Invariant Temporal Ordering Framework V31/F11: Invariant Universal Cosmic Ordering, Bearer-Specific Physical Change, and the Non-Transfer of Temporal Ontology

Youssry Ghandour
Independent Researcher

ITOF Foundation Series XI (F11)
August 1, 2026

Abstract

The Invariant Temporal Ordering Framework V31/F11 gives a reconstructed foundation for time, physical change, measurement, and interpretation. Its formal core is

$$T_{\mathrm{ITOF}} = (\mathcal{S}_{\mathrm{C}}, \prec_{\mathrm{C}})$$

Time denotes the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages in one common cosmic extension. Invariance means that realized cosmic succession does not reverse, stop, or pass through a static condition between stages. This statement does not treat physical systems as still or identical in state; physical systems continue to realize bearer-specific physical change throughout their identity domains.

V31/F11 preserves CMA, UCC, identity-bounded history, formation, ending through transformation, successor closure, recurrence without reversal, measurement restraint, remote-record restraint, and the quantitative bridge program. It also brings the preparatory CP1 non-transfer protocol into the main text. CP1 is not kept as a separate layer; its main controls are used only where they are stated. The Non-Transfer Principle says that success, consistency, prediction, synchronization, propagation, or record agreement does not transfer temporal ontology to an output, coordinate, metric quantity, quantum symbol, signal interval, or geometrical construction.

The test register applies this rule to atomic-clock comparisons, velocity- and gravity-dependent clock-record differences, GPS-type navigation, environmental clock conditions, light-path reconstruction, quantum delayed-choice and eraser records, higher-dimensional geometry, and relativistic claims about time. Each application must declare its bearers, conditions, record chain, model law, uncertainty, comparator, acceptance rule, failure rule, and warranted conclusion. V31/F11 links the definition of time, CMA, UCC, measurement rules, and test protocols without treating clocks, coordinates, signals, quantum symbols, or geometrical constructions as time, and without claiming exact-stage observational access or a completed universal microscopic clock law.

Keywords: ITOF; invariant universal ordering; uninterrupted succession; time; Cosmic Moment Axiom; Universal Change Continuity; Non-Transfer Principle; clock records; signal records; GPS; quantum measurement; higher dimensions; relativity.

Contents

Notation and statement status

Core definitions, axioms, and equations

Time. Time denotes the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages in one common cosmic extension:

$$T_{\mathrm{ITOF}} := (\mathcal{S}_{\mathrm{C}}, \prec_{\mathrm{C}})$$

Invariance belongs to the cosmic ordering itself. Realized succession does not reverse, stop, or pass through a static condition between stages. This does not mean that physical systems are still or identical in state. It also does not claim a mathematically dense order.

Cosmic Moment Axiom. At every common cosmic stage, every physical system whose identity is then realized undergoes its own bearer-specific physical change. The stage is common; the realized change belongs to each bearer according to its own physical constitution, conditions, and history. Common-stage unity does not imply the same state, mechanism, magnitude, rate, or observational outcome:

$$\begin{aligned} \mathrm{CMA}: \quad & \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\, \forall A \in \mathcal{U}_{\mathrm{phys}}, \\ & A \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow \mathrm{PhysReal}_A^{+}(s) \end{aligned}$$

Universal Change Continuity. For each physical system, realized bearer-specific physical change is not suspended while that identity remains actual:

$$\mathrm{UCC}(A) \Longleftrightarrow \mathrm{PhysicalSystem}(A) \wedge \forall s \in I_A\ \mathrm{PhysReal}_A^{+}(s)$$

Non-Transfer Principle. Success, consistency, synchronization, propagation, prediction, or record agreement does not transfer temporal ontology to the successful output, model object, coordinate, metric, signal interval, quantum symbol, or geometry:

$$\begin{aligned} & (\mathrm{OperationalSuccess}_{P,M,D}(q) \vee \mathrm{MathematicallyConsistent}(q)) \\ & \not\Rightarrow (q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}) \end{aligned}$$

These statements set the main types used in the notation table below.

Symbol or statement	Meaning and status
$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Total-history domain of common cosmic stages. Membership does not make a later member attained at an earlier reference stage.
$\preceq_{\mathrm{C}}$	Reflexive closure of the strict cosmic ordering: $r \preceq_{\mathrm{C}} s \Longleftrightarrow r = s \vee r \prec_{\mathrm{C}} s$.
$\mathcal{S}_{\mathrm{C}}^{\leq a}$	Prefix attained no later than reference stage a: $\{s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid s \preceq_{\mathrm{C}} a\}$.

Symbol or statement	Meaning and status
$T_{\text{ITOF}} = (\mathcal{S}_{\text{C}}, \prec_{\text{C}})$	Definition of time: the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages in one common cosmic extension. Physical change is bearer-specific and is neither denoted nor caused by time.
NTP	Non-Transfer Principle: operational success, mathematical consistency, prediction, synchronization, signal propagation, or record agreement does not transfer temporal ontology to outputs, instruments, coordinates, metric quantities, quantum symbols, signal intervals, or geometrical constructions.
$\text{CoPresent}_{\text{C}}(A, B; s)$	Both bearer identities are realized at the same common cosmic stage s.
$\mathcal{U}_{\text{phys}}$, $\mathcal{U}_{\text{phys}}^{\leq a}$, $\mathcal{S}_{\text{phys}}(s)$	Total-history bearer domain, bearer domain attained no later than a, and population whose identities are realized at s.
I_A, $\mathcal{H}_A$	Identity domain and identity-bounded physical history of bearer A: $\mathcal{H}_A = (I_A, \prec_{\text{C}} \|_{I_A}, X_A)$.
$\text{PhysReal}_A^+(s)$	Bearer-specific physical change realized for A at s. The superscript $+$ is classificatory, not a magnitude. Formation, continuation, and ending are classifications of realized physical change.
CMA	Axiom: every bearer present at every common cosmic stage realizes its own physical change there.
UCC	Bearer-history continuity of the same realized physical change at every stage at which the identity remains actual; it follows from CMA and identity-domain membership.
$\Gamma_\kappa^{\text{id}}$	Domain-level scientific identity criterion for bearer class κ; it supports warrant but creates no ontic identity.
f_A, e_A	Unique formation member; and the value of the ending-member map on the completed-bearer domain $\mathcal{U}_{\text{phys}}^{\text{end}}$. The symbol e_A is used only where $\text{HistoryComplete}(A)$.
No Infinite Same-Stage Cascade	Foundational constraint: successor closure cannot generate an infinite same-stage chain without independently specified physical production warrant.
$\text{ClosureOnly}((B_n)_{n\in\mathbb{N}}, e)$	Same-stage successor sequence generated solely by formal closure without independently specified physical-production warrant.
$\text{PlaceExpression}(P; \mathcal{B}_P)$	A spatial expression referring to one physical system or to a physically organized family of physical systems and representing their relevant boundaries and spatial relations. The expression is not itself a bearer.
$\text{FieldBearer}(F)$	Actually realized field entity satisfying the physical-bearer and identity conditions.

Symbol or statement	Meaning and status
$\mathrm{FieldModelObject}(q_F)$	Mathematical field quantity or representation; this classification fails to entail bearer status.
$\mathrm{Visible}_{P,M,\varepsilon}(A,\chi;s)$	Protocol-, model-, and sensitivity-relative visibility of a physical manifestation of bearer A at stage s. Visibility is not the definition of physical change.
$\not\equiv_{\mathrm{def}}$, $\not\equiv_{\mathrm{type}}$, $\nvdash$, $\neg\,\mathrm{Warrant}[\cdot]$	Respectively definitional nonidentity, type nonidentity, non-entailment in a named theory, and lack of epistemic warrant.

1. Foundational Position, Reconstruction Method, and Statement Status

1.1 Purpose of the reconstruction

V31/F11 is a foundational reconstruction of V30/F10. It retains the central architecture of V30/F10 only after revalidation, makes the invariance of the cosmic ordering explicit in the definition of time, and includes the non-transfer rule developed in the companion protocol. The revision is not justified by application growth alone. It is justified by a definitional refinement: the ordering denoted by time must be stated as invariant so that it cannot be misread as a coordinate convention, metric variable, or movable representational order.

The historical sequence from V23/F3 through V30/F10 remains evidential background rather than a store of automatically valid propositions [8, 7, 6, 5, 4, 3, 2]. V30/F10 is treated as the immediate predecessor and as the principal source of the present reconstruction [1]. No proposition is retained merely because it appeared earlier.

For every inherited element q,

$$\mathrm{Retained}_{\mathrm{V30}\to\mathrm{V31}}(q) \Longrightarrow \mathrm{Revalidated}_{\mathrm{V31}}(q). \tag{1}$$

Revalidation may preserve, restrict, relocate, reconstruct, or exclude an earlier statement. Historical continuity confers no logical validity, and authorial intention cannot replace proof of type control, internal coherence, or physical warrant.

1.2 Status classes

Every central statement is assigned one status:

(i) primitive type or primitive ontological relation;
(ii) definition;
(iii) postulate;
(iv) axiom;
(v) principle;
(vi) model constraint;
(vii) derived proposition;

(viii) application bridge;
(ix) or epistemic warrant condition.

A displayed expression is used only when it fixes a type, domain, dependency, constraint, or testable relation more sharply than prose. Equations do not acquire force from repetition, visual prominence, or prior use.

1.3 Formal levels of negation and non-transfer

Four relations that are often conflated in foundational writing are kept separate throughout V31/F11:

Form	Use
$P \not\equiv_{\mathrm{def}} Q$	P and Q are not identical by definition; this does not preclude an additional axiom or theorem relating their extensions.
$P \not\equiv_{\mathrm{type}} Q$	P and Q belong to different declared types and cannot be identified without separate justification.
$\mathcal{T} \nvdash (P \to Q)$	The stated theory or subtheory fails to entail the implication. The theory $\mathcal{T}$ must be named whenever the scope is not already fixed by the surrounding proposition.
$\neg\,\mathrm{Warrant}_{P,M}[Q \mid E]$	Evidence E, under protocol P and model M, does not warrant claim Q. This is an epistemic restraint, not an ontological negation.

The symbol $\nRightarrow$ is used only for a scoped claim that the antecedent, by itself, fails to entail the consequent under the surrounding theory, application, or evidential conditions. It is not used to express definitional nonidentity or type difference. Where the issue is lack of scientific warrant, the warrant relation is written explicitly.

1.4 Core, modules, and applications

The framework is divided into three dependency levels.

Core.

The core contains the common cosmic-stage domain, its fixed irreversible ordering, the denotation of time as invariant universal ordering, bearer identity domains, stage-indexed physical change, the non-transfer of temporal ontology, and the distinction between ontic facts and epistemic access.

Independent foundational modules.

The Cosmic Origin Postulate, the Cosmic Moment Axiom, Universal Change Continuity, formation-boundary commitment, identity-ending architecture and necessary successor closure are separately stated commitments. Their independence prevents one concept from being hidden inside the definition of another.

Applications.

Spatial realization, motion, clocks, records, remote access, reconstruction, prediction, field classification, and confrontation with relativistic models apply the core and modules. The atomic-clock bridge and the non-transfer test register are predeclared application structures with explicit type assignments of bearers, conditions, records, and model quantities. Applications neither generate the ontology nor alter the meaning of time.

1.5 Criterion for a later foundational version

V31/F11 is intended to govern until a substantial contradiction, type failure, dependency failure, decisive physical counterinstance, or superior reconstruction requires revision. Further applications, additional examples, or new presentation formats do not by themselves justify a later foundational version unless they change the core definition, the axiom structure, or the dependency architecture.

2. The Cosmic Domain, Attainment, and Cosmic Origin

2.1 Physical totality

Let

$$\mathcal{U}_{\mathrm{phys}} := \{A \mid \mathrm{PhysicalSystem}(A)\} \tag{2}$$

denote the total-history domain of actually realized physical bearers. The universe denotes the totality of those systems:

$$\boxed{\mathrm{Universe} := \mathrm{Totality}(\mathcal{U}_{\mathrm{phys}}).} \tag{3}$$

The universe is not an additional bearer, spatial arena, receptacle, or container in which the systems are placed. It is the physical totality constituted by all actually realized systems. Individual bearer histories remain the histories of their respective identities; the physical history of the universe denotes the ordered plurality, co-presence, interaction, formation, transformation, and ending of those systems within the one cosmic succession. Its content at a particular common stage is fixed later by the bearer population at that stage.

2.2 Total-history stage domain

Let

$$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \tag{4}$$

denote the complete extensional domain of common cosmic stages belonging to the complete cosmic history. For notational continuity,

$$\mathcal{S}_{\mathrm{C}} := \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}. \tag{5}$$

Membership in $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ is a theory-level historical classification. It does not assert that every member is attained at every reference stage or that later members are physically present at earlier members. The domain orders the realized cosmic history; it is not a receptacle existing before the systems and their physical realization.

For a reference stage $a \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, define the attained prefix

$$\mathcal{S}_{\mathrm{C}}^{\leq a} := \{s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid s = a \ \vee \ s \prec_{\mathrm{C}} a\}. \tag{6}$$

The corresponding relation is

$$\mathrm{AttainedAt}(s; a) \Longleftrightarrow s \in \mathcal{S}_{\mathrm{C}}^{\leq a}. \tag{7}$$

Therefore,

$$a \prec_{\mathrm{C}} v \Longrightarrow \neg\,\mathrm{AttainedAt}(v; a). \tag{8}$$

This distinction prevents a complete-history representation from being misread as simultaneous realization of all stages.

2.3 Metatheoretical status of the total-history domain

The symbol $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ is a theory-level domain used to state the one actual cosmic history as a whole. It is not a store of already realized future stages and it is not an inventory available at an earlier reference condition. At any attained reference, only the physically realized prefix is relevant to actuality, evidence, and intervention.

Global quantification over $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ expresses the completed scope of a theoretical statement; it does not make a later member present, known, causally available, predicted with certainty, or physically fixed at an earlier member. A prediction remains a model-conditioned claim concerning later physical outcomes. Once an outcome is physically realized, it belongs to the actual cosmic history; before realization, the prediction supplies neither attainment nor stage identity.

This use avoids two incompatible readings. The total domain is not a simultaneous block in which all stages are actual together, and it is not a second physical entity that grows beside the universe. The universe remains the totality of physical systems. $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ is the ordering domain through which their realized history is stated.

2.4 Cosmic origin as an explicit module

The definition of time fails to entail a first cosmic stage. V31/F11 nevertheless adopts the following independent origin-bounded module.

Postulate 2.1 (Cosmic Origin Postulate)**.** There exists one unique least common cosmic stage s_{C}^{0}:

$$s_{\mathrm{C}}^{0} \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \qquad \neg\exists r \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\,(r \prec_{\mathrm{C}} s_{\mathrm{C}}^{0}). \tag{9}$$

The postulate fixes origin-boundedness:

$$\mathrm{OriginBounded}(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}). \tag{10}$$

It is neither a consequence of T_{ITOF} nor a condition hidden in the meaning of ordering. The postulate supplies leastness only. The later conjunction of Cosmic-Stage Population, CMA, and the Actual Formation Boundary establishes the physical content of cosmic origin: the universe begins through the identity-forming physical changes of the systems present at s_{C}^{0}, not through an empty stage or a container awaiting systems. If future physical or logical analysis defeats origin-boundedness, the time definition and the remaining order-theoretic core do not thereby collapse.

2.5 Extension beyond cosmic origin

V31/F11 separately adopts the independent commitment that the actual cosmic succession contains at least one stage later than cosmic origin:

Postulate 2.2 (Cosmic Extension Beyond Origin)**.**

$$\exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\,(s_{\mathrm{C}}^{0} \prec_{\mathrm{C}} s). \tag{11}$$

This postulate is independent of the definition of time and of the Cosmic Origin Postulate. It asserts only that the actual cosmic succession extends beyond its least member. It introduces no density, discreteness, adjacency, equal spacing, metric duration, or greatest stage.

3. Physical Bearers, Ontic Identity, and Scientific Identity Criteria

3.1 Physical bearer

A physical system is an actually realized bearer possessing a distinguishable physical identity through physical organization, constitution, relations, or declared physical characteristics. It is not merely a selected variable, property, mechanism, field value, location, record, model object, or arbitrary collection.

In this paper, identity means the same bearer itself unless a qualitative, functional, or classificatory identity is explicitly declared. Similarity, replacement, continuity of function, or shared material is therefore not enough to establish that the same bearer continues.

For $A \in \mathcal{U}_{\mathrm{phys}}$, let

$$\mathrm{ExistsAs}(A, s) \tag{12}$$

state that the identity of A is physically realized at stage s. Its identity domain is

$$I_A := \{s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid \mathrm{ExistsAs}(A, s)\}. \tag{13}$$

Define directed continuation of the same bearer through an ordered portion of its history by

$$\mathrm{SameBearerThrough}_A(r, s) \iff A \in \mathcal{U}_{\mathrm{phys}} \wedge r, s \in I_A \wedge r \preceq_{\mathrm{C}} s. \tag{14}$$

Identity-Domain Convexity supplies every identity member ordered between the declared bounds. The relation states persistence of bearer identity; it does not imply equality of state, constituents, function, or observable record. Because A is an actually realized bearer,

$$A \in \mathcal{U}_{\mathrm{phys}} \Longrightarrow I_A \neq \varnothing. \tag{15}$$

For a reference stage a, define the bearer domain attained no later than a by

$$\mathcal{U}_{\mathrm{phys}}^{\leq a} := \{A \in \mathcal{U}_{\mathrm{phys}} \mid I_A \cap \mathcal{S}_{\mathrm{C}}^{\leq a} \neq \varnothing\}. \tag{16}$$

Membership in the total-history domain $\mathcal{U}_{\mathrm{phys}}$ therefore does not place a bearer at an earlier reference stage. Stage-indexed actuality remains fixed by $\mathrm{ExistsAs}(A,s)$, while $\mathcal{U}_{\mathrm{phys}}^{\leq a}$ contains identities whose formation has been attained no later than a, including bearers that may already have ended. The current population and the attained historical domain are therefore distinct:

$$\mathcal{S}_{\mathrm{phys}}(a) \subseteq \mathcal{U}_{\mathrm{phys}}^{\leq a}, \qquad \mathcal{T}_{\mathrm{core}} \nvdash (\mathcal{U}_{\mathrm{phys}}^{\leq a} \subseteq \mathcal{S}_{\mathrm{phys}}(a)). \tag{17}$$

Claims about bearers present at a quantify over $\mathcal{S}_{\mathrm{phys}}(a)$; claims about bearers whose histories have begun by a quantify over $\mathcal{U}_{\mathrm{phys}}^{\leq a}$.

3.2 Ontic identity and scientific warrant

Ontic identity is the physical fact that the same bearer exists across declared stages. Scientific identity criteria are means of justifying that attribution; they do not create the bearer or determine reality by stipulation.

Let κ denote a bearer class and let $\Gamma_\kappa^{\mathrm{id}}$ be a domain-level identity criterion. Its validity requires, at minimum:

(a) a physically meaningful bearer class;
(b) non-circular formation, persistence, and ending conditions;
(c) predeclared specification rather than adjustment after the desired result;
(d) consistent application across relevant members of the class;
(e) explicit treatment of constituent replacement, functional failure, and transformation;
(f) and declared limits of resolution and applicability.

This status is represented by

$$\mathrm{ValidIdentityCriterion}(\Gamma_\kappa^{\mathrm{id}}). \tag{18}$$

For a protocol P and model M, the specialized operator $\mathrm{IdentityWarrant}_{P,M}$ is reserved for claims of directed continuation of bearer identity of the form $\mathrm{SameBearerThrough}_A(r,s)$:

$$\mathrm{IdentityWarrant}_{P,M}[\mathrm{SameBearerThrough}_A(r,s)] \tag{19}$$

is epistemic. It neither enters nor replaces the ontic relation.

Laboratory-clock example.

For a declared optical clock bearer C, the identity criterion must state the clock boundary, the transition-bearing material system, interrogation and control subsystems, calibration continuity, and replacement rules. Replacement of a consumable atom or serviceable component need not end C, whereas replacement of the organizing reference, control architecture, and calibration lineage may constitute a new clock bearer under the declared criterion. The criterion is fixed before differential records are evaluated.

Conditional field-bearer example.

A mathematical field variable q_F possesses no bearer identity merely because it is defined over a region. A field entity F is admitted as a bearer only where the physical account supplies actual realization, distinguishable identity conditions, persistence conditions, and a valid criterion for formation and ending or ongoing continuation. If those conditions are absent, the field quantity remains a factor, relation, or model object rather than an additional bearer.

3.3 Identity-domain convexity

V31/F11 retains the identity-domain convexity principle:

Principle 3.1 (Identity-Domain Convexity)**.** For all $r, s, t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, if r and t belong to the identity domain of A, and s is ordered between them, then s also belongs to that same identity domain:

$$\forall r, s, t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad (r \in I_A \wedge t \in I_A \wedge r \prec_{\mathrm{C}} s \wedge s \prec_{\mathrm{C}} t) \Longrightarrow s \in I_A. \tag{20}$$

The principle excludes disappearance and reappearance of the same bearer across an internal gap. A later bearer that resembles or inherits from an earlier bearer is not thereby the same bearer.

3.4 Nested bearers and attribution control

Physical systems may be nested, overlapping, distributed, or component-bearing. A change realized in a component may contribute to the change of a larger bearer, but its content is not automatically identical with the complete change of every containing system. The bearer boundaries, identity criteria, part–whole relations, and the physical level at which the change is attributed must therefore be stated directly.

3.5 Physical systems, influencing systems, and physical factors

A physical system is classified by its actual identity, boundary, and persistence conditions, not by the role it plays in relation to another system. A system may influence, constrain, support, damage, transform, or exchange with another system while remaining a physical system throughout the relation. Its influencing role neither removes its bearer identity nor lowers its ontological type to that of a factor. It therefore retains its own identity domain and physical history and remains within the scope of CMA at every common stage at which it exists.

The term *physical factor* is narrower. It denotes a physically relevant property, state, condition, relation, exchange, boundary condition, constraint, interaction, disposition, or mechanism that is realized in one or more systems but is not independently admitted as a physical system. A model may represent the influence of system B on system A through a force, pressure, field value, exchanged quantity, contact relation, signal, or other factor. The represented force, condition, relation, or exchanged quantity describes how the interaction is physically expressed; it does not reclassify B itself.

This distinction prevents two opposite errors. The first is to convert every property, condition, or relation into a new system. The second is to describe an actual influencing system merely as a factor and thereby erase its identity, history, change, formation, ending, or successor relations. Domain applications must identify which entries are systems and which are non-system factors before causal, measurement, or historical claims are evaluated.

3.6 Fields, quantum-field descriptions, and bearer status

The word *field* is insufficient to determine ontological type by itself. A physical theory may use scalar, vector, tensor, spinor, operator-valued, or state-dependent field quantities. Such quantities may represent physical conditions with great empirical success, but the mathematical object used in the representation is not thereby an additional physical bearer.

Let

$$\text{FieldModelObject}(q_F) \tag{21}$$

classify a field quantity, field coordinate, state vector, wavefunction, operator assignment, or related model object. Then

$$\text{FieldModelObject}(q_F) \not\Rightarrow q_F \in \mathcal{U}_{\text{phys}}. \tag{22}$$

This restriction prevents a symbol, function, operator, or state assignment from acquiring bearer identity merely because it appears in a successful calculation.

A field entity may nevertheless qualify as a physical bearer where its physical actuality and identity are independently justified. Let $\text{ActuallyRealizedFieldEntity}(F)$ state that the proposed entity is physically actual rather than merely possible or representational, and let $\text{DistinguishableFieldIdentity}(F)$ state that one identifiable field entity can be distinguished under the declared criterion from its values, modes, excitations, regions, and representations. Define field-bearer status by

$$\begin{aligned}\text{FieldBearer}(F) \iff\ & \text{ActuallyRealizedFieldEntity}(F) \wedge \text{DistinguishableFieldIdentity}(F) \\ & \wedge \text{ValidIdentityCriterion}\left(\Gamma^{\text{id}}_{\kappa_F}\right).\end{aligned} \tag{23}$$

Admission of a field bearer to the physical-bearer domain is governed by the independent type constraint

$$\text{FieldBearer}(F) \Longrightarrow F \in \mathcal{U}_{\text{phys}}. \tag{24}$$

The type constraint is not presented as a derivation from only one direction of the preceding definition. Once $F \in \mathcal{U}_{\text{phys}}$ is admitted, the general bearer rule yields $I_F \neq \varnothing$; nonempty history is a consequence of bearer admission, not a premise used circularly to establish it. The criterion must state what makes the same field entity persist, what counts as its formation and ending, and how it is distinguished from a value, excitation, mode, region, interaction term, or representation of another bearer.

Where bearer status is not established, a field quantity may function as a physical factor, relation, coupling term, boundary condition, or model variable. Introduce

$$\text{RelevantFieldFactor}(q_F, A; s) \tag{25}$$

to state that the declared field quantity is physically relevant to bearer A at stage s. Its relevance by itself cannot establish an independent identity:

$$\text{RelevantFieldFactor}(q_F, A; s) \not\Rightarrow q_F \in \mathcal{U}_{\text{phys}}. \tag{26}$$

The same rule applies to quantum-field descriptions. Superposition, interference, entanglement, excitation number, vacuum assignment, and operator expectation values are model- or state-relative classifications. Their physical use requires no independently existing spatial receptacle. If two field realizations overlap under a declared spatial representation, the warranted conclusion concerns their physical distributions or relations:

$$\text{SpatialFieldOverlap}_{R,\Sigma}(F, G; s) \not\Rightarrow \text{IndependentSpatialContainer}\,. \tag{27}$$

The overlap may be physically consequential without making place, space, or the cosmic stage a separate medium that contains the fields.

Entanglement or state-correlation between spatially separated physical systems does not by itself decide bearer number. The relata may be two bearers connected by a warranted physical relation, one composite bearer under a declared identity criterion, or a model-level joint state assigned to several bearers. The classification depends on physical identity, persistence, production, and warrant conditions, not on correlation structure alone. In every admissible classification, the systems or composite bearer present at a common cosmic stage fall under CMA without converting nonlocal correlation into a private time or a second cosmic ordering.

This subsection fixes classification only. It supplies no quantum-field dynamics, selects no interpretation of quantum theory, and does not classify every field appearing in present physics as either a bearer or a factor. Those judgments remain domain-specific and must satisfy the same actuality, identity, and warrant requirements imposed on every other proposed physical system.

4. Universal Cosmic Succession and the Definition of Time

4.1 The cosmic ordering

Let $\prec_{\mathrm{C}}$ be one strict total ordering on $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$. For all $r, s, t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$:

$$\neg(r \prec_{\mathrm{C}} r), \tag{28}$$

$$r \prec_{\mathrm{C}} s \wedge s \prec_{\mathrm{C}} t \Longrightarrow r \prec_{\mathrm{C}} t, \tag{29}$$

$$r \neq s \Longrightarrow \big(r \prec_{\mathrm{C}} s \;\vee\; s \prec_{\mathrm{C}} r\big). \tag{30}$$

Its irreversibility is expressed by

$$r \prec_{\mathrm{C}} s \Longrightarrow \neg(s \prec_{\mathrm{C}} r). \tag{31}$$

The relation provides earlier–later order only. It introduces no metric, duration, spacing, density, rate, force, energy, or causal agency.

Its reflexive closure is fixed once for all subsequent uses by

$$r \preceq_{\mathrm{C}} s \Longleftrightarrow \big(r = s \;\vee\; r \prec_{\mathrm{C}} s\big). \tag{32}$$

The symbol $\preceq_{\mathrm{C}}$ therefore adds equality only; it introduces no interval magnitude or adjacency claim.

4.2 Definition of time

Central definition of time

Time denotes the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages in one common cosmic extension:

$$\boxed{T_{\mathrm{ITOF}} := (\mathcal{S}_{\mathrm{C}}, \prec_{\mathrm{C}}).} \tag{33}$$

It neither denotes nor causes physical change.

Invariance belongs to the cosmic ordering itself. Realized cosmic succession does not reverse, stop, or pass through a static condition between stages. This does not claim that the order is mathematically dense; it only rules out treating succession as halted between realized stages. Physical systems continue to realize bearer-specific change throughout their identity domains.

CMA is the independent physical axiom connecting stage-indexed bearer existence with realized bearer-specific change. UCC states the history-wide continuity of that same change and follows from CMA together with identity-domain membership. Neither is part of the definition of time.

Time denotes none of the following: a bearer, substance, field, force, coordinate, metric interval, proper-time functional, clock output, moving carrier, physical mechanism, or cause of change. Those objects and quantities may describe physical systems or models; none acquires temporal identity merely by being ordered, measured, or used in prediction.

