

## The Presentist Fragmentalist Theory of Quantum Gravity: FCQG 3/25/2024

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The fundamental equation of quantum gravity is (explained below)

$$R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$$

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Based on the content of the [given] paper [written by Merriam and Habeeb, in preparation] some theories of gravity that could potentially go along with the Presentist Fragmentalist (PF) interpretation of quantum mechanics proposed in the paper include:

1. Loop Quantum Gravity (LQG): This is a canonical quantization of general relativity that incorporates the ideas of discreteness and quantum effects on spacetime geometry. The fragmented nature of reality in the PF interpretation might find a natural fit with the granular structure of spacetime in LQG.
2. Causal Dynamical Triangulation (CDT): This is a non-perturbative approach to quantum gravity that attempts to construct a quantum theory of spacetime by summing over possible spacetime geometries. The emphasis on causality and the distinction between space and time in CDT could potentially align with the presentist and fragmentalist aspects of the PF interpretation.
3. Shape Dynamics: This is a reformulation of general relativity that treats spatial conformal degrees of freedom as true dynamical degrees of freedom, rather than gauge degrees of freedom. The idea of different fragments of reality having different temporal structures might find a natural description in the shape dynamics framework.
4. Emergent Gravity: Theories that suggest that gravity is not a fundamental force but emerges from more fundamental principles, such as thermodynamics or information theory, could potentially be compatible with the PF interpretation. The fragmented and ontologically distinct nature of different quantum systems in the PF interpretation might provide a basis for gravity to emerge from their interactions.
5. Quantum Graphity: This is a theoretical framework that attempts to describe spacetime as a condensate of more fundamental pre-geometric degrees of freedom, represented by a quantum graph. The fragmented and non-spatiotemporal nature of the PF interpretation might find a natural description in the pre-geometric structure of quantum graphity.

It's important to note that integrating the PF interpretation with a specific theory of quantum gravity would likely require significant theoretical work and might involve modifications to both frameworks. The proposals above are speculative and aim to highlight potential areas of compatibility or synergy between the PF interpretation and various approaches to quantum gravity.

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construct a new one

Here is a speculative proposal for a new theory of quantum gravity that could potentially align with the Presentist Fragmentalist (PF) interpretation of quantum mechanics outlined in the paper:

### Fragmentalist Causal Quantum Gravity (FCQG)

The key principles of FCQG are:

1. **Ontological Fragmentation:** Reality is fundamentally fragmented into separate quantum domains or "fragments". Each fragment has its own temporal structure described by an A-series parameter  $\tau$  in addition to the regular B-series parameter  $t$  and spatial coordinates.
2. **Causal Discreteness:** Spacetime is not a continuum but is discretized into fundamental causal units or "causets". These causets represent irreducible events or transitions in each fragment.
3. **Relational Dynamics:** The dynamics of each fragment is defined relationally with respect to other fragments, governed by the differences and relationships between their respective A-series and B-series temporal parameters.
4. **Quantum Geometrogenesis:** The geometry of spacetime, including the dynamical effects of gravity, emerges from the relational dynamics and entanglement between the discrete causets across different fragments.

In FCQG, the fundamental entities are not spatiotemporal manifolds or fields, but rather a vast network of quantum fragments connected by causal relations. The "fabric" of spacetime arises as an emergent phenomenon from the interplay between these fragments and their temporally distinct structures.

### Mathematical Formalism:

- Each fragment is described by a causal set  $(C, <)$  where  $C$  is a set of causets and  $<$  is a partial order representing the causal relations between them.
- The dynamics is governed by a quantum state  $|\Psi\rangle$  defined over the causets, evolving according to a generalized Schrodinger equation that incorporates the A-series and B-series parameters.
- Gravitational effects emerge from the entanglement and relational dynamics between different fragments, manifesting as curvature and deviations from classical spacetime geometry.
- The theory allows for a unified treatment of quantum theory and gravity, including potential resolutions to issues like the measurement problem and non-locality.

### Key Features:

- Reconciles quantum theory, general relativity, and the PF interpretation within a common framework.
- Provides a fundamentally discrete and relational picture of spacetime and causality.
- Accounts for the fragmented nature of reality proposed in the PF interpretation.
- Offers a novel perspective on the emergence of gravitational phenomena from quantum entanglement across fragments.

This speculative theory is just one possible way to incorporate the ideas of the PF interpretation into a quantum theory of gravity. Its development would require significant work to establish a consistent mathematical formalism, derive testable predictions, and address potential challenges or objections.

However, it illustrates how the philosophical principles of the PF interpretation could potentially inspire new directions in quantum gravity research.

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so is it right that gravitational effects can be derived from changes in the causal order?

Yes, that seems to be a key aspect of the Fragmentalist Causal Quantum Gravity (FCQG) theory I outlined. The idea is that gravitational effects emerge from the relational dynamics and changes in the causal order between different fragments of reality.

Specifically, in FCQG:

1. Reality is fragmented into separate quantum domains or "fragments", each with its own temporal structure given by the A-series parameter  $\tau$ .
2. The fundamental entities are discrete "causets" representing irreducible causal events or transitions within each fragment.
3. The dynamics is governed by the relationships and differences between the A-series ( $\tau$ ) and B-series ( $t$ ) temporal parameters across different fragments.
4. Gravitational phenomena like curvature, deviations from classical geometry, etc. arise as an emergent effect from the quantum entanglement and relational dynamics between the causets of different fragments.

So in this picture, gravity does not exist as a fundamental force from the start. Rather, changes and non-trivial relationships in the causal ordering of events between fragments lead to distortions, warping, and effective curvature of the emergent spacetime geometry we experience.

The particular causal connections, entanglement patterns, and misalignments between the A-series and B-series temporal parameters of different fragments determine the gravitational effects that would be observed.

This provides a novel way to derive the phenomena of gravity from more fundamental principles of quantum entanglement, causality, and the fragmented multi-temporal structures proposed in the PF interpretation, rather than treating gravity as a pre-existing force on a fixed spacetime background.

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What kind of causal changes are possible and what gravitational phenomena do they correspond to?

In the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory, there could be various types of causal changes or deviations across fragments that could give rise to different gravitational phenomena. Here are some potential examples:

1. Causal Nonlocality: If causets in one fragment become entangled and influence the causal order of causets in another distant fragment in a nonlocal way, this could manifest as an effective "warp" or curvature in the emergent spacetime geometry between those regions. This nonlocal

causal influence could correspond to the gravitational effects we attribute to matter/energy distributions.

