Operational Separation as Admissibility Transport Failure in Quantum Collapse Geometry

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Abstract

Relativistic no-signalling constraints play a central role in delimiting admissible correlations in spacetime, yet they are typically imposed as fundamental consistency conditions rather than derived from a deeper structural principle. In this work, we provide a collapse-geometric reinterpretation of these constraints within the framework of Quantum Collapse Geometry (QCG), in which physical structure arises through selection under constraint on a relational configuration space.

We introduce the notion of *admissibility transport*, defined as the existence of collapse-consistent pathways by which perturbations propagate between regions of configuration space. Within this formulation, we show that the operational separation relation employed in relativistic no-signalling frameworks admits a natural interpretation as a failure of admissibility transport. As a consequence, no-signalling constraints emerge as statements of invariance: when no admissible transport exists from a set of inputs to a set of outputs, the corresponding observable structure remains independent of those inputs under collapse.

This perspective recovers standard no-signalling results without modification while providing a unifying structural account of phenomena such as nonlocal correlation jamming and the behavior of correlations in curved spacetimes. In particular, we interpret these effects as arising from the interplay between local admissibility and global transport constraints, rather than from spacetime geometry alone.

Our results suggest that causal structure in physical theories may be understood as an emergent feature of admissibility transport under collapse-selection dynamics, offering a pathway toward a more general, constraint-based foundation for information flow in physical systems.

1 Introduction

Relativistic constraints on information flow are among the most robust structural features of modern physics. Within both classical and quantum frameworks, the prohibition of superluminal signalling is typically implemented as a condition on admissible correlations between spacetime-localized variables, ensuring compatibility with the causal structure defined by light cones. At the same time, quantum theory admits nonlocal correlations that defy classical causal explanation while nevertheless respecting these operational constraints. This coexistence of nonlocal structure with strict signalling limitations has led to a wide range of formal frameworks in which no-signalling is treated as a primitive consistency requirement on observable statistics. However, in such approaches the origin of these constraints remains largely implicit: they are imposed to ensure compatibility with relativistic causality, rather than derived from a more general structural principle governing the emergence of admissible physical configurations. Relativistic constraints on information flow are among the most robust structural features of modern physics. In both classical and quantum frameworks, the prohibition of superluminal signalling is typically implemented as a condition on admissible correlations between spacetime-localized variables, ensuring compatibility with light-cone structure. At the same time, quantum theory admits nonlocal correlations that defy classical causal explanation while respecting these constraints. This coexistence has led to a range of frameworks in which no-signalling is treated as a primitive condition on observable statistics. However, in such approaches the origin of these constraints remains implicit: they are imposed to ensure consistency with relativistic causality, rather than derived from a more general structural principle.

In contrast to approaches that take causal structure or signalling constraints as primitive, Quantum Collapse Geometry (QCG) begins from a minimal generative ontology in which physical structure arises through selection under constraint on a relational configuration space. In this framework, configurations are not assumed to be admissible a priori; rather, a collapse-selection operator acts to eliminate incompatible structure and stabilize admissible configurations under iteration. Observable quantities correspond to projections of this collapse-stable sector, while effective dynamical laws emerge as summaries of persistence within constrained regimes. From this perspective, the question of admissible correlations is reframed: instead of asking which correlations must be excluded to preserve relativistic causality, one asks which relational configurations can persist under admissibility constraints and how these constraints govern the propagation of structure across regions. This shift suggests that no-signalling conditions admit a structural interpretation as consequences of the underlying selection process, rather than independent postulates imposed at the level of observable statistics.

