Superposition, Records, and Difference

Toward a Record-Based Ontology of Quantum Definiteness

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Working paper draft — philosophical/foundational version; no new quantum dynamics claimed

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Abstract

Quantum superposition is often described either as the coexistence of incompatible physical states, as an epistemic representation of incomplete information, or as branch multiplicity in an Everettian ontology. This paper develops a different philosophical constraint: superposition should be understood, at least in part, as the absence of a record-integrated difference relative to a given informational configuration. Here and throughout, a configuration should not be read as an instantaneous slice, but as a finite temporally integrated record-structure. The proposal does not modify the quantum formalism and does not deny decoherence, environmental records, or branch structure. It instead asks what must be added to the physical description before a formal alternative becomes a definite difference for a system, observer, or subject-state. Drawing on Quantum Darwinism, Spectrum Broadcast Structures, and Relational Quantum Mechanics, the paper distinguishes three levels: physical distinguishability, public objectivity, and subject-constituting definiteness. Quantum Darwinism and SBS explain how robust, redundantly encoded environmental records can support objective classical states. Relational Quantum Mechanics denies observer-independent states and treats quantum states as relative to interacting systems. The present paper adds a record-based constraint: an alternative becomes definite-for-a-configuration only when the relevant difference is integrated into the record-structure that constitutes that configuration's state. On this view, collapse is not the destruction of possibilities, and superposition is not automatically multiplicity. Collapse is the transition from formal alternative to record-stabilized difference. The aim is not to propose a new interpretation as a replacement for existing ones, but to isolate a precise ontological pressure point: quantum definiteness requires not merely physical correlation, but record-integrated difference.

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1. Introduction

The concept of quantum superposition sits at the center of almost every interpretive difficulty in quantum mechanics. A system is said to be in a superposition of incompatible states; measurement yields one outcome; decoherence explains why macroscopic alternatives cease to interfere; Everettian interpretations treat alternatives as branch-realized; relational interpretations deny that states are absolute; Quantum Darwinism explains how stable public records emerge in the environment.

Each of these approaches captures something important. Yet a basic question remains under-discussed:

> When does a formal alternative become a difference?

Not merely a mathematical term in a state vector. Not merely a possible outcome in a basis. Not merely a component of a global quantum description. A difference: something that can constrain later updates, enter records, individuate histories, and define what has become the case for some system or subject.

This paper proposes a philosophical constraint:

> **No definiteness without record-integrated difference.**

The phrase is deliberately minimal. It does not say that consciousness collapses the wavefunction. It does not say that physical records are unreal until experienced. It does not say that quantum theory is incomplete. It says that the ontology of definiteness requires a criterion for when alternatives become differences relative to a configuration.

The guiding idea is this:

> Superposition is not primarily "many realities" or "mysterious indeterminacy"; it is the absence of a record-integrated difference relative to the relevant informational configuration.

Once a difference is stably integrated into records, the alternatives are no longer merely formal alternatives relative to that configuration. They are distinct continuations, distinct histories, or distinct subject-states, depending on the level of analysis.

The paper develops this idea by drawing on three nearby frameworks:

1. **Quantum Darwinism and Spectrum Broadcast Structures**, which explain how objective classical information emerges through redundant environmental records.
2. **Relational Quantum Mechanics**, which denies observer-independent quantum states and treats states as relative to physical systems.
3. **Record-based subjectivity**, which treats the definiteness of experience as tied to the integration of differences into subject-constituting record structures.

The proposal is not that any of these frameworks is simply wrong. Rather, each captures a different layer of the same issue. Quantum Darwinism gives us public objectivity. Relational Quantum Mechanics gives us state-relativity. A record-based account of subjectivity gives us definiteness-for-a-configuration.

The result is a modest but potentially useful thesis:

> Quantum superposition should be read as non-difference relative to an unupdated record-configuration, and collapse as the emergence of record-integrated difference.

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2. The Problem: Superposition as Coexistence, Ignorance, or Multiplicity

The standard interpretive vocabulary around superposition tends to fall into three broad families.

