Ontology of Global Time: Local Observers, Sources and Destinations

Alexey A. Nekludoff

AstraVerge Research

E-mail: an@astraverge.org
ORCID: 0009-0002-7724-5762

16 February 2026

Abstract

This note defines "global time" as an *operational* and *canonical* ordering constructed from locally registered event sequences. We separate (i) the inaccessible intrinsic order of a remote source from (ii) the only order available to a destination: the order of reception. We show that multiple sufficiently distant periodic sources distributed across the sky allow the construction of a robust canonical global order for a bounded locality (e.g. the Solar System), without requiring access to any absolute or global spacetime time coordinate. The result is an ontological specification of admissible temporal order sufficient for coordination and coherent observation.

Keywords: global time; canonical order; operational globality; local observers; sources and destinations; pulsars; synchronization; distributed systems.

Contents

1 Introduction

Most practical systems operate on *registered order*, not on reconstructed "true" histories. Whenever events originate outside a local domain of access, a destination cannot, in general, recover the intrinsic ordering of the source. What is available is only the order in which events are received and locally registered.

Despite this limitation, coordination, accounting, scientific measurement, and large-scale technical systems function reliably. They do so by imposing a *canonical order* on observable events, rather than by attempting to reconstruct inaccessible histories.

This work makes that move explicit. It treats *global time* not as a discovered physical quantity, but as a constructed canonical order, sufficient for coordination within a bounded locality. The focus is not on what time "is" in itself, but on what orderings are admissible, reproducible, and operationally meaningful.

By formulating explicit axioms, definitions, and theorems, the paper specifies conditions under which a global temporal order may be declared, how such an order attains procedural uniqueness, and why local clocks must be subordinated to it at the level of maximal attainable precision. No appeal is made to intrinsic source time, absolute temporal structure, or any particular spacetime model.

In this sense, the contribution is ontological rather than physical: it defines the status of global time as a canonical ordering constraint required for coherent coordination and observation.

Ontological context. The present approach is compatible with the broader framework of the Philosophy of Discrete Being (FDB) [1], in which temporal order is treated as ontologically primary. Within FDB, a Global Tick Generator (GTG) may be postulated as an underlying rhythm of event ordering. However, the construction developed here does not assume observational access to such a generator. Global time is introduced solely as a canonical order constructed from accessible reception sequences, independently of any deeper ontological commitments.

2 Core Distinction: Source Order vs. Reception Order

Let a *source* emit repeatable marks (ticks) and a *destination* register receptions.

Definition 1 (Local observer, source, destination). *A* local observer *is any agent capable of registering events into a finite sequence. A source $s \in \mathcal{S}$ emits marks whose internal structure is not assumed to be accessible. A* destination $d \in \mathcal{D}$ *registers receptions of marks as events.*

Definition 2 (Reception sequence). *For destination d, the* reception sequence *of source s is*

$$\mathsf{Seq}_d(s) = \langle e_1, e_2, \dots \rangle,$$

ordered by the destination's act of registration ("as received").

Axiom 1 (Operational inaccessibility of intrinsic source order). *For a remote source s and a destination d, there exists no operational procedure by which d can uniquely reconstruct the intrinsic event order of s from received marks alone. Therefore, only the reception sequence $\mathsf{Seq}_d(s)$ is admissible as a basis for canonical ordering at d.*

Remark 1. *This axiom does not deny the existence of an intrinsic source order. It states that such order is non-operational for the destination and therefore excluded from the ontology of controllable statements.*

Axiom 2 (Primacy of reception order)**.** *All canonical orderings used for coordination must be constructed solely from locally registered reception sequences.*

Axiom 3 (Multi-source synchronizability)**.** *Let d be a destination and let $S = \{s_1, \ldots, s_N\} \subset \mathcal{S}$ be a finite set of sources distributed across the celestial sphere. The concurrent reception of marks from sources in S provides sufficient structure for the destination d to establish a synchronized local ordering among the received sequences.*

