Global Branching and Everettian Probability: A Critique of Sebens and Carroll's Proposal

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Abstract

Sebens and Carroll (2018) propose that self-locating uncertainty, constrained by their Epistemic Separability Principle (ESP), derives Born rule probabilities in Everettian quantum mechanics. Their global branching model, however, leads to local amplitudes lost, undermining this derivation. This paper argues that global branching's premature splitting of observers, such as Bob in an EPR-Bohm setup, yields local pure states devoid of amplitude coefficients essential for Born rule probabilities. Despite their innovative framework, further issues with global branching—conflicts with decoherence, relativistic violations via physical state changes, and constraints on superposition measurements—render it empirically inadequate. Defenses, such as invoking global amplitudes, fail to resolve these flaws. Additionally, observer-centric proofs of the Born rule neglect objective statistics, weakening their empirical grounding. This analysis underscores the need to reconsider branching mechanisms to secure a robust foundation for Everettian probabilities.

1 Introduction

The challenge of deriving the Born rule in Everettian quantum mechanics (Many-Worlds Interpretation, MWI), where all measurement outcomes occur across branches, has long been a central problem in quantum foundations. Vaidman introduced a pivotal insight, arguing that observers experience self-locating uncertainty during the period between branch splitting via decoherence and registering the measurement outcome [5]. This uncertainty, Vaidman proposed, provides a basis for assigning probabilities in MWI, laying the groundwork for subsequent analyses. Building on Vaidman's framework, Sebens and Carroll propose a novel derivation of the Born rule by leveraging self-locating uncertainty, constrained by their Epistemic Separability Principle (ESP) [4]. They argue that an observer's uncertainty about which branch they inhabit uniquely yields probabilities proportional to the squared amplitudes of the universal wave function, offering an epistemic derivation of the Born rule.

Sebens and Carroll's approach is philosophically and technically ambitious, aiming to unify classical and quantum self-locating uncertainty. However, their assumption of global branching—where the entire universe splits upon a quantum measurement—introduces a critical flaw. This paper argues that global branching's loss of local amplitude information, as seen in an EPR-Bohm setup, severs the quantitative link to Born rule probabilities, rendering their framework empirically inadequate. Section 2 outlines Sebens and Carroll's framework, Section 3 critiques global branching's amplitude loss, Section 4 evaluates possible defenses, Section 5 explores further issues with global branching, Section 6 examines the limitations of observer-centric proofs in explaining objective Born rule statistics, and Section 7 discusses implications for MWI's probabilistic foundations.

2 Sebens and Carroll's Framework for Born Rule Probabilities

Sebens and Carroll's framework for deriving the Born rule in MWI hinges on the concept of self-locating uncertainty, a state where an observer is aware of the universal wave function but uncertain about which branch of the multiverse they inhabit [4]. This uncertainty arises in the critical post-measurement, pre-observation period, where decoherence has split the universe into distinct branches, but the observer has not yet registered the outcome of a quantum measurement. Their approach builds on Vaidman's insight that such uncertainty provides a foundation for probabilistic assignments in a deterministic multiverse [5, 6]. By introducing their Epistemic Separability Principle (ESP), Sebens and Carroll aim to constrain rational credences in a way that aligns with the Born rule, which states that the probability of an outcome is proportional to the squared amplitude of the corresponding wave function component.

To elucidate their framework, they employ thought experiments such as the "Once-or-Twice" scenario. In this setup, an observer, Alice, performs a quantum measurement on a system, such as a card drawn from a deck, which splits the universe into branches corresponding to each possible outcome. For instance, consider a quantum state:

$$|\Psi\rangle = \frac{1}{\sqrt{2}}(|\heartsuit\rangle_D |\clubsuit\rangle_E + |\diamondsuit\rangle_D |\spadesuit\rangle_E), \tag{1}$$

