Gravity as Statistical Propagation Drag in the Hypostatic Framework

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Abstract

This work outlines a conceptual interpretation of gravitational phenomena within the Hypostatic framework, an event–relational model in which physical reality is described as a network of interacting events rather than as objects embedded in a pre-existing geometric manifold. Within this framework, propagation processes occur through sequential realizations of interactions across the event network. The realization time associated with propagation may vary depending on the local interaction environment. Regions with elevated interaction density may increase the realization time required for propagation steps, producing an effective reduction in propagation rate. This effect is interpreted as propagation drag. Spatial variation in propagation drag alters the statistical behavior of propagation processes and may give rise to macroscopic phenomena corresponding qualitatively to gravitational time dilation and gravitational attraction. Under this interpretation, the geometric description employed in General Relativity may represent an emergent large-scale description of underlying propagation dynamics rather than a fundamental property of physical reality. The present work is exploratory and conceptual, and does not derive the Einstein field equations or provide a complete dynamical theory of gravity.

Keywords:
emergent gravity; spacetime emergence; event-relational ontology; propagation dynamics; statistical gravity

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1. Introduction

Modern gravitational physics is dominated by the geometric description provided by General Relativity, in which gravitational phenomena arise from curvature of spacetime induced by mass–energy distributions (Einstein 1915; Misner, Thorne & Wheeler 1973). This framework has achieved remarkable empirical success across a wide range of scales, from planetary dynamics to cosmological structure formation.

Despite this success, a number of foundational questions remain open regarding the ontological status of spacetime and geometry. Several contemporary research programs explore the possibility that spacetime geometry is not fundamental but instead emerges from deeper relational or informational structures (Jacobson 1995; Verlinde 2011; Van Raamsdonk 2010). Approaches including causal set theory, loop quantum gravity, tensor-network models of spacetime emergence, and thermodynamic interpretations of gravity all investigate mechanisms by which familiar geometric descriptions may arise from underlying non-geometric dynamics (Sorkin 2003).

The Hypostatic framework adopts a similar exploratory perspective. Rather than treating spacetime geometry as a primitive element of physical theory, the framework begins with an event-relational ontology in which physical reality is described as a network of interacting events. Within this structure, differences in operational potential (Eop) generate interaction dynamics that produce propagation processes across the event network.

Within this context, gravitational phenomena are provisionally interpreted as a statistical consequence of constrained propagation within regions of high interaction density. Increased interaction density modifies the realization time associated with propagation processes, producing an effective propagation drag. Spatial variations in this drag alter the local rate of change within the event network, leading to macroscopic phenomena that correspond observationally to gravitational time dilation and gravitational attraction.

The purpose of the present work is to outline a conceptual description of gravity within the Hypostatic framework based on this mechanism. The analysis focuses on the relationship between interaction density, realization time, and propagation behavior, and explores how gravitational phenomena may arise statistically from these dynamics.

The approach presented here does not attempt to replace the empirical success of General Relativity or to derive the Einstein field equations directly. Instead, it proposes an alternative interpretational framework in which familiar gravitational phenomena emerge from propagation dynamics within an event-relational network. In this view, spacetime geometry may be understood as a macroscopic description of propagation behavior rather than as a fundamental property of physical reality.

The present work therefore proposes a conceptual mechanism by which gravitational behavior may emerge from statistical propagation dynamics within an event-relational network.

1.1 Notation and Terminology

- **Eop (Operational Potential)** — scalar quantity representing the realized energetic state of the event network within the Hypostatic framework.
- **λ (Relocation Length)** — characteristic relational displacement associated with a propagation step.
- **τ (Realization Time)** — time required for a propagation step to be completed within the event network.
- **v** — effective propagation rate defined phenomenologically by

  $v = \lambda / \tau$
- **Interaction Density** — descriptive measure of the concentration of interaction processes within a region of the event network.
- **Propagation Drag** — reduction of effective propagation rate produced by increased realization time due to interaction density.

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2. Event Ontology

The Hypostatic framework adopts an event–relational ontology in which physical reality is described as a network of interacting events rather than as objects embedded within a pre-existing spatial geometry. In this view, events constitute the primitive elements of physical description. Similar relational perspectives appear in several approaches to quantum gravity and spacetime emergence (Sorkin 2003).

An event represents the occurrence of a local interaction or realization process. Events do not exist at predefined spatial coordinates and are not associated with fixed spatial points. Instead, the structure of physical reality is defined by the relations among events and by the propagation of interactions between them.