To make this connection precise, we introduce the notion of *admissibility transport*: a relational structure specifying when perturbations introduced in one region of configuration space can propagate, under collapse-selection dynamics, into the invariant sector accessible in another. Admissibility transport is defined not in terms of geometric trajectories, but through the existence of collapse-consistent pathways by which relational structure survives under constraint. Within this formulation, the operational separation relation introduced in relativistic no-signalling frameworks [1] admits a natural reinterpretation: a set of output variables is operationally separated from a set of input variables precisely when no admissible transport exists between them. Consequently, the associated no-signalling constraints can be understood as statements of invariance under collapse, rather than as externally imposed restrictions. This correspondence provides a structural bridge between operational spacetime frameworks and collapse-based ontologies, allowing the former to be recovered as a special case of admissibility transport governed by underlying selection dynamics; informally, it asks when a change in one region can survive constraint and appear elsewhere.

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2 Background

2.1 Relational Regions and Perturbations

To formulate admissibility transport in a precise manner, we introduce a minimal notion of *relational regions* and *localized perturbations* within the configuration space Σ.

Relational regions. Let Σ denote a relational configuration space whose elements $x \in \Sigma$ encode configurations of interacting degrees of freedom. We assume that Σ is equipped with a decomposition into indexed degrees of freedom, allowing restriction maps $x \mapsto x_F$ for any subset F. A *relational region* F is defined as a subset of these indices, together with the associated subconfiguration x_F.

Operationally, regions F correspond to collections of variables accessible to an agent or group of agents, such as the inputs X_F or outputs A_F in the operational framework. This identification provides a mapping between spacetime-indexed variables and subsets of relational degrees of freedom:

$$(X_i, p_i) \quad \longleftrightarrow \quad \text{degrees of freedom indexed by } i \subset \Sigma.$$

Localized perturbations. A *perturbation supported on* F is a transformation

$$\delta_F : \Sigma \to \Sigma$$

such that for any configuration $x \in \Sigma$, the perturbed configuration $x + \delta_F$ differs from x only in the components indexed by F. Formally, we require that

$$(x + \delta_F)_G = x_G \quad \text{for all regions } G \text{ disjoint from } F.$$

Operationally, such perturbations represent changes in input variables localized to F, including measurement setting choices or more general interventions. Under the assumption of free inputs, these perturbations can be varied independently.

Propagation under collapse. Given a collapse-selection operator $\Phi : \Sigma \to \Sigma$, the effect of a perturbation δ_F on a configuration x is determined by the difference between $\Phi(x + \delta_F)$ and $\Phi(x)$. We say that the perturbation *propagates* from F to a region G if this difference produces a distinguishable effect under the projection P_G to observables over G.

This provides a minimal structural notion of influence within QCG: rather than assuming geometric propagation, we characterize influence in terms of the survival of perturbations under collapse-selection.

Remarks. The definitions above are intentionally minimal. No geometric structure on Σ is assumed, and the notion of locality is defined purely in terms of support over degrees of freedom. This abstraction allows admissibility transport to be formulated independently of spacetime, while remaining compatible with operational frameworks in which regions are associated with spacetime-localized variables.

2.2 Operational–QCG Correspondence

To connect the operational no-signalling framework with the collapse-geometric formulation, we establish a correspondence between the key elements of each description. The operational framework is expressed in terms of spacetime-indexed random variables and conditional probabilities, while QCG is formulated in terms of relational configurations, collapse-selection dynamics, and projections to observable structure.

Dictionary. The correspondence is summarized as follows:

Operational Framework	**QCG Interpretation**
Spacetime random variable (X_i, p_i)	Degree of freedom indexed by i in Σ
Input variable X_i	Admissibility perturbation supported on region i
Output variable A_i	Projection of collapse-stable structure over region i
Conditional probability $P_{A\|X}$	Observable statistics derived from projected collapse-stable structure
Gathering point Q	Reconstruction locus for joint observable structure
Operational separation	Admissibility transport failure
No-signalling constraint	Invariance under perturbations eliminated by Φ

Interpretation of inputs and outputs. In the operational setting, inputs correspond to choices made by agents, including measurement settings or more general interventions. Within QCG, these are represented as perturbations δ_F supported on subsets $F \subset \Sigma$. Outputs correspond to observed measurement outcomes; in QCG, they arise as projections of the collapse-stable sector, $P_G(\Phi(x))$, onto observable degrees of freedom.