where $|\heartsuit\rangle_D$ and $|\diamondsuit\rangle_D$ represent distinct states of a device (e.g., a card detector), and $|\clubsuit\rangle_E$ and $|\spadesuit\rangle_E$ denote environmental states. Upon measurement, decoherence creates two branches, each containing an identical copy of Alice, unaware of which branch they occupy. Sebens and Carroll's ESP stipulates that an observer's credence for being in a particular branch depends solely on the state of subsystems containing their qualitatively identical copies, not on transformations in the external environment. In this case, swapping the environmental states $|\clubsuit\rangle_E$ and $|\spadesuit\rangle_E$ does not alter Alice's reduced density matrix:

$$\rho_{\text{Alice}} = \frac{1}{2}(|\heartsuit\rangle_D \langle\heartsuit|_D + |\diamondsuit\rangle_D \langle\diamondsuit|_D), \tag{2}$$

which reflects equal probabilities (50%) for each outcome, consistent with the Born rule's $|\alpha|^2 = 1/2$.

Sebens and Carroll's reliance on global branching is central to their framework, as it ensures a universal ontology where the entire wave function evolves unitarily, embedding all observers within a single deterministic multiverse [4]. They argue that global branching is necessary to maintain consistency in credence assignments across all observers, regardless of their spatial separation, as ESP requires credences to depend only on local subsystem states while reflecting the global wave function's amplitudes. Unlike local branching models, which tie splitting to decoherence at specific locations [5], global branching posits that a single measurement, such as Alice's, instantaneously splits the entire universe, including distant observers. This allows Sebens and Carroll to apply ESP uniformly, ensuring that all observers' credences align with the universal wave function's squared amplitudes, a prerequisite for their epistemic derivation of the Born rule. However, this assumption introduces challenges, as explored in subsequent sections.

Sebens and Carroll demonstrate that for an arbitrary quantum state $|\Psi\rangle = \sum_i \alpha_i |i\rangle$, the rational credence for an observer being in branch i is $|\alpha_i|^2$, matching the Born rule [4]. They emphasize that these probabilities arise from the amplitudes of the universal wave function, explicitly rejecting branch-counting approaches, which are problematic due to the ill-defined nature of branch numbers in realistic decoherence scenarios [7]. Their framework also extends to classical self-locating uncertainty, as seen in the "Duplicating Dr. Evil" thought experiment, where an agent is uncertain about their identity across duplicated states. Here, their Strong ESP ensures that credences remain invariant under transformations outside the observer's subsystem, unifying classical and quantum probability assignments.

By assuming global branching, Sebens and Carroll maintain a universal ontology, where the entire wave function evolves unitarily, and all observers are embedded within a single, deterministic multiverse. This global perspective distinguishes their work from local branching models, which tie branching to decoherence events at specific locations [7]. Their derivation employs epistemic principles, arguing that rational agents, constrained by ESP, assign credences proportional to squared amplitudes based on self-locating uncertainty, providing a normative justification for the Born rule in MWI.

3 Critique of Sebens and Carroll's Derivation

Despite its elegance, the reliance of Sebens and Carroll's derivation on global branching introduces a critical flaw. Their global branching model, where a quantum measurement causes the entire universe, including distant observers, to split instantaneously, succeeds in idealized scenarios but fails for distant observers due to the loss of local amplitude information. To illustrate, we analyze an Einstein-Podolsky-Rosen (EPR)-Bohm setup, first demonstrating that Sebens and Carroll's framework yields correct Born rule probabilities for Alice in an idealized case, then showing how it fails for Bob due to amplitude loss.

