

Invariant Temporal Ordering Framework V39/F19: Time as the Invariant Universal Succession of Common Stages of Change, Not Relativistic Geometry

Youssry Ghandour
Independent Researcher

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Abstract

V39/F19 defines time as the invariant universal cosmic extension: the objective, fixed, and non-reversed succession of the common stages of physical change of all physical systems in the universe:

$$T_{\text{ITOF}} := \mathcal{E}_C := (\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (1)$$

Time does not cause physical change, and physical change does not produce time. The extension is a non-metric succession, $0 \prec_C 1 \prec_C 2 \prec_C \dots$, whose numerals name stages and do not accumulate; invariance means that it is non-reversed, with no stage empty of change or static. Every admissible representation preserves the order. Every stage is a common stage of the physical systems of the universe, and, by the postulate of change, every physical system of the universe realized there undergoes its own physical change, so that every stage is a stage of change in the sense

$$\text{RealizedChangeStage}_C(s) \iff [s \in \mathcal{S}_C^{\text{tot}}] \wedge \mathcal{S}_{\text{phys}}(s) \neq \emptyset \wedge \forall A \in \mathcal{S}_{\text{phys}}(s) \text{ PhysReal}_A^+(s). \quad (2)$$

A stage is the formal expression of realized change, not a container or a physical state.

Strict Cosmic Ordering makes the earlier–later relation of the stages of the universe a strict total order whose direction no observer, coordinate, clock, physical condition, or description reverses. It implies no equal stage spacing, metric duration, universal rate of change, or identical evolution, and physical recurrence does not reverse the succession.

The Cosmic Moment Axiom (CMA) states the unity of the stages of change for all physical systems of the universe: every one of them realizes its changes on the one common succession, with no private stage or private ordering; hence all physical systems of the universe realized at each stage are objectively co-present there:

$$\text{CMA} \iff \forall A \in \mathcal{U}_{\text{phys}} : \mathcal{W}_A \subseteq \mathcal{S}_C^{\text{tot}} \wedge \triangleleft_A = \prec_C|_{\mathcal{W}_A}. \quad (3)$$

Universal Change Continuity (UCC), the postulate of change, states that physical change continues without interruption in every physical system of the universe, without exception, at every member of its

identity range:

$$\boxed{\text{UCC} \iff \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A : \text{PhysReal}_A^+(s).} \quad (4)$$

CMA and UCC are proved mutually independent by explicit countermodels. Their conjunction is the full content of the cosmic moment: all physical systems of the universe are present at one common stage, and each realizes its own change there. Stage admission and UCC give every stage the form of Eq. (2), and CMA excludes private stages: no stage of the universe is empty, static, or private. A common stage does not imply equal states, changes, rates, causes, locations, clock readings, or histories.

The physical universe is the non-container totality of physical systems and physically realized physical factors. The causes of change are internal contributors, influencing physical systems, and non-system physical factors; time, stage order, CMA, and UCC are not causes. Identity ending need not produce a successor, and absorption into an existing system creates none. Beginning and end of the cosmic succession are not treated alike, because the evidence differs: the succession has a first stage, the stage at which change in the universe begins, with the formation and genesis of the universe, adopted as the Cosmic Origin postulate; it is the first stage of the universe, not a date; non-termination remains a revisable hypothesis, because current evidence establishes neither a terminal stage nor an unbounded future.

Clocks, records, coordinates, proper-time quantities, and metrics are physical or representational constructions, not time. A dimension-admission criterion separates the mathematical consistency of a coordinate or higher dimension from its physical realization. Non-identity of T_{TOF} with relativistic geometric temporal quantities, including global time functions and cosmological time, is derived quantity by quantity. Special- and general-relativistic phenomena are read through a relativistic phenomenon bridge that retains every quantitative result and admits time neither as a model quantity nor as a contributor; the Lorentz transformations are derived as a symmetry of record assignment from physical premises about bearers, with no temporal premise. CMA is not derived from Lorentzian geometry, and any association of stages with spacetime event sets is additional structure requiring independent empirical warrant.

No foundation-specific quantitative residual follows from temporal ontology alone. UCC nevertheless has a defined countercondition, complete physical non-change of any physical system of the universe, approached under a declared currently-complete-isolation criterion that covers ground states; a global phase is not counted as change. Because finite measurement yields bounds rather than certified zeros, evidence on that countercondition accumulates through decreasing bounds: UCC is empirically accountable without being refutable by a single measurement.

Keywords: foundations of physical time; invariant cosmic succession; common stages of change; Cosmic Moment Axiom; Universal Change Continuity; postulate of change; Non-Transfer Principle; relativistic phenomenon bridge; Lorentz transformations; non-identity with geometrized time; physical-system identity; causal realization.

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Authorship and Intellectual Provenance

The Invariant Temporal Ordering Framework was conceived and developed by Youssry Ghandour through independent research. Version status and the relation to earlier versions are stated in Section 1.2.

Computational and artificial-intelligence-assisted tools were used only as supporting instruments for language refinement, document organization, consistency checking, numerical verification, typesetting, and editorial review. The conceptual ideas, theoretical architecture, definitions, original hypotheses, scientific analyses, formal judgments, interpretive positions, innovations, and final scientific and publication decisions in V39/F19 are the work and responsibility of Youssry Ghandour. No computational or artificial-intelligence system is presented as an author, originator of ITOF, independent scientific authority, evidentiary source, or substitute for author responsibility.

1. Governing Foundation of V39/F19

1.1 Foundational scope of V39/F19

V39/F19 fixes three foundational roles that must not be conflated:

$$\begin{aligned} T_{\text{ITOF}} &= \text{the invariant universal succession of the common stages} \\ &\quad \text{of change of the universe,} \\ \text{CMA} &= \text{no physical system has a private stage or ordering,} \\ \text{UCC} &= \text{the postulate of change: uninterrupted change of every} \\ &\quad \text{physical system of the universe.} \end{aligned} \tag{5}$$

The first fixes the meaning of time and of stage semantics (Eq. (11)). CMA states the unity of the stages of change for all physical systems of the universe: every one of them realizes its changes on the one common succession, which yields objective co-presence of all of them realized at each stage. UCC states the uninterrupted change of every physical system of the universe throughout its realized identity range. None of the three is a causal law, and none supplies a dynamical equation. Physical states, physical-change contents, causal sets, records, observables, metrics, dynamics, and application models are not additional members of the ordered pair T_{ITOF} .

1.2 Version status

V39/F19 is the current formulation and supersedes incompatible formulations in earlier versions. V38/F18 is the immediate predecessor; the wider V14–V38 sequence is documented in the consolidated project and archive record [3]. V39/F19 is governed by the definitions, axioms, postulates, principles, constraints, and derived results stated in this version. Earlier formulations have historical status only.

1.3 Statement-status discipline

V39/F19 distinguishes

$$\begin{aligned} &\text{Definition, Axiom, Postulate, Principle,} \\ &\text{DerivedCondition, Proposition, Construction,} \\ &\text{ApplicationPremise, EmpiricalBridge, CommitmentDistinction.} \end{aligned} \tag{6}$$

A defined construction adds no primitive physical commitment. A derived condition is available only from its declared premises. A typed object is not a proposition merely because it occurs in an equation. An application premise does not become a temporal axiom through empirical success. The “argument” environment is reserved for a CommitmentDistinction: a stated comparison between an ITOF commitment already fixed by a governing definition, axiom, or postulate and an independently stated relativistic or mathematical commitment, concluding that the two differ in type, domain of invariance, or constitution criterion. An argument does not itself introduce a new physical, causal, or ontological commitment beyond what its cited premises already fix. In V39/F19, every non-definitional and non-derived ontological, physical, causal, or identity commitment is stated as an axiom or postulate. Constitutive content fixed directly by a governing definition is not an additional axiom or postulate. The “principle” environment is reserved for type, non-transfer, epistemic, or methodological constraints whose status is declared explicitly in the status register; it is not used to conceal an additional ontological postulate.

The symbol $\nVdash$ is reserved for formal non-derivability supported by an explicit model-theoretic or proof-theoretic argument. Ordinary non-sufficiency, non-transfer, observational insufficiency, or lack of automatic implication is written with $\nRightarrow$.

1.4 Abbreviated predicates

Predicates that recur in long formulas are written in abbreviated form. Each abbreviation denotes exactly the predicate named and defined at the cited equation.

Symbol	Predicate	Definition
NTCS _C	Non-terminating cosmic succession	Eq. (17)
GCN _C (s)	Global change-null stage	Eq. (107)
MSV(s)	Mixed change–stasis violation	Eq. (108)
SCB _C (s)	Stage-to-change bridge	Eq. (111)

1.5 Framework and Time

The framework contains physical, identity, causal, observational, and application objects in addition to the temporal ordered pair. Schematically,

$$\mathfrak{F}_{39} = \left\langle T_{\text{ITOF}}, \mathcal{U}_{\text{C}}^{\text{phys}}, \mathcal{U}_{\text{phys}}, \mathfrak{F}_{\text{phys}}, \{\mathfrak{R}_{\text{C}}(s)\}_{s \in \mathcal{S}_{\text{C}}^{\text{tot}}}, \{\mathcal{H}_A\}_{A \in \mathcal{U}_{\text{phys}}}, \mathfrak{A}, \mathfrak{M}_{\text{phys}}, \mathfrak{M}_{\text{op}}, \mathfrak{D} \right\rangle. \quad (7)$$

The type boundary is

$$T_{\text{ITOF}} \nVdash_{\text{def}} \mathfrak{F}_{39}. \quad (8)$$

2. Time and Cosmic Succession

2.1 Governing definition

Definition 2.1 (Time). Time denotes the invariant universal cosmic extension: the objective, fixed, and non-reversed succession of the common stages of physical change of all physical systems in the universe.

Extension. *Extension* means the non-metric succession and following of the common stages of change: each later stage follows every earlier one, and no length, spacing, rate, or duration belongs to the succession. The succession of the stages is stated by the Ordinal Succession postulate (Postulate 2.2).

Invariance. *Invariant* means that the succession is non-reversed and that no stage in it is empty of change or static:

1. *Non-reversed.* An earlier stage remains earlier and a later stage remains later; the order never reverses, and its stages never become interchangeable. Physical recurrence, cyclic evolution, or reversal of a physical variable is a new later change, not a return.
2. *No stage empty of change or static.* Change is realized at every stage. That every physical system realized at a stage changes at it is stronger: it is the content of the postulate of change, UCC (Eq. (83)).

Formally,

$$\begin{aligned} \text{NonMetric}(\mathcal{S}_C^{\text{tot}}, \prec_C) &: \Longleftrightarrow \text{Components}(T_{\text{ITOF}}) = \{\mathcal{S}_C^{\text{tot}}, \prec_C\}, \\ \text{Invariant}(\mathcal{S}_C^{\text{tot}}, \prec_C) &: \Longleftrightarrow \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \forall s \in \mathcal{S}_C^{\text{tot}} : \mathcal{B}_\Delta(s) \neq \emptyset, \end{aligned} \quad (9)$$

This clause is definitional: the pair is the whole of time, so no distance, duration, or rate function on $\mathcal{S}_C^{\text{tot}}$ is a component of time; such functions belong to models. The physical states of the systems change at every stage, while the succession itself stays fixed: invariance belongs to the succession, not to what it orders. It does not mean that physical states are unchanging, that stages are equally spaced, that change has a universal rate or magnitude, or that different systems evolve identically or share one history.

The governing commitments secure invariance:

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \text{Invariant}(\mathcal{S}_C^{\text{tot}}, \prec_C), \quad (10)$$

since temporal admissibility supplies the strict total order, and the theorem of stages of change (Eq. (104)) makes the change population of every stage equal to its nonempty system population.

Because the order is invariant, every admissible representation (observer, coordinate, frame, clock output, synchronization convention, record, or description) must preserve it (Eq. (30)); preservation represents the invariance and does not constitute it. This is not invariance in the sense of Lorentz invariance or general covariance, and the two senses must not be confused.

That this one succession is common to every physical system of the universe, with no system-private stage or ordering, is the content of the Cosmic Moment Axiom (Eq. (73)); that every physical system of the universe changes at every stage of its existence is the content of the postulate of change, UCC (Eq. (83)). Each system retains its own physical state, change, causal conditions, and physical history.

The formal definition is

$$\boxed{T_{\text{ITOF}} := \mathcal{C}_C := (\mathcal{S}_C^{\text{tot}}, \prec_C)}. \quad (11)$$

Here $\mathcal{S}_C^{\text{tot}}$ is the one universal formal domain of the cosmic stages of the universe and $\prec_C$ is its designated objective earlier–later relation.

Illustration: a human life. A human being is a physical system. Throughout life it changes without stopping, from childhood to youth to old age. This is the extension of the stages of change across that life, and it is what time expresses, not the ticks of a clock, which are mistakenly taken to express time. The ticks are the changes of another physical system, the clock, counted.

Equation (11) is a formal definition and adds no object to physical reality; physical systems, states, change contents, and causal structures remain independently typed. Each identity range I_A lies in $\mathcal{S}_C^{\text{tot}}$ (Eq. (63)); that each system’s own realization succession coincides with its range in $\mathcal{S}_C^{\text{tot}}$ is fixed by CMA, not by

this definition.

Time is not matter, energy, mass, force, field, radiation, signal, physical substance, medium, container, physical system, causal source, interaction, dynamical mechanism, physical state, or physical-change content. It is not a clock, clock reading or rate, coordinate, coordinate time, proper-time functional, metric or spacetime interval, reference frame, synchronization or simultaneity convention, foliation, trajectory parameter, frequency standard, record, detector output, numerical duration, or measurement scale. Such quantities may describe, model, or measure physical processes; they do not constitute time in ITOF.

Time does not cause physical change, and physical change is not treated as a physical cause that produces time. Physical dynamics and causes are supplied by independently warranted physics. Stage admission requires every stage to be a common stage of the physical systems of the universe; change of every physical system realized at every stage is stated by UCC; objective co-presence of all of them at that one stage is stated by CMA. The definition of time does not require an infinite future; cosmic non-termination is a revisable cosmological hypothesis.

Postulate 2.2 (Ordinal Succession of the Stages of Change).

$$\boxed{0 \prec_C 1 \prec_C 2 \prec_C 3 \prec_C 4 \prec_C \cdots \infty \text{ (conditional)}} \quad (12)$$

1. Stage 0 is the first stage of change: the stage at which change begins, with the genesis of the universe. The postulate does not fix when that genesis began.
2. The numerals 1, 2, 3, 4 name the stages that follow stage 0, in order. They express only the fixed succession and following of the stages of change: they are ordinal names, not quantities, and they are not added.
3. The stages follow one another, and no stage between any two of them is empty of change or static.
4. The symbol ∞ is not a stage: it marks that the succession has no last stage, and it is conditional, because current science does not establish whether the succession ends.

