

Merriam-Habeb-Claude Theory of Quantum Gravity

Based on the content of the paper, 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 τ 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 τ .
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 (τ) 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 τ 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_α, x_β 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 $C_{\alpha\beta}(F1, F2)$ determines the effective curvature tensor $R_{\alpha\beta\gamma\delta}$ in the emergent spacetime geometry via a relationship analogous to the Einstein Field Equations:

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

Where G is an emergent gravitational coupling constant, Λ is a cosmological constant term, and $g_{\alpha\beta\gamma\delta}$ is the emergent metric tensor of spacetime.

Some key points:

1. Stronger quantum entanglement ωc^2 between causets across fragments leads to stronger gravitational effects.
2. Larger gaps or misalignments in the A-series (τ) 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 Λ 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 Λ :

1. $\Lambda > 0$ (Positive cosmological constant): A positive value of Λ 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 Λ CDM cosmology.
2. $\Lambda < 0$ (Negative cosmological constant): A negative Λ 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 Λ 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. Λ as a dynamical quantity: In FCQG, the cosmological constant Λ 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. Λ as an integration constant: Alternatively, Λ 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 Λ 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.