling, interference), while paired particles anchor to a specific universe and become subject to classical forces including gravity. Observation is reinterpreted as a forced anchoring event that pins a particle to the observer's universe. This framework provides a unified account of seven core quantum phenomena—superposition, wavefunction collapse, double-slit interference, quantum entanglement, tunneling, the quantum Zeno effect, and the quantum-gravity incompatibility—from a single principle. We identify testable predictions, including parity-dependent decoherence rates in controlled particle-number systems and the outcome of proposed gravitational superposition experiments, that distinguish this framework from existing interpretations.

INTRODUCTION

Quantum mechanics is the most experimentally successful theory in the history of science. It is also, after nearly a century, without a consensus interpretation. The measurement problem—why and how a system in superposition appears to "collapse" to a definite state upon observation—remains open. The Copenhagen interpretation declines to address it. Many-Worlds [2] eliminates collapse but struggles to explain interference between branches. Pilot wave theory (de Broglie–Bohm) introduces undetectable hidden variables. Objective collapse theories [3, 10] add new physics but lack experimental confirmation.

Separately, the incompatibility of quantum mechanics and general relativity remains the deepest open problem in theoretical physics. Gravity resists quantization. No quantum gravity theory has produced a testable prediction. The two pillars of modern physics do not speak to each other.

We propose that both problems—the measurement problem and the quantum-gravity divide—share a common resolution rooted in a deceptively simple property: the parity of a universe's total particle count.

The central claims of this paper are:

1. The universe's total particle count is either odd or even—a binary ($\mathbb{Z}_2$) property.

2. Odd parity corresponds to an "out of tune" state in which quantum behavior is active.

3. Particles transit between parallel universes, primarily in pairs.

4. Unpaired particles are not committed to any single universe and exhibit superposition.

5. Observation forces a particle to anchor to the observer's universe, settling parity.

6. Gravity acts only on anchored (paired, committed) matter, not on particles in transit.

These six principles, taken together, provide a unified account of the major quantum phenomena without requiring wavefunction collapse as a fundamental process, hidden variables, or quantum gravity.

THE PARITY PRINCIPLE

$\mathbb{Z}_2$ as the Fundamental Symmetry

The simplest nontrivial symmetry group is $\mathbb{Z}_2$: two states, even and odd, with addition modulo 2. A system's parity is not a matter of degree. There is no "slightly odd." The property is strictly binary.

$\mathbb{Z}_2$ symmetry already governs deep structures in physics:

- The fermion parity superselection rule forbids superpositions of states with different fermion number parity [13]. A state $|\text{even}\rangle + |\text{odd}\rangle$ is unphysical.

- The Witten index $W = \text{Tr}\big[(-1)^F\big]$ determines whether supersymmetry is spontaneously broken, depending solely on whether the total fermion number F is even or odd [14].

- Quantum error correction detects errors via parity checks—not by measuring error magnitude, but by measuring the binary even/odd state of qubit groups [12].

- Topological quantum computing encodes information in the parity of Majorana fermion occupation numbers, protected precisely because local operations cannot change nonlocal parity [7].

We elevate this pattern to a cosmological principle: we propose that the parity of a universe's total particle count determines whether that universe is in a quantum-active or classical-dominant regime.

Parity as a Global Switch

Let N be the total particle count of a universe. We propose:

- N **odd:** The universe is in an active quantum state. At least one particle is unpaired. Superposition, tunneling, and interference are ongoing processes.

- N **even:** All particles are paired. The universe is in a classical-dominant state. Quantum effects are suppressed.

The magnitude of N is irrelevant. A universe with $10^{80}+1$ particles is in the same parity state as a universe with 3 particles. The binary property, not the count, is what matters. This is consistent with the $\mathbb{Z}_2$ structure: $(-1)^N$ cares only about the last bit.

The Baryon Asymmetry Connection

The observed universe contains approximately one extra matter particle for every 10^9 matter–antimatter pairs [1]. The origin of this asymmetry is one of the great unsolved problems in physics. The Sakharov conditions [11] describe the necessary ingredients (C violation, CP violation, departure from thermal equilibrium) but the Standard Model does not produce sufficient CP violation to account for the observed excess.

Our framework offers a novel perspective: the universe is not accidentally odd. It must be odd for quantum mechanics to operate. We conjecture that the baryon asymmetry is not a defect to be explained but a necessary condition for the quantum behavior that permits structure formation, chemistry, and ultimately observation. This is not a fine-tuning argument but a parity constraint: any universe capable of sustaining quantum processes must have odd total particle count.