Stage 0 is a stage of change like every other, so the zero excludes reading the numerals as accumulated amounts: 2 is after 1 and before 3, neither twice 1 nor a duration later. Stage 0 is the first stage of the universe, not a date: no clock reading, coordinate time, or cosmological age is assigned to it, which agrees with relativity, whose time coordinates label events in charts and are not stages. Every later stage holds a fixed place after stage 0 that no later change alters; the postulate thus also expresses the invariance of the stages. The postulate neither asserts nor denies that a stage has an immediate successor. Its first-stage clause is stated formally by the Cosmic Origin postulate (Eq. (41)), and its conditional ∞ by the non-termination hypothesis (Eq. (17)). Any relabelling that preserves the order represents the same succession, and numerical values and their differences carry no physical content.

2.2 Spatial coordinates and temporal type separation

In ITOF, place or spatial location belongs to the geometric description of a physical system; it is not part of the ontological type of time. In a declared spatial or spacetime model with chart or frame F , the location of a qualified physical system A may be represented by a spatial coordinate tuple

$$\mathbf{x}_A^{(F)} = (x_A^{1(F)}, x_A^{2(F)}, x_A^{3(F)}), \quad (13)$$

with the dimension adapted to the declared geometry when necessary. When an application associates a system state with an admitted cosmic stage, the notation $\mathbf{x}_A^{(F)}[s]$ denotes the geometric position assigned to

that system state in F ; the bracketed s indexes the ITOF stage claim and is not itself a spatial coordinate. Spatial coordinates may change under a change of chart or frame without changing the type or identity of T_{ITOF} . Likewise, a coordinate- time label t_F belongs to the geometric or model representation and is not the temporal referent defined by ITOF. The type separation is

$$\mathbf{x}_A^{(F)}[s] \not\equiv_{\text{type}} s, \quad t_F \not\equiv_{\text{type}} s, \quad t_F \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (14)$$

Thus a common cosmic stage does not mean a common spatial position, and temporal co-presence must not be reconstructed as equality of spatial coordinates.

2.3 Cosmic Stage Definition

Definition 2.3 (Cosmic stage). An admitted cosmic stage is a member $s \in \mathcal{S}_C^{\text{tot}}$ that serves as the formal stage expression of objectively realized physical change and of its position in the one common objective earlier-later succession. The stage is common as a temporal member, not as physical content: every qualified system whose realized identity range contains s is incident with that same member of the single formal domain of cosmic stages, while its state, change, causes, and history remain system-specific. Objective collective co-presence of all physical systems of the universe realized at s is the content of CMA, and their change at s is the content of UCC.

A cosmic stage is not a container, receptacle, physical system, physical state, change content, change packet, causal source, clock moment, clock reading, coordinate, metric interval, duration, private system time, or additional ontic ordering-position entity. The written symbol s , the member of the formal cosmic-stage domain that it designates, and the physical changes formally expressed at that member are type-distinct. Observation is not constitutive of stagehood.

A member of $\mathcal{S}_C^{\text{tot}}$ is admitted as a common stage of the physical systems of the universe:

$$\boxed{\text{CommonStage}_C(s) \iff [s \in \mathcal{S}_C^{\text{tot}}] \wedge \mathcal{S}_{\text{phys}}(s) \neq \emptyset.} \quad (15)$$

A stage of physical change of all physical systems of the universe realized there is

$$\boxed{\text{RealizedChangeStage}_C(s) \iff \text{CommonStage}_C(s) \wedge \forall A \in \mathcal{S}_{\text{phys}}(s) \text{ PhysReal}_A^+(s).} \quad (16)$$

Temporal admissibility requires $\text{CommonStage}_C(s)$ for every member; the postulate of change, UCC, makes every member a stage of change of all physical systems realized there (Eq. (104)). Physical factors contribute to, constrain, or mediate the change of the systems; the stage is defined by the physical systems realized at it, and the factors acting there are causes of their change, not members of the stage population. This typing rule does not diminish the physical reality or causal relevance of factors. CMA supplies objective co-presence of all physical systems of the universe realized at the stage. Stage membership and temporal order do not cause the physical change they formally express. In a concrete application, scientific attribution of $\text{PhysReal}_A^+(s)$ requires applicable independently warranted physics, a declared system boundary and granularity, and an admissible evidential or modeling basis. These conditions govern attribution; they do not constitute the stage or create the physical change.

2.4 One common stage domain

The formal architecture uses one formal domain of cosmic stages $\mathcal{S}_C^{\text{tot}}$; each identity range satisfies $I_A \subseteq \mathcal{S}_C^{\text{tot}}$ by Eq. (63). A representation in which a system realizes its changes on an independent stage

succession, later synchronized or identified with another, is excluded by CMA (Eq. (73)), not by the definition of $\mathcal{S}_C^{\text{tot}}$ alone.

The dependence of stagehood on the physical systems of the universe and on their change is constitutive, not causal. Physical change does not produce, generate, or cause time, and time does not produce, generate, or cause physical change. A member of the formal cosmic-stage domain is a common stage of the physical systems of the universe, and under the postulate of change it formally expresses the change of every one of them realized there; physical dynamics and causal production remain supplied independently by applicable physics.

2.5 Common cosmic change stage

In the full V39/F19 theory, a common cosmic change stage combines a common stage of the physical systems of the universe in the universal formal cosmic-stage domain, CMA common-stage co-presence, and UCC system-specific physical-change actuality for every physical system of the universe realized there. The phrase adds no further entity, causal mechanism, or temporal layer.

2.6 Cosmic extent and conditional non-termination

ITOF does not build an unlimited future into the definition of time. The following order-theoretic condition, non-terminating cosmic succession, is retained for cosmological models in which unrestricted continuation is independently adopted or established:

$$\boxed{\text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \iff \forall s \in \mathcal{S}_C^{\text{tot}} \exists t \in \mathcal{S}_C^{\text{tot}} (s \prec_C t).} \quad (17)$$

It states exactly that the represented succession has no greatest member. It contains no physical-change magnitude, dynamics, metric, or prediction about a particular system. Its status as a revisable hypothesis is stated in Section 3.4.

Equation (17) is non-metric. It does not assert density, adjacency, topological continuity, differentiability, equal spacing, scalar duration, or infinitesimal stage interval:

$$\begin{aligned} \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{DenseOrder}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{Adjacency}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{TopologicalContinuity}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{Differentiability}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{EqualSpacing}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) &\not\Rightarrow \text{MetricDuration}. \end{aligned} \quad (18)$$

A terminal stage of a particular system identity is not thereby a terminal cosmic stage. If A ends at e_A , e_A is the final member of I_A under the applicable identity criterion. Whether that same stage is also a greatest member of the complete cosmic succession is a distinct cosmological question:

$$\begin{aligned} \text{End}_A(e_A) &\not\Rightarrow \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \\ \text{End}_A(e_A) &\not\Rightarrow \neg \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C). \end{aligned} \quad (19)$$

Where other qualified identities persist or new qualified identities are physically formed, their later

realizations remain members of the same cosmic succession; no new time or restarted temporal order is introduced.

Non-termination is also not UCC:

$$\text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\equiv_{\text{def}} \text{UCC}. \quad (20)$$

UCC states change throughout realized identity ranges; it does not predict that the universe possesses an unlimited future. If non-termination is additionally adopted, then the conditional extended realization satisfies

$$\begin{aligned} & \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \\ & \quad \wedge \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \implies \forall s \in \mathcal{S}_C^{\text{tot}} : [\exists t \in \mathcal{S}_C^{\text{tot}} (s \prec_C t) \wedge \mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) \neq \emptyset]. \end{aligned} \quad (21)$$

This is a conditional statement about an unlimited cosmological extension, not a hidden assertion that current physics has established one.

2.7 Constitutive temporal admissibility

Define

$$\begin{aligned} & \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \iff [\mathcal{S}_C^{\text{tot}} \neq \emptyset] \wedge \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \quad \wedge \forall s \in \mathcal{S}_C^{\text{tot}} \text{ CommonStage}_C(s) \\ & \quad \wedge \exists r \in \mathcal{S}_C^{\text{tot}} \exists t \in \mathcal{S}_C^{\text{tot}} (r \prec_C t). \end{aligned} \quad (22)$$

This definition fixes a nonempty strictly ordered domain of common stages of the physical systems of the universe and requires a nontrivial earlier–later pair, so the admitted totality represents a genuine succession rather than a succession-free singleton. The final conjunct is only a non-degeneracy condition: it neither assumes nor entails that every stage has a later member. The predicate is denoted $\mathfrak{T}_C$, read “temporal admissibility,” in every subsequent equation, to keep long formulas legible; $\mathfrak{T}_C$ and $\text{TemporalExtensionAdmissible}_C$ name the same predicate, and the descriptive name is retained in the symbol register (Table 4). It therefore does not settle whether the complete succession has a greatest member, specify a metric, supply system dynamics, establish CMA, or establish UCC. Temporal admissibility, CMA, and UCC retain distinct logical roles.

2.8 Designated Temporal Orientation

The notation $r \prec_C s$ has a fixed semantic role in ITOF:

$$r \prec_C s \quad \text{denotes that } r \text{ is objectively earlier than } s \text{ in the one cosmic succession.} \quad (23)$$

This designation is part of the governing meaning of the theory. Strict Cosmic Ordering does not choose one orientation from two mathematically symmetric orders; it imposes the strict-total-order properties on the relation already designated as earlier–later.

Axiom 2.4 (Strict Cosmic Ordering). The relation $\prec_C$ is the designated objective earlier–later relation on the one formal domain of the cosmic stages of the universe. Its orientation is fixed and non-reversed: if $r \prec_C s$, no observer, coordinate, clock, physical condition, signal record, or convention makes s earlier

than r . Strict Cosmic Ordering requires

$$\boxed{\text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C)}. \quad (24)$$

The axiom constrains order only. It does not supply stage spacing, duration, density, differentiability, a temporal rate, or physical dynamics.

For distinct $r, s \in \mathcal{S}_C^{\text{tot}}$, exactly one order direction holds:

$$r \neq s \implies [(r \prec_C s) \vee (s \prec_C r)] \wedge \neg [(r \prec_C s) \wedge (s \prec_C r)]. \quad (25)$$

In particular,

$$r \prec_C s \implies \neg(s \prec_C r). \quad (26)$$

The inverse relation is mathematically definable by

$$s \prec_C^{-1} r \iff r \prec_C s, \quad (27)$$

but mathematical definability does not make the inverse a second governing orientation:

$$\text{MathematicallyDefined}(\prec_C^{-1}) \not\Rightarrow \text{GoverningTemporalOrder}_{\text{ITOF}}(\prec_C^{-1}). \quad (28)$$

Nor does strict total ordering alone perform the semantic designation:

$$\text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\Rightarrow \text{SemanticSelectionOfEarlierLaterOrientation}. \quad (29)$$

2.9 Fixedness across admissible representations

The word *fixed* does not mean physical stasis. It means that the same designated objective earlier–later relation governs every admissible temporal representation. For any representation $\rho : \mathcal{S}_C^{\text{tot}} \rightarrow R$ equipped with a represented order $\prec_\rho$, admissibility requires

$$\begin{aligned} &\text{AdmissibleTemporalRepresentation}_{\text{ITOF}}(\rho, \prec_\rho) \\ &\implies \forall r, s \in \mathcal{S}_C^{\text{tot}}, \quad [r \prec_C s \iff \rho(r) \prec_\rho \rho(s)]. \end{aligned} \quad (30)$$

Labels, coordinates, or parameterizations may change; the governing objective orientation does not.

2.10 Physical recurrence does not reverse cosmic order

A system may later realize a state equal or equivalent, under a declared criterion K_A , to a state it realized earlier. If

$$r \prec_C t \wedge K_A(X_A(r), X_A(t)) = \text{Equivalent}, \quad (31)$$

then the later occurrence remains later:

$$r \prec_C t \wedge K_A(X_A(r), X_A(t)) = \text{Equivalent} \implies r \neq t \wedge r \prec_C t \wedge \neg(t \prec_C r). \quad (32)$$

Accordingly,

$$\text{PhysicalStateRecurrence} \not\Rightarrow \text{TemporalReturn}. \quad (33)$$

A repeated physical condition is a distinct later realization in the same objective succession. It does not alter the already designated order relation between the earlier and later cosmic-stage expressions.

2.11 Universal Cosmic Extension

The word *extension* means the non-metric succession and following of the common stages of change; it does not denote spatial extension, metric duration, or a medium through which systems or changes move:

$$\begin{aligned}
\mathcal{E}_C \not\equiv_{\text{type}} \text{SpatialLength}, & \quad \mathcal{E}_C \not\equiv_{\text{type}} \text{MetricDuration}, \\
\mathcal{E}_C \not\equiv_{\text{type}} \text{CoordinateInterval}, & \quad \mathcal{E}_C \not\equiv_{\text{type}} \text{ProperTimeFunctional}, \\
\mathcal{E}_C \not\equiv_{\text{type}} \text{PhysicalField}, & \quad \mathcal{E}_C \not\equiv_{\text{type}} \text{PhysicalMedium}, \\
\mathcal{E}_C \not\equiv_{\text{type}} \text{PhysicalContainer}, & \quad \mathcal{E}_C \not\equiv_{\text{type}} \text{CausalAgent}, \\
\mathcal{E}_C \not\equiv_{\text{type}} \text{ClockOutput}. &
\end{aligned} \tag{34}$$

The stage symbols do not move through a temporal receptacle, and the temporal extension does not move from stage to stage:

$$\neg \text{Moves}(T_{\text{ITOF}}), \quad \neg \text{Moves}(\mathcal{E}_C), \quad \forall s \in \mathcal{S}_C^{\text{tot}} \neg \text{StageMovesThroughTime}(s). \tag{35}$$

Earlier and later are ordering relations, not locations through which time or a packet of change travels.

2.12 Temporal and Physical Type Separation

An admitted stage member is a formal expression of realized physical change within the one universal objective earlier–later succession. The ordered-pair signature $(\mathcal{S}_C^{\text{tot}}, \prec_C)$ does not contain physical systems, state vectors, change-content values, or physical laws as additional components. In the governing theory every member is nevertheless a stage of change of all physical systems of the universe realized there:

$$\mathfrak{I}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies (s \in \mathcal{S}_C^{\text{tot}} \implies \text{RealizedChangeStage}_C(s)). \tag{36}$$

The ordered pair does not itself carry this content; it is supplied by the postulate of change, UCC, and the commonness of the stage is supplied by CMA. This type separation does not make a stage an empty temporal placeholder; it assigns each part of the content of a stage to the commitment that states it.

2.13 Order representations and non-metricity

Let $(L, <_L)$ be an ordered representation domain and let

$$\iota : \mathcal{S}_C^{\text{tot}} \longrightarrow L \tag{37}$$

be injective. It is an admissible order representation only if

$$\text{OrderRepresentation}(\iota) \iff \forall r, s \in \mathcal{S}_C^{\text{tot}}, \quad r \prec_C s \iff \iota(r) <_L \iota(s). \tag{38}$$

If f is strictly increasing, $f \circ \iota$ preserves the same governing order. A numerical interval may change under such a reparameterization, so order preservation does not produce a canonical duration:

$$\text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\Rightarrow \text{CanonicalMetricIntervalOn}(\mathcal{S}_C^{\text{tot}}). \tag{39}$$

A metric, duration scale, clock scale, or numerical stage parameter requires additional physical or mathematical structure.

