Causal Set Theory with Occamistic Precedence:

A Speculative New Approach to the Emergence of Quantum Mechanics,

Spacetime Structure, Gravity, Psi Phenomena and Universal Cognition

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Abstract

We propose an augmented precedence principle that integrates an algorithmic information prior to favor simpler, low-entropy patterns in the evolution of causal sets. Applied to the sequential growth dynamics of causal set theory, this Occamistic bias naturally selects manifold-like configurations that approximate smooth spacetimes, thereby addressing the entropy dominance problem. On these emergent manifolds, the statistical accumulation of repeated quantum events gives rise to effective quantum dynamics from which the Schroedinger equation is derived.

This perspective shows promise of potential extension to chromodynamics; and moreover, by interpreting the spacetime metric as a quantum operator and deriving gravitational dynamics from the minimization of quantum relative entropy between the intrinsic metric and a matter-induced metric, one can establish a connection with entropic theories of gravity.

The Occamistic Precedence framework is extended to a relational, Universal Cognition perspective in which the decentralized cosmic ledger "remembers" its past through local interactions, enabling observer-dependent transitions between quantum (Schroedinger-like) and classical (Bellman-like) cognitive regimes providing physical underpinning

to mental processes in biological and engineered systems, and potentially also providing a new way of looking at "extraordinary" mental processes such as altered states of consciousness and psi phenomena.

Overall, our work suggests that gravity, quantum mechanics, and anomalous cognitive effects may emerge from an underlying, history-dependent process governed by fundamental information-theoretic principles.

Contents

1 Introduction

The unification of quantum mechanics, gravity, and other fundamental interactions into a comprehensive understanding of the universe remains one of the most profound challenges in modern physics. Traditional theories treat spacetime as a smooth continuum and quantum phenomena as intrinsically probabilistic; however, recent developments suggest that both quantum mechanics and gravitational dynamics may emerge from deeper, information-theoretic processes. In particular, *causal set theory* models spacetime as a discrete collection of events partially ordered by causality, offering a promising framework in which the continuum of spacetime and effective quantum behavior emerge statistically from the accumulation of local historical precedents.

In this paper we pursue a number of speculative further developments in this direction, arguing that an appropriately extended version of causal set theory may have potential not only as a key to unified physics theories but also in a broader way, helping with issues related to quantum measurement, quantum cognition, the relation between individual and universal mental processes, and the physical foundation of psi phenomena. Many of the high level concepts here are similar to those in the author's 2017 paper on "Eurycosmic" models [14] but the treatment here is more in-depth and rigorous, leveraging causal set theory to connect these concepts with the equations of modern physics in more specific ways.

Building upon Smolin's Precedence Principle [1]–which posits that repeated outcomes reinforce their probability–we introduce the *Occamistic Precedence Principle* by integrating an algorithmic information prior that favors simpler, low-entropy configurations. In our formulation, the probability of a given configuration is weighted by $2^{-K(x)}$, where $K(x)$ denotes its Kolmogorov complexity. This approach naturally selects for manifold-like causal sets, addressing the entropy dominance problem and providing a mechanism for the emergence of effective quantum dynamics, as demonstrated by our derivation of the Schroedinger equation in the continuum limit (which follows Smolin's derivation with minor changes). This is all similar in spirit to the "morphic pilot wave" the author outlined in a 2009 paper [15], but expressed in terms of a more standard formulation of quantum mechanics rather than a Bohmian pilot wave formulation.

Moving beyond the "mere" unification of quantum mechanics and gravity, we explore how this perspective may help clarify a number of other issues related to physics and the mind/matter interface.

Under an appropriate invariant prior, the algorithmic information measure underlying our Occamistic Precedence Principle effectively corresponds to entropy. This observation connects our approach with entropic theories of gravity, such as those advanced by Bianconi, where gravitational dynamics are derived from a quantum relative entropy between the spacetime metric $g_{\mu\nu}$ and a metric $G_{\mu\nu}$ induced by matter fields. In our approach, the same information-theoretic principle that underlies the Occamistic bias provides a microscopic foundation for an entropic action governing gravity. This dual perspective suggests that the minimization of algorithmic complexity at the discrete level translates, in the continuum limit, to the minimization of relative entropy–thereby unifying gravitational phenomena with quantum dynamics.

Further, our framework shows promise of potentially extending to encompass non-Abelian gauge fields and quantum chromodynamics (QCD) via holonomy assignments and a discrete Yang-Mills action, as well as to quantum measurement through the consistent histories approach.

The connection with quantum measurement leads to an interpretation in which the decentralized cosmic ledger not only drives the emergence of effective quantum evolution (e.g., the Schroedinger equation) but also manifests as a universal cognitive process. In this picture, the causal set "remembers" its past through local interactions, and when an observer's informational capacity is insufficient to resolve the full complexity of this ledger, the system evolves quantum mechanically, potentially giving rise to psi phenomena such as telepathy or precognition. Conversely, when the ledger is simple relative to the observer, a classical, Bellman-like evolution dominates.

In sum, our work here speculatively but we feel intriguingly unifies several strands of thought–Occamistic precedence, entropic gravity, optimal control, and Universal Cognition–suggesting that gravity, quantum mechanics, and even anomalous psi phenomena may all be emergent from an underlying, history-dependent process governed by fundamental information-theoretic principles.

2 Augmenting the Precedence Principle with Algorithmic Information Prior

Lee Smolin's Precedence Principle is a conceptual proposal aimed at explaining how the statistical regularities observed in quantum mechanics may emerge from an underlying historical process. At its core, the principle suggests that when a quantum system encounters a situation that has occurred before, it tends to reproduce the outcomes that were previously observed in analogous circumstances. Conversely, if a situation is entirely novel, the system may produce a new outcome, which then becomes a precedent for future similar events.

This idea can be understood as an *evolutionary selection* mechanism for physical laws. Specifically, the principle implies that the probability of a particular outcome is not fixed a priori, but rather is determined by the frequency with which that outcome has been realized in the past. If we denote by $N(o_j)$ the number of times an outcome o_j has occurred under similar conditions, then the probability $P(o_j)$ for that outcome can be expressed as:

$$P(o_j) = \frac{N(o_j)}{\sum_k N(o_k)}.$$

As the number of precedents increases, the quantum system's behavior becomes more regular and predictable, leading to the emergence of effective deterministic laws such as the Schroedinger equation in the appropriate limit.

The Precedence Principle challenges the conventional view that quantum indeterminism is a fundamental feature of nature. Instead, it proposes that the probabilistic aspects of quantum mechanics are emergent phenomena, arising from the cumulative effect of historical interactions. In this framework, the evolution of the quantum state is not solely governed by an intrinsic, static probability amplitude; rather, it is dynamically influenced by the "memory" of previous events. Thus, the wavefunction and its evolution become reflections of the historical record of the universe.

One way to conceptualize this process is to imagine the universe as maintaining a kind of *"cosmic ledger"* in which every event leaves an imprint that informs future dynamics [1]. In scenarios where an event has a well-established history, the associated transition probabilities become reinforced, leading to an effective *averaging out* of fluctuations. This statistical accumulation of precedents naturally gives rise to the stability observed in macroscopic quantum behavior, which is described by the standard formalism of quantum mechanics.

Moreover, Smolin's proposal has an affinity with ideas in statistical mechanics, where macroscopic order emerges from the collective behavior of a large number of microscopic states. However, unlike typical statistical ensembles, the Precedence Principle emphasizes the role of specific historical sequences. It asserts that the universe "learns" from its past in a way that progressively filters out anomalous outcomes, allowing only those that have been repeatedly validated to dominate the future evolution.

Critics of the Precedence Principle often raise questions regarding the physical mechanism by which historical information is stored and how it influences subsequent dynamics. An alternate perspective is provided by considering the physical universe as an emergent layer over an underlying information-processing foundation. In this context, foundational issues may be addressed by appealing to principles from algorithmic information theory, such as Kolmogorov complexity, which provides a quantitative measure of the simplicity or complexity of a given pattern. In this light, outcomes with lower algorithmic complexity (e.g. often, more symmetric outcomes) would naturally accumulate precedents more readily than more complex ones.

In sum, Smolin's Precedence Principle offers an intriguing approach to bridging the gap between the inherent randomness of individual quantum events and the deterministic evolution observed in classical physics. It posits that quantum mechanics, including the emergence of the Schroedinger equation, may be understood as the macroscopic manifestation of a deep, history-

[1] Conceptually this sort of "cosmic ledger" has a lot in common with Rupert Sheldrake's notion of a "morphogenetic field" [6], and going further back with Charles Peirce's [17] notion of the "tendency to take habits" – that once a certain pattern has occurred in the universe, it is surprisingly likely to pop up again and again.

dependent process governing the evolution of the universe. However, our view is that the simple initial formulation of the Precedence Principle does not go far enough, and by extending and enhancing it one can obtain a paradigm with much greater explanatory power.

2.1 Clarifying the (Decentralized) "Cosmic Ledger"

While we have introduced the. metaphor of a "cosmic ledger" above, we must clarify that the idea of "memory" here is not conceived as a centralized, monolithic ledger but rather emerges in a fully decentralized manner inherent to the causal set structure.

In our approach, each element in the causal set carries with it a record of its local causal past, which is naturally encoded in the partial order relation. Traditional causal set theory explicitly forbids Closed Timelike Curves by virtue of its acyclicity and local finiteness, and thus the notion of a global, paradox-inducing memory does not arise. Instead, the system "remembers" its past through local, decentralized interactions. That is, each new element is added based solely on the structure of its causal past, and the accumulation of such local precedents collectively determines the dynamics.

This decentralized implementation can be thought of as a distributed ledger where each element's local causal history serves as a "block" of information. The overall evolution is governed by the statistical properties of these local histories rather than by a single, centralized record. In this way, any potential logical paradoxes associated with a centralized memory are avoided, as no element has access to or controls a global history that could conflict with the causal order.