PARTICLE TRANSIT BETWEEN UNIVERSES

The Many-Interacting-Worlds Foundation

Hall, Deckert, and Wiseman [4] demonstrated that quantum mechanics can be reproduced by a large but finite number of classical worlds that interact with one another. In their Many-Interacting-Worlds (MIW) approach, the repulsion between nearby worlds in configuration space produces interference, tunneling, and other quantum phenomena without invoking a wavefunction. Their framework reproduces the double-slit interference pattern and the quantum harmonic oscillator from inter-world interactions alone.

MIW establishes that interacting parallel universes can generate quantum behavior. What it does not specify is the mechanism of interaction. We propose that the interaction is mediated by particle transit: particles move between universes, and the parity change resulting from each transfer is the observable signature of the interaction.

Transit, Not Branching

In Everett's Many-Worlds Interpretation, universes branch at each quantum event and never interact thereafter. This creates a conceptual difficulty: if branches are permanently isolated, interference between them should be impossible, yet interference is experimentally observed.

Our model differs fundamentally. Universes do not branch. They coexist and exchange particles. A particle in superposition is not "in two states at once" within a single universe. It is in transit between universes, not yet committed to either. We propose that the apparent superposition is a bookkeeping artifact of observing from within one universe a particle that is between addresses.

Pairing as the Dominant Transit Mode

We propose that particles transit primarily in pairs. A pair (two particles transferring together) is an even-count event: it does not change the receiving or sending universe's parity. This makes pair transit the lowest-cost transfer—parity-neutral, requiring no global rebalancing.

This is consistent with observed physics. Particle creation overwhelmingly produces pairs: electron–positron pair production, parametric down-conversion of photons, Cooper pairing in superconductors. Nature prefers even transactions. Odd transactions (single-particle transfers) are rarer and more consequential, as they flip the parity of both universes involved.

Pairs that have transited together are correlated—they are a single transaction. This correlation persists regardless of subsequent spatial separation, because the link is not spatial but transactional. This is the origin of quantum entanglement (Sec.).

Pairs Can Superpose Together

Once formed, pairs behave as composite bosons. Unlike individual fermions, which are subject to Pauli exclusion and cannot share quantum states, boson-like pairs can occupy the same state simultaneously. Multiple pairs can superpose—overlap into a single coherent quantum state.

This is not speculative. It is the established mechanism of Bose–Einstein condensation (BEC) and superconductivity. In a BEC, thousands of atomic pairs condense into one quantum state visible to the naked eye. In a superconductor, billions of Cooper pairs occupy the same ground state, producing zero electrical resistance. The pairs superpose together.

The unpaired particle—the odd one out—cannot join this superposition. It remains quantum-active, seeking a partner, driving the system's quantum behavior.

OBSERVATION AS ANCHORING

The Measurement Problem Dissolved

The measurement problem asks: what physical process causes a quantum superposition to become a definite classical outcome upon observation?

Our answer: observation anchors a particle to the observer's universe. A particle in transit between universes has no definite address. Observation—any interaction that registers the particle's presence in a specific universe—forces it to commit. The particle is now HERE. The other universes adjust their parity accordingly.

We propose that there is no collapse of a wavefunction. There is no mysterious role for consciousness. There is a particle committing to an address. The "mystery" was an artifact

of treating superposition as a property of a single universe rather than a multi-universe transit state.

What Counts as Observation

Any interaction sufficient to register a particle's presence in a specific universe constitutes an observation. This includes:

- A detector absorbing a photon.

- An atom scattering off another atom.

- A molecule incorporating an electron into a bond.

Crucially, it does not require a conscious observer. A rock can anchor a particle as effectively as a physicist. The criterion is physical interaction that commits the particle to a local address, not awareness of that commitment.

The Quantum Zeno Effect

If a quantum system is observed rapidly and repeatedly, its evolution freezes. An unstable particle that is continuously monitored will not decay [8]. This has been experimentally confirmed [5].

In our framework, the explanation is immediate: continuous observation continuously re-anchors the particle to this universe. It never gets a chance to enter transit. Like holding a ball against a wall—it cannot move if you never let go.

Conversely, in the anti-Zeno effect, certain types of frequent measurement accelerate decay. In our model, this occurs when measurement partially dislodges a particle without fully re-anchoring it, increasing the probability of transit.

Delayed Choice

In Wheeler's delayed-choice experiment (confirmed by Jacques et al. [6]), the decision to observe which-path information is made after the particle has passed through the slits. The particle retroactively "decides" whether to show interference or not.

No retrocausality is needed in our framework. The particle is in transit between universes for the entire duration of the experiment. It has not committed. The decision to observe or not determines whether anchoring occurs, which determines whether the particle commits. The timing of the experimenter's choice relative to the particle's spatial trajectory is irrelevant, because the commitment event is not spatial—it is a universe assignment that occurs when observation forces it, whenever that is.

SEVEN PHENOMENA FROM ONE PRINCIPLE

Superposition

A particle in superposition is in transit between universes. It has not committed to an address. From within any single universe, the particle appears to be in an indefinite state—because it genuinely is not fully present.