Consider two particles, a and b, prepared in a singlet state at spacelike-separated locations x_A and x_B, observed by Alice and Bob, respectively:

$$|\Psi_0\rangle = \frac{1}{\sqrt{2}}(|{\uparrow_z}\rangle_a |{\downarrow_z}\rangle_b - |{\downarrow_z}\rangle_a |{\uparrow_z}\rangle_b) |\text{ready}\rangle_A |\text{ready}\rangle_B |E_0\rangle \,, \tag{3}$$

where $|{\uparrow_z}\rangle$ and $|{\downarrow_z}\rangle$ denote spin states along the z-axis, $|\text{ready}\rangle_A$ and $|\text{ready}\rangle_B$ are Alice and Bob's pre-measurement states, and $|E_0\rangle$ is the initial environmental state. In an idealized EPR-Bohm setup, analogous to the "Once-or-Twice" scenario in [4], suppose Alice measures the z-spin of particle a at x_A, and the outcome is recorded in a detector without immediately entangling her brain state, maintaining $|\text{ready}\rangle_A$. Global branching splits the universe into two branches, and the post-measurement state is:

$$|\Psi_1\rangle = \frac{1}{\sqrt{2}}(|{\uparrow_z}\rangle_a |{\uparrow_z}\rangle_D |\text{ready}\rangle_A |{\downarrow_z}\rangle_b |\text{ready}\rangle_B |E_1\rangle + |{\downarrow_z}\rangle_a |{\downarrow_z}\rangle_D |\text{ready}\rangle_A |{\uparrow_z}\rangle_b |\text{ready}\rangle_B |E_2\rangle), \tag{4}$$

where $|{\uparrow_z}\rangle_D$ and $|{\downarrow_z}\rangle_D$ are detector states, and $|E_1\rangle$, $|E_2\rangle$ are orthogonal environmental states. Alice's reduced density matrix, tracing out particle b, Bob, and the environment, is:

$$\rho_{AaD} = \frac{1}{2} |{\uparrow_z}\rangle_a |{\uparrow_z}\rangle_D |\text{ready}\rangle_A \langle\text{ready}|_A \langle{\uparrow_z}|_D \langle{\uparrow_z}|_a + \frac{1}{2} |{\downarrow_z}\rangle_a |{\downarrow_z}\rangle_D |\text{ready}\rangle_A \langle\text{ready}|_A \langle{\downarrow_z}|_D \langle{\downarrow_z}|_a \,. \tag{5}$$

This mixed state encodes the squared amplitudes ($\frac{1}{2}$) of the universal wave function, reflecting Alice's self-locating uncertainty about which branch she occupies during the post-measurement pre-observation period. ESP, which requires credences to depend solely on local subsystem states, assigns 50% credences to observing $|{\uparrow_z}\rangle_a$ or $|{\downarrow_z}\rangle_a$, matching the Born rule's probabilities [4]. The detector's inclusion in Alice's local subsystem ensures the mixed state structure, enabling Sebens and Carroll's derivation to succeed in this idealized scenario.

As we will argue below, however, their derivation fails for Bob in the same EPR-Bohm setup due to the loss of local amplitude information. When Alice measures the z-spin of particle a at x_A and obtains her result, Sebens and Carroll's global branching model assumes the universe splits instantly into two branches: one where Alice observes $|{\uparrow_z}\rangle_a$ (Alice+'s branch) and one where she observes $|{\downarrow_z}\rangle_a$ (Alice-'s branch). Bob, at x_B, splits into Bob+ (in Alice-'s branch, with particle b in $|{\uparrow_z}\rangle_b$) and Bob- (in Alice+'s branch, with particle b in $|{\downarrow_z}\rangle_b$). The post-measurement universal state is:

$$|\Psi_2\rangle = \frac{1}{\sqrt{2}}(|{\uparrow_z}\rangle_a |{\uparrow_z}\rangle_D |{\uparrow_z}\rangle_A |{\downarrow_z}\rangle_b |\text{ready}\rangle_B |E_1\rangle + |{\downarrow_z}\rangle_a |{\downarrow_z}\rangle_D |{\downarrow_z}\rangle_A |{\uparrow_z}\rangle_b |\text{ready}\rangle_B |E_2\rangle). \tag{6}$$