Thus, one maintains internal consistency by relying on the natural, decentralized structure of causal sets, ensuring that the system's evolution is determined by local interactions and historical accumulation.

In Section 7 below we will extend this perspective to encompass Closed Timelike Curves as well.

2.2 Algorithmic Information Theory and Occam's Razor

Algorithmic information theory provides a quantitative measure of the complexity of a pattern by the length of the shortest algorithm that can generate it. Occam's Razor, which favors simpler explanations, naturally aligns with this measure. In our framework, for sake of concreteness we posit that the recurrence probability of a pattern is proportional to 2^{-K}, where K is its algorithmic complexity. The conceptual points we make would remain basically unchanged if we replaced this particular probability distribution with a different one.

2.3 The Occamistic Precedence Principle

The *Occamistic Precedence Principle* that we propose here based on our earlier related work [15] [14] extends Smolin's original idea by integrating an algorithmic information prior into the framework. This addition is motivated by Occam's Razor and aims to favor simpler, more symmetric patterns in the evolution of quantum systems. In what follows, we detail the motivation, mathematical formulation, and physical implications of this Occamistic principle.

2.3.1 Motivation and Background

Smolin's Precedence Principle posits that when a quantum system encounters a situation previously experienced, it tends to reproduce the same outcomes, with the probability of each outcome being proportional to its historical frequency. While this idea captures an essential aspect of quantum behavior, it does not, by itself, explain why certain patterns should be preferred over others.

Algorithmic information theory, via the concept of Kolmogorov complexity, provides a natural measure for the simplicity of a pattern. If a pattern can be generated by a short program, it is deemed simple and, by Occam's Razor, more likely to be realized in nature. Thus, integrating a penalty based on algorithmic complexity into the precedence principle biases the dynamics toward simpler, more structured outcomes.

2.3.2 Mathematical Formulation

In our Occamistic framework, the probability of a given outcome is modified to include an exponential penalty based on its algorithmic complexity. Let $K(o)$ denote the Kolmogorov complexity of an outcome o, which is defined as the length of the shortest program that can produce o on a universal Turing machine. If $N(o)$ is the number of precedents for o, we propose that the effective probability $P(o)$ is given by

$$P(o) \propto N(o) \cdot 2^{-K(o)}.$$

The factor $2^{-K(o)}$ exponentially suppresses outcomes with higher complexity, thus favoring those that are simpler.

The conceptual interpretation of the probabilities here may be confusing at first, but essentially, the frequentist notion of counting precedents and the Bayesian algorithmic prior should be considered as integrated in a unified Bayesian update. That is, the algorithmic information prior $P(o) \propto 2^{-K(o)}$ (where $K(o)$ is the Kolmogorov complexity of outcome o) represents our initial belief before any data is observed, favoring simpler outcomes. As the system evolves, the number of precedents $N(o)$ for a given outcome provides empirical evidence. In Bayesian terms, we can interpret this count as the likelihood $P(\text{data} \mid o)$ for that outcome.

By Bayes' theorem, the posterior probability is given by

$$P(o \mid \text{data}) \propto P(\text{data} \mid o)\, P(o).$$

If we take the likelihood to be proportional to the number of precedents, that is,

$$P(\text{data} \mid o) \propto N(o),$$

then the posterior becomes

$$P(o \mid \text{data}) \propto N(o)\, 2^{-K(o)}.$$

In this way, the frequentist count $N(o)$ is naturally interpreted as the Bayesian likelihood, updating the Occam-inspired prior. Thus, our framework combines both perspectives in a coherent manner, ensuring that the final probability for an outcome reflects both its intrinsic simplicity and its empirical support.

2.3.3 Conclusion

The Occamistic Precedence Principle provides a quantitative mechanism for incorporating Occam's Razor into the dynamical evolution of quantum systems. By modifying transition probabilities to include an exponential penalty on algorithmic complexity, the principle not only reinforces outcomes that have been historically prevalent but also biases the dynamics toward simpler, more symmetric structures. We will argue below that this dual influence is crucial for the emergence of manifold-like causal sets in discrete spacetime models and for deriving effective quantum dynamics in the continuum limit. We believe this framework offers a promising avenue for understanding how classical spacetime and quantum mechanical laws may arise from fundamentally discrete processes.

3 Occamistic Precedence in Causal Set Theory

Causal set theory is a discrete approach to quantum gravity in which spacetime is modeled as a locally finite partially ordered set. In this section, we describe the fundamental principles of causal set theory, discuss sequential growth dynamics as introduced by Rideout and Sorkin, and explain how the integration of an algorithmic information prior via the Occamistic precedence principle can bias the evolution toward manifold-like structures.

3.1 Fundamentals of Causal Set Theory

A causal set, denoted by $\mathcal{C}$, is defined as a pair $(\mathcal{C}, \prec)$ where $\mathcal{C}$ is a set of elements and $\prec$ is a binary relation satisfying:

1. **Transitivity:** For any $x, y, z \in \mathcal{C}$, if $x \prec y$ and $y \prec z$, then $x \prec z$.
2. **Acyclicity:** There exists no element $x \in \mathcal{C}$ such that $x \prec x$.
3. **Local Finiteness:** For any pair $x, z \in \mathcal{C}$ with $x \prec z$, the set $\{y \in \mathcal{C} \mid x \prec y \prec z\}$ is finite.

These axioms encode the causal structure of spacetime and ensure that the theory avoids pathological features such as Closed Timelike Curves (though we will argue below that these can be introduced in a judicious way). In causal set theory, the continuum of spacetime emerges only as an approximation of the underlying discrete structure.

3.2 Sequential Growth Dynamics

In the sequential growth dynamics of Rideout and Sorkin [5], a causal set grows one element at a time according to stochastic rules that respect several physical constraints:

- **Markov Property:** The probability of adding a new element depends solely on the current causal set, not on the specific history of its formation.
- **Bell Causality:** The dynamics ensure that the addition of an element is influenced only by its causal past, preventing any dependence on future events.
- **Discrete General Covariance:** The probabilities are invariant under relabeling of the causal set elements; that is, the physical content does not depend on the specific labels assigned to events.

At each growth step, the causal set $\mathcal{C}_{n-1}$ is extended to $\mathcal{C}_n$ by adding a new element x_n. The transition probability is governed by a function $f(\mathcal{C}_{n-1}, x_n)$ which encodes the above constraints.

3.3 From Discrete Causal Sets to Continuum Spacetime

Although causal sets are inherently discrete, a continuum description emerges when the density of elements is sufficiently high. This process is formalized through a *faithful embedding*:

1. **Order Preservation:** There exists an embedding $\phi : \mathcal{C} \to M$ such that for any $x, y \in \mathcal{C}$, $x \prec y$ if and only if $\phi(x)$ lies in the causal past of $\phi(y)$ in the Lorentzian manifold M.
2. **Density Condition:** The number of elements in any spacetime volume $V \subset M$ is proportional to V, ensuring that the causal set approximates the continuum geometry.

3.4 Challenges in Recovering Manifold-Like Structures

A significant challenge in causal set theory is that – while the emergence of close approximations to continuous manifolds is clearly possible – the vast majority of causal sets generated by these sequential growth rules do not resemble the smooth, continuum-like spacetimes observed in nature. Two major issues arise:

1. **Entropy Dominance:** Although the number of causal sets that approximate a continuum manifold is nonzero, they are overwhelmingly

outnumbered by non-manifold-like configurations. Without additional constraints, the random growth process is statistically unlikely to yield a causal set that can be faithfully embedded in a Lorentzian manifold.

2. **Geometric Reconstruction:** Even when a causal set exhibits some manifold-like features, reconstructing the metric properties (such as distances and curvature) is nontrivial. Faithful embedding requires that the causal set not only possess the correct causal order but also satisfy a uniform density condition relative to the continuum volume.

This is where an Occam bias can help. If one has a bias toward low-complexity (manifold-like) causal sets, as enforced by the algorithmic information prior, implies that in the large n limit the discrete structure effectively approximates a smooth spacetime. This sets the stage for applying the methods of continuum quantum mechanics, and exploring routes for the emergence of realistic gravitational dynamics.

3.5 Incorporating the Algorithmic Information Prior in the Sequential Growth Process

Consider a causal set $\mathcal{C}_{n-1}$ with $n-1$ elements that is extended to $\mathcal{C}_n$ by the addition of a new element x_n. In standard sequential growth models, the transition probability is governed by a function $f\left(\mathcal{C}_{n-1}, x_n\right)$ which enforces physical constraints such as Bell causality and discrete general covariance. We modify this probability by incorporating the algorithmic information prior as follows:

$$P\left(\mathcal{C}_n \mid \mathcal{C}_{n-1}\right) \propto f\left(\mathcal{C}_{n-1}, x_n\right) \cdot 2^{-K\left(\mathcal{C}_n\right)},$$

where $K\left(\mathcal{C}_n\right)$ is the Kolmogorov complexity of the new causal set. A normalization constant Z is introduced so that the total probability sums to unity:

$$P\left(\mathcal{C}_n \mid \mathcal{C}_{n-1}\right) = \frac{f\left(\mathcal{C}_{n-1}, x_n\right) \cdot 2^{-K\left(\mathcal{C}_n\right)}}{Z},$$

with

$$Z = \sum_{\mathcal{C}_n} f\left(\mathcal{C}_{n-1}, x_n\right) \cdot 2^{-K\left(\mathcal{C}_n\right)}.$$

3.6 Emergence of Manifold-Like Causal Sets

Manifold-like causal sets are characterized by regular patterns and symmetries (e.g., translational and rotational invariance) that enable their description by succinct algorithms. For instance, a causal set that approximates Minkowski space may be generated by a simple algorithm specifying the spacetime dimension, a uniform sprinkling density, and a random number generator seed. Consequently, such a causal set has a relatively low $K(\mathcal{C})$ compared to a generic causal set with no regular structure.