Wavefunction Collapse

Observation anchors the particle to the observer's universe. Transit ends. The particle has a definite address. Other universes adjust their parity. We propose that no physical "collapse" occurs—a particle simply arrives.

Double-Slit Interference

An unpaired electron approaches two slits. It is in transit across multiple universes. In some universes it passes through slit A, in others slit B. These universes interact (per MIW mechanics), and the overlapping paths produce an interference pattern on the screen.

Placing a detector at the slits forces the electron to anchor—to commit to THIS universe, THIS slit. No transit, no multi-universe overlap, no interference. Two bands.

The detector does not "disturb" the electron. It pins it to an address. The interference disappears because there is no longer a multi-universe superposition to interfere.

Entanglement

Two entangled particles are a pair that transited together—a single even-group transaction. They are correlated because they are one event, not two. Measuring one particle breaks the pair into two singles, forcing both to anchor. The second particle's state is immediately determined because the transaction is being split, not because information travels between them.

This resolves the apparent conflict with relativity. No signal is sent. No information travels faster than light. A transaction is being settled, and settlement is not a spatial process.

A testable prediction follows: entangled groups with odd particle count (e.g., GHZ states with 3 particles) should decohere faster than even-count groups (e.g., cluster states with 4 particles), because odd groups carry a parity flip that even groups do not. Preliminary evidence is consistent—GHZ states are observed to be more fragile—but a controlled test isolating parity from system size has not been performed.

Quantum Tunneling

A particle confined behind a potential barrier lacks sufficient energy to cross it classically. In our framework, the particle is not climbing the barrier. It transits to a universe where it is on the other side of the barrier (or where the barrier has a different configuration), then re-emerges.

Tunneling probability decreases with barrier width because a wider barrier is present in more parallel universes, reducing the number of accessible destinations. Observation suppresses tunneling because an anchored particle cannot enter transit.

The Quantum Zeno Effect

Rapid repeated observation continuously re-anchors the particle. It cannot enter transit, cannot evolve, cannot decay. Continuous observation holds the system's state in place.

Quantum-Gravity Incompatibility

Gravity acts on anchored, committed, paired matter. A chair is trillions of paired particles, all anchored, all gripped by gravity. An electron in superposition is in transit, unpaired, uncommitted. Gravity has nothing to grip.

We propose that this is not a failure of theory but a category distinction. Quantum mechanics governs particles in transit. Gravity governs anchored matter. They do not conflict because they do not operate on the same objects.

We conjecture that gravity and quantum mechanics may govern different phases of matter's existence. The search for a unified quantum theory of gravity may need to be reframed in light of this distinction.

RELATIONSHIP TO EXISTING INTERPRETATIONS

Copenhagen Interpretation

Copenhagen treats collapse as axiomatic and declines to explain its mechanism. Our framework provides a candidate mechanism: observation anchors a particle to a universe. We agree with Copenhagen that observation produces definite outcomes but disagree that the question of why is unanswerable.

Many-Worlds Interpretation (Everett)

Everett eliminates collapse by proposing that all outcomes occur in branching universes. Our framework shares the commitment to multiple universes but differs fundamentally: universes do not branch. They coexist permanently and exchange particles. Interference is explained by inter-universe interaction, not by remnant overlap between branches.

Many-Interacting-Worlds (Hall, Deckert, Wiseman)

MIW is the closest existing framework to ours. We adopt its core insight—parallel worlds interact and produce quantum phenomena—and add a specific interaction mechanism: particle transit, governed by parity. MIW reproduces quantum mechanics mathematically but

is agnostic about what mediates the inter-world interaction. We propose that particle exchange mediates it.

Pilot Wave Theory (de Broglie–Bohm)

Pilot wave theory introduces a hidden guiding wave. Our framework requires no hidden variables. The particle's behavior is determined by the parity state of the universe and the availability of partner particles for pairing. Everything in our model is in principle observable.

Objective Collapse (Penrose, GRW)

Penrose proposes that gravitational self-energy causes collapse above a mass threshold [10]. Our framework predicts the opposite causal direction: we propose that pairing and anchoring come first, and gravity is a consequence, not a cause. This is an experimentally distinguishable difference. If a sufficiently isolated massive object can be placed in quantum superposition, Penrose predicts gravitational collapse on a calculable timescale. Our framework predicts the superposition persists as long as pairs remain uncommitted, regardless of mass.

TESTABLE PREDICTIONS

A framework without testable predictions is philosophy, not physics. We identify four experiments that could confirm or falsify this model.

Parity-Dependent Decoherence

Prediction: In a controlled system with exactly N particles, decoherence rates differ for odd versus even N.