4.3 One extension, not private times

Every physical bearer history uses the restriction $\prec_C |_{I_A}$ of the same cosmic ordering to its identity domain. That restricted relation is not a separate time belonging to A. Differences in state, rate, mechanism, clock output, path, or observability belong to bearers and models, not to multiple private temporal extensions. The complete history tuple is defined after formation in Section 7.

4.4 No movement of the extension

The common cosmic extension is not a moving support that carries systems from one stage to another. A later stage is the later position in the fixed ordering at which physical bearers realize their later physical conditions. Motion remains one type of physical change realized in some bearers where their physical constitution supports changing spatial position, orientation, distribution, or relation. Succession is not a transport mechanism, and CMA does not require every bearer to move.

5. Common Cosmic Stages, Realized Physical Change, and the Cosmic Moment Axiom

5.1 Common cosmic stage and universal population

A common cosmic stage is one actual member of $\mathcal{S}_C^{\text{tot}}$. It is neither a state of one system nor a signal network, coordinate slice, clock label, or record set. Define the population whose identities are physically realized at s by

$$\mathcal{S}_{\text{phys}}(s) := \{A \in \mathcal{U}_{\text{phys}} \mid \text{ExistsAs}(A, s)\}. \tag{34}$$

The universe at that stage is the totality of this population:

$$\text{UniverseAt}(s) := \text{Totality}\big(\mathcal{S}_{\text{phys}}(s)\big). \tag{35}$$

No additional container is introduced.

Principle 5.1 (Cosmic-Stage Population)**.** Every actual common cosmic stage has a physical population:

$$\forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \qquad \mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing. \tag{36}$$

5.2 Bearer-specific physical change at a stage

For $A \in \mathcal{U}_{\mathrm{phys}}$ and $s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, $\mathrm{PhysReal}_A^+(s)$ states bearer-specific physical change realized for A at s. The attribution is admissible only while the identity of A is physically realized at that stage. Its positive meaning, its location in the internal or external physical structure of the system, and its distinction from mere existence are fixed in Section 6. The physical content, magnitude, cause, rate, consequence, and observability remain system-specific.

Axiom 5.2 (Cosmic Moment Axiom)**.** At every common cosmic stage, all physical systems whose identities are then realized are present in the same common cosmic stage without exception, and every one of them realizes its own bearer-specific physical change:

$$\boxed{\forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A \in \mathcal{U}_{\mathrm{phys}}, \qquad A \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow \mathrm{PhysReal}_A^+(s).} \tag{37}$$

CMA states universal inclusion and change on equal ontological footing. Spatial separation, inaccessible records, different local conditions, unequal clock readings, and different physical causes do not remove any then-existing system from the common stage. Universality does not make the systems or their changes identical. The axiom is not a force, mechanism, or causal source. The change is realized in the internal physical structure of the system, its external physical structure, or both. Its physical causes may be internal, external, or combined. Every influencing physical system remains within CMA as a physical system in its own right and realizes its own bearer-specific change.

5.3 Every change belongs to a stage; observation does not identify it

Every actual bearer-specific change is realized at some common cosmic stage. This ontological statement does not furnish an empirical stage label. A test may observe a manifestation of change, compare records, or reconstruct development while remaining unable to determine the exact common stage or its precise ordinal position. Minute or distributed change may continue through stages before crossing a perceptual or instrumental threshold.

The stage variable in CMA is therefore bound within the foundational quantification. It is not a license to attach a stage symbol to a measured record, a reconstructed episode, or a historical example.

5.4 Cosmic origin and universal change

At the actual first cosmic stage, Cosmic-Stage Population supplies physical systems and CMA supplies physical change for all of them. Where that stage is the formation boundary of a system, the realized change is its first physical change. There is no empty preliminary universe, no changeless waiting stage, and no later starting point inserted between identity formation and change.

5.5 Spatial separation and stage unity

Distance affects interaction, transmission, reception, records, and access. It neither divides the common stage nor postpones change in distant systems. The common stage is not produced by signal exchange, and no instantaneous causal channel is required for universal stage membership.

6. Realized Physical Change and Universal Change Continuity

6.1 Bearer-specific physical change

Physical change is realized in a physical system. It is attributed only while the bearer identity of that system is physically realized at the common cosmic stage. Accordingly,

$$\mathrm{PhysReal}^{+}_{A}(s) \Longrightarrow \mathrm{PhysicalSystem}(A) \wedge \mathrm{ExistsAs}(A, s). \tag{38}$$

The identity condition is necessary for attribution, but existence alone does not define change:

$$[\mathrm{PhysicalSystem}(A) \wedge \mathrm{ExistsAs}(A, s)] \not\equiv_{\mathrm{def}} \mathrm{PhysReal}^{+}_{A}(s). \tag{39}$$

CMA is the independent axiom that universally connects every then-realized system identity with its bearer-specific change. The distinction is semantic and logical: $\mathrm{ExistsAs}(A, s)$ states that the identity of A is physically realized at s, whereas $\mathrm{PhysReal}^{+}_{A}(s)$ states that physical change is realized in that system at s.

The positive content of the change predicate is fixed without an open-ended list of loosely related expressions. The change occurs in the physical system itself: in realized differences in the properties of its material constitution, its internal physical structure, its external physical structure, or their combined condition. Here *external physical structure* means the externally realized structure, condition, boundary, orientation, placement, occupation, or path of the same system. It does not transfer the change to an external system or to a non-system factor. The disjunction is inclusive, so internal and external structural change may be realized together. Observability and functional value do not define change; they classify how a change is accessed, measured, or evaluated under a declared criterion.

This meaning applies at formation, throughout continuing identity, and at identity ending, while each boundary is treated separately under its own identity conditions. Formation does not require an earlier state of the newly realized system. At its formation stage the new identity is physically realized and its first change is realized. At an ending boundary the identity is still the bearer to which the ending change is attributed at that stage, and the identity ceases through that change.

6.2 Physical causes of change

The location of change and its physical causes are distinct questions. Change is located in the material constitution of the system, its internal physical structure, its external physical structure, or their combined condition. Its causes may arise from factors internal to the system, from physical systems and physical factors external to it, or from the combined action of internal and external causes.

A physical system that affects another system remains a physical system with its own identity domain, physical history, and bearer-specific change. Its causal or influencing role does not convert it into a factor. The term *physical factor* remains restricted to a physically relevant property, state, condition, relation, exchange, constraint, interaction, or mechanism that is not independently admitted as a physical system. A model may describe how an influencing system affects another system through such factors, but it must preserve the influencing system's ontological type.

CMA reports that change is realized for every then-existing system at each common stage. It neither produces that change nor replaces its system-specific physical explanation. Ignorance of the physical cause does not license invention of an unspecified hidden cause after a result fails. Every proposed internal or external cause must be physically identified, independently constrained, and open to examination.

6.3 Beneficial or harmful change

A realized physical change may be beneficial or harmful for the physical system under a declared criterion. These descriptions do not alter the meaning of change. The assessment must identify the physical system and the criterion under which the change is evaluated.

A harmful change does not by itself end the identity of the system. Identity ends only when the physical conditions required by the declared persistence criterion cease to be realized, and every such ending produces one or more successors. A beneficial change does not suspend further change or remove the system from CMA or UCC.

6.4 Universal Change Continuity

Definition 6.1 (Universal Change Continuity)**.** For a physical system A,

$$\boxed{\mathrm{UCC}(A) \iff \mathrm{PhysicalSystem}(A) \wedge \forall s \in I_A \; \mathrm{PhysReal}^{+}_{A}(s).} \tag{40}$$

Since $s \in I_A$ entails $A \in \mathcal{S}_{\mathrm{phys}}(s)$, CMA yields

$$\mathrm{CMA} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}} \; \mathrm{UCC}(A). \tag{41}$$

UCC states that change is never suspended while the identity remains physically realized. It requires no immediate predecessor, successor, metric duration, density, differentiability, or infinite divisibility.

6.5 One-stage histories

A system may have an identity history with one actual member. Its formation change is physically complete at that member; where its identity also ends there, ending is a distinct identity classification of the same stage-realized physical transformation. Absence of two distinct members neither implies stasis nor licenses an artificial second stage.

6.6 Complete physical stasis

For a nonempty declared portion $J \subseteq I_A$, complete physical stasis would require absence of bearer-specific physical change throughout that portion:

$$\mathrm{CompletePhysicalStasis}(A; J) \iff \varnothing \neq J \subseteq I_A \wedge \forall s \in J \, \neg \, \mathrm{PhysReal}^{+}_{A}(s). \tag{42}$$

CMA and UCC exclude this condition for an actually realized system. Criterion-relative observational stability remains possible because a declared variable or threshold may stay unchanged while other physical properties, relations, or processes continue to change.

6.7 Small, distributed, and inaccessible change

Realized change may be minute, distributed across components, hidden by noise, outside selected variables, or below human and instrumental thresholds. Non-detection cannot establish absence of change. This restraint does not authorize an unspecified hidden mechanism: a scientific application must still state its bearer, physical route, variables, evidence, uncertainty, and explanatory limits.

6.8 History does not count cosmic stages

The physical history of a system places its identity and development within the universal ordering, but the history tuple is not an empirical counter of cosmic stages. Neither the ontic history nor a reconstructed history determines the number, density, spacing, or cardinality of actual stages. Scientific histories describe observed or inferred change and its development at the resolution supported by records; they do not enumerate the cosmic-stage domain and do not assign a precise stage label to every contribution.

7. Formation, Identity-Bounded History, and Reconstruction

7.1 Formation boundary

Every actually realized bearer has one unique formation member:

Postulate 7.1 (Actual Formation Boundary)**.**

$$\forall A \in \mathcal{U}_{\text{phys}}\ \exists! f \in I_A\, [\neg\exists r \in I_A\, (r \prec_{\text{C}} f)]\,. \tag{43}$$

For each $A \in \mathcal{U}_{\text{phys}}$, let f_A denote that unique least member of I_A. This symbol assignment is not a second postulate and does not introduce an earlier state of the bearer.

Define identity-forming physical change by

$$\text{FormationChange}_A(s) \iff s = f_A \wedge \text{PhysReal}^{+}_{A}(s). \tag{44}$$

The change realized at f_A is the first physical change of bearer A and is the change through which its bearer identity becomes physically actual. It implies neither an earlier state of A, a pre-existing bearer awaiting activation, nor a point-like discontinuity in every contributor from which A forms.

The cosmic relation $\prec_{\text{C}}$ orders common cosmic stages; it does not take formation changes as its direct relata. If $\text{FormationChange}_A(r)$, $\text{FormationChange}_B(s)$, and $r \prec_{\text{C}} s$, then the stage at which A forms is earlier than the stage at which B forms. The order attributed to the two formations is inherited only from the order of their realization stages.

Where $A \in \mathcal{S}_{\text{phys}}(s^0_{\text{C}})$, leastness of s^0_{C} and uniqueness of formation give

$$f_A = s^0_{\text{C}}. \tag{45}$$

Consequently, cosmic origin is physically realized through the first physical changes that form the initial bearer population:

$$\boxed{\mathcal{S}_{\text{phys}}(s_{\text{C}}^{0}) \neq \varnothing, \qquad \forall A \in \mathcal{S}_{\text{phys}}(s_{\text{C}}^{0}), \quad f_A = s_{\text{C}}^{0} \wedge \text{FormationChange}_A(s_{\text{C}}^{0}).} \tag{46}$$

Because the universe denotes the totality of physical systems, its origin is not distinct from the origin of the systems that first constitute it. There is no earlier universe, empty cosmic container, or changeless preliminary stage.

For any attained reference stage a, CSP and CMA jointly yield

$$\boxed{\forall s \in \mathcal{S}_{\text{C}}^{\leq a}, \quad \mathcal{S}_{\text{phys}}(s) \neq \varnothing \wedge \forall A \in \mathcal{S}_{\text{phys}}(s), \text{PhysReal}_A^{+}(s).} \tag{47}$$

Thus the populated cosmic succession extends from origin through every attained reference stage, and every then-existing system realizes its own physical change at each of those stages. Formation is already change; no later starting point of change is introduced.

7.2 Physical history without stage enumeration

The identity-bounded physical history of A is

$$\mathcal{H}_A = (I_A, \prec_{\text{C}} |_{I_A}, X_A)\,. \tag{48}$$

The tuple states the identity domain, the restriction of the common cosmic ordering, and the bearer state realized through that history. It creates no private time and supplies no empirical count of actual stages. Its use does not decide discreteness, density, adjacency, spacing, or cardinality.

The map X_A represents the physical state of the bearer relative to an adopted ontology and identity criterion. A state description may be partial in scientific practice, while the ontic state is the physical realization itself. Equality of selected descriptions at two ordered portions of a history does not reverse the ordering and does not prove complete physical equality.

7.3 Ontic history and reconstructed history

An ontic physical history and a scientific reconstruction are different objects. Let

$$\widehat{\mathcal{H}}_{A;P,M} = \text{Reconstruct}_{P,M}(\mathcal{R}_A) \tag{49}$$

denote the reconstruction supported by accepted records, protocol P, and model M. Then

$$\widehat{\mathcal{H}}_{A;P,M} \not\equiv_{\text{type}} \mathcal{H}_A. \tag{50}$$

The reconstruction can show observed change, ordered development, recurrence, damage, recovery, transformation, or bounded uncertainty. It cannot enumerate the actual cosmic stages, reproduce every physical state, or assign a precise cosmic-stage symbol to each reconstructed contribution.

Long-lived trees and preserved growth records.

Growth layers and related material records may support relative ordering, environmental conditions, damage episodes, and developmental sequences. Sampling and examination are later physical interactions involving the tree or sample, instruments, investigators, and environment. The record does not relocate an earlier physical change into the examination and does not identify every actual stage in the tree history.

Genetic and lineage records.

Genetic material and sequencing records are physical. A direct longitudinal comparison of one identity-coherent system differs from an ancestral reconstruction inferred from descendant records. A warranted genetic conclusion requires provenance, sequencing quality, contamination control, variant discrimination, bearer attribution, and a validated ordering bridge. The result may establish an observed genetic difference or an ordered lineage development within the resolution of the records. It does not identify the exact mutation stage, terminate every containing system, or make genetically related systems the same bearer.

Genetic continuity and bearer identity remain distinct:

$$\mathrm{GeneticContinuity}_{P,M}(A, B) \not\Rightarrow A = B. \tag{51}$$

7.4 Formation estimates

A first accepted record of existence may support a bounded observational account of formation. It cannot identify the exact common cosmic stage of formation. The model may report a record-relative formation window, an interval on an operational scale, or a family of admissible developmental histories. None is a subset of cosmic stages unless a separate bridge is independently established; in V31/F11 no ordinary finite test is treated as supplying such a bridge.

The unique ontic formation boundary and the epistemic width of an estimate remain distinct. The estimate describes available evidence; it does not spread formation over several stages or assign a stage symbol to the observed record.

8. Identity Ending, Transformation, and Necessary Successors

8.1 Ongoing and completed histories

Let $\mathrm{End}_A(e)$ state that the identity of A ends at the actual boundary member e. Define

$$\mathrm{HistoryComplete}(A) \iff \exists e \in I_A \ \mathrm{End}_A(e). \tag{52}$$

If the identity has ended, the ending boundary is unique and greatest within I_A:

$$\mathrm{HistoryComplete}(A) \Longrightarrow \exists! e \in I_A \ \mathrm{End}_A(e), \tag{53}$$

$$\mathrm{End}_A(e) \Longrightarrow \neg \exists u \in I_A \, (e \prec_{\mathrm{C}} u). \tag{54}$$

Ongoing identity at an attained reference is the absence of an attained ending boundary, not a prediction that the identity never ends.

8.2 Ending is physical transformation

Identity ending is a bearer-specific physical change:

$$\mathrm{End}_A(e) \Longrightarrow \mathrm{PhysReal}_A^{+}(e). \tag{55}$$

Functional failure, damage, illness, loss of efficiency, or another harmful consequence ends the bearer identity only where the adopted physical identity criterion is no longer realized. The persistence criterion remains decisive regardless of whether the preceding consequence is assessed as beneficial or harmful. Ending is not mere later absence; it is the transformation through which that identity ceases.

8.3 Necessary successor closure

Every identity ending necessarily produces one or more successor identities. Other physical systems and non-system physical factors may participate in the ending transformation, but they cannot replace the required successor system or systems.

Here "successor identity" is not restricted to a macroscopic object, a functional replacement, or a visibly similar descendant. It includes any physically realized system identity, simple, composite, distributed, field-qualified, material, radiative, or otherwise domain-warranted, whose formation is physically linked to the ending transformation under the declared identity criterion.

Define direct successorship by

$$\begin{aligned}\mathrm{SuccAt}(A, B; e) \iff\ & \mathrm{End}_A(e) \land f_B = e \\ & \land \mathrm{PhysicalProductionLink}(A, B; e) \land A \neq B.\end{aligned} \tag{56}$$

The identity-ending transformation of A and identity-forming transformation of B are physically linked at the common boundary stage. The ordering relates that stage to other stages; it does not order the two transformations as separate temporal relata. The equality $f_B = e$ is an ontic boundary claim under the declared identity criterion. Scientific evidence may warrant only a formation-ending window, a family of admissible successor reconstructions, or a bounded successor attribution rather than exact empirical access to that boundary stage.

Principle 8.1 (Necessary Successor Closure)**.** For every completed system identity, its ending produces at least one successor identity:

$$\boxed{\mathrm{End}_A(e) \Longrightarrow \exists B \in \mathcal{U}_{\mathrm{phys}}\ \mathrm{SuccAt}(A, B; e).} \tag{57}$$

More generally, one ending may produce a finite or physically specified plurality of successors. Each successor has its own identity domain and physical history within the same cosmic ordering.

Whatever physical content continues through the ending transformation is attributed through the successor systems and their physical interactions. It is not a later state of the ended identity.

8.4 Similarity between predecessor and successor

A successor may resemble its predecessor in composition, organization, function, location, name, record, or visible form. Similarity can be strong and scientifically important, but it cannot restore the ended identity:

$$\mathrm{SuccAt}(A, B; e) \land \mathrm{Similar}_\Gamma(A, B) \nRightarrow A = B. \tag{58}$$

A repaired machine, biological descendant, transformed institution, replacement place referent, compact stellar remnant, or merged physical organization must therefore be classified by the appropriate successor identity criterion rather than by resemblance alone.

8.5 One-stage identities and cascade restraint

A system may form and end at its sole identity member. It still realizes physical change and necessarily produces at least one successor. The theory excludes an infinite same-stage chain introduced merely to satisfy successor closure. Domain-specific transformation accounts must identify a physically established finite successor family or an ongoing successor identity whose subsequent history continues in the cosmic ordering.

Principle 8.2 (No Infinite Same-Stage Cascade)**.** Necessary Successor Closure does not license an infinite same-stage successor chain introduced merely to satisfy formal closure. At an ending boundary, a successor family must be physically specified or independently warranted by the relevant domain account. Formal successor generation without physical production warrant is inadmissible:

$$\begin{aligned}\neg\exists e \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \exists(B_n)_{n\in\mathbb{N}}\ \Big[\Big(\forall n \in \mathbb{N}\,(B_n \in \mathcal{U}_{\mathrm{phys}} \wedge B_{n+1} \in \mathcal{U}_{\mathrm{phys}} \wedge \mathrm{SuccAt}(B_n, B_{n+1}; e))\Big) \\ \wedge\ \mathrm{ClosureOnly}\big((B_n)_{n\in\mathbb{N}}, e\big)\Big].\end{aligned} \tag{59}$$

Here $\mathrm{ClosureOnly}\big((B_n)_{n\in\mathbb{N}}, e\big)$ marks a same-stage successor sequence generated solely by formal closure, with all listed terms typed as physical bearers but without independently specified physical production warrant. The principle does not forbid domain-warranted chains of transformations; it forbids using closure itself as a substitute for physical warrant.

8.6 The universe is not an ending bearer

The universe denotes the totality of physical systems and is not one additional bearer with its own ending predicate. Statements about system endings and successors concern the members of that totality. They cannot turn the universe into a container that survives, fails, or ends independently of the systems that constitute it.

9. Stability, Recurrence, and Order-Neutral Formulation

9.1 Criterion-relative stability

For a declared component k, criterion Γ, and nonempty investigation domain $J \subseteq I_A$, define

$$\mathrm{Stable}_{A,k,\Gamma}(J) \iff \varnothing \neq J \subseteq I_A \wedge \forall r, s \in J, \quad X_{A,k}(r) \equiv_\Gamma X_{A,k}(s). \tag{60}$$

This is stability of selected represented content. It fails to entail complete physical stasis:

$$\mathrm{Stable}_{A,k,\Gamma}(J) \nRightarrow \mathrm{CompletePhysicalStasis}(A; J). \tag{61}$$

A stone, sealed sample, stable clock component, or apparently unchanged object may remain stable under a declared criterion while physical change continues below that criterion or outside the represented variables.

9.2 Recurrence without reversal

A later bearer state may match an earlier selected state:

$$r \prec_{\mathrm{C}} s \wedge X_{A,k}(r) \equiv_{\Gamma} X_{A,k}(s). \tag{62}$$

The equality does not reverse the ordering:

$$r \prec_{\mathrm{C}} s \Longrightarrow \neg(s \prec_{\mathrm{C}} r). \tag{63}$$

A patient who becomes ill, recovers, and later becomes ill again occupies a later condition that may be clinically equivalent under a selected criterion. The later illness remains later and may possess different underlying physical history.

9.3 Neutrality among order topologies

The core leaves open whether $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ is discrete, dense, countable, uncountable, or equipped with a topology. UCC is stated at every stage in one identity domain and requires no immediate predecessor or successor. If a physical application introduces continuity, differentiability, or a metric parameter, those additions belong to the application model and do not redefine T_{ITOF}.

9.4 No exact visible-onset inference from accumulated effects

A later visible effect may result from cumulative or distributed change across many stages. Its visibility does not prove that all relevant change occurred at one stage, and absence of earlier visibility does not prove earlier stasis. The exact-stage consequences are developed in Section 14.

Archaeological stone and cumulative manifestation.

The archaeological-stone example retained from V29/F9 gives this restraint a concrete material form [2]. Let $n \geq 2$, let $\mathfrak{R}_{A;P,M}$ be the accepted record family attributed to archaeological-stone bearer A, and let

$$r_1 \lhd_P r_2 \lhd_P \cdots \lhd_P r_n,$$
$$r_i \in \mathfrak{R}_{A;P,M} \quad (1 \leq i \leq n)$$

where $O(r_i)$ are typed outputs, $d_{P,D}$ is a declared discrepancy on those outputs, and $\varepsilon_{P,D}$ is the resolution or decision threshold. Define the protocol-relative cumulative record pattern by

$$\begin{aligned}
&\mathrm{CumulativeRecordPattern}_{P,M,D}(A; r_1, \ldots, r_n) \\
&\Longleftrightarrow n \geq 2 \wedge \bigwedge_{i=1}^{n} (r_i \in \mathfrak{R}_{A;P,M}) \\
&\wedge \bigwedge_{i=1}^{n-1} (r_i \lhd_P r_{i+1} \wedge d_{P,D}(O(r_i), O(r_{i+1})) \leq \varepsilon_{P,D}) \\
&\wedge d_{P,D}(O(r_1), O(r_n)) > \varepsilon_{P,D}.
\end{aligned} \tag{64}$$

The pattern cannot localize the complete alteration at one stage:

$$\mathrm{CumulativeRecordPattern}_{P,M,D}(A; r_1, \ldots, r_n) \not\Rightarrow \exists! s \in I_A \ \ \mathrm{EntireAlterationOccurredAt}(A, s). \tag{65}$$

A later crack, surface loss, colour alteration, or erosion may manifest accumulated thermal, mineral, chemical, microphysical, environmental, and stress-related changes. Prior non-detection is insufficient to establish prior stasis, and later detection does not compress the whole alteration into the detection stage. The example concerns cumulative manifestation in one bearer; it supplies no universal material mechanism.

10. Cross-Domain Clarifications and Retained Examples

The following examples do not create additional axioms. They show how the foundation applies without converting records into stages, places into bearers, or successor resemblance into bearer identity.

10.1 The archaeological stone

An archaeological stone may show no visible alteration during a short inspection. That observation is restricted by the selected surface, variables, lighting, magnification, chemical access, sampling interval, and decision threshold. It cannot establish complete physical stasis. Thermal exchange, stress redistribution, mineral reaction, microscopic fracture, surface loss, moisture interaction, radiation exposure, and environmental engagement may remain below the protocol's resolution.

A later crack or colour change may express accumulated development. The first accepted detection is a stage in the history of the detector and record procedure, not a demonstration that the whole physical alteration began at that detection. Nor does the later effect prove that one indivisible alteration occurred at a single experimentally identified cosmic stage.

This example preserves two distinct claims. Non-detection is insufficient to deny change, and a later cumulative manifestation is insufficient to compress the preceding physical history into the final record.

10.2 Illness, recovery, and recurrence

A patient may be ill, recover under a declared clinical criterion, and later become ill again. The later condition can be clinically equivalent to the earlier condition without being the same physical state and without reversing the cosmic ordering. The patient's constituents, immune condition, environment, treatment history, records, and relations have continued to change.

Recurrence therefore requires three levels of care: bearer identity of the patient, criterion-relative equivalence of the selected clinical condition, and irreversible ordering of the histories in which the conditions occur. A repeated diagnosis or code is not a repeated stage.

10.3 Long-lived trees and material records

Growth rings, scars, isotopic patterns, chemical traces, and preserved tissues may show development of one tree or of sampled successor material. Their order can support a history of seasons, damage, environmental conditions, repair, and growth. The records have their own material histories and may be altered during extraction, preparation, imaging, or storage.

No finite tree reconstruction counts the actual cosmic stages traversed by the organism. It describes development at the resolution supported by the records. The distinction matters especially where a sampled component survives after the organism's identity has ended: the sample is then part of a successor history, not a later state of the ended organism.

10.4 Genetic alteration and containing systems

A genetic difference may occur in a molecule, organelle, cell, tissue, organism, population, or lineage. These are different bearer levels. A change at one level cannot be transferred automatically to every containing or related level. The ending of one cell, for example, does not entail the ending of the organism; the ending of an organism does not entail the ending of a lineage.

Sequencing records may warrant a difference, mutation family, ancestry relation, or lineage development. They do not identify an exact cosmic stage of mutation and do not make related systems the same bearer. Where one identity ends, the physical transformation produces successor identities at the bearer levels actually generated by the process.

10.5 Machines, repair, and replacement

A machine may continue through ordinary maintenance, replacement of consumable components, software revision, or repair, depending on its physical identity criterion. Severe functional failure need not end the machine identity. Conversely, replacement of its organizing architecture, reference lineage, or defining physical integration may end the predecessor and form a successor.

The successor can look identical, perform the same function, retain the same serial designation, occupy the same represented location, and contain much of the same matter. These facts support similarity or continuity of use; they do not by themselves establish bearer identity. The ending transformation must be followed through its physically produced successor or successors.

10.6 Biological transformation and multiple successors

One ending may produce several successors. Cell division ends the bearer identity of the dividing cell under a criterion that treats the two daughter cells as new systems. Each daughter has its own identity domain and physical history. Their genetic and material continuity with the predecessor is real, but it does not make either daughter the same cell.

Other transformations may produce successors at several levels: organisms, components, microbial communities, environmental systems, and records. Necessary Successor Closure does not require all products to belong to one class. It requires at least one actual successor identity and permits a physically warranted plurality.

10.7 Stellar ending and successor resemblance

A stellar identity may persist through oscillation, mass loss, flares, or structural development. When its identity ends through collapse or explosive transformation, the process necessarily produces successor systems. A compact remnant may preserve mass, angular momentum, composition, magnetic characteristics, or spatial continuity; ejecta may form additional systems and enter later organizations.

A remnant can therefore resemble the predecessor in selected properties or features without being the predecessor. The same applies where one or more successor objects inherit a conventional name. Identity follows the physical criterion and production relation, not resemblance or naming.

10.8 Rooms, cavities, and expressed physical reality

The expression "this room" may refer to physical systems such as walls, floor, ceiling, doors, contained air, equipment, occupants, and any field entity independently admitted as a system, together with their spatial relations. Non-system properties and conditions of those systems may be relevant to a physical account, but they are not additional members of the place referent family. The expression does not add a room bearer beside the selected systems unless an independently justified system identity is being claimed for an organized physical whole. It remains a spatial way of referring to the selected physical reality.

A cavity is not empty nothing. Even where no selected occupant is present, boundaries, media, fields admitted by the physical account, and surrounding systems remain. A coordinate-defined interior has physical value only where the coordinates are applicable to those systems and relations.

10.9 Cities, forests, and overlapping place expressions

A city name may refer to buildings, roads, utilities, populations, institutions, land, and changing boundaries. A forest may refer to organisms, soil, water, atmosphere, microorganisms, and ecological relations. These referent families can overlap with watersheds, jurisdictions, transport networks, habitats, and climate regions.