For Bob- in Alice+'s branch, the local reduced density matrix for Bob and particle b, obtained by tracing out all other systems, is:

$$\rho_{Bb} = |\uparrow_z\rangle_b |\text{ready}\rangle_B \langle\text{ready}|_B \langle\uparrow_z|_b \,, \tag{7}$$

a pure state indicating particle b is definitively in $|\uparrow_z\rangle_b$. Similarly, for Bob+ in Alice-'s branch, the state is $|\downarrow_z\rangle_b |\text{ready}\rangle_B$. Note that before Alice's measurement, the local reduced density matrix for Bob and particle b is:

$$\begin{aligned} \rho_{Bb}^{\text{pre}} &= \frac{1}{2}\left(|\downarrow_z\rangle_b |\text{ready}\rangle_B \langle\downarrow_z|_b \langle\text{ready}|_B + |\uparrow_z\rangle_b |\text{ready}\rangle_B \langle\uparrow_z|_b \langle\text{ready}|_B\right) \\ &= \frac{1}{2}\left(|\downarrow_z\rangle_b \langle\downarrow_z|_b + |\uparrow_z\rangle_b \langle\uparrow_z|_b\right) \otimes |\text{ready}\rangle_B \langle\text{ready}|_B \,, \end{aligned} \tag{8}$$

a separable mixed state reflecting the 50% probabilities for particle b to be in $|\uparrow_z\rangle_b$ or $|\downarrow_z\rangle_b$, with Bob in $|\text{ready}\rangle_B$. The coefficients $1/\sqrt{2}$ from the universal wave function (Eq. 6) are absent in the post-branching pure state (Eq. 7), as global branching assigns Bob to a branch with a definite outcome.

Now ESP requires that Bob's credence for being in a particular branch depends solely on his local subsystem state [4]. For Alice, ESP ensures that the reduced density matrix's diagonal terms (e.g., 1/2 in Eq. 5) yield 50% credences, matching the Born rule. However, for Bob, the pure state (Eq. 7) lacks these amplitude-based weights. This focus on local amplitude structure is justified because ESP explicitly constrains credences based on the local reduced density matrix, which reflects the observer's subsystem state post-decoherence [4]. Without the mixed structure of Eq. (8), ESP cannot assign Bob 50% credences for $\uparrow_z$ or $\downarrow_z$, as the local state provides no statistical basis for such probabilities. While Sebens and Carroll's global branching operates within the global wave function, their reliance on ESP to derive probabilities via local subsystem states necessitates local amplitude information, which global branching eliminates.

This amplitude loss is fatal to Sebens and Carroll's derivation. Their approach relies on local reduced density matrices reflecting universal wave function amplitudes to determine credences [4]. Global branching's premature splitting of Bob discards this mixed state structure, severing the quantitative link to the Born rule. The objection that Sebens and Carroll do not assume explicit amplitude locality does not undermine this critique, as their ESP framework implicitly requires local amplitude information to function, regardless of whether global branching aligns with standard MWI dynamics. The loss of local amplitude structure highlights an internal inconsistency in their model, as it prevents ESP from delivering the Born rule probabilities it aims to derive.

In summary, Sebens and Carroll's reliance on global branching undermines their derivation of the Born rule. The loss of local amplitude information in Bob's reduced density matrix prevents ESP from constraining credences to match the Born rule's probabilities. This critique's emphasis on local amplitude structure is justified by ESP's dependence on local subsystem states, revealing a critical flaw in their global branching model.

4 Possible Responses and Counterarguments

A potential objection to this critique is that Bob could theoretically derive probabilities locally by considering information about his other copies. If Bob does not branch after Alice's measurement, his local reduced density matrix retains the mixed state structure (Eq. 8), with diagonal terms of 1/2, encoding the Born rule's 50% probabilities. This scenario would align with ESP's local applicability, as Bob's credences could be derived from his local state alone.