First, there is the **coexistence reading**. A system in superposition is said to be, in some sense, in multiple states at once. The electron is here and there; the cat is alive and dead; the spin is up and down. This language is powerful but misleading. It invites us to reify the components of a mathematical representation as co-present physical realities.

Second, there is the **epistemic reading**. The quantum state may be treated as a representation of information, uncertainty, or expectation rather than as an ontological object. This avoids crude coexistence, but it risks making definiteness depend on knowledge without explaining what it means for a record to become part of the world or part of a system's state.

Third, there is the **multiplicity reading**, especially in Everettian interpretations. Superposition is not ignorance or paradoxical coexistence; it is branch structure. All outcomes occur, each in a different branch. This preserves the unitary dynamics, but it shifts the metaphysical burden: what counts as one branch, one observer, one history, or one definite outcome?

The present paper does not attempt to settle these debates directly. Instead, it suggests that all three readings obscure a prior issue:

> alternatives are not yet differences until a record-structure makes them difference-making.

A term in a formal superposition may represent a possible distinction. But a possible distinction is not yet a definite difference for a system. To become definite, the distinction must enter a recordable structure: it must constrain future updates, participate in correlations, and resist being erased as a merely formal decomposition.

This is why the language of records matters. A record is not just a measurement result written on a device. It is any physically or informationally stabilized structure that can constrain later evolution, support recognition, and distinguish one continuation from another.

Superposition, then, may be understood as the condition in which alternatives exist formally but have not yet become record-integrated differences relative to the configuration in question.

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3. Records and Objectivity: Quantum Darwinism and SBS

Quantum Darwinism explains the emergence of classical objectivity by emphasizing the proliferation of records in the environment. A system interacts with its surroundings; information about selected pointer states becomes redundantly encoded in many environmental fragments; observers can independently access these fragments and recover the same information without directly disturbing the system.

This is a powerful account of how classical objectivity can arise from quantum dynamics. Objectivity is not primitive. It is achieved through redundancy, stability, and recoverability. A

state becomes effectively objective when many fragments of the environment carry the same record.

Spectrum Broadcast Structures sharpen this picture. They describe conditions under which information about a system is broadcast into the environment in a way that allows multiple observers to access the same classical information. In such cases, objectivity is not merely a philosophical label; it has a structural signature in the quantum state.

For the present paper, the lesson is clear:

> quantum definiteness is inseparable from record structure.

However, Quantum Darwinism and SBS primarily address public objectivity. They explain how environmental records make a state robustly accessible to many observers. But public objectivity is not identical to subject-constituting definiteness.

A record may exist in the environment before it is integrated into a given system's state. It may be redundantly encoded but not yet accessed. It may be physically available but not yet part of the subject-configuration whose definiteness we are trying to understand.

This suggests a three-level distinction:

1. **Physical correlation:** the system and environment are correlated.
2. **Public objectivity:** records are redundantly encoded and recoverable by multiple observers.
3. **Configuration-relative definiteness:** the difference has been integrated into the record-structure of the relevant system or subject-state.

Quantum Darwinism and SBS illuminate the first two. A record-based ontology of definiteness focuses on the third.

This distinction avoids a common ambiguity. If we say that decoherence or environmental redundancy "produces reality," we risk blurring public objectivity with experiential or configuration-relative definiteness. If we say that only conscious observation matters, we fall back into an unnecessary psychologism. The middle position is record-based:

> definiteness is not a mental act, but neither is it mere formal decomposition. It is the stabilization and integration of difference into a record-structure.

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4. Relational Quantum Mechanics and the Relativity of State

Relational Quantum Mechanics offers a different but complementary insight. Its central move is to reject the idea of an observer-independent state of a system. A quantum state is not an absolute property possessed by a system in isolation. It is relative to another system with which it interacts.

This is highly relevant to the ontology of superposition. If states are relational, then superposition is not an absolute metaphysical condition of the system. A system may be in a superposition relative to one system, while a definite outcome is recorded relative to another.