3. Conditional Cosmic Non-Termination

3.1 Identity ending and cosmic extent are distinct

Equation (17) defines a conditional order-theoretic property of the complete cosmic succession. It is not a foundation-level assertion that current science has established an unlimited future. Formation, persistence, ending, and successor production concern identity ranges within the one cosmic order. The terminal stage e_A of a particular identity A is therefore only the greatest member of I_A when that identity ends; it is not thereby the greatest member of $\mathcal{S}_C^{\text{tot}}$. If other identities persist or genuinely new identities form, their realizations continue in the same cosmic order.

Conversely, V39/F19 does not infer from present or ongoing physical change that $\mathcal{S}_C^{\text{tot}}$ must have no greatest member over the unknown complete future. The future extent of cosmic physical change remains a cosmological question. Where an application independently adopts non-termination (Eq. (17)), all consequences of that assumption are explicitly conditional on it.

No unconditional infinity claim follows from temporal admissibility, governing CMA, or the UCC continuity condition. In particular,

$$\begin{aligned} \mathcal{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\Rightarrow \text{Infinite}(\mathcal{S}_C^{\text{tot}}), \\ \text{CMA} \not\Rightarrow \text{Infinite}(\mathcal{S}_C^{\text{tot}}), \quad \text{UCC} \not\Rightarrow \text{Infinite}(\mathcal{S}_C^{\text{tot}}). \end{aligned} \tag{40}$$

Infinite-cardinality conclusions arise only from their explicitly declared premises. In particular, temporal admissibility supplies a nonempty strict total order, while conditional cosmic non-termination supplies the no-greatest-member premise; together these imply infinitude of the stage domain. The symbol ∞ , where used in a cardinality statement below, denotes only that the relevant set is not finite; it does not select a particular infinite cardinal, entail countability, or denote a metric, duration, magnitude, or physically measured future extent.

3.2 Cosmic origin

The cosmic succession has a first stage: the stage at which change in the universe begins, with the formation and genesis of the universe. ITOF adopts this as the additional Cosmic Origin postulate, in agreement with the evidence of cosmic expansion, the cosmic microwave background, and the abundances of the light elements, which shows that the observable universe developed from an early hot and dense state.

Postulate 3.1 (Cosmic Origin).

$$\boxed{\text{CosmicOrigin} \iff \exists! s_C^0 \in \mathcal{S}_C^{\text{tot}} \forall s \in \mathcal{S}_C^{\text{tot}} \setminus \{s_C^0\}, \quad s_C^0 \prec_C s.} \tag{41}$$

It is the first-stage clause of the Ordinal Succession postulate (Postulate 2.2). The first stage s_C^0 is a stage of change like every other: physical systems are realized there and change there. It is the stage at which change in the universe begins, with the formation and genesis of the universe. Here *formation* refers to the universe as a whole, not to the formation boundary of a system's identity range. The early hot and dense state from which the observable universe developed is the empirical anchor of the postulate. It is not the

singularity of a cosmological model, which marks where the model's equations cease to apply and is not a stage at which systems change. The age assigned to the universe is a value of cosmological time, a metric quantity of a model (Proposition 43.4); it measures records against a model and does not date s_C^0 . The contrary of Cosmic Origin is established physical evidence of physical systems realized at a stage earlier than s_C^0 .

Beginning and end are not treated alike.

They are treated differently because the evidence differs. The origin is supported by observation and is adopted as a postulate. The end is neither supported nor excluded: current evidence establishes neither a terminal stage nor an unbounded future, so non-termination remains a revisable hypothesis (Eq. (17)). Neither commitment is part of the definition of time, and neither follows from CMA or UCC.

The two commitments are logically independent:

$$\text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\Rightarrow \text{CosmicOrigin}, \quad \text{CosmicOrigin} \not\Rightarrow \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (42)$$

Temporal admissibility requires a nontrivial earlier–later pair, and the first stage precedes every other stage; hence the succession extends beyond the origin without any further postulate:

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{CosmicOrigin} \implies \exists s \in \mathcal{S}_C^{\text{tot}} (s_C^0 \prec_C s). \quad (43)$$

How far it extends is not settled by this; that every stage has a later one is the separate, revisable hypothesis of non-termination.

3.3 Reference-stage order prefix

For any admitted reference stage $a \in \mathcal{S}_C^{\text{tot}}$, define

$$\mathcal{S}_C^{\leq a} := \{v \in \mathcal{S}_C^{\text{tot}} \mid v = a \vee v \prec_C a\}. \quad (44)$$

This is a derived order prefix, not a second temporal domain, generated frontier, moving present, or presentism axiom.

3.4 Evidential justification of the conditional status

Current physical evidence establishes neither a global terminal stage nor an unbounded future succession of admitted stages. Non-termination is therefore a revisable cosmological hypothesis conditional on that evidence. It is not part of the definition of time and is not a theorem of CMA or UCC; every proposition that uses it states it as a premise.

4. Cosmic Physical Totality and CMA

4.1 Physical Systems, Physical Factors, and Physical Totality

Physical-system status is objective. V39/F19 uses $\text{PhysicalSystem}(A)$ for the ontic claim that A is a physically realized system with its own physical constitution, system-level properties, and physically

distinguishable identity:

$$\boxed{\begin{aligned} \text{PhysicalSystem}(A) \implies & \text{PhysicallyRealized}(A) \wedge \text{PhysicalConstitution}(A) \\ & \wedge \text{SystemSpecificPhysicalProperties}(A) \\ & \wedge \text{PhysicallyDistinguishableIdentity}(A). \end{aligned}} \quad (45)$$

A scientifically warranted qualification scheme Ω does not create physical-system status. It fixes the class, boundary, granularity, and numerical- identity criteria used to identify, track, or test particular systems in a specified application. Write $\text{PhysicalSystem}_\Omega(A)$ only for the application-level claim that the objectively physical system A is admissibly qualified under Ω :

$$\text{PhysicalSystem}_\Omega(A) \implies \text{PhysicalSystem}(A). \quad (46)$$

Different physically meaningful subsystem and composite levels may support qualified identities, but arbitrary description, spatial grouping, or analytical convenience neither creates a physical system nor creates a cosmic stage.

Within V39/F19, *physical factor* is one framework category spanning physically different factor families. Each factor retains the domain-specific physical classification and mechanism assigned by the applicable physics; the factor families are listed in Section 8. A physical factor is the ITOF category for a physically realized non-system physical item that can enter a warranted physical description as a condition, field, process, interaction, transfer, boundary, physically realized medium condition or structure, or other non-system physical determinant.

$$\boxed{\text{PhysicalFactor}(F) \implies \text{PhysicallyRealized}(F) \wedge \neg \text{PhysicalSystem}(F).} \quad (47)$$

The condition $\neg \text{PhysicalSystem}(F)$ is an ontological type boundary within ITOF, not a claim about causal importance. A physical system that influences another system remains a physical system and is typed by $\text{InfluencingPhysicalSystem}$, not reclassified as a factor. Application boundary and granularity determine which system identity is being tracked and which external contributors are relevant; they do not convert a physical-system identity into a physical factor or a physical factor into a physical-system identity. Detailed causal families, internal contributors, external influencing systems, and qualitative causal composition are centralized in Section 8; the present section fixes ontology and typing only.

For a declared physical system A at s , $\text{InfluencingPhysicalFactor}(F; A, s)$ means that F is outside the declared boundary of A and its actual physical influence contributes to the physical change realized in A at s . In a concrete application, scientific attribution of that influence must be warranted by the applicable physics for the declared system boundary and granularity. Thus

$$\begin{aligned} & \text{InfluencingPhysicalFactor}(F; A, s) \\ \implies & \text{PhysicalFactor}(F) \wedge \text{PhysicalSystem}(A) \wedge \text{ExistsAs}(A, s) \wedge \text{FactorRealizedAt}(F, s). \end{aligned} \quad (48)$$

Here $\text{FactorRealizedAt}(F, s)$ records stage-relative physical realization of the factor. It does not by itself assert that the factor influences a declared system or acts as a causal contributor. The full $\text{InfluencingPhysicalFactor}(F; A, s)$ relation supplies that additional causal role where independently warranted.

Define the physically realized physical-factor totality by

$$\boxed{\mathfrak{F}_{\text{phys}} := \{F \mid \text{PhysicalFactor}(F)\}}. \quad (49)$$

PhysicalFactor is a typed classification, within the framework, of physically realized non-system contributors; it does not assert that its members form a single natural kind. The stage-relative factor-realization relation is typed by

$$\text{FactorRealizedAt} \subseteq \mathfrak{F}_{\text{phys}} \times \mathcal{S}_{\text{C}}^{\text{tot}}. \quad (50)$$

Every physical factor admitted to the physically realized factor totality must have stage support in the common formal cosmic-stage domain:

$$\forall F \in \mathfrak{F}_{\text{phys}} \exists s \in \mathcal{S}_{\text{C}}^{\text{tot}} : \text{FactorRealizedAt}(F, s). \quad (51)$$

This stage-support requirement aligns global factor membership with stage-relative physical realization. It assigns neither numerical physical-system identity nor an identity range or private cosmic-stage succession to a physical factor.

Definition 4.1 (Stage-relative physical-factor population). For each admitted cosmic stage $s \in \mathcal{S}_{\text{C}}^{\text{tot}}$, define

$$\boxed{\mathfrak{F}_{\text{phys}}(s) := \{F \in \mathfrak{F}_{\text{phys}} \mid \text{FactorRealizedAt}(F, s)\}}. \quad (52)$$

Membership records physical-factor realization at s ; it does not by itself assert causal influence on any declared physical system.

Within the physical vocabulary used by V39/F19, every physically realized item admitted into the framework's system-factor classification is typed explicitly as either a physical-system identity or a physical factor. This is a framework typing rule, not a claim that present physics has exhausted every possible ontological category:

$$\text{ITOFPhysicallyTyped}(x) \implies [x \in \mathcal{U}_{\text{phys}} \vee x \in \mathfrak{F}_{\text{phys}}]. \quad (53)$$

The rule supplies no causal mechanism and does not erase domain-specific physical classifications. Define, in addition, the domain of factors that actually influence at least one realized system-stage pair by

$$\mathfrak{F}_{\text{phys}}^{\text{inf}} := \{F \in \mathfrak{F}_{\text{phys}} \mid \exists A \exists s \in \mathcal{S}_{\text{C}}^{\text{tot}} \text{ InfluencingPhysicalFactor}(F; A, s)\}. \quad (54)$$

Membership in $\mathfrak{F}_{\text{phys}}$ states physical realization as a factor; membership in $\mathfrak{F}_{\text{phys}}^{\text{inf}}$ additionally states actual influence on at least one realized system-stage pair.

An *influencing physical system* B is a distinct physical system outside the declared boundary of A whose actual physical influence contributes to the physical change realized in A at s . It remains a physical system with its own identity range and physical history:

$$\begin{aligned} \text{InfluencingPhysicalSystem}(B; A, s) \implies \\ B \in \mathcal{U}_{\text{phys}} \wedge A \in \mathcal{U}_{\text{phys}} \wedge B \neq A \wedge s \in I_B \wedge s \in I_A. \end{aligned} \quad (55)$$

Thus a stage-relative influence claim presupposes identity-stage realization of both the influencing system and the influenced system at that same admitted stage. Influencing physical factors and influencing

physical systems are therefore two physically distinct source types of external physical influence. Their common causal role is influence on A ; that role does not change the physical type of the source.

Simple and composite systems are both admitted. Qualification of a simple system does not require a constituent decomposition. For a composite system, qualification at the composite level requires physically warranted interconnection and coherence among its constituent organization:

$$\begin{aligned} \text{CompositePhysicalSystem}_{\Omega}(B) \implies \exists \mathcal{C}_B \Big[& \text{ConstituentOrganization}(\mathcal{C}_B, B) \\ & \wedge \text{PhysicalInterconnection}_{\Omega}(\mathcal{C}_B; B) \\ & \wedge \text{PhysicalCoherence}_{\Omega}(\mathcal{C}_B; B) \Big]. \end{aligned} \quad (56)$$

Interconnection is not mere proximity, and coherence is not mere co-location or set membership. The physically appropriate criterion may be structural, dynamical, organizational, or otherwise domain-specific; it need not assign a teleological function to the system.

Define the governing physical-system totality independently of any application scheme:

$$\boxed{\mathcal{U}_{\text{phys}} := \{A \mid \text{PhysicalSystem}(A) \wedge \exists s \in \mathcal{S}_{\text{C}}^{\text{tot}} \text{ExistsAs}(A, s)\}.} \quad (57)$$

V39/F19 does not define a closed, privileged catalogue of physical factors. The detailed cross-domain taxonomy of external physical factors, external influencing physical systems, internal physical contributors, descriptor-to-source discipline, and their qualitative causal composition is given in Section 8. The present ontology section therefore does not repeat that catalogue. It fixes only the system–factor type boundary and the rule that the same physical contribution is not counted twice under different causal roles.

V39/F19 uses $\mathcal{U}_{\text{C}}^{\text{phys}}$ for the physical universe understood as the physical totality itself rather than as an independent receptacle containing physical entities. Its constitutive notation is

$$\boxed{\mathcal{U}_{\text{C}}^{\text{phys}} := \mathcal{U}_{\text{phys}} \sqcup_{\text{ont}} \mathfrak{F}_{\text{phys}}.} \quad (58)$$

Here $\sqcup_{\text{ont}}$ denotes a typed ontological totality: it does not mean arithmetic addition, spatial union, or placement of systems and factors inside a further physical container. The physical universe is therefore the total physical actuality constituted by qualified physical-system identities together with physically realized physical factors. The word *universe* adds no third receptacle around those constituents. The totality does not acquire one numerical system identity, one causal agency, or one physical history replacing the many histories of its constituent systems. Influencing physical systems retain systemhood; physical factors retain factor typing; and neither causal role converts one type into the other. Time is not an additional constituent of this totality and the common cosmic stage is not a container in which the totality is placed. Accordingly,

$$\mathcal{U}_{\text{C}}^{\text{phys}} \not\equiv_{\text{type}} \text{PhysicalContainer}, \quad \mathcal{U}_{\text{C}}^{\text{phys}} \not\equiv_{\text{type}} \text{PhysicalSystemIdentity}. \quad (59)$$

Because $\mathcal{U}_{\text{phys}}$ is a domain of numerical physical-system identities, the second type boundary gives

$$\mathcal{U}_{\text{C}}^{\text{phys}} \notin \mathcal{U}_{\text{phys}}. \quad (60)$$

This does not deny that physical systems can causally affect one another or that physical factors can contribute to system change. It only prevents the physical totality itself from being silently retyped as one

system identity or as a causal container. CMA continues to quantify over physical-system identities and their common cosmic stages; inclusion of physical factors in the cosmic physical totality does not give those factors system identities or private identity ranges.