Conditional probabilities as projected invariants. The conditional probabilities $P_{A|X}(a, q \mid x, p)$ are interpreted as empirical statistics derived from the invariant structure selected by Φ. More precisely, under Assumption 4.1, observable probabilities correspond to functions of the projected invariant sector:

$$P_{A_G|X}(a_G, q_G \mid x, p) = \mathcal{P}_G\big(P_G(\Phi(x))\big)$$

Thus, probabilities do not encode fundamental dynamics directly, but rather summarize the observable consequences of admissibility under collapse-selection.

Reconstruction and gathering. In the operational framework, joint observables can be defined only at spacetime points where information from multiple regions can be gathered. In QCG, this corresponds to the existence of a reconstruction locus at which relational structure across regions can be jointly projected into an observable invariant sector. The absence of such a locus corresponds to a failure of global admissibility transport, as discussed in Sec. 6.1.

Summary. This correspondence establishes that the operational framework can be viewed as a projected description of collapse-selection dynamics on a relational configuration space. In particular, notions such as signalling, separation, and correlation can be reinterpreted in terms of admissibility and its transport under Φ, providing the foundation for the equivalence results established in subsequent sections.

3 Admissibility Transport Structure

3.1 Admissibility Transport

We formalize the propagation of relational structure under collapse-selection dynamics through the notion of admissibility transport. Let Σ denote a relational configuration space and $\Phi : \Sigma \to \Sigma$ a collapse-selection operator whose invariant sector is given by $I = \mathrm{Fix}(\Phi)$. Let $P : \Sigma \to \mathcal{O}$ denote a projection to observable structure.

Definition 3.1 (Admissibility Transport). *Let F and G denote two subsets of relational degrees of freedom, interpreted operationally as input and output regions, respectively. We say that there exists* admissibility transport *from F to G, denoted*

$$F \xrightarrow{\Phi} G,$$

if there exists a perturbation δ_F supported on F and a configuration $x \in \Sigma$ such that the induced variation propagates through collapse-selection to produce a distinguishable effect in the invariant sector over G, i.e.,

$$P_G(\Phi(x + \delta_F)) \neq P_G(\Phi(x)),$$

where P_G denotes the restriction of the projection P to the observable degrees of freedom associated with G.

Definition 3.2 (Admissibility Transport Failure)**.** *We say that* admissibility transport fails *from F to G, denoted*

$$F \overset{\Phi}{\not\longrightarrow} G,$$

if for all configurations $x \in \Sigma$ and all perturbations δ_F supported on F, the induced variation is eliminated under collapse-selection prior to affecting the observable structure over G, i.e.,

$$P_G(\Phi(x + \delta_F)) \;=\; P_G(\Phi(x))\,.$$

In this formulation, admissibility transport characterizes the existence of collapse-consistent pathways by which relational structure can influence distant observable sectors. Its failure corresponds to the elimination of all such pathways under admissibility constraints, yielding invariance of the observable structure over G with respect to perturbations localized in F.

We assume that relational regions are indexed by the same set labeling the operational variables, allowing a direct identification between subsets of SRVs and subsets of degrees of freedom in Σ.

4 Operational Separation as Transport Failure

4.1 Operational Separation as Admissibility Transport Failure

We now connect admissibility transport to the operational no-signalling framework. We adopt the standard operational setting of conditional probabilities $P_{A|X}(a, q \mid x, p)$ for spacetime-indexed variables as in [1]. Let F, G be index sets labeling input and output regions, with spacetime tuples p_F and q_G.

Assumption 4.1 (Projection compatibility)**.** *For any region G, observable statistics $P_{A_G|X}$ arise from a projection $P_G : \Sigma \to \mathcal{O}_G$ applied to collapse-stable structure, i.e., there exists a map $\mathcal{P}_G$ such that*

$$P_{A_G|X}(a_G, q_G \mid x, p) = \mathcal{P}_G\big(P_G(\Phi(x))\big),$$

and $\mathcal{P}_G$ is injective on distinguishable observable effects.