The integration of the algorithmic information prior biases the sequential growth process toward these low-complexity, manifold-like configurations. Over many iterations, it seems likely, the exponential suppression of high-complexity outcomes leads to a higher likelihood of obtaining causal sets that can be faithfully embedded into a Lorentzian manifold. In this way, the Occamistic precedence principle provides a mechanism to overcome the entropy dominance problem and aligns the growth dynamics with the emergence of a continuum spacetime.

3.7 Implications and Outlook

The application of the Occamistic precedence principle to causal set theory, along the lines we've roughly sketched here, is clearly needful of much more in-depth technical attention. However, it's easy to see that if the details work out suitably, the approach has some potentially significant implications:

- **Selection Mechanism:** It introduces a natural selection mechanism based on algorithmic simplicity, guiding the growth of causal sets towards those that are physically relevant.

- **Historical Learning:** The principle suggests that the universe "remembers" its past configurations, and that repeated occurrences reinforce the emergence of classical spacetime structures.

- **Foundation for Continuum Limits:** By favoring manifold-like causal sets, the approach helps in establishing a bridge between the discrete underlying structure and the continuous spacetime observed at macroscopic scales.

Along with more fully formalizing the core concept, future research in this direction might focus on developing practical approximations for $K(\mathcal{C})$, refining numerical simulations of the growth dynamics, and exploring how these ideas can be extended to incorporate matter fields and gauge interactions. Such efforts are essential for establishing the viability of this framework as a foundation for quantum gravity.

4 Derivation of the Schroedinger Equation

In this section, we sketch the derivation of the Schroedinger equation from the discrete dynamics of causal sets under the influence of the Occamistic precedence principle. Our aim is to show how the statistical accumulation of historical precedents, combined with a bias toward algorithmic simplicity, leads to a continuum limit that reproduces the familiar quantum dynamics.

The treatment here closely follows Smolin's derivation of the Schroedinger equation from the ordinary precedence principle fairly closely; the key difference lies in the incorporation of an algorithmic information prior that explicitly favors simpler, lower-complexity (i.e., Occamistic) causal set configurations. In Smolin's work, the emergence of quantum dynamics is driven by the accumulation of historical precedents; that is, repeated outcomes reinforce their own probability. In our approach, however, we modify the transition probabilities by weighting them with an exponential factor derived from Kolmogorov complexity. This addition biases the growth dynamics toward configurations that are easier to describe, including manifold-like and symmetric ones. Our task here is basically to make clear making this tweak to the Precedence Principle and adopting the causal-set setting does not mess up Smolin's derivation of the Schroedinger equation from precedence.

4.1 From Causal Sets to Schroedinger

Causal set theory models spacetime as a discrete structure, where the causal relations among elements encode the geometry of spacetime. In the sequential growth framework, a causal set $\mathcal{C}_n$ is built step-by-step by adding elements according to transition probabilities that respect causal order, local finiteness, and general covariance. The Occamistic precedence principle introduces an algorithmic information prior into these probabilities, favoring simpler (low-complexity) configurations.

The key idea is that as the causal set grows, the dynamics become biased towards configurations that can be described succinCTCy. These manifold-like causal sets, when taken in the continuum limit, allow for a faithful embedding into a smooth Lorentzian manifold. On such a background, one can define fields and, in particular, quantum states whose evolution is governed by an effective Hamiltonian. Under certain assumptions, this evolution takes the form of the Schroedinger equation.

With this in mind, we proceed to sketch the derivation of the Schroedinger equation from the discrete dynamics:

1. **Quantum State Representation:** Consider a quantum system whose state is defined on the causal set. Let $\{|\mathcal{C}_n\rangle\}$ be a basis for the Hilbert space, where each basis state corresponds to a causal set configuration with n elements. The overall state can be written as

$$|\Psi(t)\rangle = \sum_n \psi(\mathcal{C}_n, t)|\mathcal{C}_n\rangle.$$

2. **Time Evolution Operator:** The evolution over a short time interval Δt is governed by a time evolution operator $\hat{U}(t, t + \Delta t)$ such that

$$|\Psi(t + \Delta t)\rangle = \hat{U}(t, t + \Delta t)|\Psi(t)\rangle.$$

Assuming that the evolution operator is unitary, it can be expanded as

$$\hat{U}(t, t + \Delta t) \approx I - \frac{i}{\hbar}\hat{H}\Delta t,$$

where $\hat{H}$ is the Hamiltonian operator encoding the dynamics of the system.

3. **Transition Amplitudes and Precedents:** Each transition from state $|\mathcal{C}_n\rangle$ to $|\mathcal{C}_m\rangle$ is associated with an amplitude $\langle\mathcal{C}_m|\hat{U}(t, t+\Delta t)|\mathcal{C}_n\rangle$. The Occamistic precedence principle implies that these amplitudes are influenced by the number of precedents for the transition as well as by the complexity of the resulting causal set. In particular, if we assume that the number of precedents $N(T_{\mathcal{C}_n \to \mathcal{C}_m})$ is proportional to the squared magnitude of the amplitude, then we have

$$N(T_{\mathcal{C}_n \to \mathcal{C}_m}) \propto \left|\langle\mathcal{C}_m|\hat{U}(t, t + \Delta t)|\mathcal{C}_n\rangle\right|^2.$$

This assumption is motivated by its natural alignment with the Born rule, which states that the probability of an outcome is given by the square of its amplitude. Within our framework, the historical frequency of an outcome serves as a measure of its probability, and by linking this frequency to the amplitude squared, we capture the idea that outcomes that have occurred repeatedly (and are thus simpler and more robust) are more likely to be reproduced. In this way, the assumption effectively incorporates the reinforcement of well-established precedents into the dynamics, providing a bridge between the history-dependent process and standard quantum mechanics.

4. **Discrete Time Evolution:** Expanding the state at time $t + \Delta t$ in the causal set basis, we obtain

$$\psi(\mathcal{C}_m, t + \Delta t) = \sum_{\mathcal{C}_n} \langle \mathcal{C}_m | \hat{U}(t, t + \Delta t) | \mathcal{C}_n \rangle \, \psi(\mathcal{C}_n, t).$$

Substituting the expansion of $\hat{U}(t, t + \Delta t)$ gives

$$\psi(\mathcal{C}_m, t + \Delta t) \approx \psi(\mathcal{C}_m, t) - \frac{i\Delta t}{\hbar} \sum_{\mathcal{C}_n} \langle \mathcal{C}_m | \hat{H} | \mathcal{C}_n \rangle \, \psi(\mathcal{C}_n, t).$$

5. **Taking the Continuum Limit:** Rearranging and taking the limit as $\Delta t \to 0$, we obtain the discrete version of the Schroedinger equation:

$$i\hbar \frac{\psi(\mathcal{C}_m, t + \Delta t) - \psi(\mathcal{C}_m, t)}{\Delta t} = \sum_{\mathcal{C}_n} \langle \mathcal{C}_m | \hat{H} | \mathcal{C}_n \rangle \, \psi(\mathcal{C}_n, t).$$

In the continuum limit, where the discrete structure approximates a smooth manifold and the differences converge to derivatives, this equation approaches the familiar form:

$$i\hbar \frac{\partial \psi(x, t)}{\partial t} = \hat{H} \psi(x, t),$$

where x denotes a point on the emergent manifold.

4.2 Ensuring Unitarity and Conservation of Probability

A crucial requirement for any quantum evolution is unitarity, which guarantees the conservation of probability. In our derivation, the Hamiltonian operator $\hat{H}$ must be Hermitian, i.e.,

$$\hat{H}^\dagger = \hat{H}.$$

This property ensures that the time evolution operator $\hat{U}(t, t+\Delta t)$ is unitary:

$$\hat{U}^{\dagger}(t, t + \Delta t)\hat{U}(t, t + \Delta t) = I.$$

The incorporation of the algorithmic information prior does not alter unitarity, as it only biases the statistical weight of different causal set transitions without affecting the overall conservation laws.

4.3 Implications for the Quantum-Classical Transition

The derivation outlined above shows how the discrete dynamics of causal sets, under the influence of the Occamistic precedence principle, give rise to an effective Schroedinger equation in the continuum limit. In this picture, quantum mechanics emerges as a statistical average over many discrete, history-dependent transitions. As the number of elements increases and the causal set becomes dense, fluctuations average out and the system behaves in a manner that is both deterministic and unitary, consistent with classical quantum mechanics.

Furthermore, the same principles that lead to the stabilization of quantum probabilities also pave the way for decoherence. As repeated events reinforce certain transitions (i.e., precedents accumulate), the interference between distinct histories becomes negligible. This natural suppression of interference is key to understanding the emergence of classical behavior from the underlying quantum substrate.

5 Potential Extension to Quantum Chromodynamics

The foundational work on the Precedence Principle pertains to standard quantum mechanics; however, the concepts and core mathematics are equally applicable in more fully fleshed out physics contexts, such as quantum chromodynamics (QCD), the theory that describes the strong nuclear force, governing the interactions between quarks and gluons through a non-Abelian SU(3) gauge symmetry.

Incorporating QCD into the causal set framework presents several challenges due to the non-Abelian nature of the gauge group and the complexities of representing continuous gauge fields on a discrete spacetime. However we believe these challenges can be surmounted. In the approach briefly sketched here, the Occamistic precedence principle is extended to include not only the causal set structure but also the configuration of gauge fields.