Axiom 4 (Canonical global order as an operator)**.** *A global canonical order is constructed as a mathematical operator applied to a family of reception sequences $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$ obtained from multiple sources. The resulting order depends solely on the chosen operator and the locally registered sequences, and not on any assumed intrinsic source order.*

Remark 2. *The choice of the operator is normative rather than ontological: different operators define different, but equally admissible, canonical global orders.*

Remark 3. *Concrete examples of canonical ordering operators and practical realizations of the above axioms are provided in Appendix A and Appendix B, respectively.*

3 Scale Separation and Canonical Globality

Definition 3 (Characteristic scales)**.** *Let L_0 denote a bounded locality corresponding to the Solar System, with characteristic spatial scale $|L_0|$. Let R denote a characteristic galactic radius scale. Let L denote the distance from a destination within L_0 to a given source.*

Definition 4 (Scale separation)**.** *A source is said to be* scale-separated *with respect to locality L_0 if*

$$L \gg |L_0|.$$

In this case, all destinations within L_0 occupy effectively indistinguishable positions relative to the source, for the purpose of constructing a canonical order.

Definition 5 (Operational global source)**.** *A source s is called* operationally global *for locality L_0 if it is scale-separated with respect to L_0. Operational globality is independent of whether $L < R$ (intra-galactic) or $L > R$ (extra-galactic), provided that $L \gg |L_0|$.*

Theorem 1 (Canonical global order from scale-separated source sets)**.** *Let $S = \{s_1, \ldots, s_N\}$ be a finite set of sources with $N > 1$, scale-separated with respect to locality L_0 and geometrically distributed over the celestial sphere with comparable distances and angular separation.*

Then, for any destination $d \in L_0$, the family of reception sequences $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$ may be declared global for L_0, in the sense that all local distinctions between destinations within L_0 are operationally unresolvable.

Proof. By scale separation, each source $s_i \in S$ is observed from effectively indistinguishable positions by all destinations within L_0.

Geometric distribution of sources across the celestial sphere eliminates directional bias and prevents localization of ordering information to any particular region of L_0.

Therefore, the combined reception data $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$ cannot encode resolvable intra-L_0 distinctions and may be treated as global for L_0 in the operational sense. □

Remark 4. *A single scale-separated source may serve as a reference signal, but canonical globality requires a non-degenerate source set.*

Theorem 2 (Procedural uniqueness of the canonical global order)**.** *Let $S = \{s_1, \ldots, s_N\}$ be a finite set of scale-separated sources distributed across the celestial sphere, and let $\mathcal{C}$ be a fixed aggregation protocol.*

Then the application of $\mathcal{C}$ to the family $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$ defines a unique canonical global order H_* for locality L_0, in the sense that no alternative global order is admissible without modifying the protocol itself.

Proof. Fix the aggregation protocol $\mathcal{C}$. For a given destination-side data family $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$, the value

$$H_* := \mathcal{C}(\mathsf{Seq}_d(s_1), \ldots, \mathsf{Seq}_d(s_N))$$

is uniquely determined by the definition of the protocol.

The construction relies exclusively on reception sequences (Axiom: Primacy of reception order) and explicitly excludes intrinsic source order (Axiom: Operational inaccessibility).

Hence the resulting uniqueness is procedural: it follows from the fixed canonical protocol, not from any postulated global spacetime time coordinate. □

Remark 5 (Independence from signal propagation assumptions)**.** *The above construction does not depend on assumptions about signal propagation speed or intrinsic source order. Globality arises solely from scale separation and canonical aggregation of locally registered sequences.*

Remark 6. *The constructions above assume the availability of reception sequences from multiple geometrically distributed locations. A concrete infrastructural realization of such distributed reception is outlined in Appendix C.*

3.1 Implementation Note

A minimal realization of the proposed framework requires only destination-side registration, phase correspondence, and aggregation of reception sequences. Concrete algorithmic sketches, including phase alignment and aggregation operators, are provided in Appendix A.

4 Canonical Time and Local Clocks

Local clocks, regardless of their internal precision or physical realization, do not define time within the present framework. They register events locally and provide local orderings only.

