A $\kappa - BasedRe - InterpretationofLorentzSymmetry$

and the $\kappa - LimitedPropagationPrinciple$

Abstract

We give a UNNS (Unbounded Nested Number Sequences) interpretation of Lorentz symmetry as an *observability-preserving gauge* rather than a primitive spacetime postulate. The central idea is that a finite propagation bound emerges as a sharp transition in κ-observability: beyond a critical rate, local registrability, global consistency, and re-entry persistence fail. We formalize this as the *κ-Limited Propagation Principle* (KLP): the invariance of admissible observables under changes of observer follows from the requirement that all observers share the same κ-admissible propagation ceiling, identified operationally with c.

1 Setup: κ-Observability as a Constraint Stack

We model observation as a gated embedding of substrate states into registrable outcomes. Let $\mathcal{S}$ denote the space of substrate configurations, and let an observer-dependent registration map be

$$\mathsf{Obs}_{\kappa}^{(O)} : \mathcal{S} \to \mathcal{R},$$

where $\mathcal{R}$ is the space of registrable records and κ indexes a hierarchy of constraints.

We use the following informal but operational reading:

- κ_0 (existence): structural definability; no registrability requirement.
- κ_1 (local registrability): updates must be locally trackable at finite resolution.
- κ_2 (global consistency): cross-observer, cross-frame coherence of registrable invariants.
- κ_3 (re-entry persistence): propagated structure must re-enter observation without residue.

A *κ-admissible propagation* is any substrate transition chain that remains registrable under $\mathsf{Obs}_{\kappa}^{(O)}$ for all relevant observers O.

2 The κ-Limited Propagation Principle (KLP)

We now formalize the core law.

Principle (KLP)

There exists a finite constant $c > 0$ such that for any observer O and any attempted propagation process Π with effective propagation rate $v(\Pi)$,

1. (**Admissibility**) If $v(\Pi) \leq c$, then Π can be realized by a κ-admissible chain at least up through κ_2 (and typically through κ_3 for stable records).

2. (**Gate collapse**) If $v(\Pi) > c$, then Π fails *at or before* κ_2: either local registrability breaks (κ_1 collapse), or cross-observer consistency breaks (κ_2 collapse), and consequently persistence under re-entry fails (κ_3 collapse).

3. (**Observer-independence**) The threshold c is invariant across observers: all admissible observer descriptions share the same ceiling c.

In UNNS terms: c is not introduced as a speed of a particular object; it is the maximal κ-*admissible propagation rate* for registrable structure.

3 From KLP to Lorentz Symmetry: Re-Interpreting the Symmetry

Special relativity may be read as the statement that the transformation between inertial observers preserves the set of admissible observables while keeping the bound c invariant. We now derive a κ-based reinterpretation.

3.1 Axiom A (Observer change as κ-gauge)

An observer change $O \to O'$ induces a transformation $T_{O\to O'}$ on the coordinates or parameters used to report outcomes such that

$$\mathsf{Obs}_\kappa^{(O')} = \mathsf{Obs}_\kappa^{(O)} \circ T_{O\to O'}^{-1}$$

on the overlap of registrable records.

Interpretation: $T_{O\to O'}$ is a *gauge transformation of description* constrained to preserve what remains registrable at level κ.

3.2 Axiom B (Invariance of the κ-bound)

The KLP constant c is invariant under all admissible observer changes. Concretely, if a process achieves the ceiling in one inertial description (e.g. boundary excitations), it achieves the same ceiling in all inertial descriptions.

This is precisely the empirical content normally phrased as "the speed of light is invariant," but here the invariant is *the κ-admissible propagation ceiling.*

3.3 Axiom C (Homogeneity and isotropy at the registrable layer)

At the level of registrable records, inertial descriptions are related by linear transformations (preserving straight-line free propagation in record space), and the bound is isotropic.

These are standard structural assumptions about inertial frames, but in the UNNS reading they apply to the *record layer* $\mathcal{R}$ under Obs_κ, not to an assumed primitive background spacetime.

3.4 Theorem (Lorentz transformations as the unique κ-symmetry)

Under Axioms A–C, the coordinate transformation between inertial observers that preserves the ceiling c and the linear structure of inertial records is the Lorentz family (up to conventional sign and orientation choices). In particular, there exists an invariant quadratic form on record coordinates (ct, x, y, z) such that

$$(ct')^2 - (x')^2 - (y')^2 - (z')^2 = (ct)^2 - x^2 - y^2 - z^2.$$

UNNS reinterpretation. The invariant quadratic form is not taken as metaphysics about space-time; it is the *unique encoding* of the constraint that the κ-admissible propagation ceiling is observer-independent while inertial records remain linearly comparable.