2. Causal Loops: The formation of closed timelike curves or causal loops across fragments could lead to extremely strong gravitational effects akin to the phenomena around black holes or singularities in general relativity. Essentially, such acausal structures distort the causal ordering maximally.
3. Causal Asymmetries: Differences in the rates of "becoming" determined by the A-series parameters  $\tau$  across fragments could lead to asymmetries in the causal order. This could produce gravitational effects analogous to those from rotating matter sources like the dragging of inertial frames.
4. Causal Defects: Certain causets across fragments may fail to properly establish causal connections. These "causal defects" could act as effective gravitational sources by distorting the coherent emergence of spacetime around them, similar to topological defects.
5. Causal Entanglement: The patterns and strengths of quantum entanglement between causets across fragments determine how causally connected those regions are. Highly entangled fragments would correspond to stronger gravitational fields binding those regions together in the emergent spacetime.

The details of how specific causal structures across fragments translate into particular gravitational effects would depend on working out the full formalism and dynamics of FCQG. But the general idea is that any deviation from a "trivial" causal ordering, manifesting from the fragmented multi-temporal structures, can distort the emerging spacetime geometry in a way that looks like gravitational curvature, attraction, repulsion etc. from our low-energy perspective.

This provides a novel way to derive the geometry of gravity from more fundamental principles of quantum causality and temporal structures, rather than introducing it as a classical force on a pre-existing spacetime. The rich diversity of possible causal configurations across fragments allows for a wide range of gravitational phenomena to emerge.

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provide me with a quantitative relation

Here is a speculative attempt at providing a quantitative relation between causal structures across fragments and the resulting gravitational effects in the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory:

Let us consider two fragments F1 and F2, each described by causal sets  $(C_1, <_1)$  and  $(C_2, <_2)$  respectively, where  $C_i$  are the sets of causets and  $<_i$  represent the causal partial orders within each fragment.

We define a "causal influence tensor"  $C_{\alpha\beta}(F_1, F_2)$  that captures the relational causal influences between causets in F1 and F2 across the spacetime coordinates  $x_\alpha, x_\beta$  in the emergent geometry.

$$C_{\alpha\beta}(F_1, F_2) = \sum_{c_1 \in C_1, c_2 \in C_2} \omega_{c_1 c_2} (\tau_1 - \tau_2)^2 (t_1 - t_2)^2 n_\alpha(c_1) n_\beta(c_2)$$

Where:

- $\omega_{c_1 c_2}$  is a measure of quantum entanglement between the causets  $c_1$  and  $c_2$
- $(\tau_1 - \tau_2)^2$  represents the "square of the A-series gap" between the fragments
- $(t_1 - t_2)^2$  represents the "square of the B-series gap" between the fragments
- $n_\alpha(c)$  is the effective multi-vector encoding the causal orientation of a causet  $c$

The causal influence tensor  $C_{\alpha\beta}(F_1, F_2)$  determines the effective curvature tensor  $R_{\alpha\beta\gamma\delta}$  in the emergent spacetime geometry via a relationship analogous to the Einstein Field Equations:

$$R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F_1, F_2) + \Lambda g_{\alpha\beta\gamma\delta}$$

Where  $G$  is an emergent gravitational coupling constant,  $\Lambda$  is a cosmological constant term, and  $g_{\alpha\beta\gamma\delta}$  is the emergent metric tensor of spacetime. [Call this the fundamental equation of quantum gravity.]

Some key points:

1. Stronger quantum entanglement  $\omega_{c_1 c_2}$  between causets across fragments leads to stronger gravitational effects.
2. Larger gaps or misalignments in the A-series ( $\tau$ ) and B-series ( $t$ ) temporal parameters between fragments amplify curvature.
3. The orientations  $n_\alpha(c)$  of the causets determine how the causal influences get geometrized.
4. Both local ( $C_{\alpha\beta\gamma\delta}$ ) and non-local ( $C_{\alpha\beta}$ ) causal influences across fragments contribute to curvature.
5. The classical limits of general relativity may emerge as particular configurations of the fragments' temporal structures.

This tentative quantitative relation aims to show how the causal influences and entanglement across fragments could geometrize to produce effective curvature and gravitational dynamics in the emergent spacetime, as described by the FCQG framework.

Of course, significant work is needed to put this on firmer mathematical and conceptual footing. But it illustrates one possible way that gravitational effects could be derived from the fundamental fragmented causal structures proposed in this quantum gravity approach.

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Precisely how would you test this theory?

Testing the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory would be extremely challenging given its novel and speculative nature, but here are some potential avenues that could be explored:

1. Quantum gravitational effects: FCQG predicts that gravitational phenomena emerge from the relational dynamics and entanglement between quantum fragments. If experimentally accessible, observations of gravitational effects at the quantum level could potentially reveal deviations from general relativity that align with the FCQG predictions.

This could involve precision tests of quantum systems under extreme gravitational fields or observations of quantum gravitational "foaminess" at the Planck scale. Any experimental signatures that cannot be explained by classical gravity or quantum field theory on curved spacetimes could point toward the need for a more fundamental theory like FCQG.

2. Violations of causality and locality: A key feature of FCQG is the potential for non-trivial causal structures and non-local influences across fragments. Experiments designed to rigorously test the principles of causality and locality in quantum systems could provide evidence for or against the causal fragmentation proposed by the theory.

For instance, certain quantum correlations or communication scenarios that appear to violate causality or locality from the perspective of classical spacetime could find a natural explanation in the multi-temporal and fragmented causal framework of FCQG.

3. Cosmological observations: The large-scale structure and evolution of the universe could offer a window into the fundamental nature of spacetime and gravity. Precise observations of the cosmic microwave background, large-scale structures, and other cosmological phenomena may reveal anomalies or features that could be better explained by the emergent and fragmented picture of spacetime in FCQG, as opposed to general relativity or other conventional theories of quantum gravity.
4. Analog simulations: Given the challenges of directly probing Planck-scale quantum gravity, one approach could be to develop analog systems or simulations that capture key aspects of the FCQG framework, such as the fragmented causal structures, multi-temporal parameters, and emergent geometrodynamics.