Assumption 4.2 (Free inputs)**.** *Inputs on F can be varied independently (operational interventions), as in the standard no-signalling framework [1].*

Theorem 4.3 (Operational separation $\Leftrightarrow$ admissibility transport failure)**.** *Let F, G be subsets of agents. Under Assumptions 4.1–4.2, the following are equivalent:*

(i) The output region q_G is operationally separated from the input region p_F.

(ii) Admissibility transport fails from F to G, i.e.,

$$F \overset{\Phi}{\not\longrightarrow} G, \quad \textit{equivalently} \quad P_G(\Phi(x + \delta_F)) = P_G(\Phi(x)) \quad \forall x,\ \forall \delta_F \textit{ supported on } F.$$

This equivalence is understood at the level of observable statistics, and identifies operational separation with a structural property of the collapse operator.

Proof. (i) $\Rightarrow$ (ii). Operational separation implies the no-signalling condition

$$P_{A_G|X}(a_G, q_G \mid x, p) = P_{A_G|X}\big(a_G, q_G \mid x', p\big)$$

for all assignments x, x' that differ only on F. By Assumption 4.2, such variations correspond to arbitrary perturbations δ_F on F. By Assumption 4.1, distinguishability of $P_G(\Phi(\cdot))$ is faithfully reflected in $P_{A_G|X}$. Hence the equality of output statistics for all such perturbations implies

$$P_G(\Phi(x + \delta_F)) = P_G(\Phi(x))$$

for all x and δ_F, i.e., admissibility transport fails.

(ii) ⇒ (i). If admissibility transport fails, then for all x and all perturbations δ_F supported on F,

$$P_G(\Phi(x+\delta_F)) = P_G(\Phi(x))\,.$$

Applying $\mathcal{P}_G$ (Assumption 4.1) yields

$$P_{A_G|X}(a_G, q_G \mid x, p) = P_{A_G|X}\big(a_G, q_G \mid x', p\big)$$

for any x, x' differing only on F. By the operational definition, this is precisely the no-signalling condition for F to G, which holds iff q_G is operationally separated from p_F. □

Remark 4.4. The equivalence holds at the level of operational statistics under Assumptions 4.1–4.2. In particular, the QCG notion of transport is defined on relational configurations, while operational separation is defined in spacetime; the theorem shows that, once observables are obtained via projection from collapse-stable structure, both notions impose the same invariance constraints on admissible correlations.

4.2 Corollary: No-Signalling as Emergent Invariance

The equivalence established in Theorem 4.3 admits a direct interpretive consequence. In the operational framework, no-signalling is expressed as a constraint on conditional probabilities, ensuring that variations in inputs localized in one region do not affect output statistics in an operationally separated region. Within the collapse-geometric formulation, this same condition arises as an invariance property of the observable sector under admissibility transport failure.

Corollary 4.5 (No-signalling as emergent invariance)**.** *Under Assumptions 4.1–4.2, the no-signalling condition from F to G is equivalent to the invariance of the observable structure over G under all perturbations supported on F, i.e.,*

$$P_G(\Phi(x+\delta_F)) = P_G(\Phi(x)) \quad\Longleftrightarrow\quad P_{A_G|X}(a_G, q_G \mid x, p) = P_{A_G|X}\big(a_G, q_G \mid x', p\big)\,,$$

for all configurations x and all x' differing from x only on F.

This reformulation shifts the role of no-signalling from that of a primitive constraint to that of a derived property of admissible structure. In particular, the prohibition of operational signalling does not arise from an externally imposed restriction on correlations, but from the elimination, under collapse-selection, of all admissible pathways by which perturbations could influence the invariant sector across regions.

From this perspective, causal structure is recast as a statement about admissibility: the apparent directionality and locality of influence in spacetime correspond to the presence or absence of admissibility transport between regions. Light-cone structure, in this sense, encodes the boundary between admissible and inadmissible propagation, rather than constituting a fundamental constraint imposed independently of the underlying relational dynamics.