A canonical global order, once constructed, establishes a reference against which all local clocks must be synchronized in the domain of maximal attainable precision.

Axiom 5 (Subordination of local clocks)**.** *Let H_* be a canonical global order constructed for locality L_0. Any local clock within L_0 is admissible only insofar as its readings can be aligned with H_* up to the maximal precision supported by H_*.*

This establishes that clocks are calibrated to canonical time, not vice versa. Within a canonical framework, clocks are calibrated *to* time, not the other way around.

Remark 7. *A local clock may exhibit arbitrarily high internal resolution. However, any excess resolution beyond that supported by the canonical global order has no operational standing and cannot be used to refine the global temporal structure.*

Theorem 3 (Upper bound on temporal precision)**.** *The maximal meaningful temporal precision within locality L_0 is bounded by the precision of the canonical global order H_*. Local clocks cannot extend this bound, only approximate it.*

Proof. By construction, H_* is the sole admissible global ordering available for coordination within L_0. Any temporal claim exceeding the resolution of H_* cannot be consistently synchronized across the locality and therefore fails the criterion of operational admissibility. □

In this sense, canonical time functions as a normative constraint on all admissible temporal measurements within the locality.

4.1 Relation to COE and the Global Observation Process

Within the framework of Coherent Observational Epistemology (COE) [2], knowledge arises from the coordination of heterogeneous local observations into a coherent global structure. This coordination is formalized by the Global Observation Process (GOP), which requires a canonical ordering of observational acts.

The canonical global time constructed in the present work provides precisely such an ordering: it functions as the canonical order over which GOP sequences are defined and compared.

In this sense, global time is not an additional physical quantity, but the temporal canon required for coherent observation itself. The present construction supplies the ordering constraint assumed by GOP, without presupposing access to any intrinsic or absolute temporal structure.

5 Scope and Exclusions

The framework developed in this work operates strictly within the domain of operationally accessible order. Accordingly, the following are explicitly outside its scope:

- Reconstruction of intrinsic or "true" event histories of remote sources.
- Postulation or detection of an absolute or universal time.
- Dependence on any specific spacetime geometry or physical interpretation; the framework requires only locally registered order and a fixed canonical protocol.

The notion of global time employed here is therefore canonical rather than representational.

6 Conclusion

Global time, in the only sense needed for coordination, is a canonical order over locally registered events. Distant periodic sources provide operational globality by scale separation; multiple sources provide robustness and procedural uniqueness. The resulting global order is a constructed canon: sufficient, reproducible, and explicitly protocol-defined.

A Canonical Ordering Operators

This appendix provides a concrete example of a canonical ordering operator as introduced in Axiom 4.

A.1 Phase Correspondence and Event Alignment

Canonical aggregation of reception sequences requires that events originating from different sources be comparable at the level of reception. This comparability is not assumed at the source level, but is constructed at the destination.

Definition 6 (Phase correspondence)**.** *Let d be a destination and let $S = \{s_1, \ldots, s_N\}$ be a set of sources. A* phase correspondence *is a destination-side procedure that associates reception events $\{e_k^{(i)}\}$ from different sources s_i to a common phase index ϕ_k, based solely on locally registered information.*

Phase correspondence does not require access to the intrinsic phase or emission order of any source. It relies only on regularity and repeatability of the received signal patterns as observed at the destination.

Remark 8. *Phase correspondence is an operational alignment, not an ontological identification. Different procedures may induce different, yet equally admissible, phase correspondences.*

A.1.1 Minimal Phase Correspondence Procedure

The following pseudocode illustrates a minimal destination-side procedure for establishing phase correspondence.

```
for each source s_i:
detect recurrent signal pattern
estimate local period T_i
assign phase index φ_k to each reception event e_k^(i)
based on modulo-T_i position

for each phase index φ_k:
collect events {e_k^(i)} from all sources
if sufficient events present:
declare φ_k as a comparable phase
```

Millisecond pulsars provide a natural example of such phase correspondence, as their highly stable periodic emission allows phase indices to be assigned purely from reception regularity, without assuming access to any intrinsic pulsar time.