Within this framework, spatial geometry is not treated as a fundamental structure. Rather than beginning with a geometric manifold in which physical processes occur, the Hypostatic framework assumes that geometric structure may arise as an emergent macroscopic description of underlying propagation behavior within the event network.

The event network is governed by differences in operational potential (Eop), which act as drivers of interaction. Variations in Eop generate interaction processes between events, and these interactions produce propagation across the network. In this sense, dynamics arise from differential potential rather than from motion through a pre-existing spatial background.

Because potential differences cannot remain indefinitely static, interaction processes occur whenever differences in operational potential exist. These interactions generate propagation through the event network, establishing a continual redistribution of operational potential.

Within this ontology, propagation defines the operational structure of time. The rate at which interactions propagate through the network determines the rate at which events can occur. Consequently, time is interpreted as a measure of propagation dynamics rather than as a fundamental dimension.

Under this interpretation, familiar geometric structures emerge as large-scale statistical descriptions of propagation behavior. Geometry therefore represents an effective macroscopic representation of relational dynamics within the event network rather than a fundamental substrate of physical reality.

This event–relational ontology provides the conceptual foundation for the subsequent interpretation of gravitational phenomena as statistical propagation effects within regions of varying interaction density.

Within the broader Hypostatic framework, interaction density is associated with local differences in operational potential (Eop), which drive interaction processes within the event network.

3. Propagation Definition

Within the Hypostatic framework, propagation refers to the transmission of interaction effects between events within the event–relational network. Propagation does not occur through a pre-existing spatial background but instead arises from sequential realizations of interactions between related events.

When an interaction occurs, its influence may become realizable at neighboring relational positions within the network. The process by which such realizations occur constitutes propagation. In this sense, propagation represents the operational mechanism by which relational structure evolves.

To characterize propagation operationally, two quantities are introduced:

λ — characteristic relocation length
τ — realization time

The quantity λ represents the effective relational displacement associated with a propagation step within the event network. It does not correspond to a fixed spatial distance but rather to the characteristic scale over which an interaction influence becomes realized in the network.

The quantity τ represents the realization time required for the propagation step to occur. This realization time reflects the interaction processes that must occur before a propagation step can be completed.

An operational propagation rate may therefore be expressed phenomenologically as

$$v = \lambda / \tau$$

where v represents the effective propagation rate within the network.

This expression is not intended as a fundamental dynamical equation but as an operational definition relating the characteristic relational displacement of propagation to the realization time required for that displacement to occur.

Within this framework, variations in realization time τ modify the effective propagation rate v. Factors that increase the interaction complexity of a region of the event network may increase the realization time required for propagation processes. Consequently, propagation rates may vary across the network depending on local interaction conditions.

These variations in propagation behavior play a central role in the subsequent interpretation of gravitational phenomena. In particular, regions with higher interaction density may produce increased realization times, leading to reduced propagation rates and corresponding changes in the effective rate of change within the network.

The following section introduces the concept of realization time τ in greater detail and examines the mechanisms by which interaction processes influence propagation dynamics

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4. Realization Time τ

The realization time τ represents the temporal interval required for a propagation step to occur within the event–relational network. In the Hypostatic framework, propagation is not assumed to occur instantaneously. Instead, the realization of an interaction at a new relational position requires the completion of underlying interaction processes within the network.

The quantity τ therefore represents the time required for the conditions necessary for a propagation event to become realized. This realization time is not treated as a universal constant but as a quantity that may vary depending on the local interaction environment.

Operationally, τ functions as the temporal component in the propagation relation

$$v = \lambda / \tau$$

where λ represents the characteristic relocation length associated with a propagation step and v represents the effective propagation rate within the network.

In regions where interaction processes are sparse, the realization of propagation events may occur with relatively small τ. In regions where interactions are more frequent or complex, the realization of propagation events may require additional interaction processes before completion, resulting in larger values of τ.

This interpretation treats τ as an emergent measure of the interaction workload associated with propagation. Rather than representing an externally imposed temporal parameter, realization time reflects the internal dynamics required for propagation processes to occur.

Because propagation establishes the operational progression of events within the network, variations in realization time correspond to variations in the effective rate at which events can occur. Larger realization times therefore correspond to reduced propagation rates and slower effective rates of change within the event network.

It is important to emphasize that the present work treats τ as a phenomenological parameter describing propagation dynamics rather than as a derived quantity from a complete microscopic theory. The mechanisms determining the precise dependence of realization time on interaction processes remain an open question.