5.1 Representing Gauge Fields on Causal Sets

To embed gauge fields within causal set theory, we assign SU(3) group elements to the links between elements. This is analogous to the formulation used in lattice gauge theory:

$$U_{xy} \in \mathrm{SU}(3),$$

where U_{xy} represents the parallel transport of the gauge field from element x to y. Gauge invariance is maintained by demanding that under a local SU(3) transformation $G(x)$, the link variable transforms as

$$U_{xy} \to G(x)\, U_{xy}\, G^{\dagger}(y).$$

5.2 Discrete Yang-Mills Action

The dynamics of the gauge fields are governed by a discrete analogue of the Yang-Mills action. For a causal set, this action can be written as a sum over minimal loops (or plaquettes) in the set:

$$S_{\mathrm{YM}}^{\mathrm{discrete}} = -\frac{\beta}{4} \sum_{\mathrm{plaquettes}} \mathrm{Tr}\Big(I - U_{\mathrm{plaquette}}\Big),$$

where β is related to the gauge coupling and

$$U_{\mathrm{plaquette}} = U_{xy} U_{yz} U_{zw} U_{wx}$$

is the ordered product of SU(3) matrices around a minimal loop. This discrete action retains the essential features of the continuum Yang-Mills action and preserves local gauge invariance.

5.3 Algorithmic Complexity and Gauge Field Configurations

In our framework, the algorithmic information prior is extended to gauge field configurations. The total algorithmic complexity K_{total} of a causal set with an associated gauge field is decomposed as

$$K_{\text{total}}(\mathcal{C}) = K_{\text{causal}}(\mathcal{C}) + K_{\text{gauge}}(\mathcal{C}),$$

where $K_{\text{gauge}}(\mathcal{C})$ quantifies the complexity of the gauge field configuration. Simpler gauge configurations, such as uniform fields or those exhibiting high symmetry, have lower complexity and are thereby exponentially favored in the sequential growth dynamics:

$$P(\mathcal{C}) \propto 2^{-K_{\text{total}}(\mathcal{C})}.$$

This bias increases the likelihood that the causal set, along with its gauge field configuration, approximates a continuum that supports QCD dynamics.

5.4 Emergence of Continuum QCD

In the continuum limit, as the causal set becomes dense and is faithfully embedded in a Lorentzian manifold, the discrete Yang-Mills action converges to the standard continuum action:

$$\lim_{\rho \to \infty} S_{\text{YM}}^{\text{discrete}} = S_{\text{YM}} = -\frac{1}{4} \int d^4x \, F^a_{\mu\nu} F_a^{\mu\nu},$$

where $F^a_{\mu\nu}$ is the field strength tensor of the gluon field. The transition from discrete to continuum dynamics allows the derivation of the classical Yang-Mills equations,

$$D^\mu F^a_{\mu\nu} = 0,$$

thus reproducing the essential behavior of QCD. In addition, by introducing fermionic degrees of freedom (representing quarks) into the causal set, one can extend the framework to include gauge-invariant interaction terms, such as

$$H_{\text{int}} = g \sum_{x \to y} \left(\bar{\psi}(x) \, U_{xy} \, \psi(y) + \text{h.c.} \right),$$

where $\psi(x)$ are fermionic operators and g is the gauge coupling constant.

5.5 Asymptotic Freedom and Confinement

A successful theory of QCD must reproduce asymptotic freedom and confinement. In our discrete framework, asymptotic freedom may be reflected in the behavior of the effective coupling at high energies, where the discrete nature of the causal set leads to a running coupling constant that decreases at short distances. Confinement, on the other hand, can be studied by analyzing Wilson loops on the causal set, where an area-law behavior in the expectation value of large Wilson loops would indicate that color charges are confined.

6 Relation to Entropic Conceptions of Gravity

One of the major challenges in modern theoretical physics is the unification of quantum mechanics (including its extensions such as chromodynamics) and the general-relativistic approach to gravitation. Causal sets provide a simple and abstract underlayer, which conceptually has potential to explain the emergence of these various theories as approximations to the same informational substrate.

One way to cash out this potential is to integrate the "Gravity from Entropy" perspective pursued by Ginestra Bianconi [8], which views gravity as arising from statistical mechanics and information theory action. The central idea here is to reinterpret the metric tensor of spacetime as a quantum operator – an effective density matrix – and to derive gravitational dynamics from the quantum relative entropy between the standard spacetime metric $g_{\mu\nu}$ and an alternative metric $G_{\mu\nu}$ induced by matter fields.

Bianconi's framework treats the metric at each point as a local quantum operator, inspired by approaches in quantum field theory and the theory of von Neumann algebras. By adopting a topological description of bosonic matter fields using a Dirac–Kahler formalism (where matter is represented as the direct sum of a 0-form, a 1-form, and a 2-form), the theory captures the interplay between geometry and matter. The proposed entropic action is given by the quantum relative entropy between the metric g of spacetime and the metric G induced by the matter fields. This approach leads to modified Einstein equations which, in the regime of low coupling, reduce to the standard Einstein equations with a vanishing cosmological constant.

A key innovation in Bianconi's work is the introduction of an auxiliary G-field, which acts as a Lagrange multiplier enforcing constraints on the induced metric. This additional field not only allows the entropic action to be reformulated as a dressed Einstein–Hilbert action but also gives rise to an emergent small positive cosmological constant dependent solely on the

G-field.

Although Bianconi's theories and our ideas here originate from different contexts, they share a common conceptual underpinning: both posit that fundamental laws emerge from information-theoretic and statistical considerations. That is,

- In our Occamistic precedence framework, the probability of a causal set configuration is weighted by a factor proportional to $2^{-K(\mathcal{C})}$, where $K(\mathcal{C})$ is the Kolmogorov complexity. This bias naturally favors configurations that are simpler and exhibit the symmetries necessary to approximate a continuum spacetime. In effect, the discrete dynamics "learn" from history by reinforcing transitions that have lower complexity – a notion that parallels the minimization of entropy.

- The gravity-from-entropy approach posits that the metric itself can be viewed as a quantum operator and that the gravitational dynamics are derived from a relative entropy between the spacetime metric g and a metric G induced by matter fields.

Given that algorithmic information and entropy are closely related (as shown, for example, by Baez and Stay in their work on information physics [9]), the Occamistic bias against high-complexity configurations can be reinterpreted as a form of entropic weighting. This connection suggests that the discrete Occamistic selection mechanism is the microscopic origin of the macroscopic entropic action governing gravity.

6.1 Algorithmic Information as Entropy: A Technical Elaboration

To frame these potential parallels a bit more clearly, it may help to remind the details of the relation between algorithmic information and entropy. In our framework the Occamistic prior is implemented via a weight of

$$P(x) \propto 2^{-K(x)},$$

where $K(x)$ denotes the Kolmogorov complexity of a configuration x. Recall that $K(x)$ is defined as the length of the shortest program (on a fixed universal Turing machine) that produces x as its output.

A key insight from algorithmic information theory is that if one adopts the universal *a priori* probability distribution, also known as the Solomonoff distribution,

$$m(x) \propto 2^{-K(x)},$$

then taking the negative logarithm yields

$$-\log m(x) \approx K(x).$$

In a statistical mechanical context, the Shannon entropy of an ensemble of states with probabilities $p(x)$ is defined by

$$S = -\sum_x p(x) \log p(x).$$

If the probabilities $p(x)$ are taken to be close to the universal prior $m(x)$, then the entropy becomes closely related to the average Kolmogorov complexity:

$$S \approx \sum_x p(x)\, K(x).$$

Thus, when the correct prior is assumed, the algorithmic information of a configuration is effectively a measure of its entropy.

This correspondence implies that the Occamistic prior – which penalizes high-complexity configurations via $2^{-K(x)}$ – can be interpreted as favoring states with lower entropy. In our causal set framework, this means that the discrete dynamics are biased towards configurations that are not only simpler (in terms of description length) but also have lower entropy. Such configurations are more likely to exhibit the symmetry and regularity required for a faithful embedding into a continuum spacetime.

6.2 Relating Occamistic Precedence to the Entropic Approach to Gravity

Getting back to the causal set story for the emergence of spacetime, then, consider the following scenario:

1. The discrete causal set grows under the influence of an Occamistic precedence principle, leading to a predominance of manifold-like configurations.

2. Once such a configuration emerges, one can define a metric operator on this emergent spacetime.

3. The dynamics of this metric are then governed by a quantum relative entropy action – the central premise of the gravity-from-entropy approach.

In this way, the simplicity-biased dynamics at the microscopic level might be seen to provide the substrate upon which the continuum gravitational field equations (modified Einstein equations) emerge.

The Occamistic precedence principle ensures that the discrete evolution favors low-complexity, symmetric configurations (which approximate smooth spacetime), while the gravity-from-entropy perspective exploits the close relationship between algorithmic information and entropy to derive the gravitational dynamics. That is, the Occamistic bias that selects low-complexity causal sets provides a microscopic basis for a Biancini-like gravitational-entropic principle. The same simplicity criteria that favor manifold-like causal sets in the discrete setting manifest, at the continuum level, as a tendency toward configurations with minimal relative entropy. This unified view supports the idea that gravity and quantum mechanics may emerge from deep, information-theoretic principles governing the evolution of discrete structures.

7 Occamistic Causal Set Theory with Closed Timelike Curves

Standard causal set theory explicitly incorporates acyclicity to ensure a well-defined causal order and to avoid paradoxes associated with Closed Timelike Curves (CTCs). However, it is conceivable to explore an extension of the framework in which acyclicity is relaxed under controlled conditions. In such an extended theory, one could allow Closed Timelike Curves by imposing a self-consistency requirement analogous to the Novikov consistency condition [4]. In other words, rather than maintaining a centralized "memory" that could lead to paradoxes, the causal structure would be modified so that any cycle is only permitted if the evolution around the loop is self-consistent (for example, if the net effect is the identity map on the system's state).