Experiment: Prepare a cold atom trap with precisely counted atoms (feasible with current technology at $N < 100$). Measure coherence time for N and $N + 1$ atoms under identical conditions. Our framework predicts that odd-N systems exhibit different decoherence characteristics than even-N systems, controlling for all other variables.

Status: No such experiment has been performed with parity as the controlled variable.

Even vs. Odd Entangled Group Stability

Prediction: Entangled states with even particle count are more robust than those with odd particle count, beyond what system-size scaling alone predicts.

Experiment: Compare decoherence rates of 2-particle Bell states, 3-particle GHZ states, and 4-particle cluster states, normalizing for system-size effects. If 4-particle states are more stable than expected from the 2-to-3 scaling trend, the parity effect is present.

Status: GHZ fragility is well-documented but has not been analyzed through the lens of parity.

Gravitational Superposition

Prediction: A massive object in quantum superposition does not experience gravitational self-collapse. Gravity does not act on uncommitted matter.

Experiment: The proposed MAQRO satellite experiment and various optomechanical resonator experiments aim to test gravitational decoherence. If superposition persists beyond Penrose's predicted collapse time, our framework is supported and Penrose's is weakened.

Status: Experiments under development. Results expected within the next decade.

Vacuum Fluctuation Correlation with Expansion Rate

Prediction: If particle transit between universes is driven by cosmic expansion, vacuum fluctuation rates should correlate with the local expansion rate (Hubble parameter).

Experiment: Compare vacuum fluctuation measurements (Casimir effect, Lamb shift) at different cosmological epochs or in regions with different local expansion rates.

Status: Speculative. Would require precision cosmological measurements beyond current capability.

DISCUSSION

Strengths

The primary strength of this framework is unification. Seven distinct quantum phenomena receive a common explanation from a single principle (parity-driven universe assignment), without introducing hidden variables, new forces, or modifications to the quantum formalism. The framework is compatible with the mathematical structure of quantum mechanics while providing a physical picture that the formalism alone does not supply.

The framework also offers a natural explanation for the quantum-gravity divide that does not require quantum gravity. If gravity acts only on committed matter, the search for a quantum theory of gravity may be searching for a theory that does not need to exist—at least not in the form currently sought.

Limitations and Open Questions

Mathematical formalism. This paper presents a conceptual framework. A full theory requires a mathematical formalism that reproduces the predictions of quantum mechanics from parity-based principles. The MIW framework of Hall et al. provides a starting point, but the particle-transit mechanism and parity coupling require their own mathematical treatment.

Conservation laws. If particles transit between universes, local conservation of energy and particle number is violated. The framework assumes global (multiverse-wide) conservation, but this is not directly testable.

The parity coupling mechanism. We assert that parity acts as a global switch, but do not specify the physical mechanism by which a universe's total parity state influences local quantum behavior. This is the deepest open question within the framework and the most important target for future theoretical work.

Scope of "universe." If the universe is infinite, the total particle count may not be well-defined. The framework may require application to finite causal patches (observable universes) rather than the universe as a whole. This is analogous to the infrared regularization commonly used in quantum field theory.

13

Prior Art

We acknowledge that the individual components of this framework have precedent:

- Parity as a quantum property: Wick, Wightman, and Wigner [13].

- Parallel interacting universes: Hall, Deckert, and Wiseman [4].

- Gravity-induced collapse: Penrose [10].

- Particle creation from expanding spacetime: Parker [9].

- Pair dominance in particle physics: standard quantum field theory.

- The $\mathbb{Z}_2$ structure of fundamental symmetries: widespread in condensed matter and particle physics.

The contribution of this work is the synthesis: assembling these components into a unified framework with a specific physical mechanism (particle transit governed by parity) and identifying testable predictions that follow from the synthesis but not from any individual component.

CONCLUSION

We have proposed that the binary parity of a universe's total particle count—odd or even—is the fundamental switch governing quantum and classical behavior. Particles in transit between parallel universes are unpaired, uncommitted, and quantum. Particles that have paired and anchored to a specific universe are classical and subject to gravity. Observation is the act of forcing a particle to commit to an address.

This framework unifies superposition, collapse, interference, entanglement, tunneling, the Zeno effect, and the quantum-gravity divide under a single principle. It offers testable predictions distinguishing it from Copenhagen, Many-Worlds, pilot wave, and objective collapse interpretations.

The deepest implication is this: the universe must be odd. If every particle found its antiparticle and paired off, all matter would annihilate into radiation. No structure, no chemistry, no observers. We conjecture that the baryon asymmetry—that one extra particle

14

per billion—is not a cosmological accident. It is the condition that keeps quantum processes active, the universe dynamically evolving, and structure possible.

We invite experimentalists to test the parity-dependent predictions described in Sec. , and theorists to develop the mathematical formalism that this conceptual framework requires.

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