Overlap does not create bearer identity among the systems. Changes in a map or administrative boundary may alter the place expression while much of the physical referent family continues. Conversely, the same name may later select successor systems after substantial physical transformation. Place language must therefore remain explicit about the systems and relations to which it refers.

10.10 Coordinates that lack physical application

A coordinate system can be mathematically well formed while having no physical value for a given application. Physical value requires a documented correspondence with actual physical systems and their spatial relations, together with a domain in which the assignment can be applied, checked, and interpreted.

Coordinates drawn without a physical referent, or applied outside their validated domain, cannot establish location, motion, distance, causation, or temporal ontology. Their equations remain mathematical statements. When a coordinate scheme is physically validated against actual systems and relations, its value is representational: it helps describe physical relations without becoming the systems, relations, place, stage, or time.

10.11 Motion through expressed places

A person may be described as moving from a room to a corridor, through a building, along a road, and into a city region. The physical account concerns the person's changing relations with walls, floors, air, vehicles, roads, buildings, Earth, and other systems. The place names organize the description; they are not bearers through which an entity called motion travels.

A route reconstruction may be accurate without assigning exact cosmic stages to each point. Images, sensors, coordinates, and clock readings can support ordered development and velocity estimates within their operational scales. They do not enumerate the cosmic-stage history.

10.12 Atomic clocks and stage-indeterminate precision

Atomic and optical clocks can produce extraordinarily precise numerical comparisons. Precision narrows uncertainty in a declared record codomain; it does not identify the reading with time or provide an inverse map to a common cosmic stage. The transition-bearing system, local oscillator, servo, detector, environment, transfer path, and record bearer all undergo physical change.

A successful clock model must explain the compared physical outcomes, reproduce accepted records within stated uncertainty, and survive predeclared tests. Relativistic calculations may serve as external benchmarks, but successful calculation does not transfer temporal identity to coordinates, metric intervals, or proper-time functionals.

10.13 Historical explanation without stage counting

A system history can improve explanation and prediction by preserving information about formation, prior damage, repair, interaction, environment, and transformation. Its value lies in the development it represents, not in a count of cosmic stages. Two studies can use different sampling scales and still reconstruct compatible aspects of one physical history.

Accordingly, a scientific history should state its bearer, records, variables, uncertainty, and reconstruction method. It should not present record indices, calendar dates, clock labels, or model coordinates as symbols for the actual cosmic stages.

11. Spatial Realization, Place Expressions, and Physical Occupancy

11.1 The physical meaning of place

A place is not an additional bearer. It is a spatial expression referring to one actual physical system or to a physically organized family of physical systems and representing their relevant boundaries and spatial relations. Write

$$\mathrm{PlaceExpression}(P; \mathcal{B}_P) \tag{66}$$

where P is the spatial expression and $\mathcal{B}_P$ is its physical referent family. The members of $\mathcal{B}_P$, not the expression P, possess physical identities, histories, change, formation, and ending. Explicitly,

$$\mathrm{PlaceExpression}(P; \mathcal{B}_P) \implies P \notin \mathcal{U}_{\mathrm{phys}}. \tag{67}$$

The formula classifies the expression, not the physical referents selected by it. Every member of $\mathcal{B}_P$ is a physical system admitted under the applicable identity criterion; boundaries and spatial relations are represented features of that system family, not additional members or bearers. The place expression itself is not an additional system.

A room may refer to physical systems such as walls, floor, ceiling, contained media, equipment, occupants, and any field entity independently admitted as a system, while representing their boundaries and organized spatial relations. A road segment, city, forest, river reach, ocean region, laboratory, planetary region, or spacecraft compartment similarly refers to a selected system or organized family of systems. The appropriate system level depends on the claim; the word *place* does not create a new system beside its referents.

11.2 Simple, composite, nested, and overlapping referents

A place expression may select one system or a composite physical family. Place referents may be nested or overlap. A laboratory may be represented within a building, campus, and city; an ecological zone may overlap a river basin, atmospheric region, administrative area, and transport network. Nesting and overlap concern the represented systems and relations. They neither create bearer identity among the referents nor convert the place expression into a bearer.

11.3 Cavities, geometrical regions, and physical reference

An expression such as "inside the cavity" may refer to physical systems forming or occupying the cavity, any admitted field bearers, their boundaries, and their spatial relations. Pressure, temperature, field values, and similar non-system factors may describe conditions realized in those systems, but they are not the place referents themselves. A geometrically selected region without an independently realized system identity remains a representation of the relevant systems and relations. It is not an empty physical nothing and not a bearer merely because coordinates delimit it.

11.4 Coordinates and physical value

Coordinates, map boundaries, addresses, grid cells, and geometrical regions are representational assignments. Their mathematical consistency can be studied abstractly, but they possess physical value in an ITOF application only where they represent actual physical systems and their spatial relations and are applicable to the physical reality under investigation.

This criterion is expressed by

$$\begin{aligned}&\neg\Big(\mathrm{RepresentsPhysicalReality}_{\Sigma}(q) \wedge \mathrm{ApplicableToPhysicalReality}_{\Sigma}(q)\Big)\\&\qquad \Longrightarrow \neg\,\mathrm{PhysicalValue}_{\Sigma}(q).\end{aligned} \tag{68}$$

A coordinate assignment detached from physical reference and applicability remains a mathematical construction without physical significance. It cannot establish a place, system identity, motion, stage, time, or physical cause.

Different coordinate schemes may represent the same physical relations, and one scheme may change while the represented systems do not change in the selected represented property or relation. Numerical difference among coordinates therefore has evidential force only under a validated bridge to physical reality.

11.5 Spatial configuration

For bearer A and a declared physical referent family $\mathcal{B}_P$, let

$$\Xi_{A|\mathcal{B}_P} \tag{69}$$

denote the physically defined spatial relation of the bearer. It may include contact, containment, orientation, separation, distribution, adjacency, or another physically realized spatial relation. The symbol represents the relation; it is not identical with a coordinate tuple or place expression.

11.6 Occupancy

Occupancy relates a physical bearer to the physical system or system family selected by a place expression under a declared spatial-relation criterion:

$$\begin{aligned}\mathrm{Occupies}^{\kappa}_{P}(A;s) \iff A \in \mathcal{S}_{\mathrm{phys}}(s) \\ \wedge\ \mathrm{OccupancyRelation}^{\kappa}(A,\mathcal{B}_P;s).\end{aligned} \tag{70}$$

The physical work belongs to A, the referent physical systems, and their relations. Relevant non-system factors describe properties, conditions, or interactions of those systems; they are not independent place referents. The place expression neither contains the bearer as a physical vessel nor acts causally.

11.7 Unoccupied, reoccupied, transformed, and destroyed places

An unoccupied place means that no bearer of the selected class satisfies the declared occupancy relation with the relevant physical referents. Reoccupation is a later relation involving the continuing or successor referent systems. If the former systems transform or end, the same name or coordinate may refer later to successor systems without restoring bearer identity.

A place expression itself has no system history. The physical systems to which it refers have their own histories, changes, endings, and successors. Properties, conditions, and relations change only as physically realized in or among those systems and do not receive independent system histories merely by being represented. Changes in the referent family may justify revising the expression, its boundary, or its name.

11.8 Spatial separation and common-stage unity

Spatial separation belongs to relations among physical systems. It affects interaction, signal propagation, records, and access, but it does not split the common cosmic stage or exclude distant systems from CMA.

12. Motion, Migration, Local Cycles, and Irreversible Succession

12.1 The physical meaning of motion

Physical motion is one type of physical change realized in some physical systems. Like other change, it arises through the interaction between the system's internal constitution and properties, other physical systems that influence it while remaining systems, and non-system conditions, constraints, relations, and mechanisms relevant to its spatial development. Its realization depends on the mechanisms available to the moving system and on its spatial relations with actual physical systems selected by a place or reference expression. This type of change is not uniform across systems: translation, rotation, orbital development, deformation-linked displacement, migration, and constituent motion have different physical contents and mechanisms. A bearer may satisfy CMA through another type of physical change while remaining at rest under a declared spatial criterion. Motion is therefore included within physical change, but physical change is not exhausted by motion and motion is not required of every physical system. Where motion is realized, the moving bearer may continue in bearer identity while the relevant spatial relation changes. Motion is not an entity transported between places, and it is not movement through time.

12.2 Motion, CMA, and bearer constitution

CMA requires bearer-specific physical change at every common cosmic stage at which a system exists. It does not classify every such change as motion and does not cause either motion or another change. A system may realize change in its material constitution, internal physical structure, external physical structure, or combined condition while preserving a selected spatial relation. Motion is one physically realized type of physical change in some systems. When it occurs, it is the material transition of the system through, within, or between composite physical systems; it is not required of every physical system.

The same generic label *motion* can therefore cover physically different properties. Translational motion of a rigid body, rotation of a composite, orbital development, locomotion of an organism, migration of a population, displacement within a deforming medium, and motion of a constituent within a larger system require different bearer boundaries, mechanisms, variables, and evidential bridges. Their common spatial classification does not make their physical nature identical.

For bearer A, physical referent family $\mathcal{B}_P$, and spatial-equivalence criterion Γ^{sp}, define a net spatial difference by

$$\begin{aligned} &\mathrm{NetSpatialDifference}_{A|P,\Gamma^{\mathrm{sp}}}(r,s) \\ &\iff r,s \in I_A \wedge r \prec_{\mathrm{C}} s \\ &\quad \wedge \mathrm{SameBearerThrough}_A(r,s) \\ &\quad \wedge \Xi_{A|\mathcal{B}_P}(r) \not\equiv_{\Gamma^{\mathrm{sp}}} \Xi_{A|\mathcal{B}_P}(s). \end{aligned} \tag{71}$$

The ordered pair bounds a comparison of spatial relations used to describe or support a motion claim. It does not define motion as a type of physical change, localize the whole motion to the endpoints, or make the comparison the physical cause of motion. Endpoint equality also cannot exclude motion within the bounded history, as in rotation, return, or another recurrent spatial relation.

12.3 Motion through spatially expressed systems

A route may be described through rooms, roads, regions, media, reference systems, or nested and overlapping physical organizations. These names and boundaries are spatial expressions. The physical motion concerns the moving system and the changing relations with the physical systems represented by those expressions. Non-system factors may influence the motion or enter its model, but they are not reclassified as place referents or moving systems.

Where referent systems transform or end, a later route description concerns their successors or replacements. Reuse of the same place name, map symbol, or coordinate does not establish persistence of the former system identity.

12.4 Reference dependence and relative rest

Motion and rest are relative to declared physical references, but that reference dependence does not erase the bearer-specific physical basis of motion. A bearer may be at rest relative to one system and moving relative to another, and different components of one composite may possess different motion properties. Relative rest between two distinct ordered stages is

$$\begin{aligned}\mathrm{Rest}_{A|P,\Gamma^{\mathrm{sp}}}(r,s) \iff{}& r,s \in I_A \wedge r \prec_{\mathrm{C}} s \\ &\wedge\, \Xi_{A|\mathcal{B}_P}(r) \equiv_{\Gamma^{\mathrm{sp}}} \Xi_{A|\mathcal{B}_P}(s).\end{aligned} \tag{72}$$

Rest over a declared history portion requires the relation for every ordered pair in that portion. It is criterion-relative and does not imply complete physical stasis.

12.5 Coordinates and motion evidence

A coordinate value may change because the bearer moves, because the represented physical references change, because the coordinate scheme changes, or through a combination of these. Conversely, a scheme may keep a value fixed while physical relations change. Coordinate behavior supports a motion claim only when the scheme represents and applies to the physical systems and spatial relations involved and a validated bridge connects numerical variation to the physical spatial relation.

12.6 Motion within composite and distributed systems

Motion may occur at several bearer levels and with different physical natures. A constituent may move relative to a composite system while the composite retains a selected relation to an external reference; the composite may move while selected internal relations remain stable. Whether motion is attributable at a given level depends on the constitution, organization, boundary, constraints, and interactions of the system at that level. Individual, component, organism, group, population, lineage, instrument, and environment are distinct bearer levels unless an identity criterion establishes otherwise.

12.7 Spatial paths, velocity, and migration

A spatial path is a reconstruction of changing physical relations. It is neither an independently existing carrier nor the cosmic ordering. Path models may be continuous, discrete, piecewise, statistical, or otherwise specified. Their form belongs to the model and gains physical value only through application to the relevant physical systems and their spatial relations; non-system factors may enter the dynamics without becoming path referents.

Velocity and related rates compare physical changes with a declared clock process, parameter, or model variable. They do not assign a rate to time. Migration is an extended motion history of a declared bearer through spatially expressed physical systems and relations.

12.8 Return, rotation, and local cycles

A later return to a physically continuing referent system is a new occupancy or spatial relation at a later common stage. It does not restore the earlier stage. Rotation, orbital motion, repeated angles, recurring clock readings, night, day, seasons, and local cycles likewise repeat selected physical or representational conditions without reversing cosmic succession.

12.9 Motion records and stage restraint

Tracks, images, radar returns, coordinates, sensor outputs, and clock-tagged records may support motion, path, direction, or velocity claims under attribution and calibration. They sample observable development; they do not enumerate the actual cosmic stages. A test may detect motion or a change in spatial relation while remaining unable to determine the precise stage at which the underlying change became detectable or its exact position in the cosmic ordering. Absence of earlier detection cannot establish earlier stasis.

13. Clocks, Operational Intervals, and Local Conventions

13.1 The status of a clock

A clock is a physical system and bearer selected because one or more of its repeatable, stable, or modelled physical processes can be converted into ordered records and standardized numerical readings.

Accordingly,

$$\mathrm{Clock}(C) \Longrightarrow \mathrm{PhysicalSystem}(C). \tag{73}$$

A clock may be:

(i) an atomic or molecular system;
(ii) an oscillator or resonator;
(iii) a rotating or orbiting physical bearer;
(iv) a decaying system or ensemble;
(v) an electronic circuit;
(vi) a mechanical device;
(vii) or a composite apparatus integrating several physical processes.

Where a clock is human-designed, its artificial status concerns the organization of its components, its intended function, and the selection of a repeatable process for standardization. Its actual operation remains physical. The selected process and numerical register represent only a declared part of the clock bearer's physical history; they do not exhaust that history.

The clock remains subject to the same bearer ontology as every other physical system. It possesses:

$$\mathcal{H}_C = \left(I_C, \prec_{\mathrm{C}} |_{I_C}, X_C\right), \tag{74}$$

and, under CMA,

$$C \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow \mathrm{PhysReal}^{+}_{C}(s). \tag{75}$$

Its selection as a standard or reference does not place it outside the common cosmic extension and does not exempt it from physical change.

13.2 Clocks do not measure time as defined by ITOF

The central temporal denotation is

$$T_{\mathrm{ITOF}} = (\mathcal{S}_{\mathrm{C}}, \prec_{\mathrm{C}})$$

A clock does not directly detect, contain, transport, or measure this ordered domain.

It undergoes bearer-specific physical change at each stage of its identity; its records arise from those physical processes. When a bounded part of the operation is discussed, its endpoint stages merely delimit the stages under consideration.

Therefore,

$$\boxed{\mathrm{ClockOutput} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}} \tag{76}$$

and

$$\boxed{\mathrm{ClockRecord} \not\equiv_{\mathrm{type}} \mathrm{CommonCosmicStage}\,.} \tag{77}$$

Clocks provide standardized operational means for:

(a) ordering records;
(b) comparing physical processes;
(c) coordinating activities;
(d) navigation and communication;
(e) defining schedules and dates;
(f) and constructing quantitative physical models.

These functions do not transfer the ontological type of time to the clock, its process, its record, or its numerical output.

13.3 Clock process and record production

Let $J \subseteq I_C$ be a declared clock-history domain.

Let $\mathfrak{H}_{C,J}^{\mathrm{phys}}$ be the domain of admissible physical clock-history segments over J, and let $\Theta_{C,P}$ contain the physical and protocol conditions relevant to clock operation.

These conditions may include:

(i) physical environment;
(ii) temperature and pressure;
(iii) electromagnetic or other control fields;
(iv) power supply;
(v) motion relative to declared references;
(vi) gravitational conditions under the adopted physical model;
(vii) coupling and isolation;
(viii) device condition and ageing;
(ix) interrogation procedure;
(x) and record convention.

Define clock-record production by

$$\mathcal{R}_{C,P} : \mathfrak{H}^{\mathrm{phys}}_{C,J} \times \Theta_{C,P} \longrightarrow \mathfrak{R}_{C,P}, \tag{78}$$

with

$$r_C = \mathcal{R}_{C,P}\left(h_{C,J}, \theta_{C,P}\right). \tag{79}$$

Here:

(a) $h_{C,J}$ is a physical history segment of the clock;
(b) $\theta_{C,P}$ states the declared operating and protocol conditions;
(c) r_C is a physically realized clock record;
(d) and $\mathfrak{R}_{C,P}$ is the protocol-specific record domain.

The history-segment input is necessary because accumulation, oscillation, counting, memory, interrogation, and readout may depend upon more than one isolated clock state.

13.4 Numerical clock reading

Under protocol P, define a reading map

$$N_{C,P} : \mathfrak{R}_{C,P} \longrightarrow \mathbb{R}_P, \tag{80}$$

where $n_C = N_{C,P}(r_C)$. The codomain $\mathbb{R}_P$ is the numerical reporting scale adopted by the protocol.

The mapping may include:

(i) cycle counting;
(ii) scale and unit selection;
(iii) interpolation;
(iv) calibration;
(v) correction;
(vi) rounding;
(vii) and display or transmission rules.

The resulting type boundary is

$$\boxed{n_C \in \mathbb{R}_P, \qquad n_C \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad r_C \not\equiv_{\mathrm{type}} s \quad (s \in \mathcal{S}_{\mathrm{C}}).} \tag{81}$$

A numerical reading is a result of a physical history and a declared mapping. It is not a cosmic stage and is not time.

Clocks do not count cosmic stages

The cosmic-stage domain is not assumed to be:

(a) discrete;
(b) countable;
(c) equally spaced;

(d) metrically separated;
(e) or individually accessible to instruments.

A clock counts or measures a selected feature of its own physical process. It cannot count the members of $\mathcal{S}_{\mathrm{C}}$.

Therefore,

$$N_{C,P}(r_C) = n \not\Rightarrow \text{NumberOfCosmicStagesAttained} = n. \tag{82}$$

A clock completing more cycles than another clock does not mean that it has passed through more time or more cosmic stages.

Both clocks remain members of the same common cosmic succession wherever their identities are realized.

13.5 Operational ordering of records

For records r_1, r_2, define

$$r_1 \triangleleft_P r_2 \tag{83}$$

to mean that protocol P places r_1 before r_2.

The operational basis may include:

(i) detector architecture;
(ii) storage order;
(iii) causal or transmission sequence;
(iv) sequential clock counts;
(v) source attribution;
(vi) or another validated operational rule.

The operational relation is not identical with the cosmic ordering:

$$\triangleleft_P \not\equiv_{\text{type}} \prec_{\mathrm{C}} . \tag{84}$$

A valid physical and evidential bridge may warrant consistency between a particular record order and the order of attributed physical changes. The protocol does not create the cosmic order.

13.6 Operational interval

For clock records $r_{C,1} \triangleleft_P r_{C,2}$, define the numerical operational interval

$$\boxed{\Delta N_{C,P} := N_{C,P}(r_{C,2}) - N_{C,P}(r_{C,1}).} \tag{85}$$

The result is a difference in the clock's numerical reporting scale.

It is not:

(a) an amount of cosmic extension;

(b) a number of common cosmic stages;
(c) a quantity possessed by time;
(d) or a physical substance located between two physical changes.

Thus,

$$\Delta N_{C,P} \not\equiv_{\text{type}} \text{TemporalMagnitudeOf}\left(\mathcal{S}_{\text{C}}, \prec_{\text{C}}\right). \tag{86}$$

The interval remains scientifically meaningful because its protocol, unit, calibration, and physical production conditions are declared.

Duration language

Ordinary and scientific language may call $\Delta N_{C,P}$ a duration or elapsed time.

Within the formal ontology of ITOF, that expression is interpreted as:

a standardized operational interval derived from physical clock records.

It is not interpreted as a measured quantity of time itself.

This terminology permits continued use of conventional scientific expressions without allowing them to redefine the ontological meaning of time.

13.7 Rates of physical quantities

Let $\widehat{Q}_{A,P} : \mathfrak{R}_{A,P} \longrightarrow \mathbb{R}_{Q,P}$ be a protocol-defined measurement or estimation map for a physical quantity attributed to bearer A.

For paired sample and clock records, define

$$\Delta_P Q_A := \widehat{Q}_{A,P}(r_{A,2}) - \widehat{Q}_{A,P}(r_{A,1}), \tag{87}$$

$$\Delta_P N_C := N_{C,P}(r_{C,2}) - N_{C,P}(r_{C,1}), \tag{88}$$

and, where $\Delta_P N_C \neq 0$,

$$\boxed{\overline{v}^{P}_{Q_A|C} := \frac{\Delta_P Q_A}{\Delta_P N_C}.} \tag{89}$$

This quantity is an average operational rate of the represented physical quantity relative to the declared clock scale.

It does not divide a physical state by time as defined by ITOF.

The numerator and denominator are numerical outputs produced under declared protocols.

Therefore,

$$\overline{v}^{P}_{Q_A|C} \not\Rightarrow \text{RateOfTime}. \tag{90}$$

Fast and slow processes

A physical process may yield a larger or smaller change per clock-output unit than another process.

This comparison concerns:

(i) the physical bearers;
(ii) the measured quantities;
(iii) the clock processes;
(iv) the calibration and units;
(v) and the comparison protocol.

It is insufficient to establish that time itself moves faster or slower.

Thus,

$$\overline{v}^{P}_{Q_A|C} > \overline{v}^{P}_{Q_B|C} \nRightarrow \mathrm{TimePassesFasterFor}(A). \tag{91}$$

Different rates are differences among bearer histories and their operational representations within one cosmic ordering.

13.8 Comparison of different clocks

Two clocks may employ different mechanisms, units, records, and native reading scales.

Let C_1, C_2 be two clock bearers, and let

$$\Gamma_{i,P_{12}} : \mathrm{Range}(N_{C_i,P_i}) \longrightarrow \mathbb{R}_{P_{12}}, \qquad i \in \{1,2\}, \tag{92}$$

map their readings into one comparison codomain.

Define their protocol-relative numerical difference by

$$\boxed{\Delta N^{(P_{12})}_{C_1C_2} := \Gamma_{1,P_{12}}(n_{C_1}) - \Gamma_{2,P_{12}}(n_{C_2}).} \tag{93}$$

A nonzero difference may reflect:

(a) different clock mechanisms;
(b) different physical histories;
(c) environmental conditions;
(d) motion relative to selected references;
(e) gravitational conditions under a declared model;
(f) calibration;
(g) coupling;
(h) drift;
(i) or device degradation.

It fails to entail multiple cosmic extensions:

$$\Delta N_{C_1 C_2}^{(P_{12})} \neq 0 \nRightarrow \mathrm{DifferentTimes}(C_1, C_2). \tag{94}$$

13.9 Atomic-clock comparisons

High-precision atomic-clock experiments provide a particularly exact instance of the clock type boundary, including optical-clock networks, differential gravitational-redshift comparisons, and developing nuclear-clock transitions [32, 29, 30, 31, 33, 34, 35, 36, 37, 38]. The comparison law of the preceding subsection applies to their standardized readings. A nonzero result is a difference between physical records produced by the declared clock systems and protocols; it is not itself time:

$$\Delta N_{C_1 C_2}^{(P_{12})} \neq_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{95}$$

The bearer, cycle, response, record, alignment, uncertainty, and failure-decision specification is supplied by the integrated quantitative bridge in Section 19. This separation avoids treating the general clock ontology as though it already contained a clock-specific microscopic law.

13.10 Clock running faster or slower

The statements

"clock C_1 runs faster than clock C_2"

or

"clock C_2 runs slower"

are interpreted as comparative claims about their output rates under a declared protocol.

Define

$$\mathrm{ClockRate}_{P_{12}}(C_i) \tag{96}$$

from the change of the standardized output of C_i across the comparison domain.

Then

$$\mathrm{ClockRate}_{P_{12}}(C_1) \neq \mathrm{ClockRate}_{P_{12}}(C_2) \tag{97}$$

states unequal physical-output rates.

It does not state:

$$\mathrm{RateOfTimeFor}(C_1) \neq \mathrm{RateOfTimeFor}(C_2). \tag{98}$$

The clock rate belongs to the clock. Time has no bearer-specific rate.

Clock drift

Clock drift is a change in the relation between a clock's output and an adopted operational standard.

A discrepancy initiates assessment of the physical bearer and protocol:

$$\text{ClockDiscrepancy} \Longrightarrow \text{ClockAssessment}\left(C, \Theta_{C,P}, P, r_C\right). \tag{99}$$

Relevant causes may include:

(a) temperature variation;
(b) mechanical or electronic degradation;
(c) power instability;
(d) environmental coupling;
(e) calibration error;
(f) frequency shift;
(g) component ageing;
(h) software or counting error;
(i) or record corruption.

The diagnostic conclusion concerns the clock and its conditions, not an acceleration, slowing, damage, discontinuity, or deformation of time.

13.11 Clock stopping and failure

A clock may stop producing valid records.

Define

$$\text{ClockFailure}_P(C; s) \tag{100}$$

to state that the bearer no longer performs its declared clock function under protocol P at stage s.

Clock failure fails to entail identity ending:

$$\text{ClockFailure}_P(C; s) \not\Rightarrow \text{End}_C(s). \tag{101}$$

A failed clock may remain physically realized as the same device.

Likewise, stopping of clock output does not stop the common cosmic succession or the physical change of other systems:

$$\text{NoClockReadingAfter}_P(C; s) \not\Rightarrow \text{CosmicSuccessionStopsAt}(s). \tag{102}$$

Where the clock identity remains realized, it also remains subject to CMA despite its functional failure.

Ideal and real clocks

A real clock is a material physical system with a bearer-specific history.

An ideal clock is a modelling limit whose output is stipulated to track a selected theoretical quantity with specified accuracy or exactness.

Therefore,

$$\text{IdealClockModel} \not\equiv_{\text{type}} \text{RealClockBearer}\,. \tag{103}$$

Agreement between a real clock output and an idealized model may support the model within its tested domain. It does not convert the model quantity into the ontological definition of time.

The model remains a representation of selected physical and numerical relations.

13.12 Derived bounded response law: a pressure-rated diving watch

V16, V20, and V23 used a pressure-rated diving watch to distinguish the physical resistance and failure of a clock bearer from any alteration of time [15, 11, 8]. V31/F11 does not inherit their earlier response notation. It revalidates the underlying assignment through a bounded auxiliary law whose variables, approximations, validity domain, and failure criterion are explicit. International qualification of divers' watches likewise concerns specified requirements and test methods for physical devices, not resistance to time [47].

Let $W \in \mathcal{U}_{\text{phys}}$ be a declared diving-watch bearer with casing, seals, crystal, mechanism, record bearer, and internal gas or fluid conditions included in its model boundary. Let $J_W \subseteq I_W$ be a nonempty dive domain, and let $h_W(s) \geq 0$ denote depth below the local free surface at stage $s \in J_W$. Under hydrostatic equilibrium, the modelled external pressure is

$$\widehat{P}_{\text{ext},W}(s) = P_{\text{surf}}(s) + \int_0^{h_W(s)} \rho_{\text{w}}(z,s) g(z,s)\, \mathrm{d}z. \tag{104}$$

For approximately constant water density and gravitational acceleration across the relevant depth,

$$\widehat{P}_{\text{ext},W}(s) \simeq P_{\text{surf}}(s) + \rho_{\text{w}} g h_W(s). \tag{105}$$

Let $P_{\text{int},W}(s)$ be the internal pressure assigned by the declared sealed-device model. The differential pressure acting across the watch boundary is

$$\Delta P_W(s) := \widehat{P}_{\text{ext},W}(s) - P_{\text{int},W}(s). \tag{106}$$

Let q_W be one declared response observable, such as case deflection, seal displacement, oscillator residual, contact state, or readout deviation. On a validated local response domain $\mathcal{D}_W^{\text{lin}}$, a first-order constitutive model has the form

$$\widehat{q}_W(s) = q_{W,0} + C_{W,P}\Delta P_W(s) + C_{W,T}(T_W(s) - T_{W,0}), \qquad (\Delta P_W(s), T_W(s)) \in \mathcal{D}_W^{\text{lin}}, \tag{107}$$

where the coefficients are fixed from independent material, component, calibration, or qualification evidence. Composing Equations (104), (106), and (107) yields the derived bounded response law

$$\boxed{\begin{aligned}\widehat{q}_W(s) = q_{W,0} + C_{W,P}\left[P_{\mathrm{surf}}(s) + \int_0^{h_W(s)} \rho_{\mathrm{w}}(z,s)g(z,s)\,\mathrm{d}z - P_{\mathrm{int},W}(s)\right] \\ + C_{W,T}\big(T_W(s) - T_{W,0}\big).\end{aligned}} \tag{108}$$

Let the accepted observation satisfy

$$q_W^{\mathrm{obs}}(s) = \widehat{q}_W(s) + \eta_W(s), \qquad |\eta_W(s)| \le u_W(s), \tag{109}$$

where $u_W(s)$ is an uncertainty bound declared in advance. This is a genuine derivation inside the declared auxiliary model: the predicted response follows by composing a pressure law with a calibrated constitutive law, while Equation (109) separates prediction from accepted observation. The law is not derived from the definition of time, CMA, or UCC, and it is not a universal law for every diving watch.