The record-based view developed here agrees with this relational impulse but modifies its emphasis. The key relation is not merely between two physical systems. It is between a formal alternative and a record-configuration capable of integrating a difference.

Thus:

> Superposition is relational non-difference: alternatives remain superposed relative to a configuration for which they have not become record-integrated differences.

This does not mean the alternatives are unreal. Nor does it mean they are merely subjective. It means their definiteness is not absolute. They are definite only relative to a record structure in which the difference has been stabilized.

The advantage of this formulation is that it clarifies what "relative" means in record terms. A state is not definite relative to a system merely because that system exists. It is definite relative to a system when the relevant difference has entered the system's record-structure in a way that can constrain future updates.

This brings relational quantum mechanics and record-based definiteness into contact:

- RQM: states are relative to systems.
- Record-based definiteness: definiteness is relative to record integration.

The proposed synthesis is:

> a quantum state is definite for a configuration when a difference is record-integrated into that configuration.

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5. Difference, Not Multiplicity

A central temptation in interpreting superposition is to treat it as multiplicity. If the formalism contains multiple terms, we imagine multiple coexisting realities, multiple worlds, multiple outcomes, or multiple observers. This may be justified in some interpretations, but it should not be assumed.

A formal alternative is not automatically a distinct reality. It becomes distinct, relative to a configuration, when it makes a record-based difference.

The key contrast is therefore:

> formal multiplicity vs. record-integrated difference.

A quantum state may contain multiple components in some decomposition. But decompositions are basis-dependent unless physically stabilized. What matters for definiteness

is not the mere existence of formal components, but the emergence of stable differences that can be tracked, recorded, and integrated.

This point also clarifies a possible relation to Everettian branching. Everettianism may treat branches as physically real structures arising through decoherence. The record-based view does not deny this. It asks a different question:

> When do branch-relative alternatives become distinct histories for a given record-configuration?

The answer is not "as soon as the wavefunction can be mathematically decomposed." The answer is:

> when branch-relative differences become stable, record-integrated constraints.

This is why superposition should not be read simply as "many worlds before collapse" or "one world awaiting collapse." It is better understood as a regime of not-yet-difference relative to a configuration.

Collapse, in this sense, is not the annihilation of other terms. It is the emergence of difference.

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6. Collapse as Record-Integrated Difference

The word "collapse" carries heavy metaphysical baggage. In Copenhagen-style language, it suggests a mysterious transition from quantum possibility to actual outcome. In objective collapse theories, it may indicate a real physical modification of quantum dynamics. In Everettian interpretations, it is rejected as unnecessary.

The present proposal uses "collapse" in a thinner, record-based sense:

> **Collapse is the transition by which a formal alternative becomes a record-integrated difference relative to a configuration.**

This definition does not imply objective reduction of the wavefunction. It does not imply psychophysical intervention. It is compatible with unitary dynamics at the global level, with relational states, and with environmental decoherence.

What it adds is an ontological grammar. The problem is not only "what happens physically?" but "when does a difference become difference-making for a configuration?"

Suppose a measurement interaction produces a correlation between a system and an apparatus. At first, the formal alternatives may be represented in the quantum state. Decoherence then suppresses interference between macroscopically different records. Environmental redundancy may make those records publicly available. Finally, some observer or system integrates one of those records into its own state.

Each stage matters, but they are not the same:

1. **Correlation** creates structured dependence.

2. **Decoherence** suppresses interference between alternatives.
3. **Redundancy** supports public objectivity.
4. **Record integration** creates definiteness for a configuration.

Collapse, in the thin sense used here, is primarily the fourth. It is not a rival to the first three. It is the point at which an alternative becomes part of a configuration's own record-structure.

This helps avoid two extremes:

- Collapse is not a magical mental act.
- Collapse is not reducible to mere formal decoherence unless decoherence is linked to record integration.

The crucial point is that definiteness requires difference, and difference requires records.