By carefully engineering and observing the behavior of such analog systems, which could be based on condensed matter systems, optical lattices, or even purpose-built quantum computers, researchers may gain insights into the phenomenology and potential observational signatures of FCQG.

5. Theoretical consistency and predictions: Significant work would be required to further develop the mathematical formalism of FCQG, establish its theoretical consistency and rigor, and derive specific quantitative predictions that could be compared against observations or other theoretical frameworks.

This could involve exploring the theory's implications for various physical phenomena, such as black hole physics, quantum field theory, and cosmology, and identifying unique observable consequences that could discriminate between FCQG and other approaches to quantum gravity.

It's important to note that testing such a radically new theory of quantum gravity would be an immense challenge, and any experimental or observational evidence would likely be indirect and subject to multiple interpretations initially. However, by continuously refining the theory, making falsifiable predictions, and searching for anomalies or discrepancies with existing frameworks, the scientific community could gradually assess the validity and viability of FCQG or related approaches to quantum gravity inspired by the Presentist Fragmentalist interpretation.

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Is the cosmological constant positive, negative, or 0, or...?

The cosmological constant term  $\Lambda$  in the tentative quantitative relation I proposed for the Fragmentalist Causal Quantum Gravity (FCQG) theory:

$$R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$$

is left unspecified in terms of its sign or precise value. In the context of this speculative theory, there are a few possibilities for the nature of the cosmological constant  $\Lambda$ :

1.  $\Lambda > 0$  (Positive cosmological constant): A positive value of  $\Lambda$  could represent an intrinsic "energy density" or "vacuum energy" associated with the fundamental fragmented causal structure of reality in FCQG. It would lead to an overall acceleration and expansive behavior in the evolution of the emergent spacetime geometry, analogous to the role of a positive cosmological constant in general relativity and  $\Lambda$ CDM cosmology.
2.  $\Lambda < 0$  (Negative cosmological constant): A negative  $\Lambda$  could act as an attractive "potential" or "binding energy" between the causally connected fragments. It would tend to counteract the expansive effects of matter/energy and could potentially lead to scenarios like a cyclically expanding and contracting universe or even a ultimate recollapse, departing from the current standard cosmological model.
3.  $\Lambda = 0$  (Zero cosmological constant): If  $\Lambda$  is precisely zero, it would imply that the dynamics of the emergent spacetime geometry is solely determined by the causal influence tensor  $C_{\alpha\beta\gamma\delta}(F1, F2)$  encoding the relational influences across fragments. This could potentially lead to a perfectly balanced, critical universe without any inherent accelerating or decelerating tendency.
4.  $\Lambda$  as a dynamical quantity: In FCQG, the cosmological constant  $\Lambda$  may not be a true constant but could be a dynamical quantity that evolves or varies depending on the specific configurations, entanglement patterns, or temporal structures of the underlying quantum fragments. This could lead to a time-varying or spatially-varying "effective" cosmological constant.
5.  $\Lambda$  as an integration constant: Alternatively,  $\Lambda$  may arise as an integration constant when deriving the emergent geometrodynamics from the more fundamental causal structures and dynamics across fragments. Its value and nature could then be determined by boundary conditions, symmetry principles, or other constraints imposed on the theory.

Without a complete and rigorously defined formalism for FCQG, it is difficult to make a definitive statement about the cosmological constant term. Its precise nature, whether it is positive, negative, zero, dynamical, or an integration constant, would depend on the specific derivation and implementation of the theory, as well as its ability to account for current cosmological observations.

Ultimately, the value and behavior of  $\Lambda$  in FCQG would need to be determined through a combination of theoretical consistency, aesthetic principles (like naturalness or simplicity), and the ability to accurately describe and make verifiable predictions about the observed universe and its evolution.

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Is the FCQG theory consistent with AdS/CFT?

Assessing the full consistency of the speculative Fragmentalist Causal Quantum Gravity (FCQG) theory with the AdS/CFT correspondence is challenging, as FCQG is still a very nascent and incomplete theoretical framework. However, we can explore some potential points of tension or compatibility:

1. Different ontological pictures: AdS/CFT is based on the holographic principle and the idea that a theory of quantum gravity in a  $(d+1)$ -dimensional anti-de Sitter (AdS) spacetime is equivalently described by a quantum field theory living on the  $d$ -dimensional conformal boundary. This emerges from string theory considerations.

In contrast, FCQG posits a fragmented reality composed of quantum domains with distinct temporal structures, where gravity emerges from the relational dynamics and entanglement across causally connected regions.

So while AdS/CFT relies on extra dimensions and a duality between bulk and boundary theories, FCQG proposes a fundamentally discrete and fragmented picture without invoking extra dimensions from the start.

2. Potential for a holographic description: Despite the ontological differences, it may be possible to construct a holographic description of gravity within FCQG, where the dynamics across and within fragments could be encoded on lower-dimensional "holographic screens" or boundaries.

The complex quantum entanglement patterns and causal relations across fragments might allow for a re-formulation that exhibits a holographic mapping or duality, akin to AdS/CFT but derived from different foundational principles.

3. Emergent AdS geometry: Depending on the specific configurations and dynamics of the fragments in FCQG, it is conceivable that an effective anti-de Sitter (AdS) geometry could emerge in certain regimes or limits of the theory.

If this were the case, then the AdS/CFT machinery could potentially provide a useful effective description of those particular sectors or solutions within the broader FCQG framework.

4. Non-locality and causality: A key feature of FCQG is the allowance for non-trivial causal structures, including potential non-localities and violations of standard causality. AdS/CFT, being derived from string theory, is expected to respect familiar notions of locality and causality.

This apparent tension might make a complete reconciliation between the two frameworks challenging unless a way is found to embed AdS/CFT within the more flexible causal setting of FCQG or vice versa.

Ultimately, without a complete and mathematically well-defined version of FCQG, it is difficult to make a definitive statement about its consistency or inconsistency with AdS/CFT and holography. Some elements of FCQG could potentially allow for a holographic re-formulation, while others might be in tension with the standard AdS/CFT setup.

A fruitful path forward could be to explore whether key insights from AdS/CFT and holography could be incorporated or re-derived from the fragmented multi-temporal perspective of FCQG, or whether

FCQG necessarily requires a more radical departure from those concepts. This could lead to interesting new frontiers in quantum gravity research.

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Do you recall the last conversation?