Let $\Delta P_W^{\mathrm{cert}}$ denote the maximum differential pressure for which protocol P_W warrants the declared performance, and let $\delta q_W^{\mathrm{fail}}$ denote an independently validated threshold for the magnitude of response deviation from the reference value $q_{W,0}$. Define the attained dive prefix

$$J_W^{\preceq s} := \{u \in J_W \mid u \preceq_{\mathrm{C}} s\}. \tag{110}$$

Then

$$\mathrm{WithinCertifiedPressureDomain}_{P_W}(W;s) \iff s \in J_W \wedge \sup_{u\in J_W^{\preceq s}} |\Delta P_W(u)| \le \Delta P_W^{\mathrm{cert}}. \tag{111}$$

Exceeding the certified boundary removes the certification-based performance warrant; it by itself cannot prove immediate failure:

$$s \in J_W \wedge \sup_{u\in J_W^{\preceq s}} |\Delta P_W(u)| > \Delta P_W^{\mathrm{cert}} \not\Rightarrow \mathrm{ClockFailure}_{P_W}(W;s). \tag{112}$$

A failure prediction requires the validated response model and a declared failure criterion. For example,

$$\begin{aligned} s \in J_W \wedge \mathrm{ValidatedResponseModel}_{P_W,M_W}(W) \\ \wedge \sup_{u\in J_W^{\preceq s}} \left[|\widehat{q}_W(u) - q_{W,0}| - u_W(u)\right] \ge \delta q_W^{\mathrm{fail}} \\ \Longrightarrow \mathrm{PredictedClockFailure}_{P_W,M_W}(W;s). \end{aligned} \tag{113}$$

Under the special constant-density approximation in which $P_{\mathrm{int},W}$, P_{surf}, ρ_{w}, and g are treated as constants over the evaluated domain, and with a separately established differential-pressure failure threshold $\Delta P_W^{\mathrm{fail}}$, the corresponding modelled depth is

$$\widehat{h}_W^{\mathrm{fail}} = \frac{P_{\mathrm{int},W} + \Delta P_W^{\mathrm{fail}} - P_{\mathrm{surf}}}{\rho_{\mathrm{w}} g}, \tag{114}$$

provided the numerator is nonnegative and all quantities remain inside the validated approximation domain. The threshold is determined by the physical device and its test-supported model. It is not a property, limit, resistance, or failure point of T_{ITOF}.

The law therefore supplies a complete symbolic specification of a bounded auxiliary response bridge: identify the bearer, derive the acting physical profile, specify the constitutive response, separate certification from failure, declare uncertainty and validity limits, and test the predicted record or functional outcome. It cannot replace the still-open microscopic response law required for differential atomic-clock and gravitational-clock applications.

13.13 Synchronization

Synchronization is a protocol-relative relation imposed upon or inferred from clock records.

Let

$$\mathrm{Sync}_{F,P}(r_{C_1}, r_{C_2}) \tag{115}$$

state that synchronization convention F under protocol P classifies the two records as synchronized.

The convention may use:

(i) signal exchange;
(ii) transport or comparison of clocks;
(iii) a common source;
(iv) network correction;
(v) calculated propagation adjustments;
(vi) or another adopted operational procedure.

Synchronization creates no common-stage co-presence and does not define time:

$$\mathrm{Sync}_{F,P}(r_{C_1}, r_{C_2}) \nRightarrow \mathrm{SameCosmicStageExactlyIdentified}\,. \tag{116}$$

Conversely, two systems may be present at the same common cosmic stage without their records being operationally synchronized.

Common-stage unity is ontic. Synchronization is a procedure for organizing records.

13.14 Simultaneous clock readings

Equal clock readings do not establish identity of physical change, bearer state, or cosmic stage:

$$N_{C_1,P_1}(r_1) = N_{C_2,P_2}(r_2) \nRightarrow \mathrm{SameCosmicStage}(r_1, r_2). \tag{117}$$

The equality may arise from:

(a) calibration;
(b) reset;
(c) repeated display values;
(d) periodicity;
(e) convention;
(f) or numerical coincidence.

A warranted same-stage claim requires an independent bearer- and record-to-stage inference bridge.

13.15 Local clock conventions

A local civil clock label is constructed from:

(i) one or more standardized clock systems;
(ii) adopted units and scales;
(iii) geographical or political zone rules;
(iv) correction and dissemination systems;
(v) and social conventions.

Let

$$\mathrm{LocalClockLabel}_{Z,P}(r_C) \tag{118}$$

denote the label assigned under zone convention Z.

Two regions may assign different labels to records realized at one common cosmic stage:

$$\mathrm{LocalClockLabel}_{Z_1,P_1}(r_1) \neq \mathrm{LocalClockLabel}_{Z_2,P_2}(r_2) \not\Rightarrow \mathrm{DifferentCosmicTimes}\,. \tag{119}$$

The difference belongs to clock outputs and local conventions.

13.16 Time zones

A time zone is a conventional rule system associating geographical or administrative regions with standardized clock offsets and date practices.

It is not a temporal domain.

Therefore,

$$\mathrm{TimeZone}(Z) \not\Rightarrow \mathrm{IndependentTime}(Z). \tag{120}$$

A region does not enter a new time when a political authority changes its zone designation or offset.

The local clocks and labels change under the adopted rule. The common cosmic ordering does not.

Daylight-saving and administrative changes

A jurisdiction may advance or retard its civil clock label under an administrative convention.

Such a change may produce:

(a) repeated civil labels;
(b) skipped labels;
(c) changed schedules;
(d) and altered operational comparisons.

It does not repeat, remove, insert, or reverse common cosmic stages.

Thus,

$$\text{CivilClockAdjustment}(Z) \not\Rightarrow \text{CosmicOrderAdjustment}\,. \tag{121}$$

A repeated local clock label is a recurrence in the reporting convention, not a repeated stage.

13.17 Calendar dates

A calendar date is a conventional classification built from selected astronomical cycles, civil rules, clock outputs, historical conventions, and local zone assignments.

Let

$$\text{CalendarDate}_{K,Z}(s) \tag{122}$$

denote the date label assigned under calendar K and zone convention Z to records associated with stage s.

Different date labels may apply at the same common cosmic stage:

$$\text{CalendarDate}_{K,Z_1}(s) \neq \text{CalendarDate}_{K,Z_2}(s). \tag{123}$$

This fails to entail different times:

$$\text{DifferentLocalDates}(Z_1, Z_2; s) \not\Rightarrow \text{DifferentCosmicTimes}(Z_1, Z_2). \tag{124}$$

The date difference belongs to representation and convention, not to the universal cosmic succession.

The civil day

A civil day is an operational and conventional interval defined through clock readings and calendar rules.

It need not coincide exactly with:

(i) a local illumination cycle;
(ii) one complete terrestrial rotation under every physical definition;
(iii) a biological cycle;
(iv) or a fixed number of common cosmic stages.

Accordingly,

$$\text{CivilDay} \not\equiv_{\text{type}} \text{CosmicStageDomainSegment}\,. \tag{125}$$

Civil days remain highly useful units for human organization. Their conventional status does not diminish that usefulness.

Date boundaries and the international date line

A conventional date boundary may assign different dates to nearby regions or to one bearer crossing the boundary.

Crossing such a boundary changes the local date attribution. It cannot move the bearer forward or backward in cosmic succession:

$$\text{CrossesDateBoundary}(A) \not\Rightarrow \text{MovesBetweenTimes}(A). \tag{126}$$

The physical bearer continues its one ordered history $\mathcal{H}_A = (I_A, \prec_{\mathrm{C}} |_{I_A}, X_A)$. Only the applicable civil label changes.

Night, day, clock labels, and dates

Night and day are local illumination states. Clock readings are physical outputs. Dates and zones are conventional classifications.

These four types must remain distinct:

$$\begin{aligned} \mathsf{IlluminationState} &\neq \mathsf{ClockOutput}, \\ \mathsf{ClockOutput} &\neq \mathsf{CalendarDate}, \\ \mathsf{CalendarDate} &\neq \mathsf{TimeZone}, \\ \mathsf{TimeZone} &\neq \mathsf{ITOFTemporalDenotation}. \end{aligned} \tag{127}$$

A local region may be in daylight while its civil clock reports one label and another region in darkness reports another label and date.

All then-existing systems remain members of the same common cosmic stage.

13.18 Records do not identify exact cosmic stages

A clock record is a physical record produced through a physical change in its bearer and acquisition chain. The record, its numerical reading, and its operational position are not cosmic stages:

$$r_C \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad N_{C,P}(r_C) \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{128}$$

A numerical reading cannot identify an exact common cosmic stage or an exact ordinal position in the cosmic ordering:

$$N_{C,P}(r_C) = n \not\Rightarrow \text{ExactCosmicStageKnown}_{P,M}(r_C). \tag{129}$$

Repeated readings, resets, periodic outputs, unequal calibration histories, and different clock mechanisms preclude a universal reading-to-stage inverse. Additional physical information may improve a bounded reconstruction, but V31/F11 does not treat a finite clock record as assigning a stage symbol.

13.19 Clock-based formation and ending estimates

Clock readings may help constrain a formation, motion, threshold, or ending window.

For example,

$$\mathrm{ClockBoundedRecordSet}_{P,M}(A, W_N) \Longrightarrow \mathrm{OperationallyConstrains}_{P,M}\,(W_A)\,. \tag{130}$$

The resulting W_A is a protocol- and model-relative reconstruction window.

It does not convert clock readings into cosmic stages and does not make the first recorded reading the exact ontic formation or ending boundary.

13.20 Predictive clock use

A model may predict that a physical change will be associated with a future clock-reading range.

Let

$$\mathrm{PredictedReadingWindow}_{P,M}(A, C; [n_1, n_2]) \tag{131}$$

state such a prediction.

The interval $[n_1, n_2]$ belongs to the clock's numerical scale.

The prediction does not make the future physical change attained and cannot identify a set of future cosmic stages without an additional model bridge.

Clock-based prediction remains a relation among:

(i) a physical target bearer;
(ii) a physical clock bearer;
(iii) their reconstructed histories;
(iv) a quantitative model;
(v) and a protocol.

Empirical value without ontological transfer

Clock precision has empirical and practical importance, but precision is record quality, not temporal identity.

Clock systems support:

(a) experimental control;
(b) navigation;
(c) telecommunications;
(d) astronomy;
(e) engineering;
(f) medicine;
(g) computation;
(h) and social coordination.

Their success warrants confidence in the physical models and protocols connecting clock behaviour to selected phenomena within tested domains.

It does not warrant the additional ontological inference:

$$\text{SuccessfulClockPrediction} \not\Longrightarrow \text{ClockOutputIsTime}\,. \tag{132}$$

Predictive success and ontological identity remain distinct.

13.21 Preparation for the relativistic confrontation

Relativistic models assign coordinate and metric quantities to physical worldlines and often relate ideal clock readings to a proper-time functional.

V31/F11 retains the type boundary:

$$\text{ProperTimeFunctional} \not\equiv_{\text{type}} T_{\text{ITOF}}, \tag{133}$$

and

$$\text{RealClockOutput} \not\equiv_{\text{type}} \text{ProperTimeFunctional}\,. \tag{134}$$

The first statement rejects the relativistic functional as a definition of time. The second distinguishes a material clock output from the mathematical quantity used to model it.

The complete foundational rejection of relativistic temporal ontology is developed in Section 21.

14. Observation, Measurement, Records, and Exact-Stage Restraint

14.1 Ontic physical change and epistemic access

Physical change, visibility, detection, record formation, reading, and scientific inference are different relations. For bearer A, stage $s \in I_A$, protocol P, model M, and sensitivity ε,

$$\text{PhysReal}_A^+(s) \not\equiv_{\text{type}} \text{Detected}_{P,M,\varepsilon}\big(\text{PhysReal}_A^+(s)\big). \tag{135}$$

Consequently,

$$\text{PhysReal}_A^+(s) \not\Rightarrow \text{Detected}_{P,M,\varepsilon}\big(\text{PhysReal}_A^+(s)\big), \tag{136}$$

and

$$\neg\,\text{Detected}_{P,M,\varepsilon}\big(\text{PhysReal}_A^+(s)\big) \not\Rightarrow \neg\,\text{PhysReal}_A^+(s). \tag{137}$$

Change may be physically real while remaining below human perception, outside the sampled variables, below instrumental sensitivity, masked by noise, distributed among components, or too small to satisfy a declared decision threshold. Measurement conclusions and uncertainty statements are therefore restricted to the declared measurand, protocol, calibration, model, and coverage conditions [25, 26].

14.2 The measurement arrangement is physical

A measurement is not performed from outside the common cosmic extension. For protocol P, let the core measurement-bearer family include the sample, apparatus, detector, record bearer, observer, and reference bearer:

$$\mathcal{L}_P^{\text{core}} := \{A_{\text{sample}}, A_{\text{apparatus}}, A_{\text{detector}}, A_{\text{record}}, A_{\text{observer}}, A_{\text{reference}}\}\,. \tag{138}$$

Let $\mathcal{E}_P^{\text{sys}}$ contain protocol-relevant environmental, support, control, calibration, and communication bearers. Then

$$\mathcal{L}_P := \mathcal{L}_P^{\text{core}} \cup \mathcal{E}_P^{\text{sys}}. \tag{139}$$

At every stage s in the operational domain of the protocol,

$$X \in \mathcal{L}_P \wedge X \in \mathcal{S}_{\text{phys}}(s) \Longrightarrow \text{PhysReal}_X^+(s). \tag{140}$$

Where the same bearer persists from r to s,

$$X \in \mathcal{L}_P \wedge s \in I_X \Longrightarrow \text{PhysReal}_X^+(s). \tag{141}$$

Thus the target, instrument, detector, observer, record bearer, reference, and relevant environment realize their own physical change at every stage at which their identities exist; where an identity persists across ordered stages, that change extends through the corresponding part of its history. Measurement controls selected relations among changing systems; it creates no changeless observer or apparatus.

14.3 Measurement chain

The general evidential chain is

$$\boxed{\begin{array}{c}\text{SourceChange} \rightsquigarrow_{\text{phys}} \text{AccessInteraction} \rightsquigarrow_{\text{phys}} \text{RecordFormation} \\ \longrightarrow \text{Reading} \longrightarrow \text{RestrictedClaim}\,.\end{array}} \tag{142}$$

The first arrows are physical. The final arrows are protocol- and model-governed transformations and inferences. No adjacent pair is an identity relation. A record is a later physical bearer state; it is not the source change, source stage, or time itself.

14.4 Acquisition has physical support

A reading is often produced over an ordered acquisition support rather than by an extensionless inspection. For a record r, define

$$J_r := \text{AcquisitionSupport}_{P,M}(r) \subseteq \mathcal{S}_{\mathrm{C}}^{\text{tot}}. \tag{143}$$

The support contains the common stages whose sample, apparatus, detector, environmental, and processing states physically contribute to the record. Schematically,

$$r = \mathcal{M}_{P,M}\left[(X_Y(s))_{Y\in\mathcal{L}_P,\, s\in J_r}\,, \eta_P\right], \tag{144}$$

where η_P represents declared calibration, noise, sampling, and processing conditions.

Unless a protocol establishes otherwise,

$$|J_r| > 1 \tag{145}$$

is admissible and often physically appropriate. A record may therefore integrate, average, filter, accumulate, or transform contributions realized across several ordered stages. The stage at which a record is completed or read is not thereby the sole source stage represented by it.

14.5 Visibility and manifestation

Let χ be a declared manifestation of system A. Visibility is a relation among the manifestation, access channel, protocol, model, threshold, sensitivity, and the physical condition of the measuring arrangement. It is not identical with physical change and it is not a stage label.

A protocol may classify records as below threshold, detected, stable, varying, or uncertain. These classifications belong to the record and decision domain. They can show when a manifestation first became accepted in the protocol order, but they cannot identify the first common cosmic stage at which the underlying physical change existed or became visible.

14.6 Why the exact visible stage cannot be determined

The limitation is not merely instrumental. Change is realized throughout the identity history and may remain minute, distributed, cumulative, or inaccessible before an accepted result appears. Human perception and instruments have finite sensitivity, bandwidth, sampling, spatial coverage, model scope, and noise tolerance.

The inspection also has a physical history. The sample, detector, apparatus, observer, record medium, reference systems, and environment change during acquisition and analysis. Protocol completion is a practical boundary in the study, not a cessation boundary for the participating systems. These conditions block the inference from first accepted detection to one exact member or exact ordinal position of the cosmic ordering.

14.7 Physical basis of an observed-change conclusion

An accepted record is produced through physical change in a record bearer and acquisition chain. With valid provenance, bearer attribution, and a source–record model, an observed difference may warrant a physical change or development in the investigated system history:

$$\begin{aligned} &\mathrm{ObservedChange}_{A;P,M}(r_1,r_2) \wedge \mathrm{ValidProvenance}_{P,M}(r_1,r_2;A,\chi) \\ &\quad \Longrightarrow \mathrm{Warrant}_{P,M}\left[\mathrm{PhysicalDevelopmentObserved}(A,\chi;r_1,r_2)\right]. \end{aligned} \tag{146}$$

The conclusion has a stated physical basis but remains stage-indeterminate. It does not name the precise cosmic stage, its ordinal position, or the first stage at which the manifestation was physically present.

14.8 Observational windows and order bridges

A finite accepted record family may constrain a bearer-specific observational window or a family of admissible reconstructed histories. Let

$$\mathcal{W}^{A,\chi}_{P,M}(\mathbf{r}) \tag{147}$$

denote that protocol- and model-relative constraint. Its elements are record-compatible descriptions, intervals, or history portions in the native domain of the reconstruction. They are not cosmic stages and are not values of time.

Record order transfers to source-development order only under a validated physical bridge. Propagation, processing, buffering, storage, asynchronous acquisition, and provenance failure can defeat a naive transfer. The bridge may warrant that one observed manifestation precedes another in the reconstructed history; it cannot by itself assign either manifestation an exact cosmic-stage symbol.

14.9 Exact-stage restraint in measurement

Principle 14.1 (Exact-Stage Restraint)**.** A finite valid observation may establish a physical difference, detected change, recurrence, threshold crossing, or ordered development. It cannot by itself identify the exact common cosmic stage or exact ordinal position at which the relevant change or manifestation occurred.

$$\mathrm{ObservedChange}_{A;P,M}(r_1, r_2) \not\Rightarrow \mathrm{ExactCosmicStageKnown}_{P,M}(A, \chi). \tag{148}$$

The limitation is not confined to clock precision. Change may be continuous in the ITOF sense of never being suspended, minute before detection, cumulative across physical processes, distributed among components, or masked by measurement conditions. The test observes a manifestation of history; it does not invert the record into one cosmic stage.

14.10 First detection and threshold crossing

The first accepted detection is first only in the declared record and decision order. It does not establish the first cosmic stage of the underlying physical change. A threshold may be crossed after cumulative sub-threshold change, integration over an acquisition window, filtering, amplification, or contributions from several physical subsystems.

Accordingly,

$$\mathrm{FirstAcceptedDetection}_{P,M,\varepsilon}(A, \chi; r_d) \not\Rightarrow \mathrm{ExactCosmicStageKnown}_{P,M}(A, \chi), \tag{149}$$

and

$$Y_{P,M}(r_d) \geq \theta \not\Rightarrow \mathrm{IdentityFormationEstablished}(A). \tag{150}$$

Threshold crossing is a protocol-relative manifestation, not the definition of change, formation, or ending.

14.11 Change during examination

CMA applies throughout the physical conduct of an examination. At every common cosmic stage realized during the protocol, every then-existing system–including the sample, apparatus, detector, observer, record bearer, laboratory environment, distant systems, and systems outside the study–realizes its own change. The protocol restricts the investigated object and variables; it does not restrict the population to which CMA applies.

The result must therefore be interpreted as a controlled relation among changing physical histories, not as a comparison performed from a changeless apparatus or observer.

14.12 Change after examination

Operational completion of a protocol does not stop physical change. Where the identities of the sample, record, observer, apparatus, environment, or other systems continue, UCC remains applicable after the reading or analysis is completed. If an identity ends, the ending transformation produces one or more successors under Necessary Successor Closure.

A completed record can persist and change later. The existence of a final report or accepted reading is a boundary of the study, not a boundary of universal physical change.

14.13 Human observation and physical scale

Human observation is one physical access route with limited sensory and cognitive resolution. The absence of visible alteration to an unaided observer cannot establish complete stasis:

$$\neg\,\mathrm{HumanlyVisible}(A, \chi; J) \nRightarrow \mathrm{CompletePhysicalStasis}(A; J). \tag{151}$$

Instrumental extension improves access but creates no exhaustive inspection of every component and stage. Claims must be restricted to the variables, sensitivities, domains, and uncertainty model actually supported.

Human experience of succession as restricted evidence.

A continuing human bearer may retain, compare, and report physically distinct perceptual records. Under a valid identity attribution, a verified record order, and a source-order bridge, those records can support a restricted earlier–later conclusion about the bearer's investigated history. They do not inspect every system, establish every member of the cosmic domain, or derive the universal quantifier of CMA. Human experience is therefore evidence within the theory's epistemic layer, not the definition or cause of cosmic succession.

14.14 Formation and ending windows

First accepted records of existence or ending may support operational windows, lower or upper bounds, or families of admissible histories. Such windows are stated in the native order of the protocol–record sequence, calendar convention, clock-reading range, sampling index, or another declared scale. They are not identified with subsets of the cosmic-stage domain.

The ontic formation and ending boundaries remain unique where they exist. The observational width belongs to evidence and resolution; it neither spreads the boundary physically nor assigns a cosmic-stage symbol to the record.

14.15 Record persistence and later change

A record may remain stable under a declared reading criterion while its bearer continues to change physically. Let B_R be a record bearer and q its represented content. Then

$$\mathrm{StableRecordContent}_{q,\Gamma}(B_R; J) \nRightarrow \mathrm{CompletePhysicalStasis}(B_R; J). \tag{152}$$

The record can remain scientifically usable while undergoing microscopic, environmental, organizational, or relational change outside the preserved criterion.

14.16 Measurement conclusion

A valid observation may warrant selected physical change, ordered development, criterion-relative stability, recurrence, or a bounded reconstruction. It cannot determine the number of actual cosmic stages in the system history and cannot assign a precise stage symbol to the observed change. The sample, apparatus, detector, observer, record bearer, reference systems, environment, and all other then-existing systems continue to realize their own change under CMA. Measurement therefore relates changing physical systems; it never provides a changeless external standpoint.

15. Light, Distance, and Remote Physical Records

15.1 The physical status of light

Light is treated according to the adopted physical model as radiation, field excitation, quantum process, propagating electromagnetic relation, or another physically warranted account. A model symbol is not automatically a bearer. A radiative entity enters CMA only where it independently satisfies the physical-system and identity conditions; otherwise its variables describe physical factors and relations realized in admitted systems.

Light is not time, a cosmic stage, or a carrier of private time. Its propagation is a physical process inside the universal cosmic ordering.

15.2 Source change, emission, propagation, and reception

A source change, emitted radiation, propagation, arrival, detector interaction, processing, and accepted record are distinct physical relations. A source change may affect luminosity, spectrum, polarization, direction, pulse profile, intensity, or another accessible property. A validated source model is required to connect that change to emission.

The physical chain may be represented schematically by

$$\begin{aligned} \text{SourceChange} \rightsquigarrow_{\text{phys}} \text{Emission} \rightsquigarrow_{\text{phys}} \text{Propagation} \\ \rightsquigarrow_{\text{phys}} \text{DetectorInteraction} \rightsquigarrow_{\text{phys}} \text{AcceptedRecord}\,. \end{aligned} \tag{153}$$

No adjacent terms are identical. Each link requires a domain model and may fail, branch, be delayed, attenuated, scattered, absorbed, re-emitted, or remain inaccessible.

15.3 Propagation conditions

Propagation may depend on path length, source and detector motion, intervening media, dispersion, absorption, scattering, re-emission, lensing under the adopted model, path multiplicity, frequency-dependent response, and the changing physical conditions of the systems involved. It is not movement of a cosmic stage through space.

A resolved propagation account may warrant source-process order: emission precedes arrival, and detector interaction precedes record acceptance. This conclusion belongs to the reconstructed physical chain. It assigns no exact cosmic-stage symbol and introduces no metric magnitude into $\prec_C$.

15.4 The remote record is not the remote change

A received record is a later physical bearer produced by the detector and recording system. It is neither the source change nor the complete source state. The record can preserve information about selected source properties only through a validated source–propagation–detector bridge.

Record content may remain stable while the source changes in unmeasured properties, relations, or processes, and the record may later change through storage, copying, degradation, processing, or reinterpretation. Source history and record history remain distinct.

15.5 Operational source–reception accounting

Let $E_i^{(P,M)}$ and $R_i^{(P,M)}$ be emission- and reception-side operational labels in one declared affine quantity space. They are model or record quantities, not cosmic stages. Define

$$R_i^{(P,M)} = E_i^{(P,M)} + \Pi_i^{(P,M)} + D_i^{(P,M)}, \tag{154}$$

where $\Pi_i^{(P,M)}$ represents the declared propagation contribution and $D_i^{(P,M)}$ represents detector, processing, and record contributions.

For two records,

$$\Delta R^{(P,M)} = \Delta E^{(P,M)} + \Delta\Pi^{(P,M)} + \Delta D^{(P,M)}. \tag{155}$$

The arithmetic is admitted only in the declared operational quantity space. It is not algebra on cosmic stages and it does not turn an operational interval into time as defined by ITOF.

15.6 Cancellation of a common propagation contribution

Where two records follow sufficiently similar paths and the model warrants

$$\Delta\Pi^{(P,M)} \approx 0, \qquad \Delta D^{(P,M)} \approx 0, \tag{156}$$

then

$$\Delta R^{(P,M)} \approx \Delta E^{(P,M)}. \tag{157}$$

This differential cancellation does not erase the large propagation contribution common to both records. It only removes that contribution from the difference within the declared approximation.

Cancellation may fail because of source or detector motion, unequal paths, changing media, dispersion, scattering, lensing, different frequencies, detector drift, processing latency, storage, or provenance errors. The complete accounting equation governs when those contributions are non-negligible.

15.7 Spectral, intensity, and image changes

Differences in spectrum, intensity, polarization, pulse profile, image morphology, or timing records may support source variability under a validated model. They do not by themselves identify the complete source state, the source mechanism, the exact stage of change, or identity ending.

Equal selected records likewise do not establish complete source stability. Change may remain outside the measured variables, wavelengths, spatial scales, sensitivity, or model scope.

15.8 Source identity across records

Several records may be attributed to the same source only under a source-identity criterion, provenance, and a physically adequate association model. Similar sky position, name, catalog entry, or selected spectrum is insufficient by itself. If source identity ends, later similar records concern one or more successor systems rather than later states of the predecessor.

15.9 Record order and source-development order

Reception order does not automatically establish source-development order. A valid bridge must address propagation, path multiplicity, buffering, storage, detector processing, and provenance. Where those conditions are satisfied, records may warrant ordered source development in the reconstructed history. They still do not assign exact cosmic-stage symbols to the source changes.

15.10 Remote reconstruction windows

Remote evidence may constrain a window in an emission-coordinate domain, record sequence, operational scale, or family of admissible source histories. The window is not automatically a subset of the cosmic-stage domain. It expresses evidential resolution, not physical extension of the source change across a set of stages.

15.11 Exact-stage restraint for remote records

A remote record cannot identify the precise common cosmic stage or ordinal position of its source change. The source change had an actual stage, but finite remote access does not name it. Stronger reconstruction requires source identity, mechanism, path, motion, detector response, provenance, uncertainty, and exclusion of alternative explanations.

15.12 Distance and CMA

Distance affects propagation, interaction, record formation, and access. It does not divide the common cosmic stage or postpone physical change in distant systems. CMA applies equally to all systems whose identities are realized at each common stage, whether or not signals between them have arrived.

15.13 Reciprocal audiovisual communication

Two separated systems may exchange sound, images, or other records through two physical chains. The received record represents selected source content under a protocol; it is not the source content itself, the source system, or its cosmic stage. Delayed reciprocal access creates no private time for either system.

15.14 Remote variability and UCC

Repeated records may warrant variability, oscillation, activity, development, or criterion-relative continuity within a reconstructed source window. This is a restricted epistemic conclusion, not an empirical version of UCC. It cannot discharge the universal quantifiers of CMA or UCC.