However, Sebens and Carroll's global branching model explicitly assumes that Bob splits instantaneously into Bob+ and Bob- upon Alice's measurement, resulting in a pure local state (Eq. 7) for each copy of Bob. This premature branching eliminates the mixed state structure, leaving Bob's local state devoid of the amplitude information needed to assign 50% credences via ESP. Even if Bob could access information about his other copy locally—say, by considering the existence of Bob+ in another branch—his local pure state (e.g., $|\uparrow_z\rangle_b |\text{ready}\rangle_B$) provides no basis for assigning equal probabilities, as it indicates a definite outcome. ESP's reliance on the local reduced density matrix means that Bob's credences must be derived from his branch's state alone [4], and the pure state lacks the statistical weights required for Born rule probabilities. If Bob were not to branch, as the objection suggests, his local state would retain the necessary amplitude information, but this scenario is incompatible with Sebens and Carroll's global branching assumption, which is central to their framework. Thus, the amplitude loss critique holds, as global branching's instantaneous splitting of Bob undermines ESP's ability to derive Born rule probabilities locally.

Another potential response invokes the notion that global branching's non-locality, including the amplitude loss, is empirically benign [4]. Sebens and Carroll note that distant measurements (e.g., in Andromeda) do not alter local reduced density matrices, suggesting that local predictions remain consistent with the Born rule statistically over repeated measurements. They might argue that the pure state in Bob's branch (Eq. 7) poses no empirical issue, as aggregate outcomes across branches align with quantum probabilities. Yet, this defense misses the mark. The amplitude loss prevents initial credence assignments in each branch from matching the Born rule, as Bob's predetermined outcome (e.g., $\uparrow_z$) contradicts the 50% probability required for individual measurements. This discrepancy undermines the statistical recovery of the Born rule, as each Bob perceives a definite result, not a probabilistic distribution, making global branching empirically inadequate for local observers.

A further defense might emphasize the post-measurement pre-observation period, where self-locating uncertainty is purported to arise before Bob measures particle b [4]. Sebens and Carroll could claim that global amplitudes constrain credences via ESP during this window, before local measurements resolve the state. In their idealized scenarios, such as "Once-or-Twice," observers remain unentangled with outcomes temporarily, preserving the global amplitude structure. However, global branching disrupts this in the EPR-Bohm case by assigning Bob to a branch with a definite state (Eq. 7) before local decoherence at x_B. This premature splitting pre-empts the period where self-locating uncertainty applies, as Bob's state is already resolved, and his credences lack a local basis for 50% probabilities.

Finally, Sebens and Carroll might respond to the amplitude loss objection by arguing that the universal wave function's amplitudes, preserved in the global state (Eq. 6), suffice for deriving Born rule probabilities. They could contend that Bob's self-locating uncertainty pertains to his position within the global superposition, where the $1/\sqrt{2}$ coefficients remain, allowing to assign 50% credences to each branch. This view presupposes that rational credence assignments depend on the universal state, accessible to observers in principle, rather than local subsystem states. Yet, this approach fails for the same reason: ESP is explicitly defined over local subsystems [4], and due to global branching, Bob's reduced density matrix (Eq. 7) is pure, lacking the mixed structure (Eq. 8) needed for Born rule weights.

5 Further Issues with Global Branching

Beyond the critical amplitude loss objection, global branching introduces additional inconsistencies that challenge its coherence and empirical adequacy in MWI. These issues, rooted in the EPR-Bohm setup, highlight conflicts with decoherence dynamics, quantum measurement capabilities, and relativistic constraints, compounding the difficulties of Sebens and Carroll's framework.