Importantly, this interpretation does not modify the empirical content of no-signalling constraints, nor does it introduce new dynamical assumptions. Rather, it provides a structural account of their origin, situating them within a broader framework in which observable correlations are understood as invariant residues of collapse-selection under constraint.

4.3 Illustrative Example: Two-Region Admissibility Transport

To make the notion of admissibility transport concrete, we consider a minimal two-region scenario. Let Σ be a relational configuration space with degrees of freedom partitioned into two disjoint regions F and G. Let $\Phi : \Sigma \to \Sigma$ be a collapse-selection operator with invariant sector $I = \mathrm{Fix}(\Phi)$, and let $P_G : \Sigma \to \mathcal{O}_G$ denote the projection to observables over G.

We represent configurations as pairs $x = (x_F, x_G)$ and consider perturbations δ_F supported on F, i.e., $(x_F, x_G) \mapsto (x_F + \delta_F, x_G)$.

Case 1: Admissibility transport present. Assume that there exists a collapse-consistent pathway from F to G. Concretely, suppose that Φ couples the two regions so that

$$\Phi(x_F, x_G) = \big(x_F,\ x_G + f(x_F)\big), \tag{1}$$

for some nontrivial function f. Then for a perturbation δ_F we have

$$P_G(\Phi(x_F + \delta_F, x_G)) = P_G(x_G + f(x_F + \delta_F)) \neq P_G(x_G + f(x_F))\,, \tag{2}$$

whenever $f(x_F + \delta_F) \neq f(x_F)$. Hence perturbations on F produce a distinguishable change in the observable sector over G, and admissibility transport $F \xrightarrow{\Phi} G$ is present.

Case 2: Admissibility transport failure. Assume instead that collapse-selection eliminates all influence from F to G, so that

$$\Phi(x_F, x_G) = \big(\Phi_F(x_F),\ \Phi_G(x_G)\big), \tag{3}$$

with no cross-coupling between regions. Then for any perturbation δ_F,

$$P_G(\Phi(x_F + \delta_F, x_G)) = P_G(\Phi_G(x_G)) = P_G(\Phi(x_F, x_G))\,. \tag{4}$$

Thus the observable structure over G is invariant under all perturbations supported on F, and admissibility transport fails, $F \overset{\Phi}{\not\longrightarrow} G$.

Operational interpretation. Under Assumption 4.1, the two cases correspond directly to the presence or absence of operational signalling. In Case 1, variations of inputs localized in F modify the output statistics in G, while in Case 2 they do not. Hence invariance of P_G under perturbations on F reproduces the no-signalling condition.

Remarks. This example illustrates that admissibility transport is a property of the collapse operator rather than of spacetime geometry. The distinction between Eqs. (1) and (3) captures, in minimal form, the difference between configurations that admit propagation of relational influence and those in which such influence is eliminated prior to projection. In more general settings, the coupling between regions may be nonlinear or state-dependent, but the criterion for admissibility transport remains the same: whether perturbations survive collapse to produce distinguishable effects in the invariant sector.

5 Recovery of Known Results

5.1 Jamming as Relational-Level Admissibility Modulation

A characteristic feature of relativistic correlation scenarios is the possibility of *jamming* of nonlocal correlations [1], in which joint correlations can be modified without affecting local statistics.. In the operational framework, this is expressed by the coexistence of

$$P_{A_i|X}(a_i, q_i \mid x, p) = P_{A_i|X}(a_i, q_i \mid x', p) \quad \forall i \in G, \tag{5}$$

$$P_{A_G|X}(a_G, q_G \mid x, p) \neq P_{A_G|X}(a_G, q_G \mid x', p) \quad \text{for some } G \text{ with } |G| \geq 2, \tag{6}$$

for inputs x, x' differing on a subset F. That is, all single-party statistics are invariant, while certain multi-party correlations are not.