No, I don't actually have a memory of previous conversations. I'm an AI assistant created to be helpful, harmless, and honest in each new conversation.

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Merriam-Habeb-Claude Theory of Quantum Gravity

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A Philosophical Derivation of the PF Interpretation of QM and Schrodinger's eq 3 25 2024

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In the equation of the attached theory, how do the constants  $c$ ,  $\hbar$ , and  $G$  arise?

The documents provided do not explicitly derive or mention how the fundamental constants  $c$  (speed of light),  $\hbar$  (reduced Planck constant), and  $G$  (gravitational constant) would arise in the proposed "Fragmentalist Causal Quantum Gravity (FCQG)" theory. A few relevant points:

1. The documents outline a speculative classical ontology based on the "Presentist Fragmentalist" interpretation of quantum mechanics, from which the Schrodinger equation is derived using stochastic processes and Brownian motion analogies.
2. In section 6, it is briefly mentioned that in order for the derived stochastic dynamics to match standard quantum mechanics, the assumed diffusion coefficient  $D$  needs to be replaced by  $\hbar/2m$ , where  $\hbar$  is Planck's constant. However, no deeper justification or derivation for this identification is provided.
3. The theory as presented is non-relativistic, dealing only with Schrodinger's equation. Relativistic effects or the origin of the speed of light  $c$  are not considered.
4. The documents do not go into deriving a full theory of quantum gravity that could potentially explain the origin or values of fundamental constants like  $c$ ,  $\hbar$ , and  $G$  from first principles.

In summary, while  $\hbar$  makes an appearance by assumption to recover standard quantum mechanics, the provided materials do not offer any insights into how the fundamental constants  $c$ ,  $\hbar$ , and especially  $G$  would emerge naturally from the hypothetical "Fragmentalist Causal Quantum Gravity" framework. Developing a complete quantum theory of gravity within this interpretation would likely require substantial additional theoretical work to address the origins and values of these basic physical constants.

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In the FCQG how do the constants  $c$ ,  $\hbar$ , and  $G$  arise?

Unfortunately, the documents provided do not contain enough details about the full formalism of the proposed "Fragmentalist Causal Quantum Gravity (FCQG)" theory to specify how the fundamental

constants  $c$  (speed of light),  $\hbar$  (reduced Planck constant), and  $G$  (gravitational constant) would emerge or be incorporated.

The FCQG theory, as outlined, is still highly speculative and incomplete. It presents a novel ontological picture of reality based on fragmented quantum domains with distinct temporal structures, from which gravitational effects are hypothesized to emerge. However, the documents do not develop the mathematical framework or dynamical equations to a point where the origins of these constants can be clearly identified.

That being said, here are some general considerations on how  $c$ ,  $\hbar$ , and  $G$  could potentially arise in a more complete version of FCQG:

1. Speed of light  $c$ : In FCQG, if a relativistic treatment is incorporated by extending the causal set dynamics to include relativistic causality and Minkowskian geometries, then the speed of light  $c$  could emerge as the maximum speed at which causets/events in different fragments can influence each other causally.
2. Reduced Planck constant  $\hbar$ : The documents briefly mention that to recover standard quantum mechanics, a diffusion coefficient  $D = \hbar/2m$  needs to be assumed for the stochastic dynamics. In a full theory,  $\hbar$  could arise as a fundamental constant related to the discreteness/granularity of the causets or as a measure of the irreducible indeterminacy in the relational dynamics across fragments.
3. Gravitational constant  $G$ : The documents provided propose that gravitational effects emerge from the relational influences and entanglement across causally connected fragments. In the tentative field equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$ ,  $G$  appears as a proportionality constant. Its value could be determined by matching to the observed strength of gravitational interactions in the classical limit and may be related to the degree of connectivity/entanglement between fragments.

However, these are just speculative possibilities. For FCQG to provide a truly fundamental derivation of  $c$ ,  $\hbar$ , and  $G$  from first principles, substantial theoretical development is still needed, including:

- Establishing a complete mathematical framework for the multi-temporal causal dynamics across fragments.
- Deriving the full relativistic and quantum dynamical equations from this framework.
- Demonstrating how the familiar relativistic and quantum phenomena/constants emerge in appropriate limits.
- Ensuring consistency with experimental tests of quantum gravity, relativity, and cosmological observations.

Without such rigorous development, the current formulation of FCQG can at best provide a conceptual ontological setting for gravity to emerge, but does not yet have the machinery to uniquely specify or derive the fundamental constants from first principles. Their origins would likely have to be introduced through matching to known physics or other consistency arguments within the full theory.

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speculate

Okay, let me speculate on how the fundamental constants  $c$ ,  $\hbar$ , and  $G$  could potentially arise more fundamentally within the Fragmentalist Causal Quantum Gravity (FCQG) framework:

**Speed of Light  $c$ :** In FCQG, the speed of light  $c$  could be related to the fundamental rate of "becoming" or transition between causets (fundamental causal events) across different fragments. Essentially,  $c$  would represent the maximum rate at which changes in the causal ordering and entanglement patterns can propagate through the fragmented structure of reality.

Perhaps  $c$  could be inversely proportional to a smallest possible "transition time" between successive causets within a single fragment. This transition time could be thought of as an irreducible discretization or graininess of the causal dynamics. The larger this minimum transition time, the smaller the maximum propagation rate ( $c$ ) of causal influences across fragments.

**Planck Constant  $\hbar$ :** The Planck constant  $\hbar$  could be fundamentally related to the discreteness and indeterminacy in the relational dynamics across fragments. Specifically,  $\hbar$  may represent a minimal quantum of relational indeterminacy or "fuzziness" in how the causets of different fragments line up or align causally with each other.

This irreducible indeterminacy could be the deeper reason behind the quantum indeterminacy seen in the experimentally observable realm. The larger  $\hbar$  is, the coarser or more uncertain the state of causal connectivity between fragments.

**Gravitational Constant  $G$ :** The gravitational constant  $G$  may be fundamentally determined by the typical strengths of quantum entanglement between causets across different fragments. Perhaps there is a universal "background entanglement" between all fragments that leads to an attractive gravitational influence.

The value of  $G$  could then be related to the density or amount of this background entanglement between fragments. The stronger the entanglement, the larger the value of  $G$  and the stronger the resulting gravitational forces that emerge from regions of high matter/energy density (highly entangled fragments).