5.1 Decoherence vs. Instantaneous Branching

Global branching conflicts with the modern MWI's decoherence-driven branching, which is a local and gradual process [7]. Decoherence occurs when a system interacts with its environment, diagonalizing the reduced density matrix through subluminal propagation of interactions. In the EPR-Bohm setup, Alice's measurement decoheres her state at x_A, producing a diagonalized density matrix:

$$\rho_A \approx \frac{1}{2}(|\uparrow_z\rangle_A \langle\uparrow_z|_A + |\downarrow_z\rangle_A \langle\downarrow_z|_A). \tag{9}$$

This triggers branching into Alice+ and Alice-, but Bob, at spacelike-separated x_B, remains unaffected, as no environmental interaction reaches his laboratory. His density matrix remains:

$$\rho_B^{\text{pre}} = |\text{ready}\rangle_B \langle\text{ready}|_B\,. \tag{10}$$

Global branching, however, posits that Bob splits instantly into Bob+ and Bob-, contradicting the requirement that branching follows decoherence [7]. This instantaneous split lacks a physical mechanism, as no interaction connects Alice's measurement to Bob's state, undermining the dynamical basis of MWI branching.

However, this does not imply that global branching is impossible; rather, it means that if global branching happens, then it cannot result from decoherence, and one must find another plausible explanation for it. Recently Ney (2024) defended global branching as part of her broader locality-based argument for MWI. Bob's global branching — where Alice's measurement seems to affect Bob instantly — appears nonlocal, but Ney argued that it is a mere "Cambridge change" — a relational shift, not an intrinsic physical change, and it does not require any physical influence like decoherence to travel to Bob. For Bob, splitting into Bob+ and Bob- is extrinsic, like becoming a twin, not altering his intrinsic properties. This seems to be the only possible way to make sense of global branching. Since there is no quantum entanglement between Alice and Bob before the measurement, and immediately after Alice's measurement, the influence of the measurement has not arrived at Bob's lab and Alice and Bob are still spacelike separated, it is arguable that Alice's measurement cannot result in any real, intrinsic change of Bob.

5.2 Challenging the Cambridge Change Defense

Ney (2024) suggested that Bob's global branching is a Cambridge change — a relational alteration without intrinsic physical consequences. However, as we will argue below, Bob's global branching implies a physical change of particle b relative to him, and this cannot happen without a physical interaction between them.

According to the global branching model, after Alice's measurement (and before Bob measures particle b), relative to each of Bob+ and Bob-, the state of particle b will change from a mixed state $\frac{1}{2}(|\uparrow_z\rangle_b \langle\uparrow_z|_b + |\downarrow_z\rangle_b \langle\downarrow_z|_b)$ to a pure state or a definite spin state, either $|\uparrow_z\rangle_b$ or $|\downarrow_z\rangle_b$. This means that the state of particle b relative to Bob is changed by Alice's measurement in the same way as the state of particle a relative to Alice is changed by Alice's measurement. Since quantum states are real in MWI, this state change is not a mere Cambridge change but a real physical change for Bob. Thus, if Alice's measurement results in Bob's global branching, then it will result in a physical change of particle b relative to Bob. This is action at a distance, violating special relativity.

On the other hand, the state of particle b relative to Bob cannot change from a mixed state to a pure state without an interaction happening between them (e.g. Bob measuring particle b), while Alice's measurement does not result in their interaction. Note that a mixed state has non-zero entropy and represents ignorance or entanglement with an external system, while a pure state is a definite quantum state with zero entropy, and a mixed state cannot become a pure state without an interaction reducing its entropy. Thus, it can be argued that Alice's measurement cannot result in Bob's global branching.

5.3 Limits on Superposition Measurements

Global branching also restricts Bob's ability to measure the entangled superposition, violating quantum mechanics' experimental flexibility. Quantum mechanics allows Bob, if co-located with Alice and particles a and b, to measure their full entangled superposition after Alice's measurement, probing interference between terms. However, global branching assigns Bob to a single branch (e.g., Alice+'s world, with b in $|\uparrow_z\rangle_b$), where only definite spin states of particle b along the z-axis are accessible, and he cannot measure the entangled superposition of these states. This limitation conflicts with quantum mechanics' predictions, undermining MWI's empirical adequacy.