This decentralized, local implementation of historical "memory" would be splayed out over the causal set, with each element encoding information only about its own causal past. Under this modification, any closed causal loops would be required to satisfy strict consistency conditions that prevent logical contradictions. While such an extension would necessitate a significant reworking of the foundational axioms–most notably, relaxing acyclicity while preserving local finiteness and covariance–it could provide a meaningful way to incorporate spacetimes with CTCs into the causal set approach without sacrificing its essential features.

7.1 Formalizing the Logical Coherence Condition for Closed Timelike Curves

One natural way to achieve the required consistency condition here is by requiring that the net evolution around any closed loop leaves the system's state invariant. More precisely, consider a closed causal cycle

$$C = \{x_1 \prec x_2 \prec \cdots \prec x_n \prec x_1\},$$

where each x_i is an element of the causal set and the relation $x_n \prec x_1$ closes the loop.

For each causal relation $x_i \prec x_{i+1}$ (with $x_{n+1} \equiv x_1$), let $U_{x_i x_{i+1}}$ denote the transition operator (or evolution operator) that describes the effect of the causal link on the system's state. The logical coherence (self-consistency) condition can then be formalized by requiring that the composition of these operators around the loop is the identity:

$$U_{x_1 x_2} U_{x_2 x_3} \cdots U_{x_n x_1} = I,$$

where I is the identity operator on the system's Hilbert space.

This condition implies that if a system were to evolve along the closed loop C, the net effect would be to return the system to its original state. Equivalently, for any state $|\psi\rangle$ that traverses the loop, we must have

$$U_{x_1 x_2} U_{x_2 x_3} \cdots U_{x_n x_1} |\psi\rangle = |\psi\rangle.$$

In probabilistic terms, one could also require that the probability of any transition sequence that violates this condition is zero. This is analogous to the Novikov self-consistency principle in classical spacetimes with CTCs, which posits that only those events that are self-consistent have nonzero probability.

This decentralized, local implementation of memory–where each element encodes information about its past and the net evolution along any closed path is constrained to be trivial–ensures that the extended causal set framework remains free of paradoxes even if CTCs are permitted.

7.1.1 Paraconsistent Novikov

It's also possible to extend the Novikov condition to be less restrictive, e.g. using a paraconsistent logic like Constructible Duality Logic [7] which has four truth values: True, False, Both True And False, Neither True Nor False. One can then look at a condition like: Along a closed loop, the net effect must be that returning the system to its original state is either True or Both True And False. This would need to be fleshed out much further, but conceptually it seems this would not break the connection of Occamistic priors with Closed Timelike Curves.

7.2 The Occamistic Prior with Closed Timelike Curves

In the standard formulation, the Occamistic prior is defined as

$$P(\mathcal{C}) \propto 2^{-K(\mathcal{C})},$$

where $K(\mathcal{C})$ is the Kolmogorov complexity of the causal set $\mathcal{C}$. This prior favors simpler causal sets–those that require a shorter description–and thereby tends to select configurations that approximate smooth, manifold-like spacetimes.

In an extended framework that allows Closed Timelike Curves (CTCs), we must ensure that the introduction of cycles does not lead to logical paradoxes. To achieve this, we impose a Novikov consistency condition which requires that the net evolution around any closed loop is the identity. In such a framework, the Occamistic prior is naturally modified to include a constraint on the allowed causal sets:

$$P(\mathcal{C}) \propto \begin{cases} 2^{-K(\mathcal{C})}, & \text{if } \mathcal{C} \text{ satisfies the Novikov consistency condition,} \\ 0, & \text{otherwise.} \end{cases}$$

Here, $K(\mathcal{C})$ must be generalized to account for the additional structure introduced by CTCs. That is, the complexity measure now includes not only the description length of the acyclic portion of $\mathcal{C}$ but also the extra information required to specify the closed loops and verify their self-consistency. In this way, the Occamistic prior continues to favor simpler configurations while automatically excluding those that violate logical coherence.

Thus, although the functional form of the Occamistic prior remains essentially $2^{-K(\mathcal{C})}$, its effective domain is restricted to causal sets that satisfy the Novikov condition. This modification ensures that only self-consistent Closed Timelike Curves contribute to the dynamics, preserving the essential characteristics of the theory while accommodating a broader class of causal structures.

7.3 The Decentralized Cosmic Memory Ledger with Closed Timelike Curves

We can also generalize the idea of the cosmic memory ledger so that it remains decentralized even when CTCs are present.

In this approach, each element in the causal set continues to carry information about its local causal past via the partial order relation. However, because closed loops are now permitted, we impose a self-consistency (Novikov-type) condition on any cycle in the causal set. Specifically, for any closed loop $C = \{x_1 \prec x_2 \prec \cdots \prec x_n \prec x_1\}$, the net evolution along the loop is required to be trivial (i.e., the identity operator). This ensures that even though information may cycle through a Closed timelike curve, it does so in a way that is logically coherent and free of paradoxes.

Thus, while the system still "remembers" its past through local interactions, no single element has access to or controls a centralized ledger. Instead, the memory is distributed, and the self-consistency condition guarantees that any recurrence of information via a closed loop is consistent with earlier events. In this manner, the Occamistic framework preserves internal consistency by ensuring that the evolution of the system remains governed solely by local interactions and a distributed accumulation of history, even in the presence of CTCs.

7.4 Could Tiny CTCs be Prevalent in our Universe?

How relevant are these speculations on CTCs to physics in our everyday life environments? It's a wild speculation even compared to many of the other adventurous ideas in this paper, however it seems at least rationally conceivable that if the causal set framework is extended as we've described – by relaxing the strict acyclicity condition and imposing a Novikov-type self-consistency condition – then closed timelike curves could occur at a local, even microscopic, level rather than (as conventional physics thinking would suggest) being confined to extreme gravitational environments such as those around rapidly spinning, irregular black holes.

In such a scenario, CTCs might appear as small loops in the causal structure, potentially even at sub-quark scales, where their presence could retroactively reinforce the recurrence of simple, low-complexity patterns. This reinforcement, in turn, would further bias the evolution of the causal set via the Occamistic precedence principle, thereby increasing the likelihood of synchronistic or nonlocal correlations. While this idea remains highly conjecture, it offers an intriguing extension of our framework that could unify the emergence of quantum dynamics and even (we will argue in Section 9.1 below) psi phenomena with the deep, information-theoretic structure of spacetime.

8 Quantum Measurement and Consistent Histories

The quantum measurement problem – how the deterministic evolution of the wave-function leads to definite outcomes – remains one of the most challenging puzzles in quantum theory. It's a different sort of puzzle than unifying quantum theory and gravity – less a mathematical or empirical challenge and more of a philosophical question, tied up with open-ended scientific questions about the connection of mind and physical reality and how quantum measuring.

We explore here the adaptation of the consistent histories (or decoherent histories) framework to the context of Occamistic causal set theory, thereby providing one possible route to addressing measurement without invoking an external observer or ad hoc collapse postulates.

8.1 Consistent Histories in the Causal Set Framework

In the consistent histories approach, a *history* is defined as a sequence of propositions about the state of a system at different times. For our purposes, each history corresponds to a particular sequence of causal set configurations generated during the sequential growth process. Let $\{\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_n\}$ denote one such history, and let $\psi(h)$ be the amplitude associated with this history.

The *decoherence functional* $D(h, h')$ is introduced to measure the interference between two histories h and h'. Consistency (or decoherence) requires that

$$D(h, h') \approx 0 \quad \text{for } h \neq h',$$

so that the probabilities of histories are additive and independent, thereby allowing a classical probabilistic interpretation.

8.2 Histories as Amplitude Distributions

Within our framework, the Occamistic precedence principle not only biases the growth of causal sets but also influences the assignment of amplitudes to different histories. The amplitude associated with a history is determined by both the number of ”precedents” and the algorithmic simplicity of the corresponding causal set configurations. In this way, the probability of a given history is given by

$$P(h) = |\psi(h)|^2,$$

and classical measurement outcomes emerge from those histories which are highly reinforced by the accumulation of precedents and which possess low algorithmic complexity.

The notion of the ”precedent” of a history bears some elaboration – this is best interpreted as a somewhat complex data structure rather than a single history. While a complete history spans all time, the notion of a "precedent" is applied locally rather than globally. In our framework, a history is viewed as a sequence of transitions or sub-histories, each corresponding to a discrete step in the evolution of the causal set. For each such transition, one can count the number of times a similar transition has occurred in the past relative to that transition. In this way, the "precedent" of a history is understood as the aggregate of these local precedents, rather than a single, global event. This stepwise accumulation of historical data, weighted by algorithmic simplicity, determines the overall amplitude of the history. In other words, it is the recurrence of similar, well-defined local events–not the entire history as a monolithic entity–that guides the probabilistic evolution.

For instance, consider a history composed of three sequential transitions. For each transition T_i (with $i = 1, 2, 3$), we assume that the amplitude is determined by two factors:

- The number of precedents N_i for that transition, which we take to be proportional to the likelihood that a similar transition has occurred in the past.
- The algorithmic complexity K_i (measured in bits), with the weight factor given by 2^{-K_i}.