For an application that fixes a physically warranted qualification scheme Ω , define the application-selected subdomain

$$\mathcal{U}_{\text{phys}}^{[\Omega]} := \{A \in \mathcal{U}_{\text{phys}} \mid \text{PhysicalSystem}_{\Omega}(A)\}. \quad (61)$$

Thus Ω controls warranted identification and counting in a declared application; it does not determine whether the underlying physical system or the cosmic stage exists. In foundational statements, “qualified physical system” means an objectively admitted member of $\mathcal{U}_{\text{phys}}$, that is, a physical system of the universe; the qualifier records that its identity is objectively realized and does not select a subset of the physical systems of the universe; the indexed notation $\text{PhysicalSystem}_{\Omega}$ is reserved for application-level class, boundary, granularity, and attribution criteria. The framework does not require one unique decomposition of all physical reality for every scientific purpose.

Each $A \in \mathcal{U}_{\text{phys}}$ realizes its physical changes on its own realization succession

$$(\mathcal{W}_A, \triangleleft_A), \quad (62)$$

where $\mathcal{W}_A$ is the nonempty set of positions, in a carrier $P \supseteq S_C$ of realization positions, at which the numerical identity A is realized and $\triangleleft_A$ is the earlier–later order of those positions within the history of A . $\text{ExistsAs}(A, x)$ holds exactly when $x \in \mathcal{W}_A$. The realized numerical-identity range of A in the common domain is

$$I_A := \{s \in \mathcal{S}_C^{\text{tot}} \mid \text{ExistsAs}(A, s)\} = \mathcal{W}_A \cap \mathcal{S}_C^{\text{tot}}. \quad (63)$$

Under CMA, $\mathcal{W}_A = I_A$ and $\triangleleft_A = \prec_C|_{I_A}$; hence $I_A \neq \emptyset$, and I_A is a segment of the one cosmic succession, not a private time. Every governing result below that uses $I_A \neq \emptyset$ or orders the members of I_A by $\prec_C$ holds under CMA.

At stage s , define the complete then-realized qualified population

$$\mathcal{S}_{\text{phys}}(s) := \{A \in \mathcal{U}_{\text{phys}} \mid s \in I_A\}. \quad (64)$$

Definition 4.2 (Stage-relative cosmic physical totality). For each admitted cosmic stage $s \in \mathcal{S}_C^{\text{tot}}$, define

$$\mathfrak{L}_C^{\text{phys}}(s) := \mathcal{S}_{\text{phys}}(s) \sqcup_{\text{ont}} \mathfrak{F}_{\text{phys}}(s). \quad (65)$$

The typed union records the physical-system identities and non-system physical factors realized at s . It is not a container, does not make a factor a system, and does not enlarge CMA from physical-system co-presence into a claim that factors possess system identity ranges.

Membership in $\mathcal{S}_{\text{phys}}(s)$ is objective numerical-identity realization in the governing ontic physical-system domain, not observer knowledge, application-level classification, or successful detection:

$$\mathcal{S}_{\text{phys}}(s) \neq \text{SystemsKnownToObserverAt}(s), \quad (66)$$

$$A \in \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{Detected}(A; s). \quad (67)$$

4.2 Derived Cosmic Change-Stage Population Principle

Retain the historical acronym CSPP for the stage-population condition

$$\boxed{\text{CSPP} \iff \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \mathcal{S}_{\text{phys}}(s) \neq \emptyset.} \quad (68)$$

Under the governing stage semantics this is not an independent postulate: by temporal admissibility every member of $\mathcal{S}_C^{\text{tot}}$ is a common stage of the physical systems of the universe (Eq. (15)); hence

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \text{CSPP}. \quad (69)$$

CSPP remains useful as a named population corollary, but it must not be counted as an additional independent foundation-level burden.

4.3 Identity Incidence and Objective Common-Stage Co-Presence

$\text{ExistsAs}(A, s)$ records numerical identity–stage incidence:

$$A \in \mathcal{S}_{\text{phys}}(s) \iff A \in \mathcal{U}_{\text{phys}} \wedge \text{ExistsAs}(A, s). \quad (70)$$

Incidence states only that s belongs to the realization succession of A . It does not state that this succession is the common succession itself rather than a private succession sharing some members with it. Objective common-stage co-presence is that further condition. For $P \subseteq \mathcal{U}_{\text{phys}}$ and $s \in \mathcal{S}_C^{\text{tot}}$,

$$\boxed{\text{CosmicCoPresence}_C(P; s) : \iff \forall A \in P \left[s \in \mathcal{W}_A \wedge \mathcal{W}_A \subseteq \mathcal{S}_C^{\text{tot}} \wedge \triangleleft_A = \prec_C|_{\mathcal{W}_A} \right].} \quad (71)$$

The members of P are co-present at s when each realizes s as a member of one and the same succession $(\mathcal{S}_C^{\text{tot}}, \prec_C)$, with no member of its realization succession outside it and no ordering of its own that differs from $\prec_C$. Co-presence is therefore stronger than incidence,

$$\text{CosmicCoPresence}_C(P; s) \not\equiv_{\text{def}} [P = \{A \in \mathcal{U}_{\text{phys}} \mid \text{ExistsAs}(A, s)\}], \quad (72)$$

and it is not clock agreement, synchronization, signal access, spatial coincidence, or coordinate equality.

4.4 Cosmic Moment Axiom

Axiom 4.3 (Cosmic Moment Axiom (CMA)). The stages of change are one and the same for all physical systems of the universe: every physical system realizes its changes on the one common cosmic succession, with no private stage or private ordering of stages, and all physical systems realized at a stage are co-present at that same stage. Formally,

$$\boxed{\text{CMA} \iff \forall A \in \mathcal{U}_{\text{phys}}, \quad \mathcal{W}_A \subseteq \mathcal{S}_C^{\text{tot}} \wedge \triangleleft_A = \prec_C|_{\mathcal{W}_A}.} \quad (73)$$

By Eqs. (63) and (71), CMA gives objective co-presence of the complete then-realized population at every admitted stage:

$$\text{CMA} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s). \quad (74)$$

Under domain admissibility — every qualified system has at least one member of $\mathcal{S}_C^{\text{tot}}$ at which it is

realized, a condition enforced by the definition of $\mathcal{U}_{\text{phys}}$ rather than an added postulate, stated in full at Eq. (1003) — the converse also holds: for arbitrary $A \in \mathcal{U}_{\text{phys}}$, domain admissibility gives some $s \in \mathcal{S}_{\text{C}}^{\text{tot}}$ with $A \in \mathcal{S}_{\text{phys}}(s)$, and $\text{CosmicCoPresence}_{\text{C}}(\mathcal{S}_{\text{phys}}(s); s)$ applied to that A yields exactly $\mathcal{W}_A \subseteq \mathcal{S}_{\text{C}}^{\text{tot}} \wedge \triangleleft_A = \triangleleft_{\text{C}}|_{\mathcal{W}_A}$. So CMA is equivalent to co-presence of the complete population at every admitted stage.

CMA asserts unity of the cosmic stage, not equality of physical state, physical change, magnitude, rate, cause, location, clock reading, signal condition, or physical history. It does not state that every realized system changes; that commitment is UCC. The full content of the cosmic moment — every qualified system present at one common stage, and each realizing its own change there — is the conjunction $\text{CMA} \wedge \text{UCC}$ (Eq. (112)). The two conjuncts are stated separately because different findings would refute them: a private stage or private ordering refutes CMA; complete physical non-change of a qualified system refutes UCC.

$$\text{CMA} \not\Rightarrow \forall s \in \mathcal{S}_{\text{C}}^{\text{tot}} \forall A, B \in \mathcal{S}_{\text{phys}}(s), X_A(s) = X_B(s), \quad (75)$$

$$\text{CMA} \not\Rightarrow \forall s \in \mathcal{S}_{\text{C}}^{\text{tot}} \forall A, B \in \mathcal{S}_{\text{phys}}(s), \mathbf{x}_A^{(F)}[s] = \mathbf{x}_B^{(F)}[s], \quad (76)$$

$$\text{CMA} \not\Rightarrow \text{UniversalPairwisePhysicalInteraction}, \quad (77)$$

$$\text{CMA} \not\Rightarrow \text{UniversalInstantaneousSignalAccessibility}, \quad (78)$$

$$\text{CMA} \not\Rightarrow \text{UCC}. \quad (79)$$

CMA does not contradict the relativity of simultaneity. Coordinate simultaneity is a relation among clock records fixed by a synchronization convention, and it differs between frames; co-presence at a common stage is fixed by the realization successions of the systems, not by any convention. The Lorentz transformations are derived in Section 37.2 without using CMA, and CMA neither follows from them nor contradicts them (Eq. (775)).

4.5 CMA is non-causal

CMA supplies no physical mechanism. Neither objective co-presence nor the common cosmic stage causes system-specific physical change:

$$\text{CosmicCoPresence}_{\text{C}}(\mathcal{S}_{\text{phys}}(s); s) \not\Rightarrow \text{StageCausesChange}(s). \quad (80)$$

Time, the cosmic stage, and common-stage co-presence are not physical causal-source classes. Physical causation is governed separately by CRP.

5. Universal Change Continuity

5.1 Actual-change subset and change-content typing

For $A \in \mathcal{U}_{\text{phys}}$, define

$$I_A^{\Delta} := \{s \in I_A \mid \text{PhysReal}_A^+(s)\}. \quad (81)$$

Let Ξ_A be the system-specific physical-change-content type appropriate to A , and define

$$\boxed{\Delta_A^{\text{phys}} : I_A^{\Delta} \longrightarrow \Xi_A.} \quad (82)$$

The restricted domain keeps change content well typed in formal countermodels in which physical change is denied at selected identity-stage pairs.

5.2 Universal Change Continuity Postulate

Postulate 5.1 (Universal Change Continuity (UCC): the postulate of change). Physical change continues without interruption in every physical system of the universe, without exception: every qualified physical system A undergoes its own actual physical change at every member of its complete realized identity range I_A , whether that change is observed, unobserved, or below any detection threshold:

$$\boxed{\text{UCC} \iff \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \text{PhysReal}_A^+(s).} \quad (83)$$

UCC is an independent foundational physical postulate. It does not follow from CMA, strict ordering, stage membership, or temporal admissibility. Observation is not a condition of the change it asserts. Whether a change is noticed does not depend on whether it is measured: a change may be noticed without measurement, and a measured change may go unnoticed. Neither noticing nor measuring is a condition of the change itself.

$$\begin{aligned} & \text{PairwiseTypeDistinct}(\text{PhysReal}_A^+(s), \text{Noticed}(A, s), \text{Measured}_{P,M,\epsilon}(A, s)), \\ & \text{Noticed}(A, s) \not\Rightarrow \text{Measured}_{P,M,\epsilon}(A, s), \quad \text{Measured}_{P,M,\epsilon}(A, s) \not\Rightarrow \text{Noticed}(A, s), \\ & \neg \text{Noticed}(A, s) \wedge \neg \text{Measured}_{P,M,\epsilon}(A, s) \not\Rightarrow \text{NC}_A^{\text{phys}}(s). \end{aligned} \quad (84)$$

Here

$$\begin{aligned} \text{Measured}_{P,M,\epsilon}(A, s) &: \iff \exists \chi \exists r : \text{ManifestationAt}(A, \chi; s) \wedge \text{Detected}_{P,M,\epsilon}(A, \chi; r), \\ \text{Noticed}(A, s) &: \iff \exists O \in \mathcal{U}_{\text{phys}} \exists \chi \exists r : \text{Recognizes}_O(\text{ManifestationAt}(A, \chi; s); r), \end{aligned} \quad (85)$$

where χ is a manifestation of the change of A at s , $\text{Detected}_{P,M,\epsilon}$ is detection under a declared protocol P and model M (Eq. (404)), and Recognizes_O states that an observer system O identifies the manifestation in a record at r , with or without a declared protocol. The change itself, its being noticed, and its being measured are of different types; noticing and measuring do not imply each other, and the absence of both does not establish non-change. Detection under a declared protocol is treated in Eqs. (405) and (406). Its continuity is non-metric and does not imply differentiability, equal change magnitude, a universal rate, one universal mechanism, unlimited identity duration, or an infinite cosmic future.

“Without interruption” has two parts, secured by two commitments. UCC excludes a member of an identity range at which the system does not change. Identity-Realization Convexity (Eq. (221)) excludes a gap in the range itself: a system cannot exist, cease to exist, and then exist again as the same identity. Together they give

$$\begin{aligned} & \text{UCC} \wedge \text{IdentityRealizationConvexity} \\ & \implies \forall A \in \mathcal{U}_{\text{phys}} \forall r, t \in I_A \forall s \in \mathcal{S}_C^{\text{tot}}, \quad r \prec_C s \prec_C t \implies \text{PhysReal}_A^+(s). \end{aligned} \quad (86)$$

By Identity-Realization Convexity, $s \in I_A$; by UCC, $\text{PhysReal}_A^+(s)$. Between any two stages of a system’s existence there is no stage at which it is absent or unchanging.

Ending of identity A ends the UCC requirement only beyond I_A ; it does not suspend UCC for other realized systems and does not require successor production.

The stagewise form follows from the definition of $\mathcal{S}_{\text{phys}}(s)$:

$$\text{UCC} \iff \forall s \in \mathcal{S}_{\text{C}}^{\text{tot}} \forall A \in \mathcal{S}_{\text{phys}}(s), \quad \text{PhysReal}_A^+(s). \quad (87)$$

This is a quantifier reformulation of UCC, not CMA. CMA and UCC are logically independent (Proposition 5.4): CMA concerns private stages and orderings, whereas UCC concerns system-specific physical-change actuality.

Accordingly,

$$\text{UCC} \implies \forall A \in \mathcal{U}_{\text{phys}}, \quad I_A^\Delta = I_A. \quad (88)$$

5.3 Physical actuality criterion and genuine contrary

The predicate $\text{PhysReal}_A^+(s)$ asserts actual system-specific physical change in A at s . It is not definitionally a finite difference between two admitted stages, does not require an immediate predecessor or successor in I_A , and supplies no universal scalar magnitude or rate. Its scientific attribution is not warranted by stage membership, terminology, or detectability. In every concrete application, the physical-system boundary and organizational granularity G , together with an applicable physical theory or independently warranted physical model M , must be declared. Attribution of $\text{PhysReal}_A^+(s)$ requires M , at that declared granularity, to warrant at least one physically constitutive process, transition, formation, reconfiguration, constituent exchange, interaction-mediated modification, field-coupled change, structural change, or other physically admissible realization of change in A at s . The listed forms are illustrative rather than exhaustive and remain typed by the applicable physics.

Where M represents change through comparison of state variables or physical relations across suitable realizations, a warranted difference in at least one physically constitutive component can serve as evidence of change. Such a comparison is not the universal definition of change in V39/F19. In particular, formation at the least member f_A can realize physical change through the formation process itself even though there is no earlier member of the same numerical identity range; an ending transformation is treated analogously. Thus the criterion does not smuggle a predecessor requirement into every system stage.