Sketch of derivation. Assume a linear transform between (t, x) and (t', x') for relative motion along x. Require: (i) the set of boundary trajectories $x = \pm ct$ maps to itself (ceiling invariance), (ii) reciprocity between observers, and (iii) composition closure. These constraints determine

$$x' = \gamma(x - vt), \qquad t' = \gamma\left(t - \frac{vx}{c^2}\right), \qquad \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Here γ is not a mysterious distortion factor; it is the algebraic signature of preserving the κ-bound across observers.

4 Why γ "Breaks" Beyond c: Gate Collapse Interpretation

In standard special relativity, for $|v| > c$, γ becomes imaginary. In the κ-reading:

- The transformation remains a formal algebraic map at κ_0 (definability).
- But it ceases to represent an admissible mapping between registrable records: at κ_1 local trackability can fail, and at κ_2 cross-observer consistency fails.

Thus the "imaginary" regime is interpreted as a diagnostic for κ-admissibility failure, not as an arbitrary prohibition.

5 Results

We implemented the *κ-Limited Propagation Protocol (KLP)* in Chamber XXXIX to evaluate whether an effective propagation ceiling emerges from κ-admissibility constraints rather than being imposed kinematically. The protocol measures phase, group, and (when defined) information velocities, and evaluates three independent κ-gates: local registrability (κ_1), cross-observer consistency (κ_2), and re-entry persistence (κ_3).

Across a wide range of configurations, three distinct propagation regimes were observed.

5.1 κ-Consistent Admissible Regime

In low-dispersion, envelope-dominated configurations (group mode, small dispersive strength β, and low spatial-frequency excitation), we observe:

- sub-ceiling group velocity ($v_{\text{group}} \ll c_{\text{eff}}$),
- strong κ_1 continuity ($C_{\kappa_1} \approx 1$),
- observer-independent invariants under pseudo-boosts (κ_2 PASS),
- persistent causal records under re-entry (κ_3 PASS).

In this regime, all κ-gates pass and the protocol yields the verdict

`KLP_CONSISTENT_ADMISSIBLE (group).`

This demonstrates the existence of stable, κ-admissible propagation below the effective ceiling c_{eff}. Notably, the ceiling does not constrain phase motion directly, but rather the existence of registrable, observer-consistent carriers.

5.2 Sub-Ceiling but κ-Inadmissible (Diffusive) Regime

In configurations with stronger dispersion, higher spatial-frequency excitation, or moderate stochastic perturbation, we observe cases where:

- $v_{\text{group}} < c_{\text{eff}}$ remains satisfied,
- κ_1 collapses due to local registration discontinuity,
- κ_2 and κ_3 collapse consequentially.

Despite sub-ceiling velocities, no locally registrable carrier exists. The propagation manifests as diffusive or statistical motion without persistent structure.

This regime demonstrates that *sub-ceiling velocity is not sufficient for κ-admissibility.* The effective ceiling applies only to κ-admissible propagation, not to all forms of dynamical motion.

5.3 Phase-Dominated (Non-Registrable) Regime

In phase-dominated configurations (phase mode with high spatial-frequency excitation), phase velocity remains well-defined at the substrate level, but:

- κ_1 fails universally,
- κ_2 and κ_3 are undefined or collapse,
- no κ-admissible velocity can be assigned.

In these cases, velocities exist at the κ_0 (substrate) level but do not correspond to observable propagation. The protocol correctly returns no KLP verdict, reflecting the absence of admissible propagation rather than a violation of the ceiling.

6 Corollary: FTL $\not\Rightarrow$ Causal Paradox in UNNS

We formalize the distinction between "FTL-looking" substrate behavior and paradox-forming causal signaling in the UNNS κ-observability hierarchy.

6.1 Definitions

Let Π be an attempted propagation process on the substrate.

- (κ_0 definability) Π is κ_0-*definable* if its update rule and trajectories exist in the substrate dynamics.

- (κ_1 registrability) Π is κ_1*-registrable* if there exists a locally trackable carrier whose step-to-step continuity admits a stable registration functional. We denote its continuity score by $C_{\kappa_1}(\Pi)$.
- (κ_2 cross-observer consistency) Π is κ_2*-consistent* if for any admissible observers O, O' the registered carrier has an observer-independent description up to an admissible gauge; equivalently, the observer deviation functional is bounded.
- (κ_3 re-entry persistence) Π is κ_3*-persistent* if the registered carrier survives re-entry (replay / recomposition) as a reusable causal record. We denote its persistence score by $R_{\kappa_3}(\Pi)$.
- (Causal token) A *causal token* is a carrier that is simultaneously κ_1-registrable, κ_2-consistent, and κ_3-persistent. Such a token can be recorded, transported, and re-used to condition later events.
- (FTL-looking propagation) Π is *FTL-looking* if there exists an effective rate $v(\Pi)$ (phase-like, group-like, or inferred) such that $v(\Pi) > c_{\text{eff}}$, where c_{eff} is the κ-ceiling from the κ-Limited Propagation Principle (KLP).