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7. Subject-States and Record Chains

A record-based ontology becomes especially important when we speak of observers, subjects, or experiences. A subject is not merely a physical body, a spacetime label, or a passive recipient of environmental information. At minimum, it is a structured continuity of records: memories, expectations, perceptual integrations, and constraints that link one state to the next.

This suggests the following working notion:

> A subject-state is a record-based experiential configuration. Such a configuration should not be treated as an instantaneous frame, but as a finite temporally integrated record-structure whose identity depends on ordered continuation under record-preserving updates.

This is not simply Quantum Darwinism applied to observers. Quantum Darwinism and SBS explain how environmental information becomes redundantly encoded and publicly recoverable. That is a theory of public objectivity. A subject-state, by contrast, requires integration into a continuing record-structure that constrains that subject's admissible updates. Public recoverability and subjective integration are therefore different roles.

A record may be public without yet being subject-constituting for a given observer. A detector may encode an outcome; an environmental fragment may redundantly carry it; another system may be able to recover it. But unless that difference is integrated into the observer's continuing record-configuration, it does not yet individuate that observer's subject-state. Conversely, once a difference is integrated into the subject's record-chain, it can define a new experiential continuation even if the broader public-objective structure is still being stabilized.

The distinction can be put as follows:

1. **QD/SBS objectivity:** a difference is redundantly encoded and publicly recoverable.
2. **Subject-state definiteness:** a difference is integrated into the record-chain that constitutes a particular experiential configuration.

The second does not compete with the first. It answers a different question. Quantum Darwinism asks how a world becomes commonly accessible. A record-chain account asks how a difference becomes constitutive for a particular subject-state.

This is not a claim that consciousness has magical priority over physics. It is a claim about individuation. If the subject is constituted by records, then subject differentiation requires record differentiation.

This has direct consequences for superposition. If two physical situations support the same subject-state, and no subject-constituting record differs, then there is no subject-relative difference between them. They may be different physical realizations, different environmental contexts, or different branch locations. But they do not yet define different subject-states.

Once a record differs, the subject-state differs. This is the record-based version of the A=A point:

> A subject-configuration identical to itself is not multiplied as a subject by differences that have not entered its subject-constituting records.

Thus, superposition can be understood subject-relatively as non-difference. Collapse is the first subject-constituting difference.

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8. A Minimal Formal Schema

Let C be an informational configuration, and let D be a candidate difference represented in some physical or formal description. In what follows, C is not an instantaneous snapshot but a finite temporally integrated record-configuration.

Define:

> D is definite for C iff D is integrated into the record-structure of C in a way that constrains admissible continuations of C.

Before integration:

> C + formal alternatives = no configuration-relative difference.

After integration:

> C → C_D

where C_D is a successor configuration containing D as a record.

A superposition, relative to C, can then be described as:

> a set of formal alternatives not yet differentiated within C's record-structure.

Collapse, relative to C, can be described as:

> the transition from alternatives compatible with C to a successor configuration C_D in which one difference has become record-stabilized.

This schema is intentionally abstract. It does not specify a Hilbert-space dynamics, a collapse mechanism, or a physical threshold. It is a conceptual schema for distinguishing formal alternatives from record-integrated differences.

Its main use is diagnostic. It asks of any interpretation:

1. What counts as a record?
2. What counts as integration into a configuration?
3. What makes a difference definite relative to that configuration?
4. Does the interpretation distinguish formal multiplicity from record-based difference?

These questions are not substitutes for physics. They are constraints on the ontology we attach to the physics.

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9. Relation to Everettian Branching

Everettian quantum mechanics treats the universal state as evolving unitarily. Branching is not a fundamental dynamical process but an emergent structure associated with decoherence. Observers become correlated with different outcomes, and each branch contains a successor observer with a definite record.

The record-based view can accept much of this description while resisting one interpretive shortcut. It does not deny that decoherence produces robust branch-like structures. It denies that branch structure alone automatically settles the ontology of definiteness for every configuration.