The model and granularity indices discipline warrant; they do not relativize the foundational predicate into a model-created fact and they are not additional arguments of $\text{PhysReal}_A^+(s)$. Equality of a selected observable, a stationary coarse-grained description, equilibrium terminology, criterion-relative stability, or finite non-detection is insufficient by itself to establish complete physical non-change. Conversely, if the applicable physics at the declared system boundary and granularity positively warrants that no physically constitutive change admissible to the claim is realized in A at s , that warranted case is the genuine physical contrary targeted by $\text{NC}_A^{\text{phys}}(s)$ and is a direct countercondition to UCC. It does not by itself negate CMA, whose direct contrary is failure of objective common-stage co-presence for the complete then-realized qualified population.

Define complete physical non-change by

$$\text{NC}_A^{\text{phys}}(s) \iff \neg \text{PhysReal}_A^+(s). \quad (89)$$

Then

$$\text{UCC} \iff \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \neg \text{NC}_A^{\text{phys}}(s). \quad (90)$$

The logical contrary in Eq. (89) therefore has a demanding but non-vacuous physical warrant condition: it must be supported by the applicable physics at the declared system boundary and granularity, not inferred from an unchanging selected record. Criterion-relative stability, operational waiting, or non-detection is

not complete physical non-change. UCC is identity-bounded: if a numerical identity A ends at its terminal identity stage e_A , UCC places no condition on A beyond e_A . The ending of A does not cancel UCC for other qualified identities that remain realized or for genuinely new identities that are physically formed.

5.4 No universal change magnitude, rate, or substance

UCC universalizes physical-change actuality, not change content. Therefore

$$\text{UCC} \not\Rightarrow \text{UniversalScalarMagnitudeOfPhysicalChange}, \quad (91)$$

$$\text{UCC} \not\Rightarrow \text{UniversalScalarRateOfPhysicalChange}, \quad (92)$$

$$\text{UCC} \not\Rightarrow \text{OneUniversalChangeSubstance}. \quad (93)$$

A system-specific scalarization, where physically warranted, remains an application-level construction.

5.5 Criterion-relative stability and observation

A qualified system may satisfy a declared stability criterion while UCC remains true. Selected observables can be unchanged, unresolved, or below threshold even when physical change continues. For a declared protocol P and model M ,

$$\text{NoResolvedDifference}_{P,M}(A; r, s) \not\Rightarrow \text{NC}_A^{\text{phys}}(s). \quad (94)$$

The phrase *criterion-relative stability* is therefore reserved for a system-level observational or physical criterion. It is not the meaning of the fixed cosmic temporal order.

5.6 Exact quantum stationary states and the UCC burden

A stationary quantum representation must be handled without converting formal parameter dependence into physical change. For a time-independent Hamiltonian, let

$$\hat{H}|E\rangle = E|E\rangle, \quad |\psi(\tau)\rangle = e^{-iE\tau/\hbar}|E\rangle, \quad (95)$$

where τ is the evolution parameter of the declared quantum model and is not identified with T_{TOF} . The corresponding pure-state density operator is

$$\rho(\tau) = |\psi(\tau)\rangle\langle\psi(\tau)| = |E\rangle\langle E|, \quad (96)$$

so expectation values of time-independent observables are stationary in the standard energy-eigenstate case [50, 51].

V39/F19 therefore does not count the global phase $e^{-iE\tau/\hbar}$ by itself as $\text{PhysReal}_A^+(s)$. A global phase, a stationary wavefunction label, an unchanged selected expectation value, or a time-independent density operator is not automatically an actual physical-change content. UCC instead requires an independently warranted physical change in the qualified physical system under the declared system boundary.

The converse restraint is equally important. A stationary state assignment in an idealized model does not by itself establish complete physical non-change of the full qualified system. The physical boundary may include fields, environmental couplings, internal degrees of freedom, or other physically warranted

structure not represented by the selected stationary observable. Accordingly,

$$\text{StationaryQuantumRepresentation}_M(A) \not\Rightarrow \text{NC}_A^{\text{phys}}(s). \quad (97)$$

But if independently warranted physics and a sufficiently complete declared system model establish $\text{NC}_A^{\text{phys}}(s)$ for any qualified $A \in \mathcal{U}_{\text{phys}}$ and $s \in I_A$, that is a direct countercondition to UCC rather than something to be reclassified as hidden change:

$$\text{WarrantedCompletePhysicalNonChange}_M(A, s) \implies \text{NC}_A^{\text{phys}}(s) \implies \neg \text{UCC}. \quad (98)$$

Thus exact stationary-state cases are a genuine scientific burden for UCC: ITOF must either identify independently warranted actual physical change in the declared system or accept the warranted complete-nonchange case as falsifying that postulate. The framework does not use measurement non-resolution, a global phase, or interpretive terminology to evade this burden.

5.7 A checkable closure criterion for the quantum burden

Appeal to environmental couplings or internal degrees of freedom not represented by the selected stationary observable (Eq. (97)) is admissible only when tied to a declared, checkable criterion for when a system is closed enough that its non-change tests UCC.

Definition 5.2 (Currently-complete physical isolation). Let M be an applicable physical theory or model, and let the system boundary and organizational granularity G for A be declared as in Section 5. A is *currently-completely isolated* at s under (M, G) , written $\text{CCPI}_{M,G}(A, s)$, if and only if every interaction channel between A and its exterior that M recognizes at that boundary and granularity — at minimum, gravitational coupling, electromagnetic and vacuum-field coupling, any weak- or strong-interaction channel applicable at that scale, thermal photon or particle exchange with the surrounding bath, and measurement-induced back-action — has, for each such channel, (i) been experimentally suppressed below the best independently reported sensitivity for that channel, (ii) been shown by M to vanish by an exact selection rule or exact symmetry, or (iii) where the channel cannot be suppressed, as for gravitational coupling, been computed by M and removed from the record within stated uncertainty. Conditions (i) and (ii) are physical isolation; condition (iii) is model-based subtraction, a distinct evidential operation, and every application states which channels were isolated and which were subtracted. Channels not recognized by M lie outside the criterion; $\text{CCPI}_{M,G}$ is relative to M and is revised when M is.

$\text{CCPI}_{M,G}(A, s)$ is a checklist against a stated experimental protocol and a stated theory M ; it does not itself assert or deny physical change in A :

$$\begin{aligned} \text{CCPI}_{M,G}(A, s) &\not\Rightarrow \text{WarrantedCompletePhysicalNonChange}_M(A, s), \\ \text{CCPI}_{M,G}(A, s) &\not\Rightarrow \text{PhysReal}_A^+(s). \end{aligned} \quad (99)$$

Suppression of every channel M recognizes, to below current sensitivity, is not an exact zero, and M may be superseded by a theory recognizing a further channel. The burden therefore remains open.

Proposition 5.3 (What UCC entails under currently-complete isolation). If UCC holds and $\text{CCPI}_{M,G}(A, s)$ holds for a qualified A and $s \in I_A$, then $\text{PhysReal}_A^+(s)$ holds (Eq. (83)) despite every channel recognized by M being closed under (M, G) . UCC alone does not entail that this change is attributable to any specific, independently named channel; attribution remains a separate, model-relative question.

Proof. Immediate from Eq. (83): $A \in \mathcal{U}_{\text{phys}}$ and $s \in I_A$ jointly give $\text{PhysReal}_A^+(s)$ regardless of which channels M recognizes or has closed at (M, G) . Nothing in Definition 5.2 restricts the quantifier in Eq. (83).

Proposition 5.3 is the whole of what UCC entails here: the existence of change, not its identification. A separate expectation, with EmpiricalBridge status rather than axiom or postulate status (Eq. (6)), states where that change is expected to be found. Systems brought toward $\text{CCPI}_{M,G}$ — trapped-ion and optical-lattice clock states, superconducting qubits at their coherence limit — have so far exhibited an independently named channel (spontaneous emission into the vacuum field, blackbody-radiation shifts, gravitational-redshift gradients across the trap, magnetic- or electric-field noise). The expectation is that further isolation will continue to locate such a channel. The expectation may fail without UCC failing.

The countercondition to UCC is complete physical non-change, $\text{NC}_A^{\text{phys}}(s)$ (Eq. (98)). No finite measurement certifies an exact zero; it bounds the magnitude of change below a stated sensitivity. Evidence against UCC therefore takes the form of a sequence of bounds, each obtained under currently-complete isolation, that continues to decrease while no channel is identified. Once the bounds fall below the smallest change predicted by the channels that the model recognizes, the sequence is adverse evidence of increasing weight and is reported as evidence against UCC, not reinterpreted as hidden change; above that level it is increasingly stringent non-detection. UCC is maintained against such evidence only by an identified channel or by a stated, independently testable bound on one. No such sequence is currently known.

The examples above concern excited or interrogated states. The most demanding case is a system in the interacting ground state of its full Hamiltonian, which standard quantum theory treats as stationary and non-decaying. UCC does not count the global phase of that state as change (Eq. (95)). For such a system, UCC requires that physical change be located in the couplings to its exterior that M recognizes — gravitational, thermal-radiation, and measurement channels — and a ground-state system certified under $\text{CCPI}_{M,G}$, with each such channel bounded in the manner above, would be the strongest available adverse evidence against UCC.

Stationarity of a quantum state means that the probability distribution of every observable is constant. UCC does not contradict this mathematical property; it concerns which physical situations are realized. Three cases are distinct.

1. An exact energy eigenstate of a completely isolated system. This is an idealization. UCC asserts that no qualified system realizes it, because no qualified system is completely isolated: gravitational coupling cannot be suppressed (Definition 5.2, clause (iii)).
2. An open system in a stationary state, including a thermal steady state. The reduced state is constant while the individual system continues to undergo exchange events — absorption, emission, scattering — at rates that may be very small. Constancy of an ensemble statistic does not exhaust the history of an individual system; single-system observations resolve discrete events in systems whose ensemble description is stationary [24]. UCC is satisfied by these events.
3. A ground-state system certified under $\text{CCPI}_{M,G}$, with every recognized channel bounded. This is the case in which UCC is exposed to adverse evidence, as stated above.

The disagreement with a purely stationary reading of the ground state is therefore located precisely: it concerns whether complete isolation is physically realized, not the mathematics of stationary states.

A single electron “in a perfect vacuum” belongs to the first case: it is an idealization. A physical electron is an open system. It is coupled to the electromagnetic field, it scatters the photons of the cosmic microwave

background, and it is gravitationally coupled to every other system; its momentum state is never an exact eigenstate, so its spatial state spreads, and its relations to other systems change. These are changes of the electron itself, not of a global phase. Whether a certified isolated electron would show none of them is exactly the case in which UCC is exposed to evidence.

5.8 Mutual independence of CMA and UCC, and the no-void-stage consequence of UCC

Proposition 5.4 (Mutual independence of CMA and UCC). Under the governing definitions,

$$\text{CMA} \not\vdash \text{UCC} \quad \text{and} \quad \text{UCC} \not\vdash \text{CMA}, \quad (100)$$

established by the explicit countermodels below, per the reservation of $\not\vdash$ for model-theoretically supported non-derivability (Section 1.3).

Proof. (CMA does not entail UCC.) Let $\mathcal{S}_C^{\text{tot}} = \{0, 1\}$ with $0 \prec_C 1$, $\mathcal{U}_{\text{phys}} = \{A, B\}$, $\mathcal{W}_A = \mathcal{W}_B = \{0, 1\}$, and $\triangleleft_A = \triangleleft_B = \prec_C$; CMA holds. Assign $\text{PhysReal}_B^+(0)$, $\text{PhysReal}_B^+(1)$, $\text{PhysReal}_A^+(1)$, and $\neg \text{PhysReal}_A^+(0)$. Both stages are admitted, since each has a nonempty population; B changes at each. UCC fails at $(A, 0)$.

(UCC does not entail CMA.) Let $\mathcal{S}_C^{\text{tot}} = \{0, 1\}$ with $0 \prec_C 1$, $\mathcal{U}_{\text{phys}} = \{A, B\}$, $\mathcal{W}_A = \{0, 1\}$ with $\triangleleft_A = \prec_C$, and $\mathcal{W}_B = \{0, b\}$ with $0 \triangleleft_B b$ and $b \notin \mathcal{S}_C^{\text{tot}}$. Assign PhysReal^+ at every member of every realization succession. Both stages are admitted, since each has a nonempty population; $I_A = \{0, 1\}$, $I_B = \{0\}$, and UCC holds. CMA fails, because B has a private stage b ; in particular $\neg \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(0); 0)$, although A and B are both incident at 0.

In both structures Identity-Realization Convexity and the Actual Formation Boundary hold, and CRP is satisfied by assigning one internal contributor to each realized change, as in the joint-satisfiability witness. The non-derivability is therefore not produced by violating another governing postulate.

Corollary 5.5 (No change-void stage). By UCC, for every $s \in \mathcal{S}_C^{\text{tot}}$ and every $A \in \mathcal{U}_{\text{phys}}$ with $s \in I_A$, A undergoes actual physical change at s : no physical system of the universe is unchanging at any stage at which it exists. This is the stagewise content of UCC (Eq. (87)). The population at each stage is nonempty by stage admission (Eq. (69)).

6. Common-Stage Change and Empirical Structure

6.1 Actual-change population

Define

$$\mathcal{B}_\Delta(s) := \{A \in \mathcal{S}_{\text{phys}}(s) \mid \text{PhysReal}_A^+(s)\}. \quad (101)$$

By definition,

$$\mathcal{B}_\Delta(s) \subseteq \mathcal{S}_{\text{phys}}(s). \quad (102)$$

Under the definitions of I_A , $\mathcal{S}_{\text{phys}}(s)$, and $\mathcal{B}_\Delta(s)$,

$$\text{UCC} \iff \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s). \quad (103)$$

6.2 No physically change-null admitted stage

Stage admission and the postulate of change together make every stage of the universe a stage of change of all physical systems realized there:

$$\boxed{\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \text{RealizedChangeStage}_C(s).} \quad (104)$$

Proof. By $\mathfrak{T}_C$, $\text{CommonStage}_C(s)$ holds for every $s \in \mathcal{S}_C^{\text{tot}}$. By UCC in stagewise form (Eq. (87)), every $A \in \mathcal{S}_{\text{phys}}(s)$ satisfies $\text{PhysReal}_A^+(s)$. Eq. (16) then gives $\text{RealizedChangeStage}_C(s)$. $\square$

In particular,

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \mathcal{B}_\Delta(s) \neq \emptyset. \quad (105)$$

This is not a claim that a stage is a container that must be “filled”; it says that no stage of the universe is a stage of absence of physical change.