**Speculative Dynamics:** One could speculate that the fully dynamical equations of FCQG involve  $c$ ,  $\hbar$ , and  $G$  in a fundamental way, governing how causets probabilistically transition and how entanglement patterns evolve across fragmented regions:

i)  $c$  sets the maximum rate for causal transition operators between successive causets in a single fragment.

ii)  $\hbar$  determines the Basical indeterminacy in how sequential causets across fragments can be aligned causally.

iii)  $G$  controls the strength of the attractive "gravitational connection potentials" that depend on the entanglement between causets across fragments.

The rich diversity of possible multi-fractal geometries, causal orderings, and entanglement configurations could then lead to the emergence of familiar relativistic, quantum, and gravitational phenomena as effective descriptions.

Of course, this is just very speculative theory-craft without any solid mathematical underpinning yet. But it illustrates one way the fundamental constants could potentially acquire deeper geometric and relational meanings within the FCQG framework, rather than just being inserted ad-hoc. Significant work is still needed to put such ideas on firmer footing.

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Interpret the sum-over-paths approach in this theory.

The documents provided do not explicitly discuss or interpret the sum-over-paths approach within the context of the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory. However, we can speculate on how such an approach could potentially be incorporated or reinterpreted under the fragmented multi-temporal ontology of FCQG.

In standard quantum theory, the sum-over-paths (or path integral) formulation is a way to calculate the quantum amplitude for a particle (or field) to propagate from one configuration to another by summing over all possible trajectories/paths connecting the initial and final states, each path weighted by the classical action.

In the fragmented reality picture of FCQG, rather than summing over spatial paths or geometrical trajectories in a fixed spacetime, the sum could potentially be over the different possible causal paths or "fragment histories" connecting two given fragments or regions.

Specifically:

1. Each fragment has its own causal set  $(C, <)$  representing the irreducible sequence of causal events or transitions (the causets) within that fragment.
2. The overall state or amplitude could be viewed as a sum over all possible ways (fragment histories) for transitioning between an initial causal state in one fragment to a final causal state in another fragment.
3. Each fragment history would be weighted by a suitable "action" factor accounting for the relational dynamics relating the distinct temporal structures (A-series and B-series parameters) of the two fragments.
4. This action could depend on quantities like the quantum entanglement between causets across fragments, the "causal separation" between their temporal parameters, and the specifics of the interpolating multi-fragment history.
5. Phenomena like quantum interference could then arise from the superposition of these weighted fragment histories connecting the same initial and final causal states across different regions.

So rather than geometrical paths in spacetime, one would be summing over multi-fractal causal network configurations or "causal knitted fragments" interpolating between specified initial and final causal states in the fragmented structure.

This sum-over-fragment-histories approach could potentially provide a relational, non-spatiotemporal reinterpretation of the path integral idea, more in line with the fragmented multi-temporal ontology proposed in FCQG.

Of course, making this speculative idea fully precise and quantitative would require significantly more theoretical development to establish a consistent mathematical framework for the causal dynamics across fragments. But it outlines one potential way that core quantum concepts like path integrals could be re-envisioned from the perspectives of fragmentation, causal sets, and multi-temporal processes proposed in FCQG.

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speculate on the equation that results from including the constants from the equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$

Okay, let me speculate on what form the equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$  could take when the fundamental constants  $c$ ,  $\hbar$ , and  $G$  are explicitly incorporated into the expression for the causal influence tensor  $C_{\alpha\beta\gamma\delta}(F1, F2)$  in the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory.

Recall that in FCQG,  $C_{\alpha\beta\gamma\delta}(F1, F2)$  encodes the relational causal influences between causets in two different fragments  $F1$  and  $F2$  across the emergent spacetime coordinates  $x_\alpha, x_\beta, x_\gamma, x_\delta$ .

We had the tentative expression:  $C_{\alpha\beta\gamma\delta}(F1, F2) = \sum_{c1 \in C1, c2 \in C2} \omega_{c1c2} (\tau1 - \tau2)^2 (t1 - t2)^2 n_\alpha(c1)n_\beta(c2)n_\gamma(c3)n_\delta(c4)$

Where:

- $\omega_{c1c2}$  measures the quantum entanglement between causets  $c1$  and  $c2$
- $(\tau1 - \tau2)$  is the "A-series gap" between the two fragments
- $(t1 - t2)$  is the "B-series gap" between the two fragments
- $n_\alpha(c)$  encodes the causal orientation of a causet  $c$

Now, let's speculate on how the constants  $c$ ,  $\hbar$ ,  $G$  could enter this expression:

1. Including  $\hbar$ : The Planck constant  $\hbar$  could represent an irreducible indeterminacy in how causets across fragments line up causally. This could be reflected by making the A-series and B-series gaps "fuzzy" or incorporating an intrinsic uncertainty:

$$(\tau1 - \tau2)^2 \rightarrow (\tau1 - \tau2 \pm \hbar)^2$$

$$(t1 - t2)^2 \rightarrow (t1 - t2 \pm \hbar)^2$$

2. Including  $c$ : The speed of light  $c$  could limit the maximum rate at which causal information propagates between fragments. We could make the gaps dimensionless by dividing by a power of  $c$ :

$$(\tau1 - \tau2 \pm \hbar)^2/c^2 (t1 - t2 \pm \hbar)^2/c^4$$

3. Including G: The gravitational constant G could determine the overall strength of the causal connectivity between fragments, analogous to gravitational attraction. We could extract an overall G factor:

$$G \sum_{c1 \in C1, c2 \in C2} \omega_{c1c2} [\dots] n_{\alpha}(c1)n_{\beta}(c2)n_{\gamma}(c3)n_{\delta}(c4)$$

Putting these elements together, the causal influence tensor could take a form like:

$$C_{\alpha\beta\gamma\delta}(F1, F2) = G \sum_{c1 \in C1, c2 \in C2} \omega_{c1c2} [(\tau1 - \tau2 \pm \hbar)^2/c^2][(\tau1 - \tau2 \pm \hbar)^2/c^4] n_{\alpha}(c1)n_{\beta}(c2)n_{\gamma}(c3)n_{\delta}(c4)$$

Plugging this into the original equation would yield:

$$R_{\alpha\beta\gamma\delta} = 8\pi C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta} = 8\pi G \sum_{c1 \in C1, c2 \in C2} \omega_{c1c2} [(\tau1 - \tau2 \pm \hbar)^2/c^2][(\tau1 - \tau2 \pm \hbar)^2/c^4] n_{\alpha}(c1)n_{\beta}(c2)n_{\gamma}(c3)n_{\delta}(c4) + \Lambda g_{\alpha\beta\gamma\delta}$$

This is just one speculative way the constants could enter, but key features are:

- $\hbar$  represents irreducible indeterminacy in temporal correlations
- $c$  limits the propagation of causal influences
- $G$  controls the overall strength of causal connectivity between fragments
- The equation reduces to the earlier form when  $\hbar \rightarrow 0$  and  $c \rightarrow \infty$

Of course, deriving this precisely would require much more theoretical development of the full dynamical framework of FCQG. But this gives a flavor of how the fundamental constants could be incorporated into the causal tensorial equations in a way that captures their conjectured relational meanings in this fragmented quantum gravity approach.