The question is:

> When does branch multiplicity become record-based difference?

For environmental fragments, the answer may be: when redundant records stabilize. For an apparatus, the answer may be: when the apparatus state reliably encodes the outcome. For a subject-state, the answer may be: when the outcome difference enters the subject-constituting record chain.

Thus, Everettian branching can be rephrased in record-based terms:

> Branching is the progressive stabilization of incompatible record-structures.

This formulation does not refute Everett. It clarifies its ontology. Branches are not merely formal components; they are stable structures of differentiated records. If this is accepted, then Everettianism already depends on a record-based account of difference.

The present paper's contribution is to make that dependence explicit.

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10. Relation to Copenhagen-Style Collapse

Copenhagen-style interpretations often treat collapse as the transition from quantum indefiniteness to a measured outcome. The difficulty is that measurement is not given a fully clear ontological status. What counts as measurement? An apparatus? A conscious observer? An irreversible record? A classical context?

A record-based formulation can preserve the insight without the ambiguity:

> collapse is not measurement as such, but record-integrated difference.

Measurement is one way of producing such a difference. But the fundamental concept is not the measuring act; it is the stabilization of a difference in a record-configuration.

This reframing also removes the need to treat consciousness as a primitive collapse trigger. Conscious subjects matter when we ask about subject-relative definiteness, but physical records can exist without being consciously experienced. The hierarchy is:

- physical correlation;
- stable record;
- public objectivity;
- subject integration.

Copenhagen-style collapse often compresses these into a single mysterious moment. A record-based ontology separates them.

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11. Relation to Relational Quantum Mechanics

Relational Quantum Mechanics already rejects absolute states. The present proposal can be seen as a refinement of that intuition rather than a rival to it.

RQM says: a system has a state only relative to another system.
The record-based view says: a difference is definite only relative to a record-configuration into which it is integrated.

These claims are compatible, but not identical. RQM emphasizes relationality between systems. Record-based definiteness emphasizes the internal role that a relation must acquire in order to become difference-making for a configuration. Not every interaction, correlation, or relation automatically functions as a record. A relation becomes relevant to definiteness only when it stabilizes a difference that can constrain subsequent updates of the system or subject in question.

This is where record integration adds something to bare relationality. It distinguishes:

1. **mere relation:** two systems interact or stand in a correlation;
2. **record relation:** the interaction leaves a stable difference-making trace;

3. **configuration-relative definiteness:** that trace is integrated into the record-structure that determines the state of the relevant configuration.

RQM can say that an outcome is definite relative to a system. The record-based view asks what, within that system, makes the outcome definite rather than merely relationally correlated. The answer proposed here is: record integration.

This allows a more precise statement:

> A superposed alternative is not absolutely indefinite; it is indefinite relative to configurations that have not integrated the relevant difference.

Conversely:

> An outcome is not absolutely definite in a metaphysical void; it is definite relative to configurations in which the relevant difference is record-stabilized.

This formulation may help reduce the apparent conflict between relational and record-based approaches. Relations matter, but not every relation yields definiteness. The relation must generate a record-integrated difference.

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12. Objection: This Is Just Decoherence

One might object that the proposal adds nothing to decoherence. Decoherence already explains why interference disappears and why pointer states become stable. Why introduce record-integrated difference?

The answer is that decoherence is a physical process; record-integrated difference is an ontological role. Decoherence may be the physical mechanism by which many record-integrated differences become stable. But the concepts are not identical.

Decoherence describes the suppression of interference between components relative to an environment. It does not by itself answer all questions about:

- what counts as a record;
- which records matter for which configuration;
- when public objectivity becomes subject-relative definiteness;
- how observer-states are individuated by integrated records.

Quantum Darwinism and SBS go further by analyzing redundancy and objectivity. The present proposal goes one step further in the direction of subject- and configuration-relative definiteness.

Thus, the claim is not “decoherence is wrong.” The claim is:

> decoherence needs a record ontology if it is to explain definiteness rather than merely interference suppression.