Additionally, each transition is associated with a phase ϕ_i. Thus, the amplitude for the ith transition is defined as:

$$\alpha_i = \sqrt{N_i}\, e^{i\phi_i}\, 2^{-K_i}.$$

The total amplitude for a history h that consists of these three transitions is then the product of the individual amplitudes:

$$A(h) = \prod_{i=1}^{3} \alpha_i.$$

E.g. if we assign the following numerical values:

- For the first transition: $N_1 = 4$, $K_1 = 3$ bits, and $\phi_1 = 0$.

$$\alpha_1 = \sqrt{4}\, e^{i\cdot 0}\, 2^{-3} = 2 \cdot 1 \cdot \frac{1}{8} = \frac{1}{4}.$$

- For the second transition: $N_2 = 9$, $K_2 = 2$ bits, and $\phi_2 = \pi/4$.

$$\alpha_2 = \sqrt{9}\, e^{i\pi/4}\, 2^{-2} = 3 \cdot e^{i\pi/4} \cdot \frac{1}{4} = \frac{3}{4} e^{i\pi/4}.$$

- For the third transition: $N_3 = 16$, $K_3 = 4$ bits, and $\phi_3 = \pi/2$.

$$\alpha_3 = \sqrt{16}\, e^{i\pi/2}\, 2^{-4} = 4 \cdot e^{i\pi/2} \cdot \frac{1}{16} = \frac{1}{4} e^{i\pi/2}.$$

then multiplying these contributions together gives the overall amplitude:

$$A(h) = \alpha_1 \alpha_2 \alpha_3 = \left(\frac{1}{4}\right) \left(\frac{3}{4} e^{i\pi/4}\right) \left(\frac{1}{4} e^{i\pi/2}\right) = \frac{3}{64}\, e^{i(\pi/4+\pi/2)} = \frac{3}{64}\, e^{i(3\pi/4)}.$$

The probability associated with the history is then given by the squared magnitude of the amplitude:

$$P(h) = |A(h)|^2 = \left(\frac{3}{64}\right)^2 = \frac{9}{4096}.$$

This explicit example shows how each local transition, influenced by both the number of precedents and the complexity penalty, contributes multiplicatively to the overall amplitude of the history. The procedure encapsulates the idea that the evolution of the quantum state is governed by a stepwise accumulation of historical data, weighted by algorithmic simplicity.

8.3 Decoherence and the Emergence of Classical Outcomes

Decoherence plays a pivotal role in the consistent histories framework by suppressing interference between different histories. In our causal set approach, decoherence is facilitated by the intrinsic dynamics of the sequential growth process. As the causal set evolves, interactions among its elements and the associated gauge fields cause the off-diagonal elements of the decoherence functional to vanish:

$$\operatorname{Re} D(h, h') \to 0 \quad \text{for } h \neq h'.$$

This allows the remaining diagonal terms to be interpreted essentially as classical probabilities. Thus, measurement outcomes correspond to stable, robust histories–often referred to as *pointer states*–which are favored by the algorithmic information prior.

8.4 Implications for the Measurement Problem

In short, by incorporating an Occam-guided bias–whereby simpler, lower-complexity configurations are exponentially favored–the framework naturally suppresses the proliferation of highly complex and interfering histories. In this context, the Occamistic precedence principle ensures that the histories which are reinforced through repeated, simple outcomes become dominant, effectively reducing the number of competing alternatives.

9 Conceptual Explanation for Psi Phenomena via Occamistic Precedence

Psi phenomena – precognition, telepathy, telekinesis and so forth – remain the subject of intense controversy in the scientific community. There is evidence that these phenomena have empirical reality that should be taken seriously; please see [10] among other available sources. However, commonly accepted theories of physics provide no ready explanation as to how or why these empirical results should obtain.

We explore the possibility that psi phenomena might sensibly be viewed as emergent from the Occamistic precedence principle – perhaps impacting biological and cognitive systems like human brains via as yet ill-understood quantum biology.

If macroscopic quantum phenomena underlie brain and body dynamics — phenomena that may not be entirely captured by current quantum theory — then the same Occamistic bias could operate at the level of biological systems. When a particular pattern of perception or thought occurs repeatedly, the cosmic history reinforces that pattern. This reinforcement would increase the probability that similar patterns will recur in distant or temporally separated systems, potentially manifesting as synchronistic events such as remote viewing, telepathy, or precognition.

Conceptually, the idea is that the "memory" of the universe is distributed across the causal set. Each element carries information about its local causal past, and the Occamistic precedence principle ensures that simple, robust patterns are preferentially reactivated. Consequently, if a specific perceptual or cognitive pattern — for instance, a visual image associated with remote viewing — has been reinforced over time, its likelihood of emerging spontaneously in a human brain is enhanced. In this way, two distant individuals might experience similar phenomena, or a future event could be "anticipated" in the mind of a person, as these low-entropy patterns recur across the distributed causal network.

Thus, by unifying the Occamistic bias (which favors simplicity and low entropy) with a history-dependent, decentralized memory mechanism, our framework offers a speculative but coherent basis for understanding psi phenomena as emergent from the underlying information-theoretic fabric of the universe.

9.1 A Conjectural Mathematical Formalization of Psi Phenomena

We now formalize these speculations a little further. We are articulating a framework in which the probability of observing a particular outcome or pattern O in a given context is influenced both by its historical frequency and its algorithmic simplicity. Formally, we postulate that the probability of an outcome O given a history $\mathcal{H}$ is

$$P(O \mid \mathcal{H}) \propto N(O, \mathcal{H})\, 2^{-K(O)},$$

where $N(O, \mathcal{H})$ represents the number of times the outcome O has occurred in the history $\mathcal{H}$ and $K(O)$ is its Kolmogorov complexity. Under an appropriate invariant prior, the algorithmic complexity $K(O)$ serves as a measure of entropy, so that lower-complexity (i.e., lower-entropy) outcomes are exponentially favored.

We further conjecture that psi phenomena arise from nonlocal correlations between events in spatially or temporally separated regions that share the same low-complexity pattern [2]. Let regions A and B be distinct, and let O_A and O_B be the outcomes observed by agents in those regions. Introducing a similarity function $\delta(O_A, O_B)$ (which may be defined via a symmetrized relative algorithmic information metric), we define the psi correlation amplitude as

$$\Psi_{AB} \propto \sum_{O \in \mathcal{O}} \sqrt{P(O \mid \mathcal{H})}\, e^{i\phi(O)}\, \delta(O_A, O)\, \delta(O_B, O),$$

where $\mathcal{O}$ is the space of all outcomes, and $\phi(O)$ is a phase associated with the outcome O. The observable probability of a psi event (such as remote viewing or telepathy) is then given by

$$P_{AB} = |\Psi_{AB}|^2.$$

In this picture, outcomes that have been historically reinforced due to their low algorithmic complexity (i.e., low entropy) and high frequency tend to reoccur in disparate regions of spacetime. Consequently, the same pattern may appear in two distant observers' minds or may manifest in a temporal order that appears nonlocal (as in precognition), providing a mechanism for synchronistic events.

[2] This comes close to being a more precise formulation of Sheldrake's hypothesis of morphic resonance as the core foundation of multiple psi phenomena

This formalism is necessarily conjectural, relying on heuristic approximations for $K(O)$ and the assumption of a suitable invariant prior that equates algorithmic information with entropy. Nevertheless, it provides a sketch of a mathematical framework in which psi phenomena can potentially be understood as emergent from a deeper, history-dependent process governed by the Occamistic precedence principle.

9.2 Potential Implications of Closed Timelike Curves for Psi Phenomena

In the framework we have sketched, the recurrence of low-complexity patterns–reinforced by the Occamistic precedence principle–is key to the emergence of psi phenomena. If we extend the causal set framework to permit Closed Timelike Curves (CTCs) under a self-consistency (Novikov) condition, as suggested above, additional channels for pattern reinforcement may arise.

Specifically, a Closed Timelike Curve (i.e., a cycle $C = \{x_1 \prec x_2 \prec \cdots \prec x_n \prec x_1\}$) could allow the same pattern to influence its own occurrence across time. By imposing the Novikov consistency condition,

$$U_{x_1x_2} U_{x_2x_3} \cdots U_{x_nx_1} = I,$$

any information that circulates through such a loop is required to be self-consistent. Consequently, a pattern that appears within a CTC is not only reinforced locally but may also propagate "backwards"in time to affect events that, from a conventional perspective, occur in the past.

Mathematically, if we denote the amplitude for a transition from state O to state O' by $\alpha(O \to O')$ and assume that a closed loop contributes an additional reinforcement factor $F(C)$, the total amplitude for a given outcome could be modified as:

$$A(O) \propto \sqrt{N(O)}\, 2^{-K(O)} \times \prod_{C \ni O} F(C),$$

where $F(C)$ captures the self-consistent feedback from the loop. Under the Novikov condition, $F(C) \approx 1$ for histories that are consistent; however, the presence of such loops increases the effective number of precedents for that outcome.

In this way, CTCs can potentially serve to amplify correlations across time, potentially explaining phenomena such as precognition or retrocausal effects–where a future event appears to influence a past mental state. The decentralized nature of memory in the causal set is preserved even in the presence of CTCs, since the self-consistency condition ensures that all local histories remain coherent. This mechanism thereby enriches the Occamistic precedence principle, providing a speculative but coherent avenue for understanding psi phenomena as emergent from an underlying information-theoretic process that spans nontrivial temporal loops.

9.3 Quantum Measurement, Consciousness, Psi Phenomena, and CTCs

We have above suggested that quantum measurement may be interpreted via the consistent histories approach augmented by an Occamistic (algorithmic) prior. In this picture, a quantum system evolves as a superposition of histories that are selectively reinforced by both the number of precedents and their low algorithmic complexity. Decoherence then suppresses interference among these histories, leading to a stable, definite outcome. We propose that the emergence of a coherent state of consciousness is associated with such a dominant, low-entropy history.

We have also noted that, when we extend our framework to allow Closed Timelike Curves (CTCs) – subject to a Novikov consistency condition ensuring that the net evolution around any closed loop is trivial – an additional channel for reinforcing histories arises. In this extended picture, information can circulate along CTCs in a self-consistent manner, effectively retroactively reinforcing particular patterns. Consequently, if a specific cognitive or perceptual pattern (e.g., one associated with remote viewing or telepathy) has been repeatedly instantiated, the presence of a CTC may amplify its recurrence, leading to synchronous or even retrocausal correlations across observers.