Equivalently, in terms of the actual-change population:

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) \neq \emptyset. \quad (106)$$

Define the global change-null stage by

$$\text{GCN}_C(s) \iff \mathcal{B}_\Delta(s) = \emptyset. \quad (107)$$

and the mixed change–stasis violation, in which the change population is a nonempty proper part of the stage population, by

$$\text{MSV}(s) \iff \emptyset \neq \mathcal{B}_\Delta(s) \subsetneq \mathcal{S}_{\text{phys}}(s). \quad (108)$$

These two predicates state the two forms that a contrary to UCC would take at a stage. UCC excludes both:

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \neg \text{GCN}_C(s). \quad (109)$$

$$\text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \neg \text{MSV}(s). \quad (110)$$

Formally, the change population at a stage is either empty, a nonempty proper part of the stage population, or the whole of it; $\mathfrak{T}_C$ makes the stage population nonempty, UCC excludes the first two cases, and the third is Eq. (104). Unity of the stage for all physical systems of the universe realized there is supplied by CMA, not by UCC or by the definition of the stage domain.

Consequently no stage of the universe is empty, void of change, or static: stage admission excludes a stage without physical systems, the postulate of change excludes a stage at which any physical system realized there does not change, and CMA excludes a private stage (Eq. (73)). These exclusions concern the same common stages, shared by all physical systems of the universe. A stage is not a receptacle that change occupies; it is the formal expression that change has been realized, whether that realization is noticed, unnoticed, or below a declared detection threshold.

6.3 Foundational Stage-to-Change Representation

Define the local full-theory common-stage change condition, the stage-to-change bridge, by

$$\boxed{\text{SCB}_C(s) \iff [\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s) \wedge \mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s)]}. \quad (111)$$

This is a defined conjunction of the local CMA content and the stagewise UCC content. It is not an axiom, causal law, synchronization rule, measurement bridge, or dynamics. Therefore,

$$\text{CMA} \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \text{SCB}_C(s). \quad (112)$$

Under domain admissibility the converse also holds, because co-presence at every admitted stage yields CMA (Eq. (74) and the converse stated after it) and full coverage at every stage yields UCC. The bridge at every stage is then equivalent to $\text{CMA} \wedge \text{UCC}$, and introduces no additional foundational commitment.

6.4 Complete All-System Change Realization under UCC

Complete all-system change coverage at every admitted stage (Eq. (106)) is the burden of UCC together with temporal admissibility, not of CMA. CMA is conjoined when the full common-stage reading is required (Eq. (111)).

6.5 Common-stage system-change profile

Define

$$\mathfrak{D}_C(s) := \left(A \mapsto \Delta_A^{\text{phys}}(s) \right)_{A \in \mathcal{B}_\Delta(s)} \in \prod_{A \in \mathcal{B}_\Delta(s)} \Xi_A. \quad (113)$$

Under UCC,

$$\text{UCC} \implies \text{dom } \mathfrak{D}_C(s) = \mathcal{S}_{\text{phys}}(s). \quad (114)$$

The dependent product preserves heterogeneous system-specific change-content types and does not create a universal change codomain.

6.6 Foundational realization is not an empirical bridge

The defined proposition $\text{SCB}_C(s)$ is not a model-input map, physical dynamics, model-output map, or measurement bridge. For a declared model M , application physics requires independently specified structures such as

$$\mathcal{S}_M^{\text{phys}} \xrightarrow{\mathcal{B}_M^{\text{in}}} \mathcal{S}_M^{\text{model}} \xrightarrow{\text{Dyn}_M} \mathcal{O}_M^{\text{model}} \xrightarrow{\mathcal{B}_M^{\text{out}}} \mathcal{O}_M^{\text{phys}} \xrightarrow{\mathcal{B}_{P,M}^{\text{obs}}} \mathcal{R}_{P,M}. \quad (115)$$

Neither the temporal definition, CMA, nor UCC supplies these maps or dynamics.

6.7 Illustrative application-level measurement bridge

A concrete bridge can be specified without converting the cosmic-stage order into an observable coordinate. Let an independently warranted physical model M produce a scalar physical prediction $q_M \in \mathcal{O}_M^{\text{phys}}$. For a declared measurement protocol P , let $K_{P,M}(\text{dy} \mid q)$ be a calibrated conditional record kernel on the record space $\mathcal{R}_{P,M}$. The corresponding stochastic measurement bridge is typed as

$$\mathcal{B}_{P,M}^{\text{obs}} : \mathcal{O}_M^{\text{phys}} \longrightarrow \text{Prob}(\mathcal{R}_{P,M}), \quad q \longmapsto K_{P,M}(\cdot \mid q), \quad (116)$$

where $\text{Prob}(\mathcal{R}_{P,M})$ denotes the admissible probability measures on the declared record space. A deterministic bridge is included as the special case in which the kernel is a Dirac measure. The predicted

observable object is therefore the record law

$$\mathbf{Y}_{P,M} \sim K_{P,M}(\mathrm{d}y \mid q_M). \quad (117)$$

Calibration parameters, acquisition response, resolution, and stochastic noise belong to the independently declared kernel $K_{P,M}$; they are not supplied by $\mathcal{S}_C^{\mathrm{tot}}$, $\prec_C$, CMA, or UCC. This construction specifies no direct stage-to-record map: stage membership can index the physical realization to which the independently specified model applies, but the physical response law and the measurement bridge remain additional application structure.

For the mass-defect clock branch developed later, one may take $q_M = \Delta\omega/\omega_0$, with the physical response law supplying q_M and the declared protocol kernel supplying the record distribution. This is an example of the typed bridge architecture, not an additional foundational postulate and not an ITOF-specific modification of atomic-clock dynamics.

Worked fractional-frequency record kernel

The generic kernel above can be instantiated without assigning temporal identity to the measured quantity. For a fractional-frequency application, let

$$q_M := \frac{\Delta\omega}{\omega_0}, \quad (118)$$

where the physical model supplies the predicted fractional shift. If the declared protocol P has an independently calibrated additive record offset b_P and standard deviation $\sigma_P > 0$, one admissible illustrative record kernel is

$$K_{P,M}(\mathrm{d}y \mid q_M) = \frac{1}{\sqrt{2\pi}\sigma_P} \exp\left[-\frac{(y - (q_M + b_P))^2}{2\sigma_P^2}\right] \mathrm{d}y. \quad (119)$$

Equivalently,

$$\mathbf{Y}_{P,M} = q_M + b_P + \varepsilon_P, \quad \varepsilon_P \sim \mathcal{N}(0, \sigma_P^2). \quad (120)$$

This example demonstrates only the prediction-to-record layer. The values and uncertainties of b_P and σ_P must come from the declared calibration and acquisition model; V39/F19 supplies neither. A non-Gaussian or correlated kernel must replace this form where the experimental record process requires it. Neither q_M nor $\mathbf{Y}_{P,M}$ is thereby identified with T_{ITOF} , with a member of $\mathcal{S}_C^{\mathrm{tot}}$, or with an exact common cosmic stage. The later Mass-Defect and Clock-Response Program (Section 49) supplies the relevant physical response law explicitly: there, q_M is instantiated by a declared fractional-frequency prediction from the trapped-ion mass-defect Hamiltonian (Eq. (936)), and $\mathbf{Y}_{P,M}$ by the corresponding clock-comparison record (Eq. (922)), with the present kernel or its declared non-Gaussian replacement as the connecting measurement bridge. The present construction only makes that later instantiation's measurement-bridge typing explicit in advance.

6.8 Conditional discriminating application template

If a future independently warranted physical extension supplies a specific interaction

$$\hat{H}_I = \hat{H}_{\mathrm{base}} + \lambda_X \hat{O}_X, \quad \hat{H}_R = \hat{H}_{\mathrm{base}}, \quad (121)$$

then a candidate observable separation may take the form

$$\Delta y_{I;R}^{P^*,D^*} = \lambda_X K_X^{P^*,D^*}. \quad (122)$$

These are conditional application equations, not consequences of the temporal definition, CMA, or UCC. If the two branches have the same complete physical-to- observable specification, no ontology-only prediction separation follows.

6.9 What UCC does and does not supply without a further model

UCC supplies no numerical prediction separation without an independently supplied coupling λ_X (Eq. (122)). It does supply the qualitative content of Proposition 5.3: at a qualified system under $\text{CCPI}_{M,G}$, physical change exists, whether or not it is identified. Standard quantum theory admits an exactly stationary isolated system as an idealization; UCC excludes it as a physical realization. The difference is not a numerical residual; it is a difference in what is admitted as physically realized, and it is tested in the bounded, cumulative form stated in Section 5.7.

7. System-Specific States at Common Stages

7.1 System-specific physical state spaces

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

$$\Omega_A \quad (123)$$

denote a declared physical state space adequate to the physical description of that system under the application or theoretical context being considered.

Define:

$$X_A : I_A \longrightarrow \Omega_A. \quad (124)$$

For every $s \in I_A$,

$$X_A(s) \quad (125)$$

denotes the physical state of A realized at common cosmic change stage s .

The state and the common cosmic change stage remain type-distinct:

$$s \not\equiv_{\text{type}} X_A(s). \quad (126)$$

Likewise, under UCC,

$$s \not\equiv_{\text{type}} \Delta_A^{\text{phys}}(s). \quad (127)$$

The common cosmic change stage is universal. The physical state and the physical-change content are system-specific.

7.2 No universal physical-state codomain

Common-stage realization does not require all physical systems to be described through one state space.

For distinct systems:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \wedge A \neq B \not\Rightarrow \Omega_A = \Omega_B. \quad (128)$$

Accordingly, V39/F19 introduces no universal physical-state space Ω_{univ} satisfying

$$\text{CommonStageRealization} \not\Rightarrow \exists \Omega_{\text{univ}} \forall A \in \mathcal{U}_{\text{phys}}, \quad \Omega_A = \Omega_{\text{univ}}. \quad (129)$$

as a foundational requirement.

A common mathematical representation may be constructed in a particular physical model where scientifically justified. Such a representation remains an application-level construction and does not identify the physical states of distinct systems.

7.3 Common-stage physical-state profile

At $s \in \mathcal{S}_C^{\text{tot}}$, every $A \in \mathcal{S}_{\text{phys}}(s)$ satisfies $s \in I_A$. Therefore $X_A(s)$ is well typed for the complete then-realized qualified population.

Definition 7.1 (Common-Stage Physical-State Profile). Define:

$$\mathfrak{X}_C(s) := (A \mapsto X_A(s))_{A \in \mathcal{S}_{\text{phys}}(s)} \in \prod_{A \in \mathcal{S}_{\text{phys}}(s)} \Omega_A. \quad (130)$$

The dependent product is essential. It preserves the possibility that different physical systems require different physical state spaces.

The profile does not identify the system-specific states:

$$\mathfrak{X}_C(s) \not\equiv_{\text{def}} \text{OneUniversalPhysicalState}(s). \quad (131)$$

Nor does the existence of the profile imply:

$$\text{Defined}(\mathfrak{X}_C(s)) \not\Rightarrow \forall A, B \in \mathcal{S}_{\text{phys}}(s), \quad X_A(s) = X_B(s). \quad (132)$$

The profile is a formal population-indexed representation of physically distinct system states realized at one common cosmic change stage.

7.4 Common Stage Is Not a Totality State

Remark 7.2 (Stage/profile type boundary). The common cosmic change stage s , the temporal referent T_{ITOF} , and the stage-relative physical-state profile $\mathfrak{X}_C(s)$ remain type-distinct. The first is a common cosmic change stage, the second is the governing temporal ordered pair, and the third is a formal population-indexed representation of physical states realized by the stage-relative population. No definition in this section identifies either s or T_{ITOF} with $\mathfrak{X}_C(s)$.

8. Physical Causes and Contributors of Change

8.1 Causation remains physical and system-specific

The UCC states that each qualified physical system realizes its own physical change. It does not make time, cosmic ordering, or common-stage unity the cause of that change.

The causal architecture of V39/F19 is organized around three physically typed source classes: internal physical contributors of the changing system, external influencing physical systems, and external

influencing non-system physical factors. This section consolidates their definitions, families, interactions, and system-specific effects in one place.

For every actual-change pair:

$$A \in \mathcal{U}_{\text{phys}}, \quad s \in I_A^\Delta, \quad (133)$$

the causal account belongs to the physically realized system and its physically admissible contributors.

The following are not causal-source classes:

$$\left\{ \begin{array}{l} T_{\text{ITOF}}, \mathcal{E}_C, \mathcal{U}_C^{\text{phys}}, s, \prec_C, \text{CSPP}, \text{CMA}, \text{UCC}, \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \text{SCB}_C, \text{CRP} \end{array} \right\} \quad (134)$$

$$\cap \text{PhysicalCausalSourceClass} = \emptyset.$$

This expression states a type boundary. It does not assert that the listed formal or foundational items are members of one ordinary set-valued physical domain. In particular, $\mathcal{U}_C^{\text{phys}}$ is not itself a causal-source class or a single causal agent; its constituent physical systems and influencing physical factors may nevertheless be actual causal contributors under the causal roles defined below.

8.2 Three causal-source classes

For physical system A at s , V39/F19 separates the actual physical causal basis into internal physical contribution and external physical influence. External physical influence may be produced by an influencing physical factor or by an influencing physical system. These two source types perform the same causal role relative to A : each can produce physical influence that contributes to A 's change, while retaining its own physical type.

Let

$$\mathcal{C}_A^{\text{int}}(s) \quad (135)$$

denote the actual internal physical contributors to the change realized in A .

Define the influencing physical-system and physical-factor source sets by

$$\mathcal{C}_A^{\text{infl-sys}}(s) := \{B \in \mathcal{U}_{\text{phys}} \mid \text{InfluencingPhysicalSystem}(B; A, s)\}. \quad (136)$$

$$\mathcal{C}_A^{\text{infl-factor}}(s) := \{F \in \mathfrak{F}_{\text{phys}} \mid \text{InfluencingPhysicalFactor}(F; A, s)\}. \quad (137)$$

Thus $\mathcal{C}_A^{\text{infl-sys}}(s) \subseteq \mathcal{U}_{\text{phys}}$ and $\mathcal{C}_A^{\text{infl-factor}}(s) \subseteq \mathfrak{F}_{\text{phys}}^{\text{inf}}$. System sources remain physical systems; factor sources remain physical factors with their domain-specific physical typing.

Collect the external sources of physical influence on A as

$$\mathcal{C}_A^{\text{ext}}(s) := \mathcal{C}_A^{\text{infl-sys}}(s) \cup \mathcal{C}_A^{\text{infl-factor}}(s). \quad (138)$$

Every member of $\mathcal{C}_A^{\text{ext}}(s)$ contributes external physical influence to A . A system source remains a physical system; a factor source remains a physical factor.

The causal profile is therefore

$$\mathfrak{C}_A(s) := \left(\mathcal{C}_A^{\text{int}}(s), \mathcal{C}_A^{\text{ext}}(s) \right). \quad (139)$$

For one declared system boundary, internal contribution and external influence are distinct roles, and the

two external source types remain type-distinct:

$$\mathcal{C}_A^{\text{int}}(s) \cap \mathcal{C}_A^{\text{ext}}(s) = \emptyset, \quad \mathcal{C}_A^{\text{infl-sys}}(s) \cap \mathcal{C}_A^{\text{infl-factor}}(s) = \emptyset. \quad (140)$$

The complete actual physical causal set is

$$\mathcal{C}_A^{\text{act}}(s) := \mathcal{C}_A^{\text{int}}(s) \cup \mathcal{C}_A^{\text{ext}}(s). \quad (141)$$

This structure introduces no additional causal-source type. It distinguishes where the physical contribution comes from while stating the causal relation directly: actual internal physical contribution and/or actual external physical influence contributes to the system-specific change.