6 Observer-Centric Proofs Fail to Explain Objective Statistics

The derivation of the Born rule in MWI by Sebens and Carroll [4], as well as those by Wallace [7] and by McQueen and Vaidman [2], aim to address the probability problem in a deterministic multiverse where all measurement outcomes occur. However, these proofs rely on observers or agents, deriving subjective credences rather than explaining the objective statistical frequencies observed in quantum experiments, such as detector clicks and observer perceptions. The Born rule predicts that for a state $|\psi\rangle = \alpha\,|\uparrow\rangle + \beta\,|\downarrow\rangle$, a detector records spin-up with frequency $|\alpha|^2$, and observers report the same over repeated trials. These objective statistics, independent of subjective beliefs, are central to quantum mechanics' empirical success. This section argues that by focusing on observer-centric credences, these proofs fail to account for the physical mechanisms behind these frequencies, leaving a gap in MWI's foundation.

Wallace's decision-theoretic proof frames probabilities as rational betting behavior, where an agent assigns credences proportional to squared amplitudes, such as $|\alpha|^2$ for spin-up in the above state [7]. While this aligns with the Born rule, it does not explain why a detector's records in a single world exhibit these frequencies. Sebens and Carroll's self-location uncertainty approach, using their ESP, defines probabilities as an observer's credences about their branch location, such as Alice's uncertainty in an EPR-Bohm setup [4]. Even if their global branching flaw (amplitude loss) were resolved, the proof remains observer-centric, emphasizing Alice's beliefs rather than the frequency of detector outcomes at her location. McQueen and Vaidman's proof, while avoiding amplitude loss, still defines probabilities as observer credences, not detector frequencies [2]. The local reduced density matrix reflects device outcomes, but the derivation focuses on the observer's self-location, not the physical mechanism producing a detector's $|\alpha|^2$ frequency for a specific outcome. These observer-centric approaches leave the objective statistical behavior of devices unaddressed.

The reliance on observers reflects a philosophical stance in MWI that probabilities are inherently subjective in a deterministic universe. Wallace argues that objective probabilities are incoherent, as all outcomes occur across branches [7]. Sebens and Carroll and McQueen and Vaidman adopt similar views, treating probabilities as credences about self-location. This subjectivism aligns with MWI's deterministic ontology but, as the above analysis suggests, may be inadequate if the Born rule's empirical success is tied to objective statistical frequencies. Quantum mechanics' predictions are tested by device outcomes or observer perceptions, not solely by observer beliefs, and MWI must account for this objectivity to be empirically equivalent to standard quantum mechanics.

To address this issue, an MWI proof would need to derive the Born rule as a statistical property of physical systems, focusing on the relative frequencies of device outcomes in a world. This might involve analyzing the quantum state's evolution, decoherence, and the emergence of stable records in high-amplitude branches, without invoking conscious agents. Such a proof could explore how branch amplitudes influence the statistical mechanics of measurement outcomes, perhaps by modeling repeated measurements as a stochastic process within a single world [1]. While challenging, this device-centric approach would strengthen MWI's foundation, grounding probabilities in physical dynamics rather than observer psychology.

7 Conclusion

Sebens and Carroll's attempt to derive the Born rule via self-locating uncertainty is a significant contribution to MWI, offering a unified framework for classical and quantum probability. However, their global branching assumption introduces a critical flaw: the loss of local amplitude information, which severs the quantitative link to the Born rule. Additional issues—conflicts with decoherence, relativistic violations via physical state changes, and constraints on superposition measurements—further undermine the framework's coherence and empirical adequacy. Possible defenses—relying on global amplitudes, benign non-locality, or pre-observation uncertainty—fail to address these inadequacies. A local or nonlocal branching model, tied to decoherence propagation or entanglement-driven correlations, may preserve amplitudes and better align with MWI's empirical success. This critique underscores the need to reconsider branching mechanisms to secure a robust foundation for Everettian probabilities.

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