The following section examines how interaction density within the event network may influence realization time and how this influence may produce effective propagation drag within regions of increased interaction complexity.

5. Interaction Density and Propagation Drag

Within the event–relational network described by the Hypostatic framework, propagation processes occur through sequences of interaction realizations between related events. The local interaction environment therefore plays a direct role in determining the conditions under which propagation steps can occur.

A useful descriptive quantity in this context is the interaction density, which represents the relative concentration of interaction processes occurring within a region of the event network. Regions containing larger concentrations of realized energy or more frequent event interactions correspond to higher interaction density.

Higher interaction density increases the number of interaction processes that must occur before a propagation step can be realized. As discussed in the previous section, propagation requires a realization time τ, representing the time required for the necessary interaction conditions to be satisfied. When the number or complexity of interactions increases, the realization time required for propagation may also increase.

This effect can be interpreted as a form of propagation drag within the event network. In regions where interaction density is elevated, propagation processes encounter greater interaction workload before completion. The resulting increase in realization time reduces the effective propagation rate defined by

$v = \lambda / \tau$
where λ represents the characteristic relocation length and τ represents the realization time.

Propagation drag therefore describes the reduction in effective propagation rate produced by increased interaction density within the event network. Importantly, this drag does not represent friction in a conventional mechanical sense. Instead, it reflects the additional interaction processes required for propagation to occur in regions of higher interaction complexity.

Two conceptually distinct contributions to propagation drag may be considered. The first arises from the ambient interaction structure of the event network itself, representing a baseline level of propagation resistance present even in regions of low interaction density. The second arises from localized increases in interaction density associated with concentrations of realized energy or matter-like structures.

The total propagation drag within a region may therefore be interpreted as the combined effect of ambient interaction structure and localized interaction density. Regions containing large concentrations of realized energy correspond to regions of increased propagation drag within the event network. Conceptual links between gravitational phenomena and underlying statistical or thermodynamic processes have been explored in several previous approaches (Jacobson 1995; Verlinde 2011).

Spatial variation in propagation drag leads to corresponding variation in effective propagation rates across the network. As propagation rates vary, the rate at which events can occur within different regions of the network also varies. These variations in effective rates of change form the basis for the interpretation of gravitational phenomena developed in the following section.

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6. Emergent Gravitational Behavior

The preceding sections introduced propagation dynamics within an event–relational network and described how increased interaction density can produce propagation drag through increases in realization time τ. When propagation drag varies across the network, corresponding variations arise in the effective propagation rate

$v = \lambda / \tau$

These spatial variations in propagation rate have direct consequences for the operational progression of events. Because propagation governs the realization of events within the network, regions with larger realization times correspond to regions in which the effective rate of change is reduced.

Under this interpretation, regions of high interaction density correspond to regions in which propagation occurs more slowly. Events within such regions require longer realization times before propagation processes can occur. As a result, the effective progression of events in these regions proceeds more slowly relative to regions with lower interaction density.

This behavior corresponds qualitatively to the phenomenon commonly described as gravitational time dilation, in which physical processes occur at different effective rates depending on the surrounding gravitational environment. Within the Hypostatic framework, such differences arise from variations in realization time produced by interaction density rather than from curvature of spacetime geometry. Gravitational time dilation and related phenomena are well established predictions of relativistic gravitational theory (Einstein 1915; Misner, Thorne & Wheeler 1973).