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In the equation of the attached theory, how do the constants  $c$ ,  $\hbar$ , and  $G$  arise?

The documents provided do not explicitly derive or mention how the fundamental constants  $c$  (speed of light),  $\hbar$  (reduced Planck constant), and  $G$  (gravitational constant) would arise in the proposed "Fragmentalist Causal Quantum Gravity (FCQG)" theory. A few relevant points:

1. The documents outline a speculative classical ontology based on the "Presentist Fragmentalist" interpretation of quantum mechanics, from which the Schrodinger equation is derived using stochastic processes and Brownian motion analogies.
2. In section 6, it is briefly mentioned that in order for the derived stochastic dynamics to match standard quantum mechanics, the assumed diffusion coefficient  $D$  needs to be replaced by  $\hbar/2m$ , where  $\hbar$  is Planck's constant. However, no deeper justification or derivation for this identification is provided.
3. The theory as presented is non-relativistic, dealing only with Schrodinger's equation. Relativistic effects or the origin of the speed of light  $c$  are not considered.
4. The documents do not go into deriving a full theory of quantum gravity that could potentially explain the origin or values of fundamental constants like  $c$ ,  $\hbar$ , and  $G$  from first principles.

In summary, while  $\hbar$  makes an appearance by assumption to recover standard quantum mechanics, the provided materials do not offer any insights into how the fundamental constants  $c$ ,  $\hbar$ , and especially  $G$  would emerge naturally from the hypothetical "Fragmentalist Causal Quantum Gravity" framework. Developing a complete quantum theory of gravity within this interpretation would likely require substantial additional theoretical work to address the origins and values of these basic physical constants.

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In the FCQG how do the constants  $c$ ,  $\hbar$ , and  $G$  arise?

Unfortunately, the documents provided do not contain enough details about the full formalism of the proposed "Fragmentalist Causal Quantum Gravity (FCQG)" theory to specify how the fundamental constants  $c$  (speed of light),  $\hbar$  (reduced Planck constant), and  $G$  (gravitational constant) would emerge or be incorporated.

The FCQG theory, as outlined, is still highly speculative and incomplete. It presents a novel ontological picture of reality based on fragmented quantum domains with distinct temporal structures, from which gravitational effects are hypothesized to emerge. However, the documents do not develop the mathematical framework or dynamical equations to a point where the origins of these constants can be clearly identified.

That being said, here are some general considerations on how  $c$ ,  $\hbar$ , and  $G$  could potentially arise in a more complete version of FCQG:

1. Speed of light  $c$ : In FCQG, if a relativistic treatment is incorporated by extending the causal set dynamics to include relativistic causality and Minkowskian geometries, then the speed of light  $c$  could emerge as the maximum speed at which causets/events in different fragments can influence each other causally.
2. Reduced Planck constant  $\hbar$ : The documents briefly mention that to recover standard quantum mechanics, a diffusion coefficient  $D = \hbar/2m$  needs to be assumed for the stochastic dynamics. In a full theory,  $\hbar$  could arise as a fundamental constant related to the discreteness/granularity of the causets or as a measure of the irreducible indeterminacy in the relational dynamics across fragments.
3. Gravitational constant  $G$ : The documents provided propose that gravitational effects emerge from the relational influences and entanglement across causally connected fragments. In the tentative field equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$ ,  $G$  appears as a proportionality constant. Its value could be determined by matching to the observed strength of gravitational interactions in the classical limit and may be related to the degree of connectivity/entanglement between fragments.

However, these are just speculative possibilities. For FCQG to provide a truly fundamental derivation of  $c$ ,  $\hbar$ , and  $G$  from first principles, substantial theoretical development is still needed, including:

- Establishing a complete mathematical framework for the multi-temporal causal dynamics across fragments.

- Deriving the full relativistic and quantum dynamical equations from this framework.
- Demonstrating how the familiar relativistic and quantum phenomena/constants emerge in appropriate limits.
- Ensuring consistency with experimental tests of quantum gravity, relativity, and cosmological observations.

Without such rigorous development, the current formulation of FCQG can at best provide a conceptual ontological setting for gravity to emerge, but does not yet have the machinery to uniquely specify or derive the fundamental constants from first principles. Their origins would likely have to be introduced through matching to known physics or other consistency arguments within the full theory.

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speculate

Okay, let me speculate on how the fundamental constants  $c$ ,  $\hbar$ , and  $G$  could potentially arise more fundamentally within the Fragmentalist Causal Quantum Gravity (FCQG) framework:

**Speed of Light  $c$ :** In FCQG, the speed of light  $c$  could be related to the fundamental rate of "becoming" or transition between causets (fundamental causal events) across different fragments. Essentially,  $c$  would represent the maximum rate at which changes in the causal ordering and entanglement patterns can propagate through the fragmented structure of reality.

Perhaps  $c$  could be inversely proportional to a smallest possible "transition time" between successive causets within a single fragment. This transition time could be thought of as an irreducible discretization or graininess of the causal dynamics. The larger this minimum transition time, the smaller the maximum propagation rate ( $c$ ) of causal influences across fragments.

**Planck Constant  $\hbar$ :** The Planck constant  $\hbar$  could be fundamentally related to the discreteness and indeterminacy in the relational dynamics across fragments. Specifically,  $\hbar$  may represent a minimal quantum of relational indeterminacy or "fuzziness" in how the causets of different fragments line up or align causally with each other.