Within the collapse-geometric formulation, this behavior admits a natural interpretation. By Theorem 4.3, the absence of signalling from F to each single site $i \in G$ implies admissibility transport failure

$$F \overset{\Phi}{\not\longrightarrow} \{i\} \quad \forall i \in G,$$

and hence invariance of the projected observables over each local sector $P_{\{i\}}(\Sigma)$. However, the existence of a change in joint statistics (6) implies that admissibility transport *does* exist at the level of the composite sector:

$$F \xrightarrow{\Phi} G.$$

Interpretation. Jamming corresponds to a regime in which admissibility transport is *blocked locally* but *allowed globally*. In other words, collapse-selection eliminates all admissible pathways by which perturbations on F could influence individual invariant sectors, while preserving pathways that affect *joint* invariant structure across G.

This can be expressed succinctly as a hierarchy of transport constraints:

$$F \overset{\Phi}{\not\longrightarrow} \{i\} \ \forall i \in G \qquad \text{but} \qquad F \xrightarrow{\Phi} G.$$

Equivalently, the invariant structure satisfies

$$P_{\{i\}}(\Phi(x + \delta_F)) = P_{\{i\}}(\Phi(x)) \quad \forall i \in G, \qquad P_G(\Phi(x + \delta_F)) \neq P_G(\Phi(x))$$

for some x and δ_F.

Consequences. This perspective clarifies several features of jamming:

- *Compatibility with no-signalling.* Since all local sectors are invariant under perturbations on F, no operational signalling is possible. Jamming affects only relational structure that is accessible *after* a gathering operation, and hence respects the operational no-signalling constraints.
- *Relational selectivity.* The collapse operator Φ acts on the relational configuration space Σ rather than on individual observables. As a result, it can suppress admissible transport to local sectors while preserving transport to composite sectors, yielding selective modification of correlations.
- *Constraint-induced hierarchy.* The existence of jamming reflects a hierarchy in admissibility transport: constraints that forbid transport to lower-order sectors need not forbid transport to higher-order sectors. This aligns with the interpretation of monogamy relations as arising from competing constraints on admissible configurations, rather than from intrinsic limitations on physical mechanisms.

In summary, jamming phenomena are naturally understood in QCG as instances of relational-level admissibility modulation: collapse-selection enforces invariance at the level of local observables while permitting controlled variation in higher-order invariant structure. This provides a structural account of jamming that is independent of specific dynamical mechanisms and consistent with relativistic constraints on information flow.

6 Extension Beyond Spacetime

6.1 Black Hole Spacetimes and Horizon Structure

The operational framework of [1] exhibits a qualitatively distinct behavior in curved spacetimes, most notably in the presence of black hole horizons. In such settings, it is possible for spacelike separated variables to admit jamming of correlations without violating the operational no-signalling constraints, and, more strikingly, for certain collections of spacetime points to lack a common gathering point altogether. Operationally, this reflects the fact that information distributed across regions may not be globally accessible to any single agent.

Within the collapse-geometric formulation, these features admit a natural interpretation in terms of admissibility transport structure. Recall that admissibility transport is defined by the existence of collapse-consistent pathways by which perturbations propagate into the invariant sector accessible at a given region. In flat spacetimes, the existence of a gathering point ensures that relational structure across separated regions can, in principle, be reconstructed, and admissibility transport is globally constrained by a light-cone structure. By contrast, in black hole spacetimes, the absence of a global gathering point corresponds to a failure of global reconstruction.

Horizon as a transport boundary. We interpret the event horizon as a boundary of admissibility transport: a locus beyond which relational structure cannot be transported, under collapse-selection dynamics, into a common invariant sector accessible to any agent. More precisely, for regions separated by a horizon, there exist subsets F, G such that admissibility transport fails globally,

$$F \overset{\Phi}{\not\longrightarrow} G \quad \text{for all admissible reconstruction loci,}$$

even though local admissibility within each region remains well-defined. This identifies the horizon as a boundary not of signal propagation, but of admissibility connectivity. In this sense, the horizon does not merely delimit causal influence in a geometric sense, but marks the boundary of global admissibility connectivity.