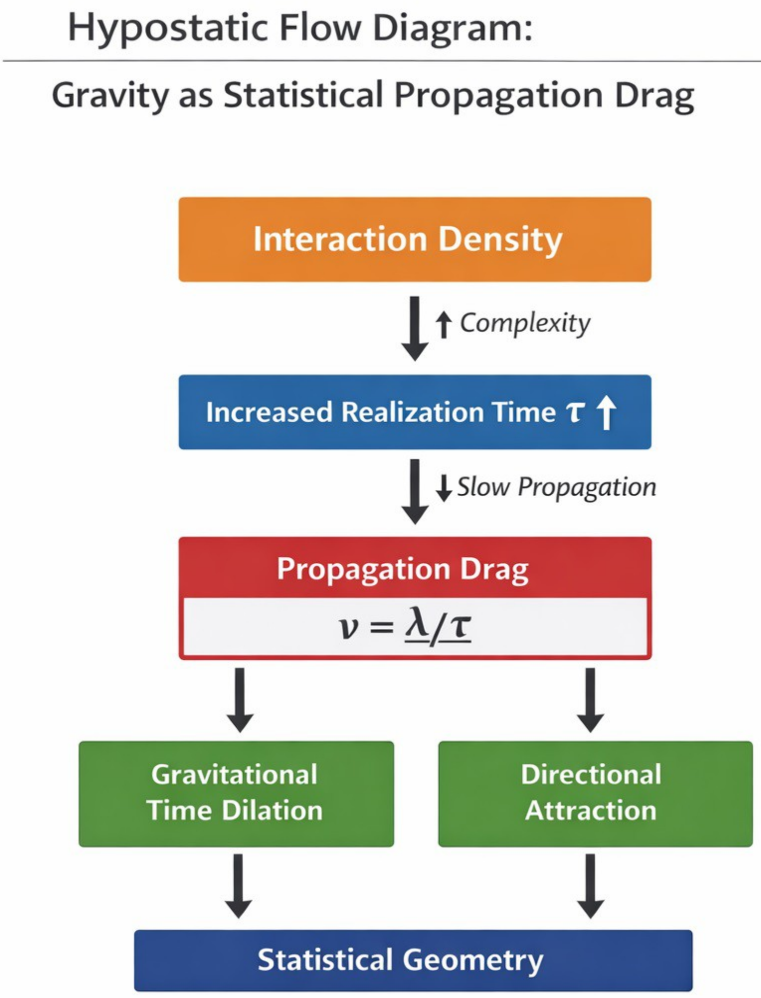
Spatial variation in propagation drag may also influence the trajectories followed by propagation processes across the event network. Propagation tends to occur preferentially along relational paths requiring smaller realization times. Regions with elevated interaction density therefore act as regions of increased propagation resistance, altering the effective propagation paths available within the network.

When propagation processes are statistically redirected toward regions of lower propagation resistance, large-scale propagation patterns may appear as systematic attraction toward regions of higher interaction density. At macroscopic scales, such statistical behavior may correspond to the dynamical effects commonly interpreted as gravitational attraction.

Within this interpretation, gravitational phenomena do not arise from intrinsic curvature of a geometric manifold but from spatial variation in propagation dynamics within the event network. Regions of increased interaction density modify the local realization time associated with propagation, producing effective propagation drag that alters the statistical behavior of propagation processes.

Macroscopic gravitational behavior may therefore be interpreted as the cumulative statistical effect of propagation drag across many interacting events. The geometric description employed in gravitational physics may then be viewed as an effective large-scale representation of these propagation dynamics rather than as a fundamental structural feature of physical reality.

It is important to emphasize that the present description is qualitative and conceptual. The development of a quantitative theory capable of reproducing the full range of gravitational phenomena remains an open problem within the Hypostatic framework.



7. Correspondence with GR Observables

The interpretation of gravity presented in the preceding sections differs conceptually from the geometric description employed in General Relativity. In General Relativity, gravitational phenomena arise from curvature of spacetime geometry produced by the distribution of stress–energy. The Hypostatic framework instead interprets gravitational behavior as a consequence of spatial variation in propagation dynamics within an event–relational network.

Despite these differing conceptual foundations, a number of observed gravitational phenomena may be interpreted qualitatively within the propagation-drag framework described above. The purpose of this section is to outline possible correspondences at the level of observable phenomena. The discussion is therefore descriptive and does not constitute a derivation of relativistic gravitational dynamics.

One of the most prominent observational features of gravitational fields is gravitational time dilation, in which physical processes occur at different effective rates depending on gravitational environment. In the Hypostatic framework, variations in realization time τ produce corresponding variations in effective propagation rate $v = \lambda / \tau$. Regions with higher interaction density correspond to larger realization times, leading to reduced effective propagation rates. Because propagation governs the realization of events within the network, such variations may correspond qualitatively to differences in the effective rate at which physical processes occur.

Another widely observed feature of gravitational systems is the systematic motion of bodies within gravitational fields, including orbital motion and gravitational acceleration toward regions of large mass–energy concentration. Within the propagation-drag interpretation, spatial variation in realization time modifies the statistical propagation paths available within the event network. Regions of elevated interaction density correspond to regions of increased propagation resistance. At large scales, propagation processes may therefore exhibit systematic statistical tendencies that appear as motion toward such regions.