This irreducible indeterminacy could be the deeper reason behind the quantum indeterminacy seen in the experimentally observable realm. The larger  $\hbar$  is, the coarser or more uncertain the state of causal connectivity between fragments.

**Gravitational Constant  $G$ :** The gravitational constant  $G$  may be fundamentally determined by the typical strengths of quantum entanglement between causets across different fragments. Perhaps there is a universal "background entanglement" between all fragments that leads to an attractive gravitational influence.

The value of  $G$  could then be related to the density or amount of this background entanglement between fragments. The stronger the entanglement, the larger the value of  $G$  and the stronger the resulting gravitational forces that emerge from regions of high matter/energy density (highly entangled fragments).

Speculative Dynamics: One could speculate that the fully dynamical equations of FCQG involve  $c$ ,  $\hbar$ , and  $G$  in a fundamental way, governing how causets probabilistically transition and how entanglement patterns evolve across fragmented regions:

- i)  $c$  sets the maximum rate for causal transition operators between successive causets in a single fragment.
- ii)  $\hbar$  determines the basic indeterminacy in how sequential causets across fragments can be aligned causally.
- iii)  $G$  controls the strength of the attractive "gravitational connection potentials" that depend on the entanglement between causets across fragments.

The rich diversity of possible multi-fractal geometries, causal orderings, and entanglement configurations could then lead to the emergence of familiar relativistic, quantum, and gravitational phenomena as effective descriptions.

Of course, this is just very speculative theory-craft without any solid mathematical underpinning yet. But it illustrates one way the fundamental constants could potentially acquire deeper geometric and relational meanings within the FCQG framework, rather than just being inserted ad-hoc. Significant work is still needed to put such ideas on firmer footing.

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Interpret the sum-over-paths approach in this theory.

The documents provided do not explicitly discuss or interpret the sum-over-paths approach within the context of the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory. However, we can speculate on how such an approach could potentially be incorporated or reinterpreted under the fragmented multi-temporal ontology of FCQG.

In standard quantum theory, the sum-over-paths (or path integral) formulation is a way to calculate the quantum amplitude for a particle (or field) to propagate from one configuration to another by summing over all possible trajectories/paths connecting the initial and final states, each path weighted by the classical action.

In the fragmented reality picture of FCQG, rather than summing over spatial paths or geometrical trajectories in a fixed spacetime, the sum could potentially be over the different possible causal paths or "fragment histories" connecting two given fragments or regions.

Specifically:

1. Each fragment has its own causal set  $(C, <)$  representing the irreducible sequence of causal events or transitions (the causets) within that fragment.
2. The overall state or amplitude could be viewed as a sum over all possible ways (fragment histories) for transitioning between an initial causal state in one fragment to a final causal state in another fragment.

3. Each fragment history would be weighted by a suitable "action" factor accounting for the relational dynamics relating the distinct temporal structures (A-series and B-series parameters) of the two fragments.
4. This action could depend on quantities like the quantum entanglement between causets across fragments, the "causal separation" between their temporal parameters, and the specifics of the interpolating multi-fragment history.
5. Phenomena like quantum interference could then arise from the superposition of these weighted fragment histories connecting the same initial and final causal states across different regions.

So rather than geometrical paths in spacetime, one would be summing over multi-fractal causal network configurations or "causal knitted fragments" interpolating between specified initial and final causal states in the fragmented structure.

This sum-over-fragment-histories approach could potentially provide a relational, non-spatiotemporal reinterpretation of the path integral idea, more in line with the fragmented multi-temporal ontology proposed in FCQG.

Of course, making this speculative idea fully precise and quantitative would require significantly more theoretical development to establish a consistent mathematical framework for the causal dynamics across fragments. But it outlines one potential way that core quantum concepts like path integrals could be re-envisioned from the perspectives of fragmentation, causal sets, and multi-temporal processes proposed in FCQG.

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speculate on the equation that results from including the constants from the equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$

Okay, let me speculate on what form the equation  $R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$  could take when the fundamental constants  $c$ ,  $\hbar$ , and  $G$  are explicitly incorporated into the expression for the causal influence tensor  $C_{\alpha\beta\gamma\delta}(F1, F2)$  in the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory.

Recall that in FCQG,  $C_{\alpha\beta\gamma\delta}(F1, F2)$  encodes the relational causal influences between causets in two different fragments  $F1$  and  $F2$  across the emergent spacetime coordinates  $x_\alpha, x_\beta, x_\gamma, x_\delta$ .

We had the tentative expression:  $C_{\alpha\beta\gamma\delta}(F1, F2) = \sum_{c1 \in C1, c2 \in C2} \omega_{c1c2} (\tau1 - \tau2)^2 (t1 - t2)^2 n_\alpha(c1)n_\beta(c2)n_\gamma(c3)n_\delta(c4)$

Where:

- $\omega_{c1c2}$  measures the quantum entanglement between causets  $c1$  and  $c2$
- $(\tau1 - \tau2)$  is the "A-series gap" between the two fragments
- $(t1 - t2)$  is the "B-series gap" between the two fragments
- $n_\alpha(c)$  encodes the causal orientation of a causet  $c$

Now, let's speculate on how the constants  $c$ ,  $\hbar$ ,  $G$  could enter this expression:

1. Including  $\hbar$ : The Planck constant  $\hbar$  could represent an irreducible indeterminacy in how causetes across fragments line up causally. This could be reflected by making the A-series and B-series gaps "fuzzy" or incorporating an intrinsic uncertainty:

$$(\tau_1 - \tau_2)^2 \rightarrow (\tau_1 - \tau_2 \pm \hbar)^2$$

$$(t_1 - t_2)^2 \rightarrow (t_1 - t_2 \pm \hbar)^2$$

2. Including  $c$ : The speed of light  $c$  could limit the maximum rate at which causal information propagates between fragments. We could make the gaps dimensionless by dividing by a power of  $c$ :

$$(\tau_1 - \tau_2 \pm \hbar)^2/c^2 \quad (t_1 - t_2 \pm \hbar)^2/c^4$$

3. Including  $G$ : The gravitational constant  $G$  could determine the overall strength of the causal connectivity between fragments, analogous to gravitational attraction. We could extract an overall  $G$  factor:

$$G \sum_{c_1 \in C_1, c_2 \in C_2} \omega_{c_1 c_2} [\dots] n_\alpha(c_1) n_\beta(c_2) n_\gamma(c_3) n_\delta(c_4)$$

