Epistemic Regimes in Relativistic Spacetime

A Semantic Theory of Observation Without Global Comparability

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Abstract

This paper develops an epistemology-first account of observation in relativistic spacetime. Observational outcomes are organized into epistemic regimes determined by access and operational distinguishability, prior to semantic interpretation. In Special Relativity, global observational comparability is preserved despite the absence of absolute rest or simultaneity, yielding a single epistemic regime. In General Relativity, spacetime curvature fragments observational access, producing multiple, locally defined epistemic regimes separated by horizons and causal boundaries. Observation is shown to preserve epistemic structure without guaranteeing semantic invariance, and no observational procedure can recover invariants eliminated by curvature-relative equivalence. Many apparent paradoxes in relativistic physics are traced to demands for global knowledge that violate epistemic regime constraints.

Contents

1 Motivation and Inversion Principle

Relativistic physics is traditionally presented as a theory of spacetime structure, with epistemic questions addressed afterward. This paper reverses that order.

1.1 Why Start With Observation

Observation is the sole interface between theory and empirical content. Any physical quantity lacking observational accessibility cannot contribute to knowledge, regardless of ontological status.

1.2 Epistemology as Constraint

Epistemology is not interpretive commentary. It constrains which questions are well-posed and which comparisons are meaningful.

1.3 Relation to SRT and QOT

This work precedes semantic interpretation (SRT) and relies on non-intervening observation (QOT). Epistemic structure determines what semantic structure can exist.

2 Observers, Observations, and Contexts

2.1 Observational Agents

Observers are not privileged entities but loci of access.

2.2 Observational Contexts

An observational context specifies admissible procedures and accessible domains.

2.3 Outcomes vs. Descriptions

Observational outcomes encode access; descriptions encode representation.

2.4 Observation Without Intervention

Observation is semantic projection, not physical execution.

3 Relativistic Constraints on Observation

3.1 Locality of Observational Access

Relativity constrains access by causal structure.

3.2 Absence of Global Observers

No observer has access to all outcomes.

3.3 Limits on Comparability

Comparability requires shared access, not shared coordinates.

4 Observation in Special Relativity

Lemma 4.1 (Global Accessibility in Flat Spacetime)**.** *In flat spacetime, observational access can be extended globally.*

Proof. Global inertial frames exist and are related by Lorentz transformations preserving causal structure and operational access. □

Proposition 4.2 (Global Epistemic Equivalence)**.** *Lorentz transformations preserve epistemic equivalence.*

Theorem 4.3 (Global Epistemic Regime in Special Relativity)**.** *Special Relativity admits a single global epistemic regime.*

Remark 4.4. Special Relativity eliminates privileged observers, not global knowledge.

5 Observation in General Relativity

5.1 Curvature and Fragmentation

Curvature restricts access itself.

5.2 Horizons

Horizons mark epistemic boundaries.

5.3 Singularities

Singularities mark breakdowns of epistemic continuation.

6 Epistemic Regimes

Let $\mathcal{O}$ denote the total observational outcome space.

Definition 6.1 (Epistemic State)**.** An epistemic state is a subset $E \subseteq \mathcal{O}$ representing all outcomes accessible to an observer.

Definition 6.2 (Epistemic Equivalence)**.** Two epistemic states E and E' are epistemically equivalent if there exists a bijection preserving operational distinguishability.

Definition 6.3 (Epistemic Regime)**.** An epistemic regime is an equivalence class of epistemic states.

Lemma 6.4 (Locality of Knowledge)**.** *All epistemic regimes are inherently local.*

Proposition 6.5 (No Global Epistemic Regime)**.** *In General Relativity, no global epistemic regime exists.*

Proposition 6.6 (Epistemic Precedence)**.** *Semantic regimes presuppose epistemic regimes.*

Remark 6.7. Epistemology fragments before meaning does.

7 Observation, Invariance, and Meaning

Definition 7.1 (Observational Projection)**.** Observation is a projection π_E from accessible outcomes to epistemic regimes.

Proposition 7.2 (Epistemic Preservation)**.** *Observation preserves epistemic invariants but not semantic invariants.*

Proposition 7.3 (Irrecoverability)**.** *No observation can recover a semantic invariant lost to curvature-relative equivalence.*

Definition 7.4 (Epistemic Invariance)**.** A quantity preserved within an epistemic regime.

Definition 7.5 (Semantic Invariance)**.** A quantity descending to a semantic regime.

Theorem 7.6 (Non-Equivalence of Invariances)**.** *Epistemic invariance does not imply semantic invariance.*

Remark 7.7. Knowledge fragments first. Meaning fragments second.

8 Consequences for Relativistic Physics

Proposition 8.1 (Ill-Posed Global Questions). *Questions requiring access across epistemic regimes are ill-posed.*

Proposition 8.2 (Invalid Global Demands). *Demands for global description exceed epistemic capacity.*

Theorem 8.3 (Epistemic Humility Principle). *Only statements invariant under epistemic and semantic regimes are observer-independent.*

Corollary 8.4 (Paradoxes as Category Errors). *Many relativistic paradoxes arise from epistemic overreach.*

9 Conclusion

Observation constrains access before interpretation assigns meaning. Relativity limits what can be known prior to limiting what can be said. Epistemic regimes form before semantic regimes, and fragmentation of knowledge is a structural feature of spacetime, not a failure of theory.

Knowledge fragments before meaning. Relativity filters epistemology first.

Appendix F: References

References

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