General Relativity also predicts the bending of light trajectories in the presence of strong gravitational fields. Within the Hypostatic framework, propagation processes involving radiation or other rapidly propagating interactions may also experience altered propagation paths in regions where realization time varies spatially. While no quantitative derivation is presented here, variations in propagation conditions could qualitatively influence the effective trajectories followed by propagating signals. (Misner, Thorne & Wheeler 1973)

These examples illustrate that a number of gravitational phenomena traditionally interpreted through spacetime curvature may also be discussed in terms of spatial variation in propagation dynamics. However, it must be emphasized that the present work does not provide a complete dynamical theory capable of reproducing the precise quantitative predictions of General Relativity.

In particular, the present framework does not yet provide explicit formulations corresponding to the tensor structure of the Einstein field equations, nor does it demonstrate recovery of the full relativistic structure associated with Lorentz invariance, geodesic motion, or gravitational wave propagation. Establishing such correspondence would require the development of a substantially more detailed dynamical theory.

The correspondences described here should therefore be regarded as qualitative interpretational parallels rather than demonstrations of theoretical equivalence. The purpose of this comparison is to clarify how familiar gravitational observables might be understood within a propagation-dynamics framework while recognizing that significant theoretical work remains necessary to establish quantitative agreement with existing gravitational theory.

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8. Limitations and Open Problems

The interpretation of gravitational phenomena presented in this work is conceptual and exploratory. While the preceding sections outline a possible mechanism by which gravitational behavior might emerge from propagation dynamics within an event–relational network, the present formulation remains incomplete in several important respects.

First, the current framework does not provide a fully developed mathematical theory describing propagation dynamics within the event network. Quantities such as interaction density, realization time τ, and propagation drag are introduced phenomenologically in order to describe possible mechanisms, but their precise definitions and governing equations remain to be established. A rigorous formulation capable of producing quantitative predictions would require a much more detailed description of the underlying interaction structure.

Second, the present work does not derive the Einstein field equations or demonstrate formal equivalence with General Relativity. While qualitative correspondences between propagation drag and gravitational phenomena have been discussed, the tensor structure central to relativistic gravitational theory has not been reproduced within the Hypostatic framework. In particular, no formulation corresponding to the Einstein tensor $G_{\mu\nu}$, the stress–energy tensor $T_{\mu\nu}$, or the associated conservation relations has yet been developed.

Third, the framework does not currently provide a quantitative description of relativistic gravitational phenomena such as orbital precession, gravitational lensing, or gravitational wave propagation. Although the propagation-drag interpretation may offer qualitative insight into these phenomena, reproducing the precise predictions verified by observational tests of General Relativity would require a significantly more detailed dynamical model.

Fourth, the relationship between propagation dynamics and the large-scale geometric structure used in relativistic physics remains unresolved. The present work suggests that geometry may emerge as a macroscopic statistical description of propagation behavior within an event network. However, the mechanism by which such an effective geometric structure would arise from microscopic interaction dynamics has not yet been derived.

Fifth, the dependence of realization time τ on interaction density and other physical conditions remains unspecified. While the concept of interaction density provides a useful descriptive framework, a complete theory would require a precise quantitative definition of this quantity and a dynamical law governing its influence on propagation processes.

Sixth, the compatibility of the proposed framework with the principles of relativistic invariance and causal structure has not yet been established. A viable gravitational theory must ultimately reproduce the experimentally verified relativistic behavior of physical systems. Demonstrating that propagation dynamics within an event network can recover these features remains an important open problem.

Finally, the present work does not attempt to address the broader unification of gravitational phenomena with other fundamental interactions. If propagation dynamics within an event–relational network provide a fundamental description of physical processes, a complete theory would ultimately need to account consistently for all known interactions within this framework.

These limitations highlight the exploratory nature of the present proposal. The interpretation of gravity as statistical propagation drag should therefore be regarded as a conceptual hypothesis rather than a completed physical theory. Substantial theoretical development, including the construction of explicit dynamical models and quantitative comparison with empirical observations, would be required to determine whether the framework can provide a viable alternative description of gravitational phenomena.

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9. Conceptual Relationship to the Geometric Description of Gravity

The Hypostatic framework proposes an alternative conceptual interpretation for phenomena commonly attributed to gravitation. This subsection outlines a tentative correspondence between the standard formulation of gravity in General Relativity and the mechanism proposed within the Hypostatic framework. The purpose of this comparison is not to claim equivalence of formalisms, but to clarify how similar observed phenomena might arise from different underlying mechanisms.