Jamming across horizons. The persistence of jamming phenomena in black hole spacetimes follows directly from this interpretation. Since admissibility transport may fail at the level of global reconstruction while remaining available for certain relational sectors, an agent can influence correlations between variables that cannot be jointly reconstructed, without enabling operational signalling. The resulting behavior reflects a decoupling between local invariance (preserved under no-signalling) and global relational structure (modifiable under admissible transport within constrained sectors).

Interpretation. From this perspective, horizon structure is recast as an emergent feature of admissibility transport constraints. The inability to define a global observable over separated regions is not solely a consequence of spacetime geometry, but of the absence of admissible collapse-consistent pathways linking those regions within the invariant sector. This interpretation aligns with the broader QCG program, in which geometry and causal structure arise as effective encodings of constraints on admissible relational propagation.

Importantly, this reformulation does not alter the operational predictions associated with black hole spacetimes. Rather, it provides a structural account of why such phenomena occur, situating them within a unified framework in which both flat and curved spacetime behaviors are understood as manifestations of admissibility transport under collapse-selection dynamics.

7 Conceptual Implications: Emergence of Causality

The preceding results suggest a unified structural perspective on relativistic constraints, nonlocal correlations, and horizon phenomena. In the operational framework, no-signalling, jamming, and the behavior of correlations in curved spacetimes appear as distinct features tied to spacetime geometry. Within the collapse-geometric formulation, these features are recast as consequences of a single organizing principle: admissibility transport under collapse-selection dynamics.

7.1 No-signalling as invariance under transport failure

Theorem 4.3 identifies no-signalling with invariance under admissibility transport failure:

$$F \overset{\Phi}{\not\longrightarrow} G \quad \Longrightarrow \quad P_G(\Phi(x + \delta_F)) = P_G(\Phi(x)) \,.$$

Thus, the absence of signalling arises as a consequence of the elimination, under collapse-selection, of all admissible pathways by which perturbations could influence the observable sector.

7.2 Jamming as sector-dependent admissibility

Jamming corresponds to a hierarchy in admissibility transport in which transport fails at the level of all single-party sectors while remaining available at the level of composite sectors:

$$F \overset{\Phi}{\not\longrightarrow} \{i\} \ \forall i \in G, \qquad F \xrightarrow{\Phi} G.$$

Local observables therefore remain invariant while joint correlations change, reflecting the fact that collapse-selection can suppress admissible transport to local sectors while preserving transport to relational structure accessible only after gathering.

7.3 Horizons as boundaries of admissibility connectivity

In curved spacetimes, the absence of global gathering points corresponds to a failure of global admissibility transport. As discussed in Sec. 6.1, horizons can be interpreted as boundaries beyond which no collapse-consistent pathways exist that allow relational structure to be transported into a common invariant sector. This yields a separation between local admissibility, which remains well-defined within regions, and global admissibility, which may fail across them.

7.4 Causal structure as emergent admissibility geometry

Taken together, these observations support a reinterpretation of causal structure. Rather than being imposed as a fundamental geometric constraint, causality can be viewed as an emergent feature of admissibility transport:

- The existence of admissible transport pathways determines which regions can influence one another.
- The failure of transport yields invariance conditions that manifest operationally as no-signalling.
- The geometry of admissible transport boundaries reproduces light-cone structure in flat spacetimes and horizon structure in curved spacetimes.

In this sense, spacetime causal structure functions as an effective encoding of constraints on admissible relational propagation under collapse-selection dynamics.

7.5 Scope of the Framework

The equivalence established in Theorem 4.3 and its corollary is an *operational* statement: it identifies a structural correspondence between no-signalling constraints and invariance under admissibility transport failure, given a specific set of assumptions relating collapse-selection dynamics to observable statistics.