6.2 Proposition (FTL does not imply causal paradox)

Proposition. In UNNS, FTL-looking propagation does not imply the existence of causal paradox. More precisely: if Π is FTL-looking, then Π cannot instantiate a causal token; hence Π cannot participate in a closed causal signaling loop.

6.3 Proof sketch (via κ-gate separation)

Assume Π is FTL-looking, i.e. $v(\Pi) > c_{\text{eff}}$.

By KLP, any attempted propagation with effective rate exceeding the ceiling fails at or before κ_2; operationally, one of the following must occur:

1. κ_1 **collapse (non-registrable pattern).** The process remains κ_0-definable, but no locally registrable carrier exists:

   $$C_{\kappa_1}(\Pi) \text{ undefined or below threshold.}$$

   Then no causal token exists, because κ_1 is necessary.

2. κ_2 **collapse (observer inconsistency).** A locally registrable carrier may appear, but cross-observer consistency fails:

   $$\Pi \text{ is observer-dependent beyond admissible gauge.}$$

   Then no causal token exists, because κ_2 is necessary for a shared causal object.

3. κ_3 **collapse (non-persistent record).** Even if κ_1 and κ_2 hold transiently, re-entry persistence fails:

   $$R_{\kappa_3}(\Pi) \text{ below threshold.}$$

   Then no causal token exists, because κ_3 is necessary for a reusable message.

In all cases, Π fails to produce a causal token. But causal paradox requires a reusable message-token that can be registered, transported across observers, and re-used to form a closed loop ("send a message that prevents itself"). Without a causal token, no stable loop can be instantiated.

Therefore, FTL-looking propagation does not imply causal paradox in UNNS. □

6.4 Interpretation

This result decomposes "FTL" into distinct failure modes rather than treating it as a single forbidden condition:

- *FTL pattern* $\Rightarrow \kappa_1$ collapse (no carrier).
- *FTL carrier attempt* $\Rightarrow \kappa_2$ collapse (no shared causal object).
- *FTL token attempt* $\Rightarrow \kappa_3$ collapse (no persistent record).

Consequently, the conventional route from FTL to paradox is blocked not by algebraic prohibition but by κ-admissibility: paradox formation requires κ_3, and κ_3 is precisely what fails beyond the admissible ceiling.

6.5 Corollary (Lorentz-like symmetry as a κ-gauge)

Since κ_2 encodes cross-observer consistency, the admissible observer transformations are exactly those that preserve κ_2 below the ceiling. In this sense, Lorentz-like symmetry is not postulated but emerges as the unique gauge family compatible with κ-admissible propagation.

7 Relation to Physical Propagation and Relativity

The results of Chamber XXXIX clarify the operational meaning of relativistic speed limits.

In conventional formulations, the invariance of the speed of light is postulated at the level of spacetime geometry, and superluminal velocities are excluded kinematically. In contrast, KLP demonstrates that an effective ceiling emerges from *structural admissibility constraints*:

- Phase motion (analogous to phase velocity in wave mechanics) may exceed the ceiling but is κ_1-inaccessible and therefore non-physical.
- Group-like motion corresponds to κ_1-registrable carriers and is constrained by κ-admissibility rather than coordinate postulates.
- Information-bearing propagation requires κ_3 persistence and cannot exist beyond the κ-admissible ceiling.

This naturally mirrors the standard distinction between phase velocity, group velocity, and signal or information velocity in physical systems, but reframes it as a hierarchy of κ-gates rather than a hierarchy of speeds.

From this perspective, Lorentz-like symmetry is not fundamental but *emerges as the unique transformation class preserving κ-admissibility under observer changes*. The breakdown of relativistic transformations beyond the speed of light corresponds to κ-gate collapse rather than algebraic inconsistency.

8 Summary of Empirical Implications

The Chamber XXXIX results support the following conclusions:

1. A finite effective propagation ceiling exists for κ-admissible structures.

2. This ceiling does not apply to all dynamical motion, only to registrable, observer-consistent carriers.
3. Superluminal patterns are generically present at the substrate level but are excluded from observability by κ-gate collapse.
4. Relativistic speed limits can be interpreted as consequences of κ-admissibility rather than axioms of spacetime geometry.