In General Relativity, gravitational phenomena are described through the Einstein field equations,

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = (8\pi G/c^4)\, T_{\mu\nu}$$

where the stress–energy tensor $T_{\mu\nu}$ represents the local distribution of mass–energy, and the Einstein tensor $G_{\mu\nu}$ describes the curvature of spacetime geometry. In this formulation, spacetime geometry is treated as fundamental, and gravitational effects arise from curvature induced by matter–energy. The Einstein field equations provide the standard mathematical description of relativistic gravity (Einstein 1915).

Within the Hypostatic framework, gravity is interpreted differently. Rather than being associated with intrinsic curvature of spacetime, gravitational behavior is provisionally interpreted as arising from statistical propagation drag within an interaction network of events. In this picture, regions with higher realized energy content and higher interaction density increase the realization time τ associated with propagation processes. The local propagation rate may be expressed phenomenologically as

$$v = \lambda / \tau$$

where λ represents a characteristic relocation length and τ represents the realization time required for propagation processes. Increasing interaction density increases τ, which reduces the effective propagation rate and therefore modifies the local rate of change.

Within this interpretation, gravitational phenomena such as gravitational time dilation and dynamical attraction are understood as macroscopic consequences of spatial variations in propagation drag. Regions of higher interaction density correspond to regions of increased propagation resistance, producing systematic differences in effective propagation rates across the event network.

The Hypostatic framework therefore reverses the usual hierarchy assumed in General Relativity. Instead of treating geometry as a primitive structure from which gravitational dynamics follow, the Hypostatic approach treats geometry as an emergent macroscopic description of propagation behavior within an event–relational network. In this interpretation the conceptual hierarchy may be summarized schematically as

event interactions

↓
propagation dynamics
↓
local propagation rate ($v = \lambda / \tau$)
↓
propagation drag
↓
effective gravitational behavior
↓
emergent geometric description

Under this interpretation, the geometric description employed in General Relativity may be viewed as an effective macroscopic representation of underlying propagation dynamics rather than as a fundamental property of physical reality.

It should be emphasized that the present work does not attempt to derive the Einstein field equations or to demonstrate mathematical equivalence between the two descriptions. The correspondence outlined here is therefore purely conceptual and intended to clarify how the Hypostatic framework might reproduce familiar gravitational phenomena through a different underlying mechanism.

A full comparison with relativistic gravitational dynamics, including the recovery of Lorentz invariance, light-cone structure, and quantitative gravitational effects, remains an open problem for future work.

Conceptual Summary

> The Hypostatic framework interprets gravitational phenomena as arising from statistical propagation dynamics within an event–relational network. Differences in interaction density modify the realization time τ associated with propagation processes. Increased realization time reduces the effective propagation rate $v = \lambda / \tau$, producing propagation drag within regions of elevated interaction density. Spatial variation in this drag alters the statistical behavior of propagation processes, leading to macroscopic phenomena corresponding to gravitational time dilation and effective gravitational attraction. In this view, spacetime geometry represents an emergent large-scale description of propagation dynamics rather than a fundamental structure.

10. Conclusion

This work has outlined a conceptual interpretation of gravitational phenomena within the Hypostatic framework. The analysis begins with an event–relational ontology in which physical reality is described as a network of interacting events rather than as objects embedded within a pre-existing geometric manifold.

Within this framework, propagation processes occur through sequential realizations of interactions between events. The realization time τ required for these propagation steps may vary depending on the local interaction environment. Regions with higher interaction density may require larger realization times before propagation events can occur, producing an effective reduction in propagation rate.

This effect was described as propagation drag, representing the increased interaction workload associated with propagation in regions of elevated interaction density. Spatial variation in propagation drag alters the effective rate at which events occur within different regions of the event network.

Such variations in propagation dynamics may correspond qualitatively to gravitational phenomena commonly interpreted through spacetime curvature, including gravitational time dilation and large-scale gravitational attraction. Within the Hypostatic framework, these effects arise from statistical propagation behavior within an interaction network rather than from intrinsic geometric curvature.

The discussion presented here is conceptual and exploratory. The present formulation does not derive the equations of relativistic gravity or provide a complete dynamical theory capable of reproducing the full range of gravitational phenomena. Instead, the analysis proposes a possible interpretational framework in which gravitational behavior may emerge from propagation dynamics governed by interaction density and realization time.

Further theoretical development would be required to establish a rigorous mathematical description of the event network, to define interaction density and realization time quantitatively, and to determine whether such a framework can reproduce the empirical predictions of established gravitational theory.

The interpretation of gravity as statistical propagation drag should therefore be regarded as a conceptual hypothesis intended to explore an alternative perspective on the emergence of gravitational phenomena from underlying interaction dynamics.

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