13. Objection: This Reintroduces Consciousness

A second objection is that the proposal smuggles consciousness back into quantum mechanics. If definiteness depends on subject-constituting records, is this not a return to observer-based collapse?

No. The proposal distinguishes different layers of definiteness. Physical records can be stable without being conscious. Environmental redundancy can support public objectivity without subjective integration. Subject-relative definiteness is only one layer, relevant when the configuration in question is a subject-state.

The general claim is not:

> no definiteness without consciousness.

The general claim is:

> no configuration-relative definiteness without record-integrated difference.

For non-conscious physical systems, the relevant configuration may be an apparatus, an environment fragment, or a relationally defined physical system. For conscious subjects, the relevant configuration is experiential and record-based.

This avoids both extremes:

- It does not make consciousness the magical cause of collapse.
- It does not erase the special individuation problem that arises when the configuration is a subject.

Consciousness is not the universal trigger. It is one important case of record-based configuration.

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14. Objection: Records Are Themselves Quantum

A third objection is that records are not classical primitives. A record is itself a physical system governed by quantum mechanics. If the record is quantum, how can it ground definiteness?

This objection is correct and important. The proposal should not treat records as metaphysically primitive classical objects. A record is not a little classical fact inserted into the quantum world. It is a stable difference-making structure.

Quantum Darwinism and SBS are important precisely because they show how record-like classicality can emerge from quantum dynamics. Records are not assumed; they are stabilized through correlations, decoherence, redundancy, and recoverability.

The record-based view therefore does not require primitive classical records. It requires emergent record roles:

> a record is whatever structure can preserve a difference, constrain future updates, and support recognition or recoverability within a relevant configuration.

This definition is compatible with records being physically quantum in origin. What matters is not that records are classical substances, but that they perform the ontological role of stabilizing differences.

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15. What This Paper Does Not Claim

This paper does not claim that quantum mechanics is wrong. It does not propose a new equation, a new collapse mechanism, or a new experimental prediction. It does not claim that Quantum Darwinism, SBS, RQM, Everettianism, or Copenhagen-style interpretations are simply mistaken.

It claims that the ontology of quantum definiteness requires a distinction between:

1. formal alternatives;
2. physical correlations;
3. stable records;
4. public objectivity;
5. subject-constituting definiteness.

Superposition is often confusing because these levels are compressed. Collapse is mysterious because the transition from formal alternative to definite difference is not given a sufficiently clear ontological grammar.

The proposed grammar is record-based:

> Superposition is non-difference relative to an unupdated record-configuration.
> Collapse is record-integrated difference.

This is a philosophical constraint, not a new physical theory.

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16. Conclusion

Quantum superposition is usually interpreted through the language of coexistence, ignorance, or multiplicity. Each vocabulary captures something, but each risks obscuring the role of difference.

A formal alternative is not yet a definite difference. A branch component is not yet a history for every configuration. A correlation is not yet public objectivity. A public record is not yet subject-

relative experience. What matters, across these levels, is the stabilization and integration of difference into records.

This paper has proposed a record-based ontology of quantum definiteness:

> Superposition is the absence of record-integrated difference relative to a configuration.
>
> Collapse is the emergence of such difference.

The proposal is compatible with the physical insights of decoherence, Quantum Darwinism, SBS, and relational approaches. Its role is not to replace them, but to clarify a conceptual transition they often leave compressed: the transition from formal alternative to definite difference.

If the argument is right, then the foundational question should not be merely:

> How does the wavefunction collapse?

Nor merely:

> How many branches exist?

But rather:

> When does an alternative become a difference, and for which record-configuration?

That question may be the missing bridge between quantum formalism, public objectivity, and the definiteness of experience.

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Author note

This paper is part of a broader project on record-based subjectivity and quantum definiteness. It is a philosophical/foundational argument and does not propose a modification of quantum mechanics. AI tools were used for drafting assistance, critical review, and editing; the author takes responsibility for all claims, sources, and final wording.