The classification into internal contributors, external influencing systems, and external influencing non-system factors is exhaustive at the ITOF causal-typing level. It does not assert that every member of any broad physical family is causally active in every application; actual membership requires warranted physical contribution to the particular change.

8.3 Physical-factor families and effects

Physical factors fall within a limited set of physically recognized families. The list below is near-exhaustive at the level of families, in contrast to physical systems, whose population is not enumerated; it remains open to a family established by future physics. Each entry identifies a physical-factor family and effects that may occur when a factor in that family is physically realized and actually influences the system. An influencing physical system may generate, carry, or mediate such physical influence while remaining a physical system. The list does not create additional causal-source types or universal response laws.

- (i) **Mechanical, contact, and kinematic contributions.** Physically realized loads, pressure conditions, stress or strain, contact, impact, shock, vibration, acceleration, rotation, and momentum-transfer processes may alter motion, configuration, deformation, oscillation, structural integrity, transport, or failure behaviour according to the system's mechanics and constitutive law.
- (ii) **Thermal and thermodynamic contributions.** Physically realized thermal conditions, temperature differences or gradients, heat-transfer processes, and phase conditions may alter internal-energy distribution, expansion or contraction, phase, transport coefficients, reaction rates, material properties, or other system-specific thermodynamic responses.
- (iii) **Electromagnetic contributions.** Physically realized electric or magnetic fields and gradients, charge and current distributions, and electromagnetic couplings may produce forces, polarization, excitation, ionization, current redistribution, heating, transition response, or other field-dependent changes permitted by the physical model.
- (iv) **Gravitational contributions.** Physically realized gravitational relations, field or potential gradients, and tidal conditions may contribute to acceleration, trajectory change, binding, stress, energy-state response, or other gravity-dependent behaviour permitted by the physical model.
- (v) **Radiative and particle-transfer contributions.** Photon, particle, material, momentum, or energy transfer and exposure may contribute to excitation, ionization, heating or cooling, momentum exchange, detector response, photochemical change, material modification, or biological effects where the applicable physics warrants them.
- (vi) **Nuclear, subatomic, and reaction-channel contributions.** Physically realized nuclear interactions, incident particle channels, capture, scattering, transmutation, externally induced decay or excitation pathways, and related subatomic processes may contribute where the applicable nuclear or particle physics establishes an actual influence. A decay constant, cross section, or branching ratio is

a descriptor or model quantity; causal attribution belongs to the realized physical process and interaction.

- (vii) **Chemical and material contributions.** Composition, concentration or chemical-potential gradients, chemical interaction, material exchange, solvent or medium conditions, adsorption, dissolution, corrosion, and related processes may alter bonding, composition, phase, diffusion, structure, or reaction pathways.
- (viii) **Fluid, plasma, and transport contributions.** Physically realized fluid conditions, pressure and flow fields, shear, material transport, plasma conditions, and associated couplings may contribute to drag, compression, mixing, heat or mass transfer, erosion, transport, or other continuum or plasma responses allowed by the governing physics.
- (ix) **Wave, oscillatory, and resonant contributions.** Mechanical, acoustic, electromagnetic, or other physically instantiated wave and oscillatory processes may transfer energy or momentum, excite modes, produce resonance, fatigue, transition response, interference effects, or other coupling-dependent changes. A numerical frequency by itself is only a descriptor; causal attribution belongs to the realized oscillatory process or interaction carrying it.
- (x) **Boundary, interface, confinement, and structural contributions.** Physically realized boundaries, interfaces, confining boundaries or support relations, lattice or confinement conditions, trapping arrangements, and structural constraints may alter permitted modes, stress distribution, transport, interaction strength, transition conditions, or stability. Geometric or boundary parameters are not causes merely because they occur in an equation; the relevant physical realization must be identified.
- (xi) **Fluctuation, collision, disturbance, and noise contributions.** Physically realized collisions, perturbations, fluctuations, disturbances, or noise may contribute to diffusion, broadening, stochastic transitions, heating, decoherence, loss of stability, or other model-specific effects. Labels such as “vacuum fluctuation” or “noise” do not settle ontic or causal typing without the physical model and declared system boundary.
- (xii) **Biological, environmental, and complex-system influences.** Nutrient or material availability, pathogens, tissue or fluid conditions, regulatory couplings, surrounding instruments, atmosphere, direct exposure, and other environmental circumstances can matter only through their physically realized constituents, processes, pathways, boundaries, or influencing systems. The word “environment” is a descriptive aggregation, not an additional causal-source type.

The list does not restrict what physical factors may exist. An unlisted factor is admissible when the applicable physics establishes its physical realization and actual influence. A numerical property or model parameter does not enter $\mathcal{C}_A^{\text{act}}(s)$ by itself; causal attribution belongs to the physically realized source and influence to which that description applies.

8.4 Descriptor-to-source discipline

Terms such as temperature, frequency, velocity, pressure, intensity, density, or field strength often denote measured or modelled properties rather than separate causal entities. Their causal use in ITOF is therefore tied to the physically realized condition or process that the descriptor characterizes. For example:

- temperature is causally relevant through a realized thermal condition, gradient, heat-transfer process, phase condition, or temperature-dependent physical interaction;
- frequency is causally relevant through a physically realized oscillatory, wave, radiative, resonant, or driven process characterized by that frequency;
- velocity or motion is causally relevant through the realized kinematic state, momentum transfer,

collision, transport, inertial relation, or other motion-dependent physical interaction specified by the applicable model.

This discipline preserves the distinction between physically realized causal conditions and their numerical descriptors without reifying a descriptor into an independent causal source.

8.5 External influencing physical systems

External physical influence is not restricted to non-system factors. A numerically and physically distinct system B may contribute to the change realized in A while remaining a physical system with its own identity, state, change, causal profile, and physical history. The source relation is represented by $B \in \mathcal{C}_A^{\text{infl-sys}}(s)$; it does not convert B into a physical factor.

At the level of causal families, external influencing physical systems may include, where independently warranted by the applicable physics:

- (i) **Contacting, colliding, loading, or constraining systems**, including bodies, supports, tools, boundaries realized by another system, impactors, and mechanically coupled assemblies.
- (ii) **Gravitationally interacting systems**, including physical systems whose mass–energy distribution contributes gravitationally to the state or motion of A under the adopted gravitational model.
- (iii) **Electromagnetic source systems**, including charged bodies, current-bearing systems, electrodes, magnets, resonators, antennas, cavities, and other systems producing or shaping physically realized electromagnetic interaction.
- (iv) **Radiative or particle-emitting systems**, including sources whose photons, particles, or other physically transported emissions interact with A .
- (v) **Material reservoirs, fluids, plasmas, or surrounding media that satisfy the physical-system criterion**, where exchange, flow, pressure, shear, transport, reaction, or other interaction with A is physically established.
- (vi) **Control, preparation, interrogation, and measurement systems**, including apparatus whose fields, pulses, contacts, feedback actions, sampling, or other physically realized operations contribute to the state or change of A . The resulting record remains distinct from the causal interaction that produced it.
- (vii) **Chemical, biological, or complex interacting systems**, where an independently identified system contributes through contact, exchange, regulation, signaling, metabolism, reaction, transport, or another physically warranted pathway.
- (viii) **Composite environmental or structural systems**, where the surrounding entity itself satisfies the system criterion and its interaction with A is physically resolved. A loose word such as “environment” does not by itself establish this status.

The list is a causal taxonomy, not a claim of universal all-to-all interaction. Cosmic co-presence under CMA does not imply that every physical system influences every other physical system, and causal influence need not be symmetric.

8.6 Internal physical contributors

Internal causal contribution includes more than externally visible activity. The internal physical basis of A may contain operative contributors arising from its realized constitution, organization, state, relations, retained conditions, and internal processes. Where independently warranted, the internal causal set $\mathcal{C}_A^{\text{int}}(s)$ may include contributions associated with:

- (i) **Material constitution and composition**, including constituent species, bonding structure, phase composition, concentration distributions, and other physically realized compositional organization.
- (ii) **Constituent arrangement and structural organization**, including geometry, topology, interfaces, defects, lattice organization, compartmentation, and other realized structural relations internal to the declared system.
- (iii) **Present internal state and distributions**, including population, occupation, density, charge, current, momentum, energy, polarization, or other physically warranted state distributions.
- (iv) **Stored or internally distributed energy and excitation**, including elastic, chemical, electromagnetic, thermal, rotational, vibrational, electronic, nuclear, or other model-warranted internal energy content.
- (v) **Internal stress, strain, pressure, deformation, and constitutive constraints**, where these are physically realized and operative in the change.
- (vi) **Internal field configurations and couplings**, where the fields or couplings belong to the declared physical description of the system and make an actual contribution rather than appearing only as mathematical parameters.
- (vii) **Internal motion and transport**, including constituent motion, rotation, vibration, oscillation, currents, flows, diffusion, and internal momentum or material transfer.
- (viii) **Microscopic interactions and transition dynamics**, including bonding, scattering, collisions, exchange, reaction, decay, excitation, relaxation, and other physically realized constituent-level processes.
- (ix) **Order, correlation, coherence, regulation, and feedback embodied physically in the system**, where such organization is part of the applicable physical model and is causally operative.
- (x) **Present physically embodied consequences of prior change**, including retained damage, stored strain, altered composition, remanent field configuration, memory state, or other currently realized condition. The past as such is not a cause; only the presently embodied physical condition can enter the current causal profile.

A descriptive property or a numerical state variable is not promoted to an independent causal entity merely because it characterizes the internal system. Causal attribution belongs to the physically realized constitution, condition, interaction, process, or constraint to which the descriptor refers.

8.7 Pathways of physical influence and mediation

An influencing physical factor or system contributes to the change of A only through a physically realized pathway. The pathway families are

$$\text{Pathway}(c \rightarrow A; s) \in \{\text{contact and mechanical coupling, field relation, radiative or particle transfer, gravitational relation, material or energy exchange, boundary access}\}. \quad (142)$$

A third system lying on a pathway may mediate the influence: it may shield, attenuate, filter, redirect, transform, or amplify it. A mediating system remains a physical system and changes under UCC like any other; its effect on the pathway is part of the causal account of A only through its own realized physical influence. The same system may be influencing in one analysis and influenced in another, and influence need not be reciprocal or symmetric. Presence of a factor or nearness of a system is therefore not influence:

a factor may be present without an effective pathway, and a system may be near without coupling,

$$\text{Present}(c; s) \not\Rightarrow c \in \mathcal{E}_A^{\text{ext}}(s). \quad (143)$$

8.8 Characteristics of a realized influence

For an influence of $c \in \mathcal{E}_A^{\text{ext}}(s)$ on A , an application may declare its influence profile

$$\mathbf{i}_A(c; s) = (\text{mode}, \text{intensity}, \text{exposure}, \text{pathway}, \text{coupling}). \quad (144)$$

Mode states how the influence acts: mechanically, thermally, electromagnetically, gravitationally, radiatively, chemically, by flow, oscillation or resonance, or through confinement. *Intensity* states how strong the influence is, from weak and bounded to extreme. *Exposure* states how the influence reaches the system across stages: once or repeatedly, suddenly or progressively, locally or over the whole system, directly or through shielding. *Pathway* is the member of Eq. (142) through which it acts. *Coupling* states whether it acts alone or together with other contributors, which may reinforce, oppose, gate, or transform it. The profile consists of descriptors of the realized influence; under the descriptor-to-source discipline it is not itself a cause.

8.9 Responsiveness of a physical system

The same influence does not produce the same change in every system, because the realized change depends on the system that receives it. The features of A on which this depends form its responsiveness profile at s :

$$\text{RespProf}_A(s) = (\Theta_A, \Gamma_A^{\text{coh}}, \Sigma_A, R_A^{\text{cap}}, Q_A, \mathcal{K}_A)(s). \quad (145)$$

Here Θ_A is the constitution and internal organization of A ; Γ_A^{coh} its internal cohesion and coherence — the holding together of its elements, their organized relation, and the integrity of its structure; Σ_A its susceptibility to each mode of influence; R_A^{cap} its capacity to absorb, buffer, redirect, repair, or regulate; Q_A its thresholds (Section 8.10); and $\mathcal{K}_A$ its kind, which distinguishes, for example, living from non-living response organization. Each component is a physically realized feature of A at s . The profile belongs to the internal basis $\mathcal{E}_A^{\text{int}}(s)$ and to the arguments of the application-specific composition map $\mathfrak{G}_A^{\text{phys}}$ (Eq. (148)); it is not a fourth causal-source class, and *responsiveness* is not a quantity that exists apart from the system.

Responsiveness is relative to the influence. A system may withstand one mode and yield to another: a material may withstand pressure and degrade under heat; a chemical system may be inert in one medium and reactive in another; a resonant system may remain bounded under one oscillatory influence and respond strongly near resonance:

$$\Sigma_A(\text{mode}_1) \text{ low} \not\Rightarrow \Sigma_A(\text{mode}_2) \text{ low}. \quad (146)$$

Where an application supplies an order on influence intensities and on realized change for a declared mode, cohesion and susceptibility act in opposite directions: other features held fixed, greater cohesion against that mode is accompanied by smaller realized change, and greater susceptibility by larger realized change. This is a qualitative relation within the declared application, not a universal law, and it never makes the realized change zero: under UCC the system continues to change whatever its cohesion.

8.10 Response classes and thresholds

Relative to a declared criterion and resolution, the change that an influence contributes to falls into one of five classes, separated by system-relative thresholds

$$Q_A = \{Q_A^{\text{det}}, Q_A^{\text{maint}}, Q_A^{\text{adapt}}, Q_A^{\text{dam}}, Q_A^{\text{fail}}\}. \quad (147)$$

1. *Below detection.* The contributed change is not resolved at the declared resolution. This is a limit of the record, not an absence of change: under UCC the system continues to change.
2. *Maintained change.* The system keeps its organization, function, or classification while continuing to change. Stability is maintained change within thresholds, not changelessness.
3. *Adaptive or regulatory change.* The system changes so as to preserve, restore, or modify its organization or viability, as in regulation, repair, or acclimatization.
4. *Damage.* The change leaves retained effects that reduce cohesion, capacity, or function while the identity persists; such effects become part of the presently embodied condition.
5. *Failure, transformation, or ending.* The change crosses the failure threshold, or cohesion falls below the minimum that the identity criterion requires; the system fails functionally, transforms, or ends. An ending is then governed by PIECP and the ending conditions; a successor exists only where a new identity is physically produced.

Thresholds are system-relative and criterion-relative; they are not universal constants. Because retained damage lowers cohesion and capacity, a small further influence may cross a threshold that earlier influences did not: a sudden failure after gradual change is a property of the system's response conditions, not of time.