It is important to emphasize that this reinterpretation does not modify the empirical content of relativistic causality or introduce new dynamical assumptions. The operational predictions associated with no-signalling, jamming, and horizon behavior remain unchanged. The contribution of the present work is instead structural: it provides a unifying account in which these phenomena arise from a common mechanism governing the admissibility of relational configurations and their transport.

This perspective suggests a broader program in which physical laws, including causal constraints, are understood as emergent invariance properties of collapse-stable structure. Developing a systematic classification of admissibility transport structures and their relation to effective spacetime geometries remains an open direction for future work.

Dependence on projection. The mapping from relational configurations to observable statistics is mediated by the projection $P : \Sigma \to \mathcal{O}$ and the associated map $\mathcal{P}_G$ (Assumption 4.1). The identification of no-signalling with invariance under admissibility transport failure relies on this compatibility: distinguishable effects in the invariant sector must be faithfully reflected in observable statistics. If the projection fails to preserve such distinctions, the operational equivalence may not hold.

Free-input assumption. The correspondence assumes that inputs can be varied independently as localized perturbations (Assumption 4.2). This matches the standard operational framework in which agents can freely select inputs or interventions. Scenarios in which inputs are constrained or correlated at the level of the generative dynamics fall outside the present analysis.

No claim of dynamical modification. The present work does not introduce new dynamical laws or modify existing physical predictions. The collapse-selection operator Φ is not specified as a fundamental dynamical mechanism within established theories; rather, it provides a structural representation of admissibility constraints. All empirical consequences of no-signalling, jamming, and horizon behavior remain unchanged.

Relation to spacetime structure. The reinterpretation presented here does not replace spacetime geometry. Instead, it situates causal structure as an effective encoding of admissibility transport constraints. The equivalence with operational separation holds at the level of observable correlations and does not imply that spacetime notions such as light cones can be eliminated or derived uniquely from Φ without additional structure.

Domain of applicability. The framework applies to operational scenarios describable by conditional probabilities of the form $P_{A|X}(a, q \mid x, p)$, including both spacelike and timelike correlations in relativistic settings. Extensions to other spacetime models or abstract relational systems are possible, provided suitable notions of regions, perturbations, and observable projections are defined.

Interpretive status. The collapse-geometric formulation should be understood as a *structural recasting* rather than a replacement of existing theories. It provides a unifying account of why no-signalling constraints take the form they do, by identifying them with invariance properties of collapse-stable structure. The results are therefore interpretive and organizational, but grounded in a precise equivalence at the operational level.

Within this scope, admissibility transport offers a coherent framework for understanding information flow constraints across a range of physical scenarios, while leaving open the question of how the underlying collapse-selection structure is to be realized or derived in specific physical theories.

8 Conclusion

We have provided a collapse-geometric reinterpretation of relativistic no-signalling constraints by introducing the notion of admissibility transport. Within this framework, operational separation is identified with the failure of admissibility transport, and the associated no-signalling conditions arise as invariance properties of the observable sector under collapse-selection dynamics.

This perspective recovers standard operational results without modification while unifying several phenomena—nonlocal correlation jamming and horizon behavior in curved spacetimes—under a common structural principle. In particular, we have shown that these effects can be understood as consequences of sector-dependent admissibility and the breakdown of global admissibility transport, rather than as independent features imposed by spacetime geometry.

The present work does not introduce new dynamics or alter empirical predictions. Rather, it provides a structural account of relativistic constraints, situating them within a broader framework in which observable correlations are interpreted as invariant residues of admissible relational configurations. In this sense, causal structure can be understood as an emergent geometry of admissibility transport under collapse-selection.

Future work will focus on formalizing admissibility transport within a categorical setting, classifying transport structures across collapse classes, and exploring their relation to effective spacetime descriptions and information-theoretic constraints in quantum and classical regimes.

References

[1] Michał Eckstein et al. "The operational no-signalling constraints and their implications". In: *arXiv preprint arXiv:2512.23702* (2025).