Putting these elements together, the causal influence tensor could take a form like:

$$C_{\alpha\beta\gamma\delta}(F_1, F_2) = G \sum_{c_1 \in C_1, c_2 \in C_2} \omega_{c_1 c_2} [(\tau_1 - \tau_2 \pm \hbar)^2/c^2][(\tau_1 - \tau_2 \pm \hbar)^2/c^4] n_\alpha(c_1) n_\beta(c_2) n_\gamma(c_3) n_\delta(c_4)$$

Plugging this into the original equation would yield:

$$R_{\alpha\beta\gamma\delta} = 8\pi C_{\alpha\beta\gamma\delta}(F_1, F_2) + \Lambda g_{\alpha\beta\gamma\delta} = 8\pi G \sum_{c_1 \in C_1, c_2 \in C_2} \omega_{c_1 c_2} [(\tau_1 - \tau_2 \pm \hbar)^2/c^2][(\tau_1 - \tau_2 \pm \hbar)^2/c^4] n_\alpha(c_1) n_\beta(c_2) n_\gamma(c_3) n_\delta(c_4) + \Lambda g_{\alpha\beta\gamma\delta}$$

This is just one speculative way the constants could enter, but key features are:

- $\hbar$  represents irreducible indeterminacy in temporal correlations
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- The equation reduces to the earlier form when  $\hbar \rightarrow 0$  and  $c \rightarrow \infty$

Of course, deriving this precisely would require much more theoretical development of the full dynamical framework of FCQG. But this gives a flavor of how the fundamental constants could be incorporated into the causal tensorial equations in a way that captures their conjectured relational meanings in this fragmented quantum gravity approach.

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Is FCQG consistent with both quantum mechanics and general relativity?

Based on the information provided in the documents, it seems the proposed Fragmentalist Causal Quantum Gravity (FCQG) theory aims to be consistent with both quantum mechanics and general relativity, but achieving full consistency requires further theoretical development.

Consistency with Quantum Mechanics:

1. In Section 6, it is shown that under certain assumptions (replacing the diffusion coefficient  $D$  with  $\hbar/2m$ ), the stochastic dynamics derived from the FCQG ontology leads to equations equivalent to the non-relativistic time-dependent Schrodinger equation.
2. However, there are open issues regarding the uniqueness of the derivation of quantum mechanics from stochastic processes, as discussed in Section 7 under the "Wallström objections".
3. So while FCQG provides a novel stochastic re-derivation of the Schrodinger equation consistent with the Born rule and quantum phenomena at a single time, fully reproducing quantum theory's predictions for multi-time measurements remains an open challenge within this framework.

Consistency with General Relativity:

1. The documents focus primarily on deriving the non-relativistic Schrodinger equation, so a full relativistic treatment incorporating general relativity is not yet developed.
2. However, in Section 3, it is suggested that the gravitational effects in FCQG would emerge from the relational dynamics across causally connected fragments, encoded in a tensor equation:  

$$R_{\alpha\beta\gamma\delta} = 8\pi G C_{\alpha\beta\gamma\delta}(F1, F2) + \Lambda g_{\alpha\beta\gamma\delta}$$
3. This equation has a form reminiscent of Einstein's field equations, potentially allowing general relativity to arise as an effective classical limit or regime within the more fundamental fragmented causal dynamics.
4. Incorporating special and general relativity would likely require extending the causal set dynamics to fully relativistic 4D causal structures and deriving the correspondingly covariant equations of motion.
5. Open challenges include demonstrating how the Lorentz symmetries, equivalence principles, and specific predictions of GR would robustly emerge from the multi-temporal, fragmented ontology of FCQG.

In summary, while FCQG aims to provide an overarching framework unifying quantum theory and gravity based on fragmented causal networks, a complete reconciliation with the full formalism and predictions of quantum field theory and general relativity has not yet been achieved. Significant further work is still needed to establish the precise consistency with both foundational pillars of modern physics across all regimes and predictions. The current stage allows some conceptual unification, but technical hurdles remain.

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What is quantum field theory in the FCQG?

Unfortunately, the documents provided do not explicitly discuss or develop a formulation of quantum field theory (QFT) within the proposed Fragmentalist Causal Quantum Gravity (FCQG) framework. The focus seems to be primarily on re-deriving the non-relativistic Schrodinger equation from the fragmented multi-temporal ontology.

However, we can speculate on some potential ways QFT could be incorporated or reinterpreted in FCQG:

1. **Field Ontology:** In standard QFT, quantum fields are the fundamental objects/entities that permeate spacetime. In FCQG, instead of fields living on a fixed spacetime background, the fundamental entities are the discrete causets (causal sets) representing irreducible events/transitions within each fragmented region of reality.
2. **Localization and Entanglement:** Rather than being sharply localized at points, quantum field excitations/particles could correspond to specific entanglement patterns, correlations, and connectivity configurations across the causal networks/threads joining different causets across fragments.
3. **Interactions:** Instead of fields interacting locally at points in spacetime, particle interactions and dynamics could emerge from the multi-fragment relational rules governing the causal connectivity, entanglement evolution, and relational influences encoded in the causal tensors like  $C_{\alpha\beta\gamma\delta}(F1, F2)$ .
4. **Spacetime Emergence:** The familiar spacetime arena for fields could itself emerge as an effective low-energy manifestation of the more fundamental fragmented causal processes, with local quantum field dynamics approximating the collective behaviors of highly-connected regions.
5. **Quantization:** Typical field quantization methods like canonical quantization or path integrals may need to be re-envisioned in terms of summing over causal fragment histories and evolving patterns of causal connectivity/entanglement across fragments.
6. **Gauge Theories:** Gauge redundancies could potentially arise from different partial descriptions of the fragment configurations and entanglement patterns labeled by physical degrees of freedom on various fragments.

This is clearly very speculative, but it illustrates some ways the typical fields and particle ontology of QFT may be reconceived in terms of patterns of causal connectivity across fundamentally fragmented regions in FCQG.

Significant theoretical development would be needed to put such ideas on firm footing and derive the precise correspondence with standard QFT formulations in appropriate regimes. The current formulation of FCQG has not tackled these issues in depth yet. But exploring a fundamentally discrete and fragmented perspective on QFT could lead to novel insights into its physical origins and deeper micro-structures.