A.2 Weighted Median Operator

Assume that a phase correspondence ϕ_k has been established for a family of reception sequences $\{\mathsf{Seq}_d(s_i)\}_{i=1}^N$.

For each phase index ϕ_k, let $\tau_k^{(i)}$ denote the locally registered reception ordinal or timestamp associated with source s_i.

Let $w_i > 0$ be a weight assigned to source s_i, reflecting stability, accessibility, or other normative criteria.

Definition 7 (Weighted median canonical order)**.** *The weighted median canonical order H_* is defined by assigning to each phase index ϕ_k the value*

$$\tau_k = \mathrm{median}_w\big(\tau_k^{(1)}, \ldots, \tau_k^{(N)}\big),$$

and ordering events by increasing τ_k.

The resulting order H_* is robust under outliers: deviations or failures of a minority of sources do not alter the induced canonical order.

Remark 9. *The choice of weights and of the phase correspondence is normative. Different choices define different, but equally admissible, canonical global orders.*

A.2.1 Minimal Aggregation Operator

The following pseudocode illustrates a minimal aggregation procedure for constructing a canonical global order from phase-aligned reception data.

```
for each phase index φ_k:
collect timestamps {τ_k^(i)} from available sources s_i
apply weights {w_i} to collected values
compute aggregated value τ_k = weighted_median({τ_k^(i)}, {w_i})

order phases φ_k by increasing τ_k
declare the resulting sequence as the canonical global order H_*
```

Remark 10. *The aggregation function is not required to approximate any intrinsic temporal quantity. Its sole purpose is to induce a stable and reproducible canonical order over locally registered events.*

B Practical Realizations

This appendix briefly indicates how several existing systems instantiate the axioms of Section 2.

B.1 Global Positioning System (GPS)

GPS realizes Axioms 2–4 by:

- using multiple independent sources (satellites),
- relying on reception order and locally registered timestamps,
- constructing a canonical time scale via aggregation of received signals.

Notably, GPS time is not an intrinsic source order but a constructed canonical order maintained by protocol and correction procedures.

B.2 Pulsar Timing Arrays (PTA)

Pulsar Timing Arrays employ a distributed set of stable astrophysical sources. Reception sequences from multiple pulsars are aggregated to form a highly stable reference order.

This directly instantiates multi-source synchronizability (Axiom 3) and canonical aggregation (Axiom 4), independently of assumptions about intrinsic pulsar time.

B.3 Network Time Protocol (NTP)

NTP provides a purely terrestrial example: multiple time servers act as sources, clients register reception sequences, and a selection/combination algorithm constructs a canonical local time order.

NTP explicitly treats individual sources as fallible and relies on consensus rather than intrinsic correctness, closely mirroring the axiomatic framework of this paper.

References

[1] A. A. Nekludoff, *Philosophy of discrete being: Foundations and structural architecture*, Version 1.0, 2025. DOI: 10.5281/zenodo.17690594 [Online]. Available: https://doi.org/10.5281/zenodo.17690594

[2] A. A. Nekludoff, *Coherent observational epistemology: Foundational principles, secondary principles, and axiomatic system*, Zenodo Report, 2025. DOI: 10.5281/zenodo.17632756 [Online]. Available: https://doi.org/10.5281/zenodo.17632756

[3] P. W. Bridgman, *The Logic of Modern Physics*. New York: Macmillan, 1927.

[4] H. Reichenbach, "The philosophy of space and time," *Dover Publications*, 1958, Original work published 1928.

[5] B. C. van Fraassen, "The scientific image," *Oxford University Press*, 1980, Book.

[6] D. R. Lorimer, "Binary and millisecond pulsars," *Living Reviews in Relativity*, vol. 11, no. 8, 2008. DOI: 10.12942/lrr-2008-8

[7] G. Hobbs, A. Archibald, Z. Arzoumanian, et al., "The international pulsar timing array project: Using pulsars as a gravitational wave detector," *Classical and Quantum Gravity*, vol. 27, no. 8, p. 084 013, 2010. DOI: 10.1088/0264-9381/27/8/084013