Stars and stellar transformation.

Stellar records may support development, mass loss, oscillation, collapse, or explosive transformation under astrophysical models and survey pipelines [51, 52, 54, 55, 56, 57]. When a stellar identity ends, one or more successor systems necessarily result, such as compact remnants, ejecta systems, or other physically identified organizations. Similar appearance or continuity of material does not restore the predecessor identity.

Galaxies and mergers.

Galaxy interaction, tidal deformation, redistribution, and merger require class-specific identity criteria [53]. A predecessor may continue or end. If it ends, successor organizations necessarily result, even where a successor receives the predecessor name or resembles one component strongly.

15.15 Remote stability and no private time

Criterion-relative equality of remote records establishes only record stability. It cannot establish complete source-state equality or absence of physical change. Source and detector histories belong to the same universal cosmic ordering; propagation connects physical processes within that ordering and creates no separate time for either system.

16. Explanatory and Predictive Use of Individual Physical History

16.1 The central distinction

The complete physical history of a bearer and the evidential reconstruction available to an investigator are different objects.

For a physical bearer A,

$$\mathcal{H}_A = (I_A, \prec_{\mathrm{C}} |_{I_A}, X_A)$$

is the bearer's complete ontic physical history.

By contrast, $\widehat{\mathcal{H}}_{A;P,M}$ is a protocol- and model-conditioned reconstruction warranted by available physical records.

Accordingly, Equation (50) governs the predictive use of reconstructed history.

Explanation and prediction operate through the reconstructed history. They do not provide direct epistemic possession of the complete ontic history.

16.2 Ontic identity-domain prefix

For an actual stage $s \in I_A$, define the attained identity-domain prefix

$$I_A^{\leq s} := \{r \in I_A \mid r = s \ \vee \ r \prec_{\mathrm{C}} s\} . \tag{158}$$

The corresponding ontic physical-history prefix is

$$\mathcal{H}_A^{\le s} := \left(I_A^{\le s}, \prec_{\mathrm{C}}|_{I_A^{\le s}}, X_A|_{I_A^{\le s}} \right). \tag{159}$$

This prefix is an actual part of the bearer's physical history.

It is not:

(i) a detector record;
(ii) a collection of clock readings;
(iii) a coordinate interval;
(iv) an investigator's reconstruction;
(v) or a predictive model.

The prefix exists because those bearer stages and physical states are actually realized within the complete history.

16.3 Operational data cutoff

Prediction ordinarily begins from an operational data cutoff rather than from direct access to one exactly identified cosmic stage.

Let u be a declared cutoff in the native order of protocol P.

All records, calibrations, reconstructions, and model-selection operations admitted into the predictive analysis must be available no later than u.

Define

$$\widehat{\mathcal{H}}_{A;P,M}^{\le u} \tag{160}$$

as the reconstruction of the bearer's physical history warranted by the record family admitted at or before u.

Likewise, define

$$\widehat{\mathcal{G}}_{A;P,M}(u) \tag{161}$$

as the available reconstruction of the bearer's constitution, selected state components, physical environment, relations, and actual engagements at the cutoff.

The types remain distinct:

$$\mathrm{Type}\left(\mathcal{H}_A^{\le s}\right) = \mathsf{OnticPhysicalHistoryPrefix}, \tag{162}$$

$$\mathrm{Type}\left(\widehat{\mathcal{H}}_{A;P,M}^{\le u}\right) = \mathsf{ProtocolModelHistoryReconstruction}. \tag{163}$$

Therefore,

$$\widehat{\mathcal{H}}_{A;P,M}^{\le u} \not\equiv_{\mathrm{type}} \mathcal{H}_A^{\le s}. \tag{164}$$

The cutoff u need not identify a unique common cosmic stage.

16.4 Historical explanation

A reconstructed individual history may contribute to explanation by showing how the bearer's present or later physical condition depends upon its earlier constitution, transformations, interactions, accumulated effects, and environmental engagements.

Let Y_A be a declared bearer-level outcome or state feature.

A history-informed explanatory claim has the general form

$$\begin{aligned}&\widehat{\mathcal{H}}^{\le u}_{A;P,M} \wedge \widehat{\mathcal{G}}_{A;P,M}(u) \wedge \mathrm{ValidExplanatoryModel}_{P,M} \\ &\quad \Longrightarrow \mathrm{ExplanatoryWarrant}_{P,M}\left[Y_A \mid \widehat{\mathcal{H}}^{\le u}_{A;P,M}, \widehat{\mathcal{G}}_{A;P,M}(u)\right].\end{aligned} \tag{165}$$

The two operator names in Equation (165) are schematic evidential labels rather than new ontological primitives: $\mathrm{ValidExplanatoryModel}_{P,M}$ records the declared adequacy of the explanatory model, and $\mathrm{ExplanatoryWarrant}_{P,M}$ records the resulting restricted inferential warrant.

The conclusion remains restricted to the records, variables, model, bearer criterion, and domain actually used. Historical explanatory value fails to imply that the reconstructed history exhausts all physical contributions to the outcome.

Historical dependence and causal restraint

Predictive or explanatory improvement from historical information by itself cannot establish that every included historical variable is a physical cause of the outcome.

Thus,

$$\mathrm{HistoryImprovesExplanation}_{P,M}(A, Y_A) \not\Rightarrow \mathrm{EveryHistoricalFeatureCauses}(Y_A). \tag{166}$$

The improvement may arise from:

(a) direct causal contribution;
(b) indirect causal ancestry;
(c) correlation with an omitted physical factor;
(d) accumulated bearer condition;
(e) environmental exposure;
(f) state dependence;
(g) or another model-valid relation.

Causal attribution requires an additional physical and inferential bridge.

Such predictive or explanatory benefit may arise under multiple dynamical and statistical frameworks. It tests the utility of the declared bearer-history representation under the stated protocol and model; it by itself cannot establish the ITOF definition of time, CMA, or UCC.

16.5 Prediction origin and ontic future target

At the complete-history ontic level, let $s_\star \in I_A$ be an actual prediction-origin stage.

Define an actual later target set by

$$J_A^+(s_\star) \subseteq \{v \in \mathcal{S}_\mathrm{C} \mid s_\star \prec_\mathrm{C} v\}\,. \tag{167}$$

This target set belongs to the complete-history formulation.

It fails to follow that its members are known or exactly stage-resolved at $s_\star$.

The target set may contain stages at which:

(i) the identity of A continues;
(ii) functional failure occurs;
(iii) the identity of A ends;
(iv) transformation outcomes are realized;
(v) or successor identities form.

16.6 Protocol-relative future evaluation window

A prediction study declares a future evaluation window in the native order of its protocol: sampling indices, clock-reading ranges, visits, detector-record sequences, calendar conventions, or another operational order. The window is not a cosmic-stage subset and cannot assign a symbol to a future stage.

Prediction does not actualize the future.

A prediction is a model-conditioned claim. It neither causes the outcome nor makes it attained, inserts a stage into actuality, moves the bearer, or determines the cosmic ordering. Evaluation occurs only when later physical records become available through the declared protocol.

16.7 Distinct predictive outcomes

Functional failure, identity ending, and successor transformation remain distinct targets. A protocol may predict failure without predicting identity ending. Whenever identity ending is predicted, the corresponding physical target must include production of one or more successor identities; an ending prediction that omits successors is incomplete under Necessary Successor Closure.

Predictions are expressed in operational windows and outcome classes rather than exact cosmic-stage symbols. A predicted formation or ending window states the resolution of the model and protocol. It does not assert that the boundary is physically extended across the window or that a future boundary has already been attained.

16.8 No future-data leakage

Every predictor, reconstruction, calibration rule, feature-selection operation, and model-selection decision must use only information available at or before the declared cutoff u.

Let $D_\mathrm{pre}(u)$ be the admissible pre-cutoff data domain and D_future the future evaluation data.

A valid predictive construction requires

$$\boxed{D_\mathrm{train} \subseteq D_\mathrm{pre}(u), \qquad D_\mathrm{test} = D_\mathrm{future}, \qquad D_\mathrm{train} \cap D_\mathrm{test} = \varnothing}\,. \tag{168}$$

A preregistered validation design may partition the pre-cutoff data for training and tuning, but no future target outcome or post-cutoff information may enter model construction, preprocessing, feature selection, threshold choice, or model selection.

Records from the future target window must not enter:

(a) feature construction;
(b) historical reconstruction;
(c) parameter tuning;
(d) model selection;
(e) threshold choice;
(f) or preprocessing decisions.

Otherwise, the reported performance is not a valid predeclared prediction. In later formulas, $\mathrm{PredictionStudyAdmissible}_{P,M}$ abbreviates satisfaction of the declared cutoff, no-leakage, target, bearer-identity, predeclaration, comparison, and uncertainty conditions stated in this section.

16.9 Common baseline information

Let the common baseline information be

$$\mathcal{Z}_{A;P,M}(u) := \left(\mathfrak{K}_A, \widehat{\mathcal{G}}_{A;P,M}(u), D_A\right), \tag{169}$$

where:

(i) $\mathfrak{K}_A$ contains declared class-level information;
(ii) $\widehat{\mathcal{G}}_{A;P,M}(u)$ contains the reconstructed cutoff configuration;
(iii) and D_A contains the declared data-quality, calibration, uncertainty, and admissibility conditions.

The same baseline must be supplied to the compared models unless a predeclared design states and justifies a different comparison.

16.10 Class-only model

Define the class-only model by

$$M_{\mathrm{class}} := \mathfrak{M}_0\left(\mathcal{Z}_{A;P,M}(u); D_{\mathrm{train}}\right). \tag{170}$$

This model uses the declared class and cutoff information but does not use the reconstructed ordered individual history as an additional input.

It supplies an external nonhistorical benchmark.

16.11 History-informed model

Define the history-informed model by

$$M_{\mathrm{hist}} := \mathfrak{M}_1\left(\mathcal{Z}_{A;P,M}(u), \widehat{\mathcal{H}}^{\le u}_{A;P,M}; D_{\mathrm{train}}\right). \tag{171}$$

This model receives the same baseline information together with the reconstructed individual history.

Its performance tests whether historical information contributes to the declared prediction under the adopted architecture and data conditions.

16.12 History-ablation model

Define a preregistered history-ablation operation

$$\mathcal{A}\left(\widehat{\mathcal{H}}^{\leq u}_{A;P,M}\right) \tag{172}$$

that removes, replaces, or order-disrupts the historical input while preserving the history-capable model architecture, tuning budget, cutoff, and evaluation protocol.

The ablation model is

$$M_{\mathrm{abl}} := \mathfrak{M}_1\left(\mathcal{Z}_{A;P,M}(u), \mathcal{A}\left(\widehat{\mathcal{H}}^{\leq u}_{A;P,M}\right); D_{\mathrm{train}}\right). \tag{173}$$

The class-only comparison and the ablation comparison answer different questions.

The class-only model supplies an external benchmark. The ablation model tests the incremental contribution of ordered historical information within a fixed history-capable architecture.

16.13 Predictive comparison

For a predeclared higher-is-better score, define

$$\Delta_{\mathrm{pred}} := \mathrm{Score}\left(M_{\mathrm{hist}}; D_{\mathrm{test}}\right) - \mathrm{Score}\left(M_{\mathrm{class}}; D_{\mathrm{test}}\right), \tag{174}$$

and define the architecture-controlled historical contribution by

$$\Delta_{\mathrm{hist}} := \mathrm{Score}\left(M_{\mathrm{hist}}; D_{\mathrm{test}}\right) - \mathrm{Score}\left(M_{\mathrm{abl}}; D_{\mathrm{test}}\right). \tag{175}$$

The first difference evaluates the history-informed model against a nonhistorical benchmark.

The second evaluates whether the ordered historical input contributes under the same model architecture.

16.14 Predeclared comparison rule

A specific predictive contribution from individual history is accepted only under a decision rule fixed before test-outcome inspection.

For example,

$$\Delta_{\mathrm{hist}} > \delta_{\mathrm{hist}}, \qquad \delta_{\mathrm{hist}} \geq 0, \tag{176}$$

together with an uncertainty analysis appropriate to the score, sampling design, target prevalence, and model-selection procedure.

The threshold, score, uncertainty procedure, and model-comparison rules must not be selected after observing the test results. Their predeclared specification follows ordinary requirements for uncertainty analysis, model comparison, and out-of-sample evaluation [27, 28].

Interpretation of positive predictive contribution

Where the declared rule is satisfied, the warranted conclusion is restricted:

$$\begin{aligned}\Delta_{\text{hist}} > \delta_{\text{hist}} \wedge \text{PredictionStudyAdmissible}_{P,M} \\ \implies \text{HistoryContributesPredictively}_{P,M}(A, Y_A; \widehat{J}^{+}).\end{aligned} \tag{177}$$

This conclusion is insufficient to establish that:

(i) the reconstruction equals the complete ontic history;
(ii) every historical feature is causally relevant;
(iii) the model uniquely establishes CMA or UCC;
(iv) the future outcome is inevitable;
(v) or the exact stage of the outcome has been identified.

Negative and inconclusive predictive results

Failure of the history-informed model to outperform the comparison models does not prove that the bearer lacks a physical history or that history has no ontic relevance.

A negative result may reflect:

(a) inadequate historical reconstruction;
(b) inappropriate variables;
(c) insufficient sample size;
(d) weak model architecture;
(e) excessive uncertainty;
(f) poor target definition;
(g) or absence of predictive contribution in the tested domain.

The result must be classified according to the predeclared decision rule as supportive, contrary, or inconclusive for the restricted predictive claim.

It does not alter the actual history of the bearer.

Exact-stage restraint in prediction

Even a highly accurate prediction identifies at most an operational record range, clock-output interval, calendar window, examination window, or model-conditioned outcome class. None assigns a unique common cosmic stage. Prediction quality concerns the declared target and protocol; it cannot invert the target into a stage symbol or ordinal position.

Prediction and the fixed cosmic order

Prediction neither determines nor modifies the cosmic ordering.

The earlier–later relation remains $\prec_{\mathrm{C}}$, independently of whether an outcome is correctly predicted, incorrectly predicted, or not predicted.

A prediction model may represent order, estimate record intervals, and assign probabilities. It creates no lateness, move stages, or produce the succession of the cosmic domain.

Cross-domain applicability

The predictive architecture is bearer-general but not mechanism-general.

It may be applied to:

(i) biological organisms;
(ii) patients and medical systems;
(iii) molecular and genetic systems;
(iv) mechanical devices;
(v) materials and constructed components;
(vi) ecological systems;
(vii) stars and other astrophysical bearers;
(viii) or social and technological composite systems,

only where the relevant bearer criterion, state variables, records, mechanisms, and outcome definitions are independently declared.

Success in one domain does not validate the same identity criterion or mechanism in another domain.

17. Empirical Access, Demanding Tests, and Evidential Limits

17.1 Restricted evidence and unrestricted ontology

A finite experiment cannot inspect every bearer, component, or common cosmic stage. Empirical claims must therefore be restricted to declared domains. Let

$$H^{\mathrm{OpCh}}_{A;P,M,V,\varepsilon,J} \tag{178}$$

denote the hypothesis that accepted records under protocol P, model M, variable family V, sensitivity ε, and study domain $J \subseteq I_A$ warrant physical change in bearer A. This restricted hypothesis is not identical with the universal commitments of CMA and UCC.

17.2 Predeclared demanding test

A valid high-risk test specification shall declare before outcome inspection:

(1) the bearer A and bearer class κ;
(2) the valid identity criterion $\Gamma^{\mathrm{id}}_{\kappa}$;
(3) the investigation domain $J \subseteq I_A$, with any required earlier–later pair stated directly;
(4) the physical bearer component or relation expected to carry the tested change;
(5) the variable family, apparatus, detector, and record chain;
(6) sensitivity, uncertainty, sampling support, and accepted coverage;
(7) supportive, contrary, and inconclusive decision rules;
(8) the level of theory placed at risk;
(9) the dependency argument connecting the foundational commitment, application bridge,

and contrary observable;
(10) permitted model revisions;
(11) and prohibited post hoc rescue moves.

No component may be silently replaced after the result without classifying the analysis as a new test.

17.3 Positive witnesses

A positive witness requires valid bearer attribution, warranted record order, a physically justified source–record route, and a criterion-relative difference exceeding accepted uncertainty. It may warrant observed change or ordered development in the supported history window:

$$\text{PositiveWitness}_{A;P,M,V,\varepsilon}(r_1, r_2) \Longrightarrow \text{Warrant}_{P,M}\left[\text{ObservedChangeInHistory}_{A;P,M}(r_1, r_2)\right]. \tag{179}$$

The witness does not warrant PhysReal_A^+ at two named cosmic stages and does not identify the exact stage of the observed change.

17.4 Independence of evidence

Nested bearers and shared measurement chains can make several apparent witnesses depend on one physical change. Define

$$\text{IndependentWitness}(w_1, w_2 \mid \Pi) \tag{180}$$

to require that the witnesses do not merely duplicate the same source change, component, detector, calibration chain, processing algorithm, record bearer, or decisive model assumption.

17.5 Operational stasis and complete physical stasis

Operational stasis means that no accepted difference was resolved in the declared variables and comparisons:

$$\text{OperationalStasis}_{A;P,M,V,\varepsilon}(J). \tag{181}$$

It fails to entail complete physical stasis:

$$\text{OperationalStasis}_{A;P,M,V,\varepsilon}(J) \not\Rightarrow \text{CompletePhysicalStasis}(A; J). \tag{182}$$

A bearer-complete stasis warrant requires unusually strong coverage of the bearer's constitution, internal changes, relations, exchanges, boundary conditions, and identity persistence:

$$\text{BearerCompleteStasisWarrant}_{\Pi}(A, J) \Longleftrightarrow \text{Warrant}_{\Pi}\left[\text{CompletePhysicalStasis}(A; J)\right]. \tag{183}$$

The warrant is revisable and cannot be obtained from one unchanged reading.

17.6 Interpreting failed tests

A failed study must identify the level at which failure occurs.

Implementation failure.

The apparatus, provenance, data quality, calibration, or identity attribution is inadequate. The study is inconclusive.

Application-bridge failure.

The declared physical route, measurement bridge, or quantitative model fails. The restricted application claim is rejected or revised.

Foundational status.

CMA and UCC are universal ontological commitments and are not directly exhausted by a finite experiment. A limited test samples selected systems, variables, and records; it cannot establish complete access to the internal and external physical structure of a system at every stage of its identity. A foundational challenge therefore requires an independently justified argument that the universal commitment itself is incoherent or that a genuine then-existing physical system possessed no change in either its internal physical structure or its external physical structure. Ordinary non-detection, operational stability, and bridge failure are insufficient.

17.7 No post hoc hidden-change rescue

After a contrary result, the statement "some undetected change must have occurred" is not a scientific explanation unless a physically specified route, bearer attribution, model, and independently assessable consequence are supplied:

$$\mathrm{ContraryResult}_{\Pi} \wedge \mathrm{UnspecifiedHiddenChange}(A, J) \nRightarrow \mathrm{ResolvedContraryResult}_{\Pi}\,. \tag{184}$$

17.8 Decision rule

A predeclared decision rule distinguishes support for a restricted application, rejection of a declared bridge, and inconclusive evidence. No finite result is reported as a direct experimental verification of CMA or UCC. Empty comparison sets, failed provenance, or invalid calibration yield an inconclusive outcome rather than support by default.

18. Quantitative Bridge Program

18.1 Why a quantitative bridge is required

Ontological type rules do not calculate observations. If ITOF rejects the identification of time with coordinates, metric intervals, proper-time functionals, or clock readings, it retains the independent burden of explaining and predicting the accepted physical records to which those quantities are applied. V31/F11 therefore distinguishes:

$$\text{ontological nonidentity} \quad \text{from} \quad \text{quantitative physical adequacy.} \tag{185}$$

Neither entails the other.

18.2 Physical record law for a clock

A clock C is a physical bearer selected for standardized record production. Let $J \subseteq I_C$ be a declared clock-history segment and let $\Theta_{C,P}$ contain protocol settings. Define the physical record law

$$R_{C,P}(J) = \mathcal{F}_{C,P}\left(\mathcal{H}_C|_J, \mathcal{G}_C|_J, \Theta_{C,P}\right), \tag{186}$$

where $\mathcal{G}_C$ contains the declared internal properties, external conditions, influencing systems, and interactions relevant to clock operation. A numerical reading is then

$$N_{C,P}(J) = \mathcal{N}_{C,P}\left(R_{C,P}(J)\right). \tag{187}$$

The reading is a physical-model output. It is not a member of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, a segment of T_{ITOF}, or a quantity by which the cosmic ordering is caused.

18.3 Relative record comparison

For clocks C and R, a comparative prediction may be represented by

$$\widehat{\Delta N}_{C/R;P,M}^{\mathrm{ITOF}} = \Phi_{C,R;P,M}\left(\widehat{\mathcal{G}}_C, \widehat{\mathcal{G}}_R, \widehat{\mathcal{E}}_{C,R}, \widehat{\mathcal{P}}_{C,R}, \eta\right), \tag{188}$$

where the arguments include reconstructed clock conditions, mutual environment, propagation and comparison paths, and uncertainty parameters. No argument is described as a rate or deformation of time.

The observed comparison is mapped into a declared common codomain $\mathfrak{O}_{D;P}$. With discrepancy functional $\Delta_{D;P,M}$ and tolerance $\varepsilon_{D;P,M}^{\mathrm{acc}}$, model-bounded adequacy requires

$$\Delta_{D;P,M}\left(\widehat{O}_{D;P,M}^{\mathrm{ITOF}}, O_{D;P}^{\mathrm{obs}}\right) \leq \varepsilon_{D;P,M}^{\mathrm{acc}}. \tag{189}$$

The tolerance, domain, calibration, and uncertainty treatment must be fixed in advance.

18.4 Explanatory adequacy

Numerical fit alone is insufficient. A quantitative ITOF model must state:

(i) the physical bearer and identity domain;
(ii) the physical mechanism or response law;
(iii) the record-production and reading maps;
(iv) the comparison and propagation paths;
(v) the variables excluded or marginalized;
(vi) the uncertainty model;
(vii) and the conditions under which the model fails.

A free reparameterization that merely reproduces an accepted result without bearer-specific physical explanation does not satisfy the quantitative burden.

18.5 Prediction that distinguishes competing models

A physically competitive theory should eventually produce a domain $D^\star$ in which its output calculated in advance differs from a rival model by more than the combined accepted uncertainty:

$$\Delta_{D^\star}\left(\widehat{O}^{\mathrm{ITOF}}_{D^\star}, \widehat{O}^{\mathrm{rival}}_{D^\star}\right) > \varepsilon^{\mathrm{sep}}_{D^\star}. \tag{190}$$

The experiment must then be capable of deciding between the predictions. Until such a result exists, ITOF's ontological critique and its quantitative physical program must be reported as distinct achievements.

18.6 Bridge failure and foundational consequence

Failure of one quantitative model cannot automatically refute the time definition, CMA, or UCC. It refutes the declared bridge unless the failed prediction follows uniquely from the foundational commitments. Conversely, repeated failure of all physical bridges admissible under the predeclared protocol in a domain can motivate foundational reassessment. The dependency must be stated before the outcome.

19. Integrated Quantitative Bridge Specification I: Differential Atomic-Clock Records

Application title and status

Differential Atomic-Clock Records under Invariant Cosmic Ordering. This self-contained bridge specification is embedded in V31/F11 so that its assumptions, record maps, decision rules, and limitations remain governed by the same ontology and type rules as the foundational text. It is an application bridge, not an additional axiom, a redefinition of time, or a claim that a complete replacement dynamics has already been achieved.

19.1 Application abstract

High-precision atomic, optical, and nuclear clocks are physical systems whose quantum transitions, oscillators, controls, environments, signal paths, and readout devices produce standardized records. Recent multispecies optical-clock comparisons reinforce the need for independent repetition, stable transfer links, and explicit residual accounting, while solid-state thorium-clock studies show that concentration, temperature, and long-term reproducibility belong to the physical clock and host-system model [37, 38]. The application below specifies how two such record-producing systems can be compared without identifying their outputs with time. It revalidates the physical-output assignment introduced in V15 and progressively constrained in later versions, but it does not inherit their earlier notation or any unverified causal claim. The application defines the bearer boundary, accepted cycle domain, physical-state and condition variables, record-production map, comparison codomain, residual, uncertainty treatment, failure criterion, and the conditions required for a prediction capable of distinguishing competing physical models.

19.2 Sequential application lineage and revalidation

The atomic-clock bridge has a documented developmental history. V15 assigned measured clock asymmetry to differential physical realization rather than temporal deformation; V16 required predictive closure; V17 made prediction conditional on the declared implementation and domain; V18 separated the physical outcome from the entity to which it was attributed; V19 applied the reassignment directly to relativistic interpretation; V20 prohibited transfer from successful calculation to temporal identity; and V21–V22 generalized the assignment and located physical realization in the affected systems [16, 15, 14, 13, 12, 11, 10, 9]. V29 later supplied a clock-record framework with explicit type distinctions and exact-stage restraint [2].

Only the following revalidated commitments govern the present application:

(i) each clock and each indispensable measurement component possessing its own identity is a physical bearer under an explicit system boundary; non-system properties, conditions, relations, and model quantities are declared separately as physical factors;
(ii) each accepted reading is produced by a physical record chain;
(iii) a measured difference requires a physical and statistical account of the compared systems;
(iv) the numerical difference is not time and is insufficient to establish deformation of time;
(v) and quantitative adequacy requires a predeclared prediction, uncertainty specification, and failure criterion.

Earlier response functions, influence profiles, coefficients, or residual formulae are used only where they are reintroduced below with a declared domain and status. The bounded diving-watch law in Subsection 13.12 demonstrates an actual composition of physical pressure and constitutive relations for one engineered clock class. It is a methodological benchmark, not a substitute for the atomic-clock response law sought in this section.

19.3 Declared clock and measurement-system boundaries

Let C_i, $i \in \{1, 2\}$, denote two atomic-clock bearers. Under protocol P_i, define the core clock family

$$\mathcal{L}^{\text{core}}_{i,P_i} = \{C_i, A_i, L_i, S_i\}, \tag{191}$$

where A_i is the selected atom, ion, ensemble, or nucleus furnishing the reference transition; L_i is the local oscillator or interrogation source; and S_i is the servo or control bearer. The enlarged measurement family is

$$\mathcal{L}_{i,P_i} = \mathcal{L}^{\text{core}}_{i,P_i} \cup \{D_i, B_i, E_i, Q_i\}, \tag{192}$$

where D_i is the detector, B_i the record bearer, E_i the declared environmental and support-bearer family, and Q_i the comparison or communication apparatus used by the protocol. The symbols denote functional roles, not a claim that every laboratory implements the same hardware decomposition. The family may contain nested bearers; its members do not constitute independent evidence merely because they are listed separately.

The bearer identity and admissible replacement conditions of C_i must be fixed by a valid clock-class identity criterion. Replacement of an atom, laser component, cable, or controller cannot automatically preserve or end the clock identity. The protocol must state which replacements are ordinary maintenance, which create a new calibrated realization of the clock, and which end the identity of the declared clock bearer.

A field used to interrogate the transition is classified according to Subsection 3.6. Its amplitude, phase, polarization, mode, potential, or operator assignment may enter the physical model as a field factor without being counted as an independent bearer. If a particular field entity independently satisfies the bearer conditions, it is included in the relevant measurement family and falls under CMA in its own right.

19.4 Accepted interrogation-cycle domain

Let K_i be the finite set of accepted interrogation cycles for clock C_i, ordered by the protocol-relative relation $\triangleleft_{P_i}$. This is an operational order on records, not the cosmic ordering:

$$\triangleleft_{P_i} \not\equiv_{\text{type}} \prec_{\text{C}} . \tag{193}$$

Each accepted cycle produces a physical record through a physical record-completion change. The cycle index, numerical reading, metadata, and record order do not identify the exact cosmic stage of record formation:

$$(k, r_{i,k}, N_{i,k}) \not\Rightarrow \text{ExactCosmicStageKnown}_{P_i,M_i}(r_{i,k}). \tag{194}$$

19.5 Physical state, conditions, and record production

For each accepted cycle, let

$$x_{i,k} \in \mathcal{X}_i, \qquad z_{i,k} \in \mathcal{Z}_i, \qquad \nu_{i,k} \in \mathcal{V}_i \tag{195}$$

denote, respectively, the declared physical state of the core clock family, the declared internal and external condition vector, and the stochastic or unresolved contribution admitted by model M_i. The condition vector may contain, where physically relevant, magnetic and electric conditions, interrogation-field properties, collisional conditions, thermal conditions, motion relative to declared physical references, gravitational-model inputs, electronic control states, calibration parameters, propagation-path conditions, and detector or readout settings. Inclusion in $z_{i,k}$ is insufficient to determine whether the represented item is a bearer, factor, relation, or model variable; that type is fixed separately.