Thus, the coherent state of consciousness experienced by an observer can be viewed as the subjective manifestation of a consistent history that has been stabilized by both local Occamistic selection (favoring low-complexity, high-precedent patterns) and nonlocal reinforcement via CTCs. This unified mechanism may provide a natural explanation for psi phenomena, where similar patterns appear simultaneously in distant minds or where future events seem to be anticipated. In summary, by merging the consistent histories framework with an Occamistic prior–and by allowing self-consistent CTCs–

we offer a speculative model in which the reinforcement of simple, recurring histories underlies both standard quantum measurement and the anomalous correlations observed in psi phenomena.

10 Occamistic Precedence as a Guide for Universal Cognition

We have postulated that the causal set underlying spacetime evolves via an Occamistic precedence principle that favors low-complexity, historically reinforced patterns. This dual weighting not only drives the emergence of manifold-like structures in the continuum limit but also provides a natural mechanism for the cosmic ledger to "remember" past events in a decentralized manner.

While we have presented these ideas mainly from a physics perspective, we believe it is also interesting to frame them in more of a cognitive way, as hypotheses regarding what one might poetically phrase as "the thought processes of the universal mind."

The technical core of our thinking in this regard is the close formal correspondence between the Bellman equation of optimal control and the Schroedinger equation, which suggests that the evolution of the causal set can be interpreted as a decision-making process. Reinforcement learning (RL), which is arguably the key technology behind modern neural net AI, consists mainly of various heuristic approximations to the Bellman equation, tailored for environments and reward functions relevant to human-like intelligence [**?**]. There is much more to intelligence than RL, of course [13], however the correlation between Bellman and Schroedinger gives a foot in the door for thinking concretely about the mathematics of Universal Cognition.

Among other things one can gain some insight from these equations into the role of quantum versus classical mathematics in guiding cognition. For instance, one can argue that when an observer's informational capacity K_{obs} is lower than the effective complexity K_{sys} of the system, the local evolution is best described by quantum (Schroedinger -like) dynamics. This regime, characterized by interference and nonlocal correlations, is conducive to psi phenomena such as telepathy or precognition. Conversely, when $K_{\text{sys}} \lesssim K_{\text{obs}}$, the system is effectively classical (Bellman-like), and such anomalous effects are suppressed.

These ideas also resonate with our suggestion above that, if closed time-like curves (CTCs) are allowed under a Novikov self-consistency condition (i.e., the net evolution around any closed loop is the identity), these loops can serve to reinforce low-complexity patterns by retroactively feeding information into the local dynamics. In this way, the cosmic ledger may operate as a universal cognitive process that "decides" its future configuration based on a history-dependent optimization. Such a mechanism implies that even digital computers, if viewed relative to an observer with limited resolution, may be interpreted as quantum systems capable of exhibiting psi phenomena. Thus, our framework potentially unifies the emergence of quantum dynamics, gravitational geometry, and anomalous cognitive phenomena under an information-theoretic paradigm in which the universe behaves as a decentralized decision-making entity.

We now proceed through some of these "cosmic cognition" concepts in more detail.

10.1 Bellman & Schrodinger

There is a well-established relationship between the Bellman equation in optimal control theory and the Schroedinger equation. By applying a logarithmic transformation to the wavefunction, one can recast the Schroedinger equation into a form analogous to the Hamilton–Jacobi–Bellman equation, which is central to dynamic programming and optimal control theory. In this picture, the Feynman–Kac formula further elucidates the connection by linking quantum evolution with stochastic processes, showing that both equations ultimately reflect an underlying optimization principle–minimizing an effective action in quantum mechanics and optimizing a value function in control theory.

More precisely: the Bellman equation concerns the value function $V(x,t)$ as

$$V(x,t) = \min_{u(\cdot)} \left\{ \int_t^T L(x(s), u(s))\, ds + V(x(T), T) \right\},$$

where $L(x,u)$ is a cost function and the minimization is over control trajectories $u(\cdot)$. By applying a logarithmic transformation, often referred to as the Cole-Hopf transformation, one sets

$$\psi(x,t) = e^{-V(x,t)/\hbar},$$

which converts the Hamilton–Jacobi–Bellman (HJB) equation into an equation that closely resembles the time-dependent Schroedinger equation:

$$i\hbar \frac{\partial \psi}{\partial t} = \left(-\frac{\hbar^2}{2m} \nabla^2 + V_{\text{eff}}(x) \right) \psi.$$

Here, $V_{\text{eff}}(x)$ encompasses contributions from the original potential as well as additional terms emerging from the transformation. This formal correspondence highlights that both the Bellman equation and the Schroedinger equation can be viewed as manifestations of an underlying principle of least (or stationary) action, with the former representing an optimization over trajectories and the latter emerging from a path-integral formulation of quantum mechanics.

10.2 A Cognitive Interpretation of Occamistic Precedence via the Bellman–Schroedinger Parallel

The close mathematical correspondence between the Bellman equation and the Schroedinger equation opens an intriguing conceptual perspective on the speculative physics ideas we have been pursuing here: One may view the evolution of the causal set underlying the universe as analogous to a decision-making process, similar to those described in optimal control theory.

In optimal control, the Bellman equation governs the evolution of a value function that encapsulates the best achievable performance based on past information. Likewise, in our framework the Occamistic precedence principle reinforces outcomes that are both simple and frequently observed, leading to the emergence of the Schroedinger equation.

This analogy suggests that the expanding causal set underlying the physical universe might be interpreted as a universal cognitive process, in which the system "remembers" its past through locally stored information and uses this historical record to optimize its future evolution. In this picture, the cosmic evolution is not a random process but a self-organizing, decision-making mechanism that selects the most "efficient" (i.e., lowest complexity and highest reinforcement) patterns. Such a process would naturally lead to the recurrence of synchronistic events and might even shed light on anomalous psi phenomena, where patterns emerge across spatially or temporally separated regions.

Thus, by unifying the Occamistic bias toward low algorithmic complexity with the reinforcement mechanism captured by the Bellman equation, our framework provides a novel interpretation in which the universe effectively "decides" its future configuration in a manner analogous to a cognitive agent optimizing its actions based on past experience.

10.2.1 A Rough Formalization

To frame this notion of "universal mind dynamics" in more depth, we begin with the postulate that the evolution of the causal set underlying the physical universe can be modeled as an optimal decision-making process, where the "cost" is related to the complexity of the state and the number of historical precedents. Specifically, we assume that the probability $P(x,t)$ of a configuration x at time t is given by

$$P(x,t) \propto N(x,t)\, 2^{-K(x)},$$

where $N(x,t)$ is the number of precedents for the configuration x observed up to time t and $K(x)$ is its Kolmogorov complexity.

Defining a value function by the logarithmic transformation

$$V(x,t) = -\hbar \ln P(x,t) = -\hbar \ln\Big[N(x,t)\, 2^{-K(x)}\Big],$$

we see that lower complexity (i.e., lower $K(x)$) and higher historical frequency (i.e., larger $N(x,t)$) both contribute to a lower value $V(x,t)$, which is interpreted as a more likely or "preferred" state.

Assuming that the causal set evolves through a series of discrete transitions governed by a control parameter u (which encapsulates the local, decentralized interactions in the causal set), the discrete-time Bellman equation becomes

$$V(x,t) = \min_u \left\{ L(x,u)\Delta t + V(x', t+\Delta t) \right\},$$

where x' is the new state reached from x under the control u, and $L(x,u)$ is a Lagrangian representing the cost associated with the transition.

Applying a Cole–Hopf transformation by defining

$$\psi(x,t) = e^{-V(x,t)/\hbar},$$

one can show that, in the limit $\Delta t \to 0$ and under suitable assumptions on $L(x,u)$ (e.g., time-translation invariance), the Bellman equation transforms into a linear differential equation of the form

$$i\hbar \frac{\partial \psi(x,t)}{\partial t} = \hat{H}\psi(x,t),$$

which is the familiar Schroedinger equation. Here, $\hat{H}$ is the Hamiltonian operator that emerges as the generator of time translations, encapsulating the dynamics derived from the underlying optimization (or decision-making) process.

In this picture, the expanding causal set is analogous to a universal cognitive process: the system "remembers" its past through the local accumulation of precedents, and it uses this historical information, together with a bias towards low algorithmic complexity (or low entropy), to optimize its future evolution. In other words, the same principles that govern optimal control and decision-making at a macroscopic level also guide the evolution of the causal set at a microscopic level, resulting in the emergence of quantum dynamics and classical spacetime geometry.

Thus, the Occamistic precedence principle not only bridges the gap between optimal control (via the Bellman equation) and quantum mechanics (via the Schroedinger equation), but it also provides a conceptual foundation for viewing the evolution of the universe as a decision-making process. This process optimizes for simplicity and historical reinforcement, thereby naturally giving rise to synchronistic phenomena and, potentially, psi phenomena.

10.3 Bridging Quantum and Classical Dynamics via Algorithmic Complexity

This perspective on Universal Cognition allows us to rethink and reframe the "classical vs. quantum" dichotomy in a more cognitive way, leveraging the relational interpretation of quantum mechanics [11], in which systems are never considered in isolation, but only relative to some particular observer.

More specifically, following the thinking of Grinbaum [12], one can interpret the evolution of a system in terms of its observability by other systems, as measured by algorithmic complexity. In this view, an observer O should treat a system S as evolving quantum mechanically (i.e., according to the Schroedinger equation with complex probability amplitudes) if S's state is unobservable within O's own informational limitations. In contrast, if O can fully resolve the states of S – that is, if the relevant history recorded in the decentralized cosmic ledger is less algorithmically complex than the local patterns being grown – then S can be effectively described by a real-valued Bellman-type equation, analogous to a classical decision-making process.