The numerical cycle output is represented by a bearer-specific physical model:

$$y_{i,k} = \mathcal{O}_{i,M_i}(x_{i,k}, z_{i,k}; \theta_i) + \nu_{i,k}, \tag{196}$$

where θ_i contains model parameters fixed in advance and calibration parameters. The physical record map is

$$r_{i,k} = \mathcal{R}_{i,P_i}(y_{i,k}, m_{i,k}) \, , \tag{197}$$

with metadata $m_{i,k}$ sufficient to establish provenance, calibration state, accepted-cycle status, uncertainty assignment, and relation to the declared clock bearer.

The standardized numerical reading is

$$N_{i,k} = \mathcal{N}_{i,P_i}(r_{i,k}). \tag{198}$$

Neither $y_{i,k}$, $r_{i,k}$, nor $N_{i,k}$ is time:

$$y_{i,k} \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad r_{i,k} \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad N_{i,k} \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{199}$$

19.6 Local response expansion and its limits

Where $\mathcal{O}_{i,M_i}$ is differentiable in a declared neighbourhood of a calibrated operating condition $(x_{i,0}, z_{i,0})$, a local perturbative model may be written as

$$\delta y_{i,k} \approx \sum_j a_{ij}\,\delta z_{ij,k} + \sum_{j\le\ell} a_{ij\ell}\,\delta z_{ij,k}\delta z_{i\ell,k} + \epsilon^{\text{tr}}_{i,k}, \tag{200}$$

where the coefficients, domain, truncation order, and remainder bound must be physically justified. This is the restricted form in which the response and residual programme developed in V15–V17 is retained. It is not a universal additive law. Strong coupling, hysteresis, nonlocal control, correlated noise, state preparation, or nonlinear field response may require a different model.

The coefficients describe the physical response of the declared clock system. They are not temporal parameters, and unequal coefficients do not imply unequal times:

$$a_{1j} \neq a_{2j} \not\Rightarrow \text{DifferentTimes}(C_1, C_2). \tag{201}$$

19.7 Record alignment without cosmic-stage identification

Let $\pi_{12} : K_1 \rightharpoonup K_2$ be a partial alignment map admitted only for accepted record pairs whose provenance, communication path, protocol labels, and comparison conditions satisfy the declared bridge. Alignment supplies the operational relation needed for numerical comparison. It cannot establish that the paired record changes occupy one exactly identified common cosmic stage and does not assign stage symbols to them.

19.8 Common comparison codomain and differential record

Let

$$\Gamma_{i,12} : \text{Range}(N_{i,\cdot}) \longrightarrow \mathfrak{O}_{12} \tag{202}$$

map accepted readings into a common comparison codomain. For an aligned pair (k, ℓ), define

$$d^{\text{obs}}_{12;k\ell} := \Gamma_{1,12}(N_{1,k}) - \Gamma_{2,12}(N_{2,\ell}), \tag{203}$$

where subtraction is admitted only because $\mathfrak{O}_{12}$ has been declared as a numerical codomain for this application. The corresponding model prediction is

$$\widehat{d}^{\text{ITOF}}_{12;k\ell} = \Psi_{12;P,M}\left(\widehat{x}_{1,k}, \widehat{z}_{1,k}, \widehat{x}_{2,\ell}, \widehat{z}_{2,\ell}, \widehat{\mathcal{E}}_{12;k\ell}, \theta_{12}\right), \tag{204}$$

where $\widehat{\mathcal{E}}_{12;k\ell}$ contains the declared comparison, propagation, transfer, and common-environment assignments. The model must identify which inputs are directly measured, reconstructed, calibrated, marginalized, or externally supplied.

The differential residual is

$$\varepsilon_{12;k\ell} := d^{\text{obs}}_{12;k\ell} - \widehat{d}^{\text{ITOF}}_{12;k\ell}. \tag{205}$$

A nonzero observed difference is a difference between physical records produced by distinct clock histories under declared conditions:

$$d^{\text{obs}}_{12;k\ell} \neq 0 \nRightarrow \text{TimeDilated} \vee \text{DifferentTimes}(C_1, C_2). \tag{206}$$

This non-entailment does not explain the difference. Explanation requires the bearer-specific model in Equation (204) and its empirical assessment.

19.9 Protocol-level prediction and quantitative acceptance

Let $J_{12} \subseteq K_1 \times K_2$ be the preregistered accepted-pair set. Collect the predicted and observed differences as

$$\widehat{\boldsymbol{d}}^{\text{ITOF}}_{12} = \big(\widehat{d}^{\text{ITOF}}_{12;k\ell}\big)_{(k,\ell)\in J_{12}}, \qquad \boldsymbol{d}^{\text{obs}}_{12} = \big(d^{\text{obs}}_{12;k\ell}\big)_{(k,\ell)\in J_{12}}. \tag{207}$$

Let

$$\Delta_{\text{AC};P,M} : \mathfrak{D}^{J_{12}}_{12} \times \mathfrak{D}^{J_{12}}_{12} \longrightarrow \mathbb{R}_{\geq 0} \tag{208}$$

be the discrepancy functional declared in advance. It need not be a metric unless the protocol imposes metric properties. Model-bounded acceptance requires

$$\Delta_{\text{AC};P,M}\Big(\widehat{\boldsymbol{d}}^{\text{ITOF}}_{12}, \boldsymbol{d}^{\text{obs}}_{12}\Big) \leq \varepsilon^{\text{acc}}_{\text{AC};P,M}. \tag{209}$$

The accepted tolerance, uncertainty propagation, multiple-comparison treatment, excluded-cycle rule, calibration policy, and nuisance-parameter bounds must be fixed before examining the comparison outcome.

19.10 External relativistic calculation and type restraint

A relativistic model may supply a comparison calculated in advance

$$\widehat{\boldsymbol{d}}^{\text{rel}}_{12} = \mathcal{K}_{\text{rel}}(g, \gamma_1, \gamma_2, \text{clock and transfer data}). \tag{210}$$

Within the present application this object has one of two legitimate roles: an external benchmark prediction, or an input to a declared physical clock model whose use and limitations are stated. Its type remains distinct from time as defined by ITOF:

$$\widehat{\boldsymbol{d}}^{\text{rel}}_{12} \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{211}$$

Agreement with observed clock records establishes only bounded quantitative adequacy in the tested domain. Even where

$$\Delta_{\text{AC};P,M}\Big(\widehat{\boldsymbol{d}}^{\text{rel}}_{12}, \boldsymbol{d}^{\text{obs}}_{12}\Big) \leq \varepsilon^{\text{acc}}_{\text{AC};P,M}, \tag{212}$$

it fails to follow that the calculation is identical with time:

$$\Delta_{\text{AC};P,M}\Big(\widehat{\boldsymbol{d}}^{\text{rel}}_{12}, \boldsymbol{d}^{\text{obs}}_{12}\Big) \leq \varepsilon^{\text{acc}}_{\text{AC};P,M} \nRightarrow \text{Warrant}_{P,M}\Big[\widehat{\boldsymbol{d}}^{\text{rel}}_{12} \equiv T_{\text{ITOF}}\Big]. \tag{213}$$

Neither numerical agreement nor the use of a relativistic comparator proves that the cosmic ordering dilated, curved, slowed, or acquired different rates for the two clocks.

A complete ITOF replacement calculation cannot consist solely of relabelling $\widehat{\boldsymbol{d}}^{\text{rel}}_{12}$. It must identify the physical response law of the clock bearers, the interactions represented by the model inputs, the record-production chain, and a predeclared consequence not obtained by unrestricted parameter adjustment.

19.11 Concrete differential optical-clock case

Consider two optical clocks placed under different declared physical conditions and compared through a validated transfer chain, as in modern network and differential-height experiments [32, 29, 30, 31]. The accepted data may establish a reproducible ratio or difference between their standardized outputs. Under ITOF the directly warranted conclusion is

$$\mathrm{DifferentClockConditions}(C_1, C_2) \wedge d_{12}^{\mathrm{obs}} \neq 0 \Longrightarrow \mathrm{DifferentPhysicalRecordOutcomes}(C_1, C_2). \tag{214}$$

The physical account must examine, according to the selected apparatus and model, the atomic or ionic transition, interrogation field, local oscillator, servo, electromagnetic and thermal conditions, collisions or lattice effects, motion relative to declared references, gravitational-model inputs, signal transfer, detector response, and calibration chain. The list is not a license to add unmeasured causes after the outcome; only predeclared or independently warranted contributions may enter the accepted explanation.

The example is stronger than the statement that clocks are physical. It supplies a fully specified inferential route from bearer definition through record comparison to a failure decision. It remains weaker than a completed replacement theory because the present version does not derive one universal microscopic response law or a unique set of coefficients for all clock types.

19.12 Recovery target for accepted gravitational clock comparisons

A differential clock result commonly described as a gravitational frequency shift sets a quantitative recovery target for ITOF; it is insufficient to determine the ontology of time. For each accepted pair $(k, \ell) \in J_{12}$, let $\rho_{12;k\ell}^{\mathrm{obs}}$ denote the standardized observed ratio or equivalent comparison quantity in the declared codomain. A clock-specific ITOF model must calculate

$$\widehat{\rho}_{12;k\ell}^{\mathrm{ITOF}} = \mathcal{Q}_{12;P,M}\Big(\widehat{X}_{1,k}, \widehat{X}_{2,\ell}, \widehat{Z}_{1,k}, \widehat{Z}_{2,\ell}, \widehat{\Pi}_{12;k\ell}, \vartheta\Big), \tag{215}$$

where the arguments are typed physical-state estimates, operating and environmental conditions, transfer-chain assignments, and model parameters fixed in advance. None is a measure, rate, deformation, or portion of T_{ITOF}.

For a preregistered gravitational-comparison domain D_{g}, define bounded recovery by

$$\begin{aligned} \mathrm{Recovered}_{D_{\mathrm{g}}}(M) \Longleftrightarrow\ & \mathrm{SpecifiedInAdvance}(M, D_{\mathrm{g}}) \\ & \wedge \Delta_{\mathrm{g};P,M}\Big(\widehat{\boldsymbol{\rho}}_{12}^{\mathrm{ITOF}}, \boldsymbol{\rho}_{12}^{\mathrm{obs}}\Big) \leq \varepsilon_{\mathrm{g};P,M}^{\mathrm{acc}}. \end{aligned} \tag{216}$$

Recovery requires more than numerical coincidence. The response map $\mathcal{Q}_{12;P,M}$, its parameter restrictions, the physical meaning of its inputs, the calibration data, and the failure rule must be fixed independently of the target comparison. Merely assigning an external result to the ITOF symbol supplies no independent derivation:

$$\widehat{\boldsymbol{\rho}}_{12}^{\mathrm{ITOF}} := \widehat{\boldsymbol{\rho}}_{12}^{\mathrm{rel}} \not\Rightarrow \mathrm{IndependentPhysicalRecovery}_{D_{\mathrm{g}}}. \tag{217}$$

V31/F11 therefore states the exact recovery criterion and the evidential conditions for a future derivation. It does not claim that one universal clock-response law has already been obtained.

Adding an unconstrained formula merely to reproduce an accepted relativistic result would weaken, rather than complete, the quantitative program.

19.13 Failed outcomes and bridge revision

The application bridge fails where all of the following hold:

(i) the bearer identities and record provenance are warranted;
(ii) the accepted-pair set is nonempty and was fixed in advance;
(iii) calibration, transfer, uncertainty, and nuisance rules were applied as registered;
(iv) no declared exclusion or model-domain failure invalidates the comparison;
(v) and Equation (209) fails.

Then

$$\mathrm{FailedAtomicClockBridge}_{P,M} \Longrightarrow \neg\,\mathrm{AcceptedAtomicClockBridge}_{P,M}\,. \tag{218}$$

The result refutes the declared clock model and comparison bridge. It refutes CMA, UCC, or the definition of time only if the failed prediction was shown in advance to follow uniquely from that foundational commitment. An unspecified appeal to hidden clock change, an unknown field effect, or an unmodelled environmental contribution leaves unresolved the contrary result.

19.14 Requirement for a prediction that distinguishes competing models

Quantitative competition requires more than matching an already accepted relation. The application can distinguish competing models only if a domain fixed in advance $D^{\star}_{\mathrm{AC}}$ satisfies

$$\Delta_{D^{\star}_{\mathrm{AC}}}\left(\widehat{\boldsymbol{d}}^{\mathrm{ITOF}}, \widehat{\boldsymbol{d}}^{\mathrm{rival}}\right) > \varepsilon^{\mathrm{sep}}_{D^{\star}_{\mathrm{AC}}} \tag{219}$$

and the experiment has sufficient sensitivity and independent controls to decide between the predictions. V31/F11 does not claim that this discriminator has already been produced. It defines the conditions that a later clock-specific physical theory must satisfy before quantitative superiority or replacement can be asserted.

19.15 Exact-stage restraint in atomic-clock experiments

Every interrogation, transition, control update, detection, signal transfer, record completion, and reading is physical. The clocks, atoms or ions, oscillators, electronics, detectors, record bearers, observers, environments, and comparison systems continue to realize their own change under CMA and UCC.

An observed frequency difference narrows uncertainty in a declared numerical comparison. It cannot invert a reading into one exact member or exact ordinal position of the cosmic ordering. The clock response may be minute, cumulative, distributed across subsystems, and below threshold before first detection.

19.16 Atomic-clock bridge conclusion

This bridge specification accepts established experimental records as quantitative constraints and supplies a predeclared assessment framework with explicit type assignments for future clock-specific bridge models. It requires physical explanation of the compared systems and record chain, permits external calculations as declared benchmarks, and rejects transfer from numerical success to temporal identity. The current specification does not derive a universal microscopic clock-response law and does not yet furnish an implemented prediction that distinguishes competing models. Those remain explicit scientific obligations.

20. Integrated Quantitative Bridge Specification II: Velocity- and Gravity-Dependent Clock-Record Differences

Application title and status

Velocity- and Gravity-Dependent Clock-Record Differences under Invariant Cosmic Ordering. This application module supplies a bounded recovery bridge for the class of clock comparisons commonly described through kinematic and gravitational time dilation. It is not an axiom, a redefinition of time, a rate assigned to cosmic ordering, or a completed replacement dynamics for all relativistic phenomena. It states the conditions under which an ITOF-admissible physical record law can reproduce accepted clock-record differences while preserving the nonidentity of time, coordinate quantities, metric intervals, proper-time functionals, and clock outputs.

20.1 Purpose and restricted domain

The preceding application specified the general record architecture for differential atomic-clock comparisons. The present module specializes that architecture to domains in which velocity-dependent and gravitational-condition-dependent record differences are experimentally relevant, including optical-clock networks, differential-height comparisons, and modern high-precision frequency-ratio work [32, 29, 30, 31, 37, 38]. Its purpose is neither to deny established clock records nor to rename an external formula as ITOF. Its purpose is to state a physically typed bridge whose inputs are bearers, bearer states, environmental and gravitational-model conditions, kinematic conditions relative to declared references, transfer-chain corrections, and uncertainty assignments.

Let D_{VG} denote a declared velocity–gravity clock-comparison domain. A comparison belongs to this domain only if the protocol supplies:

(i) warranted clock-bearer identities and accepted interrogation-cycle sets;
(ii) declared reference systems for kinematic quantities;
(iii) a gravitational model assigning potential-like or field-condition values to the clock locations or world-tube approximations used by the experiment;
(iv) transfer-chain, synchronization, and propagation corrections with stated uncertainty;
(v) environmental and systematic-shift budgets for each clock;
(vi) and a predeclared failure rule.

No member of this list is time as defined by ITOF. Each member is a physical bearer, physical factor, relation, model variable, record, or uncertainty assignment whose type must be declared before the comparison.

20.2 Local notation for the velocity–gravity bridge

The following notation is local to this application module. It summarizes the symbols used in the velocity–gravity bridge; each symbol remains a bearer, condition, model variable, record quantity, uncertainty term, or decision predicate, and none denotes time.

Local symbol	Meaning in this bridge
D_{VG}, M, P	Declared velocity–gravity comparison domain, bridge model, and comparison protocol.
C_i, $i \in \{1, 2\}$, $m \in J_{12}$	Compared clock bearers, clock index, and aligned comparison index in the accepted comparison set.
$\mathcal{B}^{\mathrm{VG}}_{i,m}$	Velocity–gravity condition bundle for clock C_i at aligned comparison index m.
$\widehat{X}_{i,m}$, $\widehat{\Psi}_{i,m}$, $\widehat{\mathbf{v}}_{i,m}$	Reconstructed clock-core physical state, gravitational-condition value, and kinematic condition relative to the declared reference construction.
$\widehat{Z}_{i,m}$, $\widehat{\Pi}_{i,m}$	Systematic operating conditions and comparison-path or record-transfer assignments.
$\nu_{i,0}$, $\widehat{\nu}^{\mathrm{phys}}_{i,m}$, ρ^0_{12}	Nominal transition quantity, predicted physical record-producing response, and nominal class ratio or baseline.
$\Xi_{i,M}$, θ_i	Bearer-specific response factor and predeclared model parameters.
$\alpha^{\mathrm{g}}_{i,M}$, $\alpha^{\mathrm{v}}_{i,M}$, $\boldsymbol{\beta}_{i,M}$	Response coefficients for gravitational conditions, kinematic conditions, and other systematic sensitivities.
$\xi_{i,M}$, $\Lambda_{12,M}$, $\lambda_{12,M,m}$	Path, transfer, codomain, or comparison corrections as declared by the model and protocol.
$\epsilon^{\mathrm{rem}}_{i,m}$, $\epsilon^{\mathrm{rem}}_{12,m}$	Bounded remainder terms fixed before outcome evaluation.
$\widehat{\delta}^{\mathrm{ITOF}}_{12,m}$, $\widehat{\delta}^{\mathrm{rec}}_{12,m}$	Predicted ITOF fractional record difference and leading recovery-target fractional record difference.
$\widehat{s}_{12,m}$, $\widehat{\lambda}_{12,m}$, $\widehat{\epsilon}^{\mathrm{rem}}_{12,m}$	Independently specified systematic, comparison-path, and remainder contributions in the recovery target.
$\widehat{\boldsymbol{\delta}}^{\mathrm{ITOF}}_{12}$, $\boldsymbol{\delta}^{\mathrm{obs}}_{12}$	Collected predicted and observed fractional comparison records over the declared domain.
$\Delta_{\mathrm{VG};P,M}$, $\varepsilon^{\mathrm{acc}}_{\mathrm{VG};P,M}$	Discrepancy measure and acceptance tolerance under protocol P and model M.
$\mathrm{Recovered}_{D_{\mathrm{VG}}}(M)$	Bounded-recovery predicate for the declared velocity–gravity domain.
SpecifiedInAdvance	Predeclared-specification predicate for model M in domain D_{VG}.

20.3 Clock-condition bundle

For each aligned comparison index $m \in J_{12}$, let C_i, $i \in \{1, 2\}$, be the compared clock bearers and define the velocity–gravity condition bundle

$$\mathcal{B}^{\mathrm{VG}}_{i,m} := \left(\widehat{X}_{i,m}, \widehat{\Psi}_{i,m}, \widehat{\mathbf{v}}_{i,m}, \widehat{Z}_{i,m}, \widehat{\Pi}_{i,m}\right). \tag{220}$$

Here $\widehat{X}_{i,m}$ estimates the transition-bearing physical state of the clock core; $\widehat{\Psi}_{i,m}$ is the gravitational-condition value supplied by the adopted physical model; $\widehat{\mathbf{v}}_{i,m}$ is the velocity condition relative to a declared reference construction; $\widehat{Z}_{i,m}$ collects electromagnetic, thermal, collisional, lattice, pressure, ageing, control, and other systematic conditions; and $\widehat{\Pi}_{i,m}$ contains comparison-path and record-transfer assignments. The hat marks reconstruction or model assignment. It does not convert the assigned quantity into a cosmic stage or an item of T_{ITOF}.

The gravitational symbol Ψ is not introduced as curved time. It is a physical-model quantity representing the relevant gravitational condition used to calculate the clock response. Likewise, $\mathbf{v}$ is not a temporal deformation parameter. It is a kinematic condition of the clock bearer relative to the declared physical reference system.

20.4 Bearer response factor

Let $\nu_{i,0}$ be the nominal transition-comparison quantity for clock class κ_i under a declared reference operating condition. The predicted local record-producing response is represented by

$$\widehat{\nu}^{\mathrm{phys}}_{i,m} = \nu_{i,0}\, \Xi_{i,M}\left(\mathcal{B}^{\mathrm{VG}}_{i,m}; \theta_i\right), \tag{221}$$

where $\Xi_{i,M}$ is a bearer-specific physical response factor and θ_i contains predeclared model parameters. The symbol ν denotes a transition or oscillator comparison quantity used in clock science. It is not a definition of time, not a rate of the cosmic ordering, and not a measure of how fast time passes.

In a weak-field, slow-motion, small-systematic-shift domain, an admissible first-order bridge may take the bounded expansion

$$\begin{aligned}\Xi_{i,M}\left(\mathcal{B}^{\mathrm{VG}}_{i,m}; \theta_i\right) = 1 &+ \alpha^{\mathrm{g}}_{i,M} \frac{\widehat{\Psi}_{i,m} - \Psi_0}{c^2} - \alpha^{\mathrm{v}}_{i,M} \frac{\|\widehat{\mathbf{v}}_{i,m}\|^2}{2c^2} \\ &+ \boldsymbol{\beta}^{\mathsf{T}}_{i,M} \widehat{Z}_{i,m} + \xi_{i,M}(\widehat{\Pi}_{i,m}) + \epsilon^{\mathrm{rem}}_{i,m}.\end{aligned} \tag{222}$$

The coefficients are clock-model response coefficients, not temporal coefficients. $\alpha^{\mathrm{g}}_{i,M}$ and $\alpha^{\mathrm{v}}_{i,M}$ describe how the declared clock bearer responds, within the stated approximation, to gravitational and kinematic conditions. $\boldsymbol{\beta}_{i,M}$ describes other systematic sensitivities. $\xi_{i,M}$ represents transfer-chain and comparison-path assignments. $\epsilon^{\mathrm{rem}}_{i,m}$ is a bounded remainder, not a license for post hoc rescue.

Equation (222) is admissible only when its approximation domain, coefficients, excluded terms, and remainder bound are fixed before outcome evaluation. A model that chooses α^{g}, α^{v}, systematic coefficients, or remainders after viewing the data has not supplied an ITOF bridge; it has supplied a fit.

20.5 Pairwise recovery law

Let $\rho_{12}^0 = \nu_{1,0}/\nu_{2,0}$ be the nominal class ratio or declared comparison baseline. The predicted ratio for an accepted aligned comparison m is

$$\widehat{\rho}_{12,m}^{\mathrm{ITOF}} = \rho_{12}^0 \frac{\Xi_{1,M}\left(\mathcal{B}_{1,m}^{\mathrm{VG}};\theta_1\right)}{\Xi_{2,M}\left(\mathcal{B}_{2,m}^{\mathrm{VG}};\theta_2\right)} \Lambda_{12,M}(\widehat{\Pi}_{1,m},\widehat{\Pi}_{2,m}), \tag{223}$$

where $\Lambda_{12,M}$ contains declared transfer, comparison-path, and codomain corrections. Define the fractional predicted difference by

$$\widehat{\delta}_{12,m}^{\mathrm{ITOF}} := \frac{\widehat{\rho}_{12,m}^{\mathrm{ITOF}}}{\rho_{12}^0} - 1. \tag{224}$$

To first order, where higher products fall inside the declared remainder,

$$\begin{aligned} \widehat{\delta}_{12,m}^{\mathrm{ITOF}} \simeq \alpha_{1,M}^{\mathrm{g}} \frac{\widehat{\Psi}_{1,m} - \Psi_0}{c^2} - \alpha_{2,M}^{\mathrm{g}} \frac{\widehat{\Psi}_{2,m} - \Psi_0}{c^2} \\ - \alpha_{1,M}^{\mathrm{v}} \frac{\|\widehat{\mathbf{v}}_{1,m}\|^2}{2c^2} + \alpha_{2,M}^{\mathrm{v}} \frac{\|\widehat{\mathbf{v}}_{2,m}\|^2}{2c^2} \\ + \boldsymbol{\beta}_{1,M}^{\mathsf{T}} \widehat{Z}_{1,m} - \boldsymbol{\beta}_{2,M}^{\mathsf{T}} \widehat{Z}_{2,m} + \lambda_{12,M,m} + \epsilon_{12,m}^{\mathrm{rem}}. \end{aligned} \tag{225}$$

This expression has the same recovery target as the standard weak-field clock-comparison form when the declared model sets the leading gravitational and kinematic response coefficients to their benchmark values and independently bounds the systematic and transfer terms [18, 19, 20, 21]. The ITOF interpretation is different: the formula predicts differences among physical records produced by clock bearers. It does not state that time dilates, that a metric interval is time, or that two clocks occupy two private times.

20.6 Benchmark recovery and independent warrant

A benchmark-recovery specialization is obtained only under the predeclared condition

$$\alpha_{1,M}^{\mathrm{g}} = \alpha_{2,M}^{\mathrm{g}} = 1, \qquad \alpha_{1,M}^{\mathrm{v}} = \alpha_{2,M}^{\mathrm{v}} = 1, \tag{226}$$

with systematic terms, transfer terms, environmental effects, and remainders assigned by independently warranted clock physics and protocol data. Then Equation (225) reduces to the accepted leading recovery target

$$\widehat{\delta}_{12,m}^{\mathrm{rec}} \simeq \frac{\widehat{\Psi}_{1,m} - \widehat{\Psi}_{2,m}}{c^2} - \frac{\|\widehat{\mathbf{v}}_{1,m}\|^2 - \|\widehat{\mathbf{v}}_{2,m}\|^2}{2c^2} + \widehat{s}_{12,m} + \widehat{\lambda}_{12,m} + \widehat{\epsilon}_{12,m}^{\mathrm{rem}}, \tag{227}$$

where $\widehat{s}_{12,m}$ collects independently specified systematic clock shifts and $\widehat{\lambda}_{12,m}$ collects comparison-path terms. The recovery target is quantitative, but its type is still a clock-record prediction:

$$\widehat{\delta}_{12,m}^{\mathrm{rec}} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{228}$$

For a declared domain D_{VG}, collect the predicted and observed fractional differences as $\widehat{\boldsymbol{\delta}}_{12}^{\mathrm{ITOF}}$

and $\boldsymbol{\delta}_{12}^{\text{obs}}$. Bounded recovery holds when

$$\begin{aligned}\text{Recovered}_{D_{\text{VG}}}(M) \iff \text{SpecifiedInAdvance}(M, D_{\text{VG}}) \\ \wedge \Delta_{\text{VG};P,M}\left(\widehat{\boldsymbol{\delta}}_{12}^{\text{ITOF}}, \boldsymbol{\delta}_{12}^{\text{obs}}\right) \le \varepsilon_{\text{VG};P,M}^{\text{acc}}.\end{aligned} \tag{229}$$

The recovery bridge licenses a bounded claim only: the declared physical clock model reproduces accepted comparison records within its domain and uncertainty. It does not establish identity between time and the mathematical quantities used in the calculation:

$$\text{Recovered}_{D_{\text{VG}}}(M) \not\Rightarrow \text{Warrant}_{P,M}\left[\widehat{\delta}_{12}^{\text{ITOF}} \equiv T_{\text{ITOF}}\right]. \tag{230}$$

Nor does it prove full equivalence to general relativity:

$$\text{Recovered}_{D_{\text{VG}}}(M) \not\Rightarrow \text{EquivalentToGR}(M). \tag{231}$$

Equivalence would require a wider class of phenomena, equations of motion, propagation laws, gravitational modeling, independent parameter determination, and successful tests beyond the clock-record domain.

20.7 Application to differential-height optical clocks

In a differential-height optical-clock comparison, the declared gravitational model assigns distinct $\widehat{\Psi}_{1,m}$ and $\widehat{\Psi}_{2,m}$ to the clock bearers or to the experimentally valid spatial averages over their transition-bearing ensembles. If the kinematic, thermal, electromagnetic, collisional, lattice, servo, detector, and transfer-chain terms are independently controlled or bounded, Equation (227) predicts a reproducible fractional record difference dominated by the gravitational-condition contrast. The ITOF conclusion is

$$\begin{aligned}\text{DifferentGravitationalConditions}(C_1, C_2) \wedge \text{Recovered}_{D_{\text{VG}}}(M) \\ \implies \text{DifferentClockRecordOutcomes}(C_1, C_2).\end{aligned} \tag{232}$$

The conclusion is deliberately weaker than the statement that gravitational time has dilated and stronger than the statement that clocks are merely conventional. It identifies the affected physical systems, the response law, the comparison codomain, and the recovery criterion.

A result commonly reported as agreement with gravitational redshift therefore becomes, within ITOF, agreement between accepted records and a physical response bridge whose leading gravitational-condition term has been fixed in advance. The gravitational model may remain the same mathematical model used by external relativistic practice; its use as a successful input does not transfer temporal identity to the model.

20.8 Application to moving transported clocks

In a transported-clock or satellite-linked comparison, the clock bearer has a kinematic condition $\widehat{\mathbf{v}}_{i,m}$ relative to the declared reference construction and a gravitational-condition assignment along the validated operating path. Equation (225) then separates the velocity-dependent response contribution, gravitational-condition contribution, systematic shifts, transfer-chain terms, and residual. The ITOF conclusion is

$$\begin{aligned}&\text{DifferentKinematicConditions}(C_1, C_2) \vee \text{DifferentGravitationalConditions}(C_1, C_2)\\&\quad \Longrightarrow \text{PossibleDifferentClockRecordOutcomes}_M(C_1, C_2).\end{aligned} \tag{233}$$

where the consequent becomes an accepted prediction only after Equation (229) is satisfied. Motion remains a physical condition of the bearer, not evidence for motion of time. A moving clock may produce different records because the transition-bearing system, its fields, controls, transfer chain, and environment realize different physical conditions.

20.9 No relabelled derivation

The bridge prohibits the following shortcut:

$$\widehat{\delta}^{\text{ITOF}}_{12,m} := \widehat{\delta}^{\text{rel}}_{12,m} \quad \text{with no bearer response law} \not\Rightarrow \text{ITOFRecovery}_{D_{\text{VG}}}. \tag{234}$$

A legitimate ITOF derivation must state why the transition-bearing system has the response factor $\Xi_{i,M}$, how the gravitational and kinematic inputs enter that factor, how systematic shifts are separated from the leading terms, and how the comparison path is controlled. The same numerical expression can be used as a recovery target, a benchmark, or a provisional physical law; those roles are not identical. A gravitational or kinematic correction may therefore be used as a benchmark for clock-record production without becoming a definition of time.

Benchmark recovery is therefore a constraint on an admissible ITOF physical model, not by itself an independent derivation of the benchmark from the foundational ontology alone.

20.10 Failure, revision, and future strength

The velocity–gravity bridge fails in a declared domain if warranted records, calibrated inputs, and accepted uncertainty treatment yield

$$\Delta_{\text{VG};P,M}\left(\widehat{\boldsymbol{\delta}}^{\text{ITOF}}_{12}, \boldsymbol{\delta}^{\text{obs}}_{12}\right) > \varepsilon^{\text{acc}}_{\text{VG};P,M} \tag{235}$$

without a predeclared exclusion, instrument failure, or domain violation. Such a result rejects the declared bridge model. It rejects the definition of time, CMA, or UCC only if the failed prediction was shown in advance to follow uniquely from those foundational commitments.

The next required step is clear. A later application may attempt to derive the coefficients in Equation (222) from a deeper physical model of the atomic, optical, nuclear, or solid-state clock bearer and its interaction with gravitational and kinematic conditions. A stronger application would also predeclare a domain in which its prediction differs from the external relativistic benchmark by more than combined uncertainty. Until then, V31/F11 provides a bounded-recovery specification and type separation, not completed empirical recovery or complete replacement dynamics.

20.11 Velocity–gravity bridge conclusion

The module addresses the quantitative objection in a restricted form. It shows how ITOF can host a velocity- and gravity-dependent clock-record law that reproduces the leading accepted comparison target without identifying clock-record differences with time. The result preserves the core definition: time denotes the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages, while the magnitude, mechanism, rate, and record of clock change remain properties of physical systems and their declared models.

21. Direct Ontological Confrontation with Relativity

21.1 Level I: internal type result

Let $\mathcal{Q}_{\mathrm{rel}}$ be the typed family containing relativistic coordinates, metric tensors, intervals, worldline functionals, simultaneity relations, and model-derived clock quantities. The external formalisms and interpretive positions under examination are represented by the standard relativistic and philosophical literature [17, 18, 19, 20, 21, 22, 23, 24]. For every $q \in \mathcal{Q}_{\mathrm{rel}}$,

$$q \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{236}$$

In particular,

$$x^{\mu}_{F}(e) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad ds^2 \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad \tau[\gamma, g] \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad N_{C,P} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{237}$$

These consequences follow from the declared type distinctions in the ITOF definition of time. Coordinate transformation, metric calculation, or clock agreement cannot convert one type into another.

21.2 Level II: external ontological criticism

The internal nonidentity result by itself cannot prove that every competing ontology is false. The external criticism rests on independent arguments:

(a) calculational success cannot transfer ontological identity;
(b) a clock reading is produced by a physical bearer under physical conditions;
(c) a metric representation is insufficient to establish that its interval is the entity denoted by time;
(d) coordinate simultaneity is convention- and frame-dependent and is not common-stage identity;
(e) and physical differences among clocks, paths, fields, and records can be assigned to the systems and models without turning time into a variable physical participant.

These arguments directly reject relativistic temporal ontology as an account of what time is.

21.3 Strong-form relativistic comparison

The confrontation is not restricted to the phrase "time dilation." It addresses the transfer from local Lorentz covariance, metric and connection fields, causal relations, coordinate foliations, worldline functionals, and clock observables to an ontology of time. A foliation, smooth global time function, coordinate covariance, or clock agreement is not a common cosmic stage and does not define the invariant cosmic ordering [19, 48]. The ITOF commitment is to invariant cosmic ordering, not to an added dynamical mechanism.

Experimental constraints from clock comparisons and satellite-orbit analyses apply to any ITOF application that adds frame-dependent dynamics, anisotropy, or altered propagation [49, 50]. They do not convert a bare ordering relation into a tested preferred-frame mechanism. The bounded recovery bridge in Section 20 supplies a typed velocity–gravity response law for clock records; it does not remove the wider empirical burden. A physical bridge must relate accepted local records and dynamics to the common ordering while reproducing established observations and, for genuine competition, yielding a distinguishable consequence under a predeclared test. Mathematical foliation, coordinate covariance, and clock agreement settle neither temporal ontology nor the empirical burden [19, 48, 20, 21, 24, 49, 50].

21.4 No identity transfer from relativistic quantities

No coordinate, metric interval, proper-time functional, spacetime geometry, or clock output is identical with the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages. Predictive or calculational success cannot transfer the type of time to those quantities.

21.5 Rejection of relativistic temporal ontology

ITOF rejects relativistic temporal ontology and refuses to identify geometrical or metric quantities with time. External calculations can serve as benchmarks for recovery and comparison, but benchmark use is not temporal identity. Their success does not alter the ITOF definition of time or establish geometrical deformation, dilation, curvature, multiplicity, or bearer-specific portions of time.

21.6 Level III: quantitative competition

Rejection of relativistic temporal ontology leaves ITOF responsible for reproducing accepted observations. For every declared domain D, the ITOF physical model must meet the quantitative criterion of Section 18. A direct empirical competition additionally requires the model-distinguishing condition stated in Equation (190). Until then, the ontological rejection is explicit, while the full quantitative replacement program remains an open scientific obligation.

21.7 Clock experiments

Experiments comparing atomic, optical, or nuclear clocks establish reproducible differences among physical record-producing systems under declared conditions [32, 29, 30, 31, 33, 34, 35, 36, 37, 38]. Within ITOF, those results are typed as physical record differences. Their explanation must be expressed through bearer dynamics, interactions, environmental conditions, signal paths, and record maps. Describing the calculated quantity as proper time does not, by itself, prove that time itself changed.

22. Non-Transfer Principle, Experimental Anchors, and Test Register

Non-Transfer Principle

Operational success, mathematical consistency, predictive fit, synchronization, signal propagation, or record agreement does not by itself transfer temporal ontology to the output, instrument, coordinate, metric quantity, quantum symbol, signal interval, or geometrical construction that participates in the successful practice.

For any model object, instrument output, coordinate label, signal quantity, quantum state assignment, or geometrical construction q, success under a protocol P, model M, and domain D fails to establish type identity with time:

$$\mathrm{OperationalSuccess}_{P,M,D}(q) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{238}$$

Likewise, mathematical consistency does not establish physical reality:

$$\mathrm{MathematicallyConsistent}(q) \not\Rightarrow \mathrm{PhysReal}(q). \tag{239}$$

The issue is type transfer. A clock reading remains a clock record; a coordinate remains a coordinate; a metric interval remains a model quantity; a proper-time functional remains a path-dependent comparison quantity; a quantum symbol remains a model-state assignment unless independent bearer warrant is supplied; and a geometrical construction remains representational unless physically anchored.

22.1 CP1-to-V31 integration map

The companion-protocol material is used in V31/F11 as a set of test and interpretation rules, not appended as a separate essay. The map below states where the main CP1 controls operate inside V31/F11. Administrative repository metadata from CP1 is not part of the foundation and is therefore not included.

Preparatory CP1 control	**V31/F11 location**	**Function in V31/F11**
Predeclared closed test protocol	Quantitative Bridge Program; Predeclared Bridge Protocol	A bridge must fix bearers, domains, law, comparator, parameters, uncertainty, exclusions, acceptance, failure, and distinguishing condition before outcome interpretation.
Clock readings as physical records	Clocks; Observation; Test Register	A reading can warrant a physical record difference; it does not become time or locate one exact cosmic stage.
Condition removal and accumulated offset	Clock-record subsection; Interpretation Rules	Removing a declared velocity or gravitational condition removes the current rate effect if no residual disturbance remains; accumulated offset is record history, not stored time.

Preparatory CP1 control	V31/F11 location	Function in V31/F11
GPS and signal-record navigation	Remote records; Experimental Anchors; Interpretation Rules	Navigation success is signal-record reconstruction using clocks, signals, propagation, synchronization, and correction models; it is not transfer of time to a signal interval.
Light-path reconstruction	Light and radiation as bearers; Experimental Anchors	Optical deviation is path or reconstruction deviation under physical conditions; it is not bending, transport, or deformation of time.
Pressure, heat, solar exposure, vibration, and shock	Clock-record conditions; Documented experimental anchors	Environmental effects are bearer-condition variables affecting the record-producing chain, not temporal variables.
Higher-dimensional or coordinate geometry	Non-Transfer Principle; Model Constructions; Interpretation Rules	Mathematical consistency or geometrical construction does not establish physical existence without physical reference and testable application.
Quantum measurement, delayed choice, and eraser records	Quantum measurement and model-state classifications; Exact-stage restraint	Quantum records classify apparatus-conditioned outcomes; they do not rewrite an earlier cosmic stage, create private time, or establish a second cosmic ordering.
Relativistic transfer claims	Direct Ontological Confrontation with Relativity; Relativistic transfer claims	Coordinate transformations, metric intervals, proper-time functionals, curvature, light cones, and twin-clock differences do not define time.

22.2 Controls retained from the preparatory discussion

The application layer is governed by five controls.

Closed-protocol control. A claimed test is not a bridge if the bearer class, instrument boundary, physical variables, model law, comparator, parameter values, uncertainty model, exclusion rules, acceptance rule, failure rule, and model-distinguishing condition are not declared before outcome interpretation. Post-outcome parameter selection is fitting, not a bridge.

Record-chain control. Clock, detector, GPS, optical, and quantum results must be described through the physical chain that produced the accepted record. The record may support order, comparison, bounded reconstruction, or model recovery. It does not transfer temporal ontology to the record, the instrument, the signal, or the computation.

Bearer-condition control. Pressure, heat, solar exposure, vibration, shock, gravity, velocity, calibration state, oscillator properties, electronics, detector response, medium, source, receiver, and reconstruction procedure are declared physical conditions of bearers and record chains. They are not names for time and they do not make time a physical participant.

Representation-control. Coordinates, Lorentz transformations, metric intervals, proper-time functionals, spacetime curvature, light-cone structure, higher-dimensional geometry, and model-state symbols remain representational or calculational objects unless an independent physical bearer, reference, domain of applicability, and testable effect are supplied. No mathematical construction becomes physical reality by consistency alone.

Quantum-record control. Superposition, interference, entanglement, collapse language, delayed-choice classification, and quantum-eraser coincidence patterns are typed as model-state or record-classification claims unless bearer identity and physical warrant are separately supplied. They do not create a private time, a second cosmic ordering, or a retroactive alteration of a realized cosmic stage.

22.3 Measurement chain without movement of time

A measurement application must type the chain that produces its accepted record:

$$\begin{aligned}\text{SourceCondition} &\longrightarrow \text{Interaction} \longrightarrow \text{InstrumentResponse} \longrightarrow \text{SignalOrTransferChain}\\ &\longrightarrow \text{DetectorOrClockRecord} \longrightarrow \text{Computation} \longrightarrow \text{AcceptedRecord}\,.\end{aligned} \tag{240}$$

Each arrow is a physical or protocol-defined relation. No arrow is movement of time. The final record may warrant a physical difference, an order among records, or a bounded reconstruction. It cannot be inverted into one exact cosmic stage, and it cannot become time by successful use.

22.4 Clock records, condition removal, and accumulated offsets

Clock comparisons are record comparisons among physical bearers under declared conditions. Velocity, gravitational condition, pressure, heat, direct solar exposure, vibration, shock, calibration state, oscillator properties, electronics, environmental coupling, and signal processing are bearer-condition variables or model terms. They must be typed before interpretation.

If a clock-record difference is attributed to a velocity or gravitational condition, removal of that condition should remove its present rate effect when no residual damage, hysteresis, calibration error, or environmental disturbance remains. A previous offset is different: it belongs to the record history already produced during the earlier condition. Its persistence is not stored time, delayed time, or time inside the clock. It is an accumulated physical record difference.

$$\text{ConditionRemoved}(C) \wedge \neg\,\text{ResidualPhysicalDisturbance}(A) \Longrightarrow \text{CurrentRateEffect}_C(A) = 0, \tag{241}$$

while

$$\text{AccumulatedRecordOffset}(A, B) \nRightarrow \text{StoredOrDelayedTime}(A, B). \tag{242}$$

This distinction prevents two errors: treating a continuing device disturbance as time, and treating a past accumulated reading difference as a substance or metric deformation of time.

22.5 Documented experimental anchors

V31/F11 uses documented experiments and operational systems as anchors for classification, recovery, and future distinction. Each anchor must be connected to a bearer, condition, record chain, comparator, and interpretation restraint.

Anchor	Bearer-condition focus	Record or comparator	ITOF interpretation
Transported atomic clocks	Clock bearers under kinematic and gravitational conditions	Eastward and westward accumulated clock-record differences [39, 40]	Differential record production, not transport or dilation of time itself.
Differential optical clocks	Clock bearers under small height and speed changes	Frequency and accumulated record comparisons [41, 29]	Severe test of bearer response laws and condition typing.
GPS-type navigation	Satellite clocks, receiver clocks, signals, propagation, synchronization, correction models	Position and timing records in a signal-record system [42, 43]	Navigation by signal-record reconstruction, not proof that a signal interval is time.
Pressure, heat, solar exposure, vibration, and shock	Ordinary and precision clock bearers under environmental stresses	Rate shifts, noise, record degradation, failure, or recalibration needs	Physical bearer-condition effects, not temporal effects.
Light-path reconstruction	Source, propagation path, medium or field conditions, receiver, detector, reconstruction model	Spectral, intensity, image, arrival, or path records	Path and record reconstruction, not bending or transport of time.
Delayed-choice and quantum-eraser experiments	Quantum source, apparatus settings, detectors, coincidence electronics, selection windows	Correlation records and conditioned patterns [44, 45, 46]	Record classification under apparatus conditions, not rewriting of an earlier cosmic stage.
Higher-dimensional or coordinate geometry	Mathematical construction with proposed physical use	Equations, embeddings, coordinates, or model spaces	Physical status requires reference, applicability, and testable warrant; consistency is not existence.

22.6 Relativistic transfer claims

The relativistic quantities under review are coordinates, transformations, metric intervals, proper-time functionals, simultaneity conventions, light-cone relations, curvature terms, and worldline descriptions. None is time as defined by T_{ITOF}. Lorentz transformations and Minkowski geometry are coordinate and model tools for arranging records and constraints. Their formal role does not make the coordinate description identical with the invariant cosmic ordering.

$$\mathrm{LorentzTransform}(q) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad \mathrm{MinkowskiGeometry}(G) \not\Rightarrow G \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \quad (243)$$

Relativity of simultaneity is an assignment result inside a coordinate and synchronization scheme; it does not establish the absence of invariant universal cosmic ordering. Proper time is a path-dependent clock-comparison quantity; it is not universal cosmic succession. Time dilation and gravitational time dilation are retyped as differential clock-record production under declared conditions. Curvature in a spacetime model is not bending of time itself. Light-cone accessibility is not the cosmic ordering. Twin-clock cases are differential record-history cases between bearers that undergo different physical condition histories. The block-universe interpretation is not forced by clock records or coordinate transformations; it is an ontological addition that identifies representation with reality.

The rule is compact:

$$\mathrm{RelativisticQuantity}(q) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \quad (244)$$

Relativistic temporal ontology has no defining authority inside ITOF. The burden on any quantitative model is recovery, scope, uncertainty, and prediction; the ontology of time is fixed by the definition.

22.7 Light and radiation as bearers

Light is treated by role and warrant, not by slogan. A radiation process, photon-counted event, pulse, beam, or field excitation may be admitted as a qualified physical bearer only when the application supplies actuality, identity, production, persistence or traceability, and measurement warrant. When those conditions are not supplied, the item remains a signal quantity, model variable, record relation, or event classification. In either case, propagation is not movement of time.

$$\mathrm{RadiationRecord}(R) \not\Rightarrow R \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \quad (245)$$

Path deviation, lensing reconstruction, spectral change, delay, attenuation, interference, or detection order may require physical explanation in the source, propagation conditions, detector, and reconstruction model. They do not establish temporal bending or a transfer of time from source to receiver.

22.8 Quantum measurement and model-state classifications

Quantum formalism is treated without adding a private time or second cosmic ordering. A state vector, density operator, wavefunction, path amplitude, which-path label, collapse statement, or entanglement relation does not automatically become an independent physical bearer. Bearer status requires physical identity and warrant. Model-state language may organize prediction and record classification; it does not define time.

Delayed-choice and quantum-eraser cases must separately type the source, apparatus setting, path or polarization markers, beam splitters, detectors, timing windows, coincidence electronics, data-selection rules, and final records. The later classification of correlations does not rewrite an earlier cosmic stage:

$$\text{DelayedChoiceCorrelationRecord}(R) \not\Rightarrow \text{RetroactiveTemporalChange}, \tag{246}$$

$$\text{QuantumEraserCoincidencePattern}(R) \not\Rightarrow R \equiv_{\text{type}} T_{\text{ITOF}}. \tag{247}$$

If collapse language is used, the application must state whether it means model update, physical change in a measurement chain, or another declared process. None of those meanings is a jump of time, creation of a private cosmic stage, or evidence that time itself changed.

22.9 Predeclared bridge protocol

A bridge model that claims recovery, explanation, or model distinction must declare the following before outcome interpretation:

No.	Protocol item	Required content
1	Objective	The record, comparison, or phenomenon to be recovered or distinguished.
2	Bearers	Physical systems admitted as bearers, with boundaries and identity criteria.
3	Non-bearer factors	Conditions, fields, pressures, temperatures, signals, coordinates, state variables, and relations not admitted as independent bearers.
4	Record chain	Source, emission, propagation, interaction, detector, clock, processing, storage, and accepted record.
5	Model law	Response law or calculation rule, including domain limits.
6	Parameters	Coefficients, environmental terms, systematic corrections, and residual bounds fixed in advance.
7	Comparator	Rival or external model used for recovery or distinction.
8	Prediction vector	Predicted output in the common comparison codomain.
9	Uncertainty	Calibration, statistical uncertainty, systematic uncertainty, transfer uncertainty, and combined separation threshold.
10	Exclusions	Variables, causes, or post-outcome adjustments that cannot be introduced after the result.
11	Acceptance	Criterion for successful recovery or adequate explanation.
12	Failure	Conditions under which the declared bridge fails.
13	Distinguishing condition	Whether the test separates the model from a rival by more than accepted uncertainty.

No.	Protocol item	Required content
14	Interpretation	What the result warrants and what it does not warrant.

A fitted outcome without predeclared boundaries, parameters, uncertainty, and failure rules is not a bridge. It is an after-the-fact adjustment.

22.10 Definition-test linkage table

Foundation item	Application or test class	Required linkage
Invariant universal ordering	All record-order applications	Records may be ordered or compared; no record becomes the ordering itself.
CMA	Clock, light, quantum, and material-bearer cases	Each admitted bearer must have identity and bearer-specific physical change at the relevant common stages.
UCC	Stability, recurrence, long-lived objects, and delayed detection	Apparent stability or repeated state descriptions do not suspend bearer-specific change.
Identity domain I_A	Formation, ending, transported clocks, twin-clock cases	Claims apply only while the bearer's identity remains realized.
Non-Transfer Principle	Relativity, GPS, quantum records, higher dimensions	Success or consistency cannot transfer the type of time to an output, coordinate, metric, quantum symbol, signal interval, or geometry.
Exact-stage restraint	Remote records, clock readings, first detections, delayed-choice data	Accepted records can warrant bounded reconstruction, not exact cosmic-stage identification.
Quantitative bridge requirement	Atomic-clock, velocity-gravity, navigation, and future distinguishing tests	Recovery or distinction must be predeclared with model law, uncertainty, comparator, acceptance, and failure rules.

22.11 Interpretation rules

Rule 1. A clock reading is a physical record, not time.

Rule 2. A signal interval is a propagation and record-comparison quantity, not travelling time.

Rule 3. GPS-type success demonstrates signal-record navigation, not transfer of time.

Rule 4. Optical path deviation is path or reconstruction deviation under physical conditions, not bending of time.

Rule 5. Heat, sunlight, pressure, vibration, shock, gravity, and kinematic conditions are bearer-condition variables to be declared before interpretation.

Rule 6. Removal of a velocity or gravitational condition should remove its present rate effect unless a residual physical disturbance remains; an accumulated offset is a record history, not stored or delayed time.

Rule 7. Relativistic coordinates, proper-time functionals, metric intervals, spacetime curvature, light-cone structure, and twin-clock record differences do not define time.

Rule 8. A quantum-state assignment is not automatically a physical bearer, and a quantum record is not a private time.

Rule 9. Higher-dimensional or coordinate equations do not establish physical reality without physical reference and testable application.

Rule 10. Recovery of accepted results must be separated from explanatory adequacy and from model-distinguishing prediction.

23. Model Constructions and Dependency Audit

23.1 Purpose of the constructions

The following mathematical constructions test relative satisfiability and dependency. They are not claims that the models exhaust physical reality. The stage labels used in these constructions are formal order-theoretic labels only. They do not assert that actual cosmic-stage rank can be observationally identified with exact numerical precision. A visible or recorded change indicates that some cosmic stage has realized the relevant physical difference, but it does not by itself reveal the exact order-position of that stage. This restraint follows from the continuity and universality of realized change across all existing systems. The models therefore test logical coherence, not empirical stage-number recoverability.

23.2 Discrete origin-bounded model

Let

$$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} = \mathbb{N}_0, \qquad m \prec_{\mathrm{C}} n \Longleftrightarrow m < n. \tag{248}$$

Let U be an ongoing bearer with $I_U = \mathbb{N}_0$. For each $k, n \in \mathbb{N}_0$, let $A_{k,n}$ have

$$I_{A_{k,n}} = \{k, k+1, \ldots, k+n\}. \tag{249}$$

Declare

$$\mathrm{PhysReal}_A^+(s) = \top \quad \Longleftrightarrow \quad s \in I_A. \tag{250}$$

Equation (250) supplies stage-indexed physical change at every identity member. Declare U ongoing. For each finite bearer $A_{k,n}$, set

$$\mathrm{End}_{A_{k,n}}(k+n) = \top. \tag{251}$$

For each finite bearer $A_{k,n}$, assign at least one same-stage successor. One explicit assignment is

$$\begin{aligned} \mathrm{PhysicalProductionLink}(A_{k,n}, A_{k+n,1}; k+n) &= \top, \\ \mathrm{ExistsAs}(A_{k+n,1}, k+n) &= \top, \\ A_{k+n,1} &\neq A_{k,n}. \end{aligned} \tag{252}$$

Thus the ending stage of the predecessor and the formation stage of the successor coincide formally in the model. The successor does not arise at a later cosmic stage and does not occupy a gap after the predecessor. The same-stage notation expresses identity transformation, not observational access to an exact cosmic-stage number. Additional successors may be added without changing the dependency claim. With this assignment, the model satisfies cosmic origin, extension beyond origin, nonempty stage population, CMA, UCC, convex identity domains, unique formation, identity ending, and necessary successor closure. One-stage bearers occur when $n = 0$ and realize physical change at their sole stage.

23.3 Dense origin-bounded model

Let

$$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} = \{0\} \cup \mathbb{Q}_{>0} \tag{253}$$

with the usual strict order. Let one bearer occupy the full domain and let other bearer domains be convex rational intervals with included least members and optional greatest members. Set $\mathrm{PhysReal}_A^+(s) = \top$ exactly on each identity domain. CMA and UCC hold without immediate successors. Thus the rebuilt formulation does not presuppose discrete stages.

The model also supplies visible-stage sets with no least member. For $0 \leq \alpha < \beta$,

$$\mathcal{V} = \{q \in \mathbb{Q} \mid \alpha < q < \beta\} \subseteq \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \tag{254}$$

is nonempty and has no least member. Thus a first visible stage is not guaranteed by the ordering alone.

23.4 Selected dependency results

Time definition without CMA.

Use the discrete ordered stage domain and bearer populations but assign $\mathrm{PhysReal}_A^+(s) = \bot$ for a present bearer-stage pair. The time definition and ordering remain satisfied while CMA and UCC fail. This establishes that change is not hidden inside the definition of time.

CMA and UCC without cosmic origin.

Let $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} = \mathbb{Z}$ with the usual order, use nonempty bearer populations, and set $\mathrm{PhysReal}_A^+(s) = \top$ on each identity domain. CMA and UCC hold while the Cosmic Origin Postulate fails. Origin-boundedness is therefore independent of the change commitments.

Ongoing bearer without ending.

The discrete model contains U with no greatest identity member. CMA, UCC, formation, and the outcome architecture for completed bearers remain satisfied. Eventual ending is not presupposed.

Place and representation.

Let one physical system or a physically organized family of systems possess the relevant bearer identities and spatial relations, while a place expression refers to them and two coordinate schemes assign different numerical representations to the same relation. The physical systems and their motion claims remain fixed while the place expression and coordinate representations differ. Neither the place expression nor the coordinate representation is constitutive of the bearers, motion, or time.

23.5 Dependency order

The rebuilt dependency order is:

(1) $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ and $\prec_{\mathrm{C}}$;
(2) the denotation T_{ITOF};
(3) bearer identities, identity domains, and Cosmic-Stage Population;
(4) stage-indexed realized physical change $\mathrm{PhysReal}_A^+(s)$;
(5) CMA;
(6) UCC as the bearer-history consequence of CMA;
(7) formation, history, identity ending and necessary successors;
(8) spatial expressions, occupancy, and motion;
(9) records, measurement bridges, quantitative models, and restricted empirical decisions.

No later item redefines time or creates the cosmic ordering.

24. Scope, Limits, and Conclusion

V31/F11 retains the central identity of ITOF while making one definitional correction and one integration step explicit. Relative to V30/F10, it states the invariance of the universal cosmic ordering inside the definition of time and includes the Non-Transfer Principle as a rule for measurement, modelling, and interpretation. Relative to V29/F9 and the earlier foundational sequence, the retained reconstruction preserves five bounded corrections: it states physical change directly at every realized stage while separating that ontic claim from observed historical reconstruction; distinguishes complete-history quantification from attainment at a reference stage; makes identity ending inseparable from the production of one or more successors; requires an independent bearer criterion before a field entity enters the scope of CMA; and converts the atomic-clock discussion into a quantitative bridge specification open to rejection under a predeclared test with an explicit recovery target. No earlier proposition governs merely because it appeared in a prior version.

Time denotes the invariant universal cosmic ordering and uninterrupted succession of common cosmic stages in one common cosmic extension:

$$T_{\mathrm{ITOF}} = (\mathcal{S}_{\mathrm{C}}, \prec_{\mathrm{C}}). \tag{255}$$

Physical change remains bearer-specific: time neither denotes nor causes it. The total-history domain is distinguished from the prefix attained at a reference stage. Every continuing bearer realizes its own physical change at every stage of its identity, without a suspension of change and without turning an observed record into an exact stage assignment.