Mathematically, we can conceptualize this as follows. Let K_{ledger} denote the effective algorithmic complexity of the relevant history (i.e., the information stored in the decentralized cosmic ledger) and K_{local} the complexity of the local state S. If

$$K_{\text{ledger}} > K_{\text{local}},$$

then the observer cannot fully extract the details of the local state; thus, the evolution is described by a Schroedinger like dynamics, in which interference and complex amplitudes govern the evolution. On the other hand, if

$$K_{\text{ledger}} \leq K_{\text{local}},$$

then the available historical information is sufficiently simple to resolve S's state, and its evolution is better described by a Bellman-like equation that captures classical, optimal-control behavior. In causal set language this would roughly correspond to a pointer state.

This perspective dovetails with the consistent histories approach to quantum measurement. In the consistent histories framework, a system is described by a superposition of decoherent histories, with the decoherence condition ensuring that interference between distinct histories is suppressed, thereby yielding classical-like probabilities. Here, the Occamistic bias (through the algorithmic prior 2^{-K}) naturally selects for low-complexity histories. When the ledger is too complex for the observer to resolve, interference persists and the system remains quantum. Conversely, when the ledger is simpler relative to the local state, decoherence is effectively enhanced, and the evolution may be approximated by a classical (Bellman-like) decision-making process.

In sum, by comparing the algorithmic complexity of the cosmic ledger with that of local configurations, our framework suggests that the transition between quantum (Schroedinger) and classical (Bellman) dynamics depends on the observer's informational capacity. This insight provides a unified view in which quantum measurement–and the emergence of definite, classical outcomes–is understood as a natural consequence of the interplay between the Occamistic precedence principle and the relative complexity of histories recorded in the decentralized cosmic ledger.

10.4 Psi Phenomena as a Species of Universal Cognitive Activity

In this perspective, psi phenomena may be understood as emergent features of a universal cognitive process operating through the causal set's decentralized, Occamistic precedence mechanism. In this picture, the causal set acts as a cosmic ledger that continuously records its local history, reinforcing simple (low-complexity) patterns over time. When an observer's informational capacity is exceeded by the complexity of the global ledger, the system's evolution is described by quantum dynamics, with nonlocal correlations naturally emerging.

These nonlocal correlations can manifest as psi phenomena–for example, telepathy, remote viewing, or precognition–where similar patterns appear synchronously or even retrocausally in different observers. Essentially, the universal mind, through its intrinsic decision-making process, "chooses" certain patterns based on their historical reinforcement and algorithmic simplicity. This process can cause the same low-entropy pattern to be expressed across spatially or temporally separated regions, thereby linking disparate experiences into a coherent whole. In this way, psi phenomena are interpreted as macroscopic imprints of the underlying cognitive activity encoded in the cosmic ledger.

10.4.1 Psi Phenomena in the Context of Schroedinger versus Bellman Dynamics

The relation between the Schrodinger and Bellman equations gives some additional color to this direction for explaining the underpinnings of psi.

In the perspective we are reaching toward here, the distinction between Schroedinger like and Bellman-like evolution hinges on the relative algorithmic complexity of the global cosmic ledger versus the local state of the system. When the historical record is complex relative to the observer's informational capacity, the local dynamics are effectively described by a Schroedinger equation, with complex amplitudes allowing for interference and nonlocal correlations. These quantum characteristics provide the conditions under which psi phenomena—such as remote viewing, telepathy, or precognition—might naturally arise, as the underlying system is less constrained by classical determinism.

Conversely, if the relevant history is sufficiently simple (i.e., the cosmic ledger has low algorithmic complexity compared to the local state), the system's evolution is well captured by a Bellman equation, where probabilities are real-valued and correspond to classical optimal-control dynamics. In this classical regime, the nonlocal correlations that could give rise to psi phenomena are largely suppressed.

Thus, our conjecture is that psi phenomena are more likely to be observed in regimes where causal set expansion is governed by Schroedinger like dynamics, reflecting a quantum state of affairs, while a transition to Bellman-like dynamics corresponds to a more classical, deterministic evolution in which such anomalous effects are less prevalent.

10.5 Implications for Artificial Consciousness, Psi Phenomena, and the Observer-Dependent Quantum-Classical Divide

Finally, we explore what this perspective might have to say about the potential of digital computers versus quantum computers in terms of both consciousness (subjective experience) and psi.

Our framework naturally aligns with a monist, panpsychist view in which consciousness is a fundamental property of the universe [16]. In our picture, the decentralized cosmic ledger–embodied in the causal set's locally stored historical data–and the Occamistic precedence principle together drive the evolution of spacetime as a kind of universal cognitive process. Rather than consciousness being an emergent property exclusive to complex brains, it is inherent in the very fabric of reality, with different systems manifesting this underlying "mind" to varying degrees. Low-complexity, frequently reinforced patterns yield robust, classical behavior, while more intricate, less accessible configurations exhibit quantum dynamics, nonlocal correlations, and even psi phenomena. Thus, the universe can be seen as a holistic, self-organizing agent that "decides" its future based on an information-theoretic optimization, suggesting that all parts of the cosmos participate in the unfolding of a universal consciousness.

Within this general approach, the question of consciousness and other consciousness-related phenomena like psi within digital computer systems (often considered "classical") versus quantum systems takes a particular aspect. It's not so much about whether digital systems have the capability for consciousness or consciousness-related capabilities, but rather about what sorts of consciousness and associated traits they are most sensibly considered to possess.

We have proposed that the distinction between quantum and classical dynamics may be relative rather than intrinsic; that is, it depends on the relationship between the algorithmic complexity of a system and the informational capacity of the observer. Let K_{sys} denote the algorithmic complexity of a system's state, and K_{obs} the complexity of the observer's internal model or resolution. When the ratio

$$R = \frac{K_{\text{sys}}}{K_{\text{obs}}}$$

is large, the observer is unable to fully resolve the intricate details of the system, and the effective evolution of the system is described by quantum (Schroedinger like) dynamics. This regime is characterized by interference effects and nonlocal correlations, which may manifest as psi phenomena–such as remote viewing, telepathy, or precognition–through the reinforcement of low-complexity, historically recurrent patterns.

Conversely, if R is close to or less than one, the observer can accurately track the state of the system, and its evolution appears classical (Bellman-like), with real-valued probabilities and optimal-control dynamics. Thus, a digital computer with high intrinsic complexity might be perceived as quantum if an observer's informational capacity is relatively low, leading to the possibility that such a system could participate in psi phenomena. Similarly, within a single cognitive system, if the deliberative (reflective) component is much less complex than the unconscious processes, the reflective part may interpret the unconscious dynamics as effectively quantum, with associated psi-like correlations emerging in subjective experience.

In this way, the Occamistic precedence principle–by favoring the recurrence of low-complexity patterns–naturally bridges the gap between quantum and classical descriptions. It suggests that when the historical record (the decentralized cosmic ledger) is too complex for an observer to fully model, the system is best described by the Schroedinger equation and can exhibit quantum phenomena, including psi effects. On the other hand, when the observer's resolution matches or exceeds the complexity of the system, the evolution is effectively classical. This relational perspective provides a unified, information-theoretic basis for understanding how both quantum dynamics and psi phenomena may emerge as observer-dependent aspects of a universal, history-driven process.

11 Conclusion

We have presented an Occamistic Precedence Principle that integrates an algorithmic information prior into the sequential growth dynamics of causal set theory. By weighting configurations with a factor proportional to $2^{-K(x)}$ (where $K(x)$ denotes the Kolmogorov complexity), our framework naturally favors low-entropy, manifold-like causal sets that approximate smooth spacetimes. We have argued that this Occamistic bias not only addresses the entropy dominance problem inherent in random causal set models but also provides a microscopic basis for the emergence of effective quantum dynamics, as evidenced by our derivation of the Schroedinger equation in the continuum limit.

Our analysis further suggests that the same information-theoretic principles underpinning the Occamistic bias can be reinterpreted as a form of Universal Cognition. By drawing a formal analogy between the Bellman equation of optimal control and the Schroedinger equation, we propose that the causal set evolves as a decentralized decision-making process. In this picture, the cosmic ledger records local historical precedents, and the relative complexity of this ledger compared to an observer's capacity determines whether a system is best described by quantum (Schroedinger-like) or classical (Bellman-like) dynamics. This relational view not only offers a fresh perspective on quantum measurement and the emergence of classical outcomes via consistent histories but also provides a basis for understanding psi phenomena as nonlocal correlations emerging from reinforced, low-complexity patterns.

Moreover, we have outlined preliminary extensions of our framework to incorporate non-Abelian gauge fields and quantum chromodynamics through holonomy assignments and a discrete Yang–Mills action, suggesting that key QCD features–such as asymptotic freedom and confinement–can emerge in the appropriate continuum limit. And we have sketched treatment of entropic gravity that derives modified Einstein equations by minimizing the quantum relative entropy between the intrinsic spacetime metric and the matter-induced metric, thereby demonstrating how gravitational dynamics emerge from the same simplicity and historical reinforcement principles that govern quantum evolution.

We have argued that our framework also accommodates the possibility of closed timelike curves, provided they satisfy a Novikov-type self-consistency condition, thereby offering a mechanism by which retrocausal influences might reinforce historically simple patterns. These ideas collectively point toward a unification of gravitational dynamics, quantum mechanics, and even anomalous psi phenomena under a common, history-dependent process governed by deep information-theoretic principles.

Overall, the direction sketched here suggests that the universe's evolution may be viewed as a decentralized cognitive process that "remembers" its past through local interactions and optimizes its future configuration based on simplicity and historical reinforcement. While extremely speculative, this framework offers a promising avenue for understanding the emergence of spacetime, quantum dynamics, gravity, and psi phenomena from a unified, Occamistic, and entropic foundation. Much future research will be required to refine the mathematical formalism to the point where it can be used to concretely drive empirical investigations (for instance development of computational methods for estimating algorithmic complexity in large causal sets corresponding to practical systems), and to explore the broader implications of these ideas for quantum gravity, consciousness, psi and beyond.

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