CMA states physical change at every stage:

$$A \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow \mathrm{PhysReal}_A^+(s). \tag{256}$$

UCC states that physical change is realized at every stage at which the bearer identity exists:

$$\mathrm{UCC}(A) \Longleftrightarrow \mathrm{PhysicalSystem}(A) \wedge \forall s \in I_A,\ \mathrm{PhysReal}_A^+(s). \tag{257}$$

Formation is a unique least identity member. Ending is unique when the bearer history is completed; ongoing histories remain admissible. Every attained identity ending necessarily produces one or more successor identities. Other systems and non-system physical factors may participate in the ending transformation, but none can replace the required successor system or systems.

Physical change is realized in the physical system, in the properties of its material constitution, its internal physical structure, its external physical structure, or their combined condition, and it is attributed only while the system's identity is physically realized. Its physical causes may be internal, external, or combined. Another physical system may influence it while remaining a system with its own identity and change; a non-system physical factor remains a factor. Motion, where realized, is the material transition of the moving system through, within, or between composite physical systems and is a change of that bearer itself. Time, the common stage, the ordering relation, CMA, and UCC are not causal agents. A physical explanation must identify the system and the relevant internal or external causes without using an unknown cause as an unrestricted escape from evidence.

A realized change may be beneficial or harmful for the system under a declared criterion. Benefit and harm do not redefine change. A harmful change alone is insufficient to end identity; ending occurs only when the persistence conditions cease and necessarily produces one or more successors. A beneficial change likewise leaves CMA and UCC in force.

Motion has a narrower status than universal physical change. It is one type of physical change realized in some systems, while CMA requires every then-existing system to change without requiring every system to move. The realization and nature of motion depend on the system's constitutive and structural properties, mechanisms, constraints, and spatial relations. Translation, rotation, orbital development, locomotion, migration, deformation-linked displacement, and constituent motion therefore need not possess one identical physical content. Relative rest under a declared spatial criterion remains consistent with continuing physical change of another type.

Observation belongs to this same physical account. Every then-existing bearer undergoes its own physical change, and every continuing bearer undergoes change at every stage of its identity, including the sample, detector, apparatus, observer, record, environment, and systems beyond the study. A visible difference has a physical basis, but finite observation normally cannot identify the exact common cosmic stage at which the relevant change first became visible. The change may have been minute, distributed, cumulative, and below human or instrumental perception before detection. It continues during the examination while the measuring arrangement changes; where the relevant bearer identity persists beyond operational completion, its physical change continues through every later stage. A record therefore constrains the physical history without automatically fixing one exact stage or ordinal position in the cosmic ordering.

The framework rejects relativistic temporal ontology. Relativistic quantities remain model objects and physical record quantities, not time as defined by ITOF. This rejection is not a substitute for quantitative work. The field classification prevents mathematical field objects from being counted automatically as physical bearers while preserving CMA for every field entity that independently satisfies the bearer conditions. The atomic-clock bridge supplies one application bridge specified in advance from bearer definition to failure decision, but it does not claim a universal microscopic clock law or an implemented prediction that distinguishes competing models. The long-term scientific strength of the framework depends on bearer-specific physical models that reproduce accepted observations, survive preregistered demanding tests, and eventually yield predictions that distinguish competing models.

V31/F11 is therefore a strengthened foundation rather than a claim of finality. Its central standard is explicit: no inherited statement is protected from revalidation, no negative result may be dismissed by an unspecified hidden mechanism, no record may be identified with its source stage, and no successful calculation may transfer ontological identity to the quantity calculated.

25. Methodological Consequences for Scientific Use

The theory distinguishes ontological commitments from the methods used to investigate particular systems. This distinction is essential because the universal claims concern all physically realized systems, whereas any experiment has limited bearers, variables, instruments, and records.

25.1 What a change claim must identify

A domain-specific change claim should identify the physical system and the identity criterion under which its bearer identity is tracked. It should state whether the claimed change is realized in the system's material constitution, internal physical structure, external physical structure, motion, or combined condition. It should then identify the internal causes, external influencing physical systems, external non-system physical factors, record or access route, and uncertainty that are relevant to the claim. An influencing system must not be relabelled as a factor. When the change is described as beneficial or harmful, the claim must identify the system and the declared criterion used for that assessment. No structural location, material-transition attribution, or physical cause may be introduced only after a result has failed to match the model; it must be physically meaningful for the system under study and independently constrained by the application.

The requirement does not turn change into a comparison between two recorded states. Formation is change even though the new identity has no earlier state of its own. A continuing process may be physically real while no record resolves each of its manifestations. Ending is change because the identity ceases through a transformation, not because a later record merely fails to find the predecessor.

25.2 Universal change and restricted tests

CMA applies to every then-existing physical system at every common stage. A laboratory test cannot recreate that universal quantification. It can test a physical model of a sample, clock, detector, field-bearing system, organism, material, or astronomical source. Success supports that restricted model within the tested domain. Failure rejects or revises the implementation or bridge unless the failed prediction was derived uniquely from the foundational commitment.

This distinction prevents two opposite errors. The theory cannot claim direct experimental verification of CMA from one observed difference, and a null result cannot be treated automatically as a physical system without change. Both conclusions would exceed the evidence.

25.3 Historical records and scale

Records have a scale and a history of their own. A photograph, spectrum, clock output, genetic sequence, growth layer, clinical report, or sensor trace represents selected physical content under a protocol. It may integrate contributions, omit unmeasured variables, and undergo later alteration. A record sequence therefore gives an operational order whose relation to source development must be physically justified.

Different studies can reconstruct the same system at different resolutions. One may sample daily, another continuously on an instrumental scale, and another only at major transformations. None of these resolutions determines the number of actual cosmic stages. Agreement is judged by the physical developments represented, not by equality of record counts.

25.4 Stages in the formal core and stages in applications

Stage variables are indispensable in the formal statement of the common ordering, CMA, UCC, formation, and ending. Their role is bound and ontological. In applications, a record ordinarily does not justify replacing that bound variable with a named or measured stage.

For this reason, V31/F11 permits operational labels, record indices, source-history windows, and model coordinates while withholding exact cosmic-stage assignment. The distinction preserves the claim that every change is realized at a stage without pretending that an experiment has identified that member of the cosmic ordering.

25.5 Ending, successor plurality, and conservation accounts

Necessary Successor Closure is not a substitute for conservation laws or domain dynamics. It states that the ended identity cannot be the sole outcome of its ending. The transformation produces one or more new systems. Domain physics determines their composition, organization, energy and matter relations, fields, trajectories, and interactions.

Where several predecessor systems contribute to one successor, successorship may be many-to-one. Where one predecessor produces several systems, it is one-to-many. Nested transformations can occur at different bearer levels. The identity criterion must therefore specify whether the relevant predecessor is a molecule, cell, organism, machine, institution embodied in physical systems, star, galaxy, or another system class.

Similarity has no fixed threshold across all classes. A daughter cell, repaired machine, rebuilt city referent, or stellar remnant may preserve different properties, relations, or features of the predecessor. The scientific account should state which properties, relations, or features continue and the physical reason bearer identity ended.

25.6 Place expressions in measurement and modeling

Scientific practice often uses phrases such as “at the detector,” “inside the chamber,” “in the atmosphere,” or “at the source.” Each phrase should be read as a spatial expression selecting one or more physical systems and representing their relevant boundaries and spatial relations. Relevant pressure, temperature, radiation, field values, or other non-system factors describe conditions of those systems; they are not additional spatial referents. The expression itself neither acts nor changes.

A measurement model should state which physical referents are included. For a chamber, this may include walls, windows, gas, vacuum conditions represented by field and particle models, supports, sensors, and external systems. For a geographical region, it may include material systems and relations whose boundaries are selected for the study. Ambiguous place language should be resolved before causal or identity claims are made.

25.7 Coordinate validation

A coordinate scheme gains physical value through calibration, reference selection, correspondence with physical systems and their spatial relations, and successful application within a declared domain. A model should specify what the coordinates represent, how the representation is established, which transformations preserve the physical content, and where the scheme ceases to apply.

Numerical elegance, internal consistency, or predictive convenience alone cannot turn a coordinate into physical reality. Representational usefulness is not ontological identity. ITOF separates representational success from ontological identity.

25.8 Clocks and operational precision

Clock readings are physical outputs obtained from repeated or controlled processes. Their precision depends on system preparation, transition or oscillator behavior, servo control, environment, signal transfer, detection, calibration, and statistical treatment. These details belong to physical models of clocks.

A record comparison may be extraordinarily precise and still remain an operational relation. It can test clock-specific models, recover accepted relations, reveal residuals, and constrain physical explanations. It cannot by itself show that time is a clock output, that the cosmic ordering has a rate, or that a reading names one cosmic stage.

25.9 Remote systems and delayed access

Delayed access is a property of physical propagation and record chains. It should not be translated into a delay of the source's participation in the common stage. A distant system continues its physical history whether or not a record has reached an observer. The observer later interacts with a record produced through propagation, not with the earlier source change itself.

Differential techniques can cancel common propagation contributions and preserve source-relative separations within a model. Such success is important, but the resulting numerical interval remains an operational quantity. It neither transports a remote time nor identifies the source changes with reception records.

25.10 Publication and review standard

A later version should preserve the distinction among definition, axiom, identity criterion, physical model, record, and inference. New equations should be admitted only after their domains and types are stated. Historical formulas from earlier versions carry no authority merely because they appeared before; each must be revalidated in the current ontology.

Review should examine whether a symbol has acquired an unintended physical role, whether an observational claim has become an exact-stage assertion, whether a place expression has been turned into a bearer, whether ending lacks successors, or whether a coordinate has been granted physical value without a physical referent. These checks protect the theory more effectively than mechanical consistency alone.

A. Statement Status and Dependency Register

Item	Status	Direct dependencies
$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Primitive domain	None.
$\prec_{\mathrm{C}}$	Primitive relation	$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.
T_{ITOF}	Definition	$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}$.
s_{C}^{0}	Cosmic Origin Postulate	$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}$; independent of the time definition.
Cosmic Extension Beyond Origin	Independent postulate	$s_{\mathrm{C}}^{0}, \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}$; requires at least one later stage and leaves undecided whether a greatest stage exists.
Cosmic-Stage Population	Foundational principle	$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \mathrm{ExistsAs}, \mathcal{S}_{\mathrm{phys}}(s)$.
$\mathrm{PhysicalSystem}(A)$	Primitive bearer predicate	Physical ontology and bearer criterion.
I_A	Definition	$\mathrm{ExistsAs}(A, s), \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.
$\mathrm{PhysReal}_A^{+}(s)$	Primitive stage-indexed physical-change relation	Realized bearer identity and change in the system's material constitution, internal physical structure, external physical structure, motion, or combined condition.
CMA	Axiom	Stage population and $\mathrm{PhysReal}_A^{+}(s)$.
UCC	Defined bearer-history consequence	CMA and $s \in I_A$.
$\mathrm{CompletePhysicalStasis}(A; J)$	Defined contrary condition	Nonempty $J \subseteq I_A$ and absence of $\mathrm{PhysReal}_A^{+}(s)$ at every member.
Identity-Domain Convexity	Principle	$I_A, \prec_{\mathrm{C}}$.
$\mathrm{SameBearerThrough}_A(r, s)$	Defined directed identity relation	$A \in \mathcal{U}_{\mathrm{phys}}$, $r, s \in I_A$, and $r \preceq_{\mathrm{C}} s$.
f_A	Postulate-derived boundary	Nonempty I_A and the formation commitment.
$\mathrm{FormationChange}_A(s)$	Defined boundary classification	$s = f_A$ and $\mathrm{PhysReal}_A^{+}(s)$.
$e : \mathcal{U}_{\mathrm{phys}}^{\mathrm{end}} \to \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Restricted ending-member map	Defined only for $\mathrm{HistoryComplete}(A)$.

Item	Status	Direct dependencies
$\mathrm{EndingChange}_A(s)$	Defined boundary classification	$s = e_A$, $\mathrm{End}_A(s)$, and $\mathrm{PhysReal}_A^+(s)$.
Necessary Successor Closure	Foundational principle	Every attained identity ending produces at least one distinct successor identity.
No Infinite Same-Stage Cascade	Foundational constraint	One-stage identity domains and SuccAt.
SuccAt	Derived relation	Ending of the predecessor, formation of the successor at the same boundary stage, physical production linkage, and nonidentity.
$\mathrm{PlaceExpression}(P; \mathcal{B}_P)$	Defined spatial expression	Refers to actual physical systems and represents their relevant boundaries and spatial relations; the expression is not a bearer.
Candidate-stage and unique-stage maps	Epistemic/model maps	Accepted record families, attribution, order bridges, and separate uniqueness warrant.
Exact-stage restraint	Epistemic principle	Record chain, acquisition support, admissible reconstructed histories, and continuing physical change.
Quantitative adequacy	Application criterion	Physical model, observations, discrepancy, and tolerance.
Relativistic nonidentity	Type-based conclusion	Definition of time and types of relativistic quantities.

B. Logical Level and Type Register

Let $\mathfrak{C}$ denote the typed claim space, $\mathfrak{R}_P$ the accepted single-record domain of protocol P, and $\mathfrak{R}_{P,+}^{<\omega}$ the nonempty finite accepted-record-family domain.

Item	Logical level	Schematic signature or scope
$e : \mathcal{U}_{\mathrm{phys}}^{\mathrm{end}} \to \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Restricted-domain ending map	e_A is unavailable outside $\mathcal{U}_{\mathrm{phys}}^{\mathrm{end}}$.
$\mathrm{SameBearerThrough}_A(r, s)$	Defined directed identity relation	Persistence of one bearer through ordered history bounds.
IdentityWarrant	Epistemic specialization	Reserved for warranting $\mathrm{SameBearerThrough}_A(r, s)$.
Direct CMA/UCC challenge	Ontic condition	A bearer belongs to the stage population while its stage-specific physical change is absent; scientific attribution requires separate warrant.

Item	Logical level	Schematic signature or scope
CompletePhysicalStasis	Defined ontological claim	Nonempty $J \subseteq I_A$ and no realized physical change at any member.
Manifestation	Application-level physical classification	Bearer, physical manifestation, and stage.
Warrant	Epistemic relation	$C \in \mathfrak{C}$; warrant neither creates nor enters the ontic fact asserted.
PhysicalProductionLink	Primitive physical-origin relation	Bearers and common stage; same-stage use requires ending and formation changes.
ClosureOnly$((B_n)_{n\in\mathbb{N}}, e)$	Formal-closure marker	Same-stage successor sequence generated solely by formal closure without independently specified physical-production warrant.
PredictedOutcome$_{P,M}(Y_A \mid \widehat{J}^+)$	Epistemic/model predicate	Declared outcome and future protocol domain; prediction does not actualize its target.
Predicted ending window	Epistemic/model predicate	Predicts a window without asserting completed ending.
OrderBridge	Epistemic bridge	Accepted records and candidate source stages; it is not an identity relation.

C. Measurement and Application Audit

A measurement claim is admissible only when it identifies the sample bearer, apparatus, detector, record bearer, observer or automated reading system, relevant environment, acquisition support, physical source change, record-production relation, reading map, uncertainty model, observational-window relation, and scope of the conclusion. The audit shall state whether the result warrants a physical difference, a record or source-development order, a bounded observational window, or a threshold classification. None of these conclusions assigns an exact cosmic stage.

The following inferences are prohibited without additional warrant:

$$\text{first detection} \not\Rightarrow \text{first physical change,} \tag{258}$$

$$\text{threshold crossing} \not\Rightarrow \text{formation or ending,} \tag{259}$$

$$\text{stable reading} \not\Rightarrow \text{complete physical stasis,} \tag{260}$$

$$\text{record time label} \not\Rightarrow \text{exact common cosmic stage,} \tag{261}$$

$$\text{protocol completion} \not\Rightarrow \text{cessation of physical change.} \tag{262}$$

References

[1] Ghandour, Y. (2026). *Invariant Temporal Ordering Framework V30/F10: Reconstructed Foundations of Universal Cosmic Succession and Bearer-Specific Physical Change*. Preprint and repository version.

[2] Y. Ghandour, *Invariant Temporal Ordering Framework V29/F9: The Comprehensive Central Synthesis of Universal Cosmic Succession, Physical Identity, Transformation, Spatial Realization, and Cross-Domain Application*, ITOF Foundation Series IX (F9), Central Foundational Preprint, July 25, 2026.

[3] Y. Ghandour, *Invariant Temporal Ordering Framework V28/F8: A Foundational Historical-Critical Reconstruction of Transformation Semantics, Physical Production Linkage, and Successor Attribution*, ITOF Foundation Series VIII (F8), Foundational Historical-Critical Reconstruction Preprint, July 23, 2026.

[4] Y. Ghandour, *Invariant Temporal Ordering Framework V27/F7: A Foundational Ontology of Universal Cosmic Succession, Identity-Bounded Physical Histories, and Bearer-Specific Change*, ITOF Foundation Series VII (F7), Author-Reconstructed and Internally Audited Preprint, 2026.

[5] Y. Ghandour, *Invariant Temporal Ordering Framework V26/F6: A Foundational Theory of Cosmic Onset, Common Cosmic Stages, Universal Physical Change, and Identity-Bounded Physical Histories*, ITOF Foundation Series VI (F6), Foundational Reconstruction Preprint, OSF, 2026.

[6] Y. Ghandour, *Invariant Temporal Ordering Framework V25/F5: A Foundational Theory of Temporal Succession, Realized Physical Change, the Cosmic Moment Axiom, and Relativistic Measurement*, ITOF Foundation Series V Preprint, Version V25/F5, OSF and Zenodo, 2026.

[7] Y. Ghandour, *Invariant Temporal Ordering Framework V24/F4: A Universal Theory of Temporal Succession, Realized Physical Change, and Relativistic Measurement*, ITOF Foundation Series IV Preprint, Version V24/F4, Research21.org, 2026.

[8] Y. Ghandour, *Invariant Temporal Ordering Framework V23/F3: Universal Temporal Meaning and the Systemwise Realization of Physical Change*, ITOF Foundation Series III Preprint, Version V23/F3, Research21.org, 2026. Project and archive identifiers: DOI: 10.17605/OSF.IO/CWYFX; DOI: 10.5281/zenodo.19542538.

[9] Y. Ghandour, *Invariant Temporal Ordering Framework V22/F2: A Fundamental Assignment Law of Systemic Change-Realization under Invariant Ordered Succession*, ITOF Foundation Series II, 2026.

[10] Y. Ghandour, *Invariant Temporal Ordering Framework V21/F1: A Fundamental Reassignment Law for Time-Attributed Phenomena under Invariant Ordered Succession*, ITOF Foundation Series I, 2026.

[11] Y. Ghandour, *Invariant Temporal Ordering Framework V20: Ontological Assignment Closure under Invariant Ordered Succession*, preprint, 2026.

[12] Y. Ghandour, *Invariant Temporal Ordering Framework V19: Relativistic Interpretation Reassignment under Invariant Ordered Succession*, preprint, 2026.

[13] Y. Ghandour, *Invariant Temporal Ordering Framework V18: Outcome Assignment and Non-Transfer to Time under Implementation-Conditioned Physical Realization*, preprint, 2026.

[14] Y. Ghandour, *Invariant Temporal Ordering Framework V17: Implementation-Conditioned Domain-Realization Law under Invariant Ordered Succession*, preprint, 2026.

[15] Y. Ghandour, *Invariant Temporal Ordering Framework V16: Predictive Physical-Realization Closure under Invariant Ordered Succession*, preprint, 2026.

[16] Y. Ghandour, *Invariant Temporal Ordering Framework V15: Physical Realization and Residual Reassignment Under Invariant Ordered Succession*, preprint, 2026.

[17] A. Einstein, "Zur Elektrodynamik bewegter Körper," *Annalen der Physik*, vol. 17, pp. 891–921, 1905. DOI: 10.1002/andp.19053221004.

[18] A. Einstein, "Die Grundlage der allgemeinen Relativitätstheorie," *Annalen der Physik*, vol. 49, pp. 769–822, 1916. DOI: 10.1002/andp.19163540702.

[19] R. M. Wald, *General Relativity.* Chicago: University of Chicago Press, 1984.

[20] H. R. Brown, *Physical Relativity: Space-Time Structure from a Dynamical Perspective*, Oxford University Press, 2005. DOI: 10.1093/0199275831.001.0001.

[21] H. R. Brown, "The Behaviour of Rods and Clocks in General Relativity, and the Meaning of the Metric Field," in D. E. Rowe, T. Sauer, and S. A. Walter (eds.), *Beyond Einstein*, Einstein Studies 14, Birkhäuser, 2018, pp. 51–66. DOI: 10.1007/978-1-4939-7708-6_2.

[22] T. Maudlin, *Philosophy of Physics: Space and Time*, Princeton University Press, 2012.

[23] C. Callender, *What Makes Time Special?*, Oxford University Press, 2017. https://doi.org/10.1093/oso/9780198797302.001.0001.

[24] J. O. Weatherall, "Two Dogmas of Dynamicism," *Synthese*, vol. 199, suppl. 2, pp. 253–275, 2021. DOI: 10.1007/s11229-020-02880-0; preprint: arXiv:2006.11400.

[25] Joint Committee for Guides in Metrology, *Evaluation of Measurement Data—Guide to the Expression of Uncertainty in Measurement*, JCGM 100:2008, 2008. https://doi.org/10.59161/JCGM100-2008E.

[26] Joint Committee for Guides in Metrology, *International Vocabulary of Metrology—Basic and General Concepts and Associated Terms*, 3rd ed., JCGM 200:2012, 2012. DOI: 10.59161/JCGM200-2012.

[27] A. Gelman, J. B. Carlin, H. S. Stern, D. B. Dunson, A. Vehtari, and D. B. Rubin, *Bayesian Data Analysis*, 3rd ed., CRC Press, 2013.

[28] K. P. Burnham and D. R. Anderson, *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*, 2nd ed., Springer, 2002. DOI: 10.1007/b97636.

[29] T. Bothwell et al., "Resolving the Gravitational Redshift Across a Millimetre-Scale Atomic Sample," *Nature*, vol. 602, pp. 420–424, 2022. DOI: 10.1038/s41586-021-04349-7.

[30] X. Zheng, J. Dolde, V. Lochab, B. N. Merriman, H. Li, and S. Kolkowitz, "Differential Clock Comparisons with a Multiplexed Optical Lattice Clock," *Nature*, vol. 602, pp. 425–430, 2022. DOI: 10.1038/s41586-021-04344-y.

[31] X. Zheng, J. Dolde, M. C. Cambria, H. M. Lim, and S. Kolkowitz, "A Lab-Based Test of the Gravitational Redshift with a Miniature Clock Network," *Nature Communications*, vol. 14, art. 4886, 2023. DOI: 10.1038/s41467-023-40629-8.

[32] Boulder Atomic Clock Optical Network (BACON) Collaboration, "Frequency Ratio Measurements at 18-Digit Accuracy Using an Optical Clock Network," *Nature*, vol. 591, pp. 564–569, 2021. DOI: 10.1038/s41586-021-03253-4.

[33] S. Kraemer et al., "Observation of the Radiative Decay of the ^{229}Th Nuclear Clock Isomer," *Nature*, vol. 617, pp. 706–710, 2023. DOI: 10.1038/s41586-023-05894-z.

[34] J. Tiedau et al., "Laser Excitation of the ^{229}Th Nucleus," *Physical Review Letters*, vol. 132, art. 182501, 2024. DOI: 10.1103/PhysRevLett.132.182501.

[35] R. Elwell et al., "Laser Excitation of the ^{229}Th Nuclear Isomeric Transition in a Solid-State Host," *Physical Review Letters*, vol. 133, art. 013201, 2024. DOI: 10.1103/PhysRevLett.133.013201.

[36] C. Zhang et al., "Frequency Ratio of the ^{229m}Th Nuclear Isomeric Transition and the ^{87}Sr Atomic Clock," *Nature*, vol. 633, pp. 63–70, 2024. DOI: 10.1038/s41586-024-07839-6.

[37] A. Aeppli et al. (BACON Collaboration), "Atomic Clock Frequency Ratios with Fractional Uncertainty $\leq 3.2 \times 10^{-18}$," *Physical Review Letters*, vol. 137, art. 033201, 2026. DOI: 10.1103/g865-9mk1.

[38] T. Ooi, J. F. Doyle, C. Zhang, J. S. Higgins, J. Ye, K. Beeks, T. Sikorsky, and T. Schumm, "Frequency Reproducibility of Solid-State Thorium-229 Nuclear Clocks," *Nature*, vol. 650, pp. 72–78, 2026. DOI: 10.1038/s41586-025-09999-5.

[39] Hafele, J. C., and Keating, R. E. (1972). Around-the-world atomic clocks: predicted relativistic time gains. *Science*, 177(4044), 166–168. DOI: 10.1126/science.177.4044.166

[40] Hafele, J. C., and Keating, R. E. (1972). Around-the-world atomic clocks: observed relativistic time gains. *Science*, 177(4044), 168–170. DOI: 10.1126/science.177.4044.168

[41] Chou, C. W., Hume, D. B., Rosenband, T., and Wineland, D. J. (2010). Optical clocks and relativity. *Science*, 329(5999), 1630–1633. DOI: 10.1126/science.1192720

[42] Ashby, N. (2003). Relativity in the Global Positioning System. *Living Reviews in Relativity*, 6, 1. DOI: 10.12942/lrr-2003-1

[43] National Institute of Standards and Technology. (accessed 2026). Time and frequency from A to Z: G is for GPS. https://www.nist.gov/pml/time-and-frequency-division/popular-links/time-frequency-z/time-and-frequency-z-g

[44] Jacques, V., Wu, E., Grosshans, F., Treussart, F., Grangier, P., Aspect, A., and Roch, J.-F. (2007). Experimental realization of Wheeler's delayed-choice Gedanken experiment. *Science*, 315(5814), 966–968. DOI: 10.1126/science.1136303

[45] Kim, Y.-H., Yu, R., Kulik, S. P., Shih, Y., and Scully, M. O. (2000). Delayed "choice" quantum eraser. *Physical Review Letters*, 84(1), 1–5. DOI: 10.1103/PhysRevLett.84.1

[46] Ma, X.-s., Kofler, J., Qarry, A., Tetik, N., Scheidl, T., Ursin, R., Ramelow, S., Herbst, T., Ratschbacher, L., Fedrizzi, A., Jennewein, T., and Zeilinger, A. (2013). Quantum erasure with causally disconnected choice. *Proceedings of the National Academy of Sciences*, 110(4), 1221–1226. DOI: 10.1073/pnas.1213201110

[47] International Organization for Standardization, *ISO 6425:2018, Horology—Divers' Watches*, 4th ed. (ISO, Geneva, 2018), confirmed 2024.

[48] A. N. Bernal and M. Sánchez, "Smoothness of Time Functions and the Metric Splitting of Globally Hyperbolic Spacetimes," *Communications in Mathematical Physics* **257**, 43–50 (2005), doi:10.1007/s00220-005-1346-1.

[49] C.-G. Qin, Y.-J. Tan, X.-Y. Lu, T. Liu, Y.-R. Yang, Q. Li, and C.-G. Shao, "Constraints on Violation of Lorentz Symmetry with Clock-Comparison Redshift Experiments," *Physical Review D* **111**, 055008 (2025), arXiv:2503.13564.

[50] D. Lucchesi et al., "Local Lorentz invariance test with the LAGEOS satellites," arXiv:2602.00867 [gr-qc] (2026), doi:10.1103/hj6p-bfyr.

[51] Planck Collaboration, "Planck 2018 Results. VI. Cosmological Parameters," *Astronomy & Astrophysics*, vol. 641, art. A6, 2020; erratum vol. 652, art. C4, 2021. DOI: 10.1051/0004-6361/201833910.

[52] A. Heger, C. L. Fryer, S. E. Woosley, N. Langer, and D. H. Hartmann, "How Massive Single Stars End Their Life," *The Astrophysical Journal*, vol. 591, pp. 288–300, 2003. DOI: 10.1086/375341.

[53] A. Toomre and J. Toomre, "Galactic Bridges and Tails," *The Astrophysical Journal*, vol. 178, pp. 623–666, 1972. DOI: 10.1086/151823.

[54] G. R. Ricker et al., "Transiting Exoplanet Survey Satellite," *Journal of Astronomical Telescopes, Instruments, and Systems*, vol. 1, art. 014003, 2014. https://doi.org/10.1117/1.JATIS.1.1.014003.

[55] E. C. Bellm et al., "The Zwicky Transient Facility: System Overview, Performance, and First Results," *Publications of the Astronomical Society of the Pacific*, vol. 131, art. 018002, 2019. DOI: 10.1088/1538-3873/aaecbe.

[56] M. W. Coughlin et al., "The ZTF Source Classification Project II: Periodicity and Variability Processing Metrics," *Monthly Notices of the Royal Astronomical Society*, vol. 505, pp. 2954–2965, 2021. DOI: 10.1093/mnras/stab1502.

[57] W. J. Chaplin et al., "Ensemble Asteroseismology of Solar-Type Stars with the NASA Kepler Mission," *Science*, vol. 332, no. 6026, pp. 213–216, 2011. DOI: 10.1126/science.1201827.