8.11 Living and non-living response organization

The three causal-source classes and the responsiveness profile apply to living and non-living systems alike. What differs is the content of Θ_A , R_A^{cap} , Q_A , and $\mathcal{K}_A$. For a non-living system these include material composition, phase, bonding, rigidity, elasticity, brittleness, conductivity, and thermal, pressure, rotational, or orbital state. For a living system they include, in addition, physically realized regulatory, sensory, adaptive, and motor organization, and cognitive organization where present. These are physical properties of the living system itself, not external agencies and not exemptions from physical causation. Motor capacity is a property; motion is realized change when that capacity is exercised.

8.12 Qualitative causal composition and non-isolation of external influence

The three source classes are exhaustive at the framework-typing level: internal physical contributors, external influencing physical systems, and external influencing non-system physical factors. No fourth causal-source class is introduced. A particular change need not contain a member of every class, but its complete actual causal set must be nonempty under CRP.

The operative contributors may interact, combine, oppose, reinforce, attenuate, transform, gate, or condition one another in system-specific qualitative ways. ITOF therefore imposes no universal additive law in which a realized change is the arithmetic sum of independent factor effects. Where an application supplies an independently warranted causal-composition map, its generic role may be written schematically as

$$\Delta_A^{\text{phys}}(s) = \mathfrak{G}_A^{\text{phys}}\left(X_A(s); \mathcal{C}_A^{\text{int}}(s), \mathcal{C}_A^{\text{infl-sys}}(s), \mathcal{C}_A^{\text{infl-factor}}(s)\right), \quad (148)$$

where $\mathfrak{G}_A^{\text{phys}}$ is application-specific and is not a new universal ITOF law. Linearity, superposition, independence, or simple additivity may be used only when the applicable physics independently warrants them.

In physical reality influences do not act singly. The physical factors and influencing physical systems that act on a system at a stage act together, and their effects overlap and combine qualitatively with one another and with the internal basis of the system: one influence may reinforce, oppose, attenuate, transform, gate, or condition another. The change that an influence would produce alone is therefore an idealization of a model, defined only relative to the other influences held fixed, and the realized change is not in general the sum of such single-influence changes:

$$\Delta_A^{\text{phys}}(s) \neq \sum_{c \in \mathcal{C}_A^{\text{ext}}(s)} \Delta_{A|c}^{\text{phys}}(s) \quad \text{in general,} \quad (149)$$

where $\Delta_{A|c}^{\text{phys}}(s)$ denotes the change a model attributes to c acting alone. Simple additivity is admissible only where the applicable physics independently warrants it.

In particular, an external factor does not determine the realized change in isolation from the receiving physical system. Even where only one external source is identified, the consequence depends on the realized state, constitution, organization, coupling, boundary conditions, susceptibility, and other physically relevant features of A , collected in its responsiveness profile (Eq. (145)). Whether a particular element of that internal basis is entered explicitly in $\mathcal{C}_A^{\text{int}}(s)$ depends on the warranted causal model; the external source is never converted into a complete system-independent effect law merely by being named.

Thus a common external contributor can produce qualitatively different changes in distinct physical systems:

$$\begin{aligned} c \in \mathcal{C}_A^{\text{ext}}(s) \cap \mathcal{C}_B^{\text{ext}}(s), \quad A \neq B \\ \not\Rightarrow \Delta_A^{\text{phys}}(s) \equiv \Delta_B^{\text{phys}}(s). \end{aligned} \quad (150)$$

The difference may arise from physical-system identity, constitution, organization, present state, spatial relation, coupling strength, intensity and extent of exposure, internal coherence or stability, and presently embodied conditions produced by earlier change.

8.13 System-specific effect of external physical influence

Every member of $\mathcal{C}_A^{\text{ext}}(s)$ is an external source of physical influence on A . The source may be an influencing physical factor or an influencing physical system; its physical type does not change. The influence contributes to the physical change realized in A according to the applicable physics.

The resulting physical change is system-specific. Its physical form, magnitude, direction, or other measurable consequence is governed by the applicable dynamics, coupling, state, constitution, boundary conditions, and deterministic or stochastic structure of the receiving-system model. The term *response* is only an application-level description of that result; it is not an intermediate causal entity or a universal response law. Quantitative comparison across different systems requires physically justified comparison variables or a declared comparison map.

Where a physical or functional criterion is declared, the consequence may be classified relative to that criterion. Let $\mathfrak{J}_A^{\text{imp}}$ denote such an application-level impact criterion. When the physical evidence is sufficient for classification,

$$\text{Impact}_{\mathfrak{J}_A^{\text{imp}}}(c; A, s) \in \{\text{Supportive, Adverse, Mixed, Neutral}\}. \quad (151)$$

The terms *beneficial* and *harmful* may be used only where the declared criterion gives them a physically or functionally precise meaning; otherwise *supportive* and *adverse* are preferred. An unresolved classification is an epistemic status, not a fifth physical impact type. The same contributor may be supportive for one physical system and adverse for another, or may change classification with state, intensity, extent of exposure, coupling, internal coherence, or criterion; an influence supportive at moderate intensity may be adverse at extreme intensity. UCC asserts the actuality of system-specific change; it assigns no universal positive or negative sign to that change.

8.14 Actual physical contribution

Let:

$$\text{PhysicallyContributes} \left(c; \Delta_A^{\text{phys}}(s) \right) \quad (152)$$

mean that physically admissible contributor c makes an actual physical contribution to the system-specific physical change designated by $\Delta_A^{\text{phys}}(s)$.

For an actual-change pair:

$$c \in \mathcal{C}_A^{\text{act}}(s) \iff \text{PhysicallyContributes} \left(c; \Delta_A^{\text{phys}}(s) \right). \quad (153)$$

Membership in the actual causal set asserts physical contribution only. It does not by itself make c the sole, sufficient, deterministic, universally earlier, or complete causal explanation; any such stronger status requires an independently established physical model.

8.15 Quantum and stochastic physical models

Causal typing is fixed by the declared system boundary, not by whether the application model is classical, deterministic, stochastic, or quantum. Internal physical contributors belong to $\mathcal{C}_A^{\text{int}}(s)$; external physical influence is sourced by $\mathcal{C}_A^{\text{ext}}(s)$, whose members are influencing physical factors or influencing physical systems. A mathematical state, operator, channel, probability law, or Hamiltonian is not thereby a physical causal source.

Entanglement, correlation, or nonfactorization alone does not establish PhysicallyContributes. Causal membership requires an actual physical contribution whose attribution is independently warranted under the declared application model and system boundary. Conversely, an intrinsically stochastic description does not conflict with CRP merely because it lacks a deterministic sufficient antecedent: CRP requires a nonempty set of actual physical contributors, not a hidden variable, unique antecedent, or deterministic mechanism.

Accordingly, CRP is neutral with respect to whether the admitted transition law is deterministic or intrinsically stochastic. It constrains the existence and typing of actual physical contributors, not the uniqueness of an outcome conditioned on those contributors.

If a declared interpretation of a quantum process positively denies every actual physical contributor in $\mathcal{C}_A^{\text{int}}(s) \cup \mathcal{C}_A^{\text{ext}}(s)$ for a change that nevertheless satisfies $\text{PhysReal}_A^+(s)$, that application stands in direct tension with CRP. V39/F19 does not resolve such a tension by reclassifying probability, entanglement, the common cosmic stage, or time itself as a cause.

Interpretive scope and concrete examples.

V39/F19 does not classify a named quantum interpretation as globally “compatible” or “incompatible” merely from its label. The relevant application-level question is whether the declared quantum model supplies physically realized contributors that can be typed within $\mathcal{C}_A^{\text{int}}(s) \cup \mathcal{C}_A^{\text{ext}}(s)$ without reclassifying a state vector, probability law, operator, the common cosmic stage, or time itself as a physical cause.

A de Broglie–Bohm application provides one example of a quantum formulation with additional explicit physical variables and trajectories [52, 53]. Such variables may furnish candidates for application-level physical-contributor attribution where the declared system boundary and applicable dynamics warrant that attribution. This observation is not an endorsement of Bohmian mechanics, does not import its dynamics into ITOF, and does not establish compatibility with every ITOF commitment without a separate model-level analysis.

Environment-induced decoherence is treated differently. Decoherence is a physical open-system process or model structure, not by itself a complete interpretation of quantum mechanics, and it does not by itself settle the measurement problem [54]. Where an independently warranted system–environment interaction physically contributes to a realized change, that interaction may enter the appropriate causal set. Decoherence as a label, a reduced density matrix, or suppression of interference terms is not by itself a new causal-source type. Thus the limited claim of V39/F19 is interpretation-neutral: quantum applications are admissible when their physical ontology, dynamics, and causal attribution satisfy the declared ITOF typing conditions. ITOF neither derives quantum mechanics nor supplies a new quantum interpretation.

8.16 Causal Realization Principle

Postulate 8.1 (Causal Realization Principle (CRP)). Every actually realized system-specific physical change has a nonempty actual physical causal set:

$$\boxed{\text{CRP} \iff \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \text{PhysReal}_A^+(s) \implies \mathcal{C}_A^{\text{act}}(s) \neq \emptyset.} \quad (154)$$

The causal set is typed relative to the declared physical-system boundary. It contains actual internal physical contributors and/or external physical-influence sources. An external source may be an influencing physical factor or an influencing physical system; each retains its physical type. In a concrete application, attribution of the external influence must be warranted by the applicable physics. A descriptive property, model variable, or numerical parameter is not by itself a physical cause.

The realized effect remains system-specific and is realized according to the applicable physical dynamics and actual physical conditions of the receiving system. Time, the common cosmic stage, the earlier–later relation, a clock output, and the historical description of earlier change are not additional physical causes.

CRP is an independent foundational physical postulate; it is not derived from UCC, CMA, or the temporal definition. CRP and UCC have different functions:

$$\text{UCC} \implies \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \text{PhysReal}_A^+(s), \quad (155)$$

$$\text{CRP} \implies \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \text{PhysReal}_A^+(s) \implies \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \quad (156)$$

Thus:

$$\{\text{UCC}, \text{CRP}\} \vdash \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \text{PhysReal}_A^+(s) \wedge \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \quad (157)$$

CRP does not cause the physical changes whose causal realization it governs.

8.17 Unknown Cause Is Not Absent Causation

Epistemic incompleteness is not an additional causal category.

Thus:

$$\text{CauseNotIdentified}_{P,M}(A;s) \not\Rightarrow \mathcal{C}_A^{\text{act}}(s) = \emptyset. \quad (158)$$

An unresolved mechanism remains a scientifically incomplete causal account. The incompleteness is not converted into an untyped causal entity or treated as a complete causal explanation.

8.18 Common-stage causal-realization profile

For each admitted stage s , define:

Definition 8.2 (Common-Stage Causal-Realization Profile).

$$\mathfrak{G}_C(s) := (A \mapsto \mathcal{C}_A^{\text{act}}(s))_{A \in \mathcal{S}_{\text{phys}}(s)}. \quad (159)$$

This profile may contain an empty causal set in a dependency structure in which the relevant causal principle is not imposed.

In a governing V39/F19 realization satisfying UCC and CRP:

$$\{\text{UCC}, \text{CRP}\} \vdash \forall s \in \mathcal{S}_C^{\text{tot}} \forall A \in \mathcal{S}_{\text{phys}}(s), \quad \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \quad (160)$$

The existence of the causal-realization profile does not imply a common cause:

$$\text{Defined}(\mathfrak{G}_C(s)) \not\Rightarrow \exists c \forall A \in \mathcal{S}_{\text{phys}}(s), \quad c \in \mathcal{C}_A^{\text{act}}(s). \quad (161)$$

Nor does it imply one common causal mechanism:

$$\text{Defined}(\mathfrak{G}_C(s)) \not\Rightarrow \text{OneUniversalCausalMechanism}(s). \quad (162)$$

9. Complete-Population Physical Realization

9.1 Motivation and scope

V36/F16 [2] made complete-population physical-change coverage explicit. V37/F17 then introduced the dependent state, change, causal-realization, and complete physical-realization profiles used to represent that coverage without erasing system-specific typing. V39/F19 retains that architecture under its governing temporal-status discipline; it does not present the profile family as a new V39 ontological or representational primitive.

The incidence definitions identify the complete then-realized qualified population at each member of the common formal cosmic-stage domain. CMA makes that population co-present at the stage, while UCC independently requires system-specific actual physical-change realization in every member of that population and throughout each realized identity range. The retained profile architecture represents the corresponding population, state, change, and causal roles without redefining time or confusing these

definitionally distinct commitments.

9.2 Aligned domains in the governing theory

The state profile has domain:

$$\text{dom } \mathfrak{X}_C(s) = \mathcal{S}_{\text{phys}}(s). \quad (163)$$

The change profile has domain:

$$\text{dom } \mathfrak{D}_C(s) = \mathcal{B}_\Delta(s). \quad (164)$$

Under UCC the change profile has domain $\mathcal{S}_{\text{phys}}(s)$ (Eq. (114)). The causal-realization profile is indexed by $\mathcal{S}_{\text{phys}}(s)$, and under UCC plus CRP every indexed system has a nonempty actual causal set.

Therefore:

$$\begin{aligned} \text{dom } \mathfrak{X}_C(s) &= \mathcal{S}_{\text{phys}}(s), \\ \{\text{UCC}, \text{CRP}\} \vdash \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \text{dom } \mathfrak{D}_C(s) &= \mathcal{S}_{\text{phys}}(s), \\ \text{dom } \mathfrak{G}_C(s) &= \mathcal{S}_{\text{phys}}(s). \end{aligned} \quad (165)$$

With CSPP:

$$\{\text{CSPP}, \text{UCC}, \text{CRP}\} \vdash \forall s \in \mathcal{S}_C^{\text{tot}}, \quad \mathcal{S}_{\text{phys}}(s) \neq \emptyset. \quad (166)$$

CMA makes that population co-present at s ; UCC requires complete actual-change coverage of it.

9.3 Definition of the complete physical-realization profile

Definition 9.1 (Complete-Population Common-Stage Physical-Realization Profile). In a governing V39/F19 realization, define:

$$\boxed{\mathfrak{R}_C(s) := (\mathcal{S}_{\text{phys}}(s), \mathfrak{X}_C(s), \mathfrak{D}_C(s), \mathfrak{G}_C(s))}. \quad (167)$$

The profile is indexed by the complete admitted physical-system population $\mathcal{S}_{\text{phys}}(s)$ under the governing ontic systemhood and numerical-identity conditions. Its completeness is exactly completeness of representation over that population. It is not a claim to enumerate every constituent of $\mathcal{U}_C^{\text{phys}}$: physical factors are not converted into system-profile entries and appear only where an explicitly typed physical relation or causal contribution requires them. The profile supplies neither a universal system boundary nor a universal identity criterion, common state space, common change codomain, common causal mechanism, or exhaustive set of physical relations at s .

9.4 Illustrative typed physical instantiation

The following example is explanatory only. It introduces no new axiom, postulate, physical dynamics, system-boundary rule, identity criterion, or empirical claim. Consider two qualified physical clock systems $C, D \in \mathcal{S}_{\text{phys}}(s)$ in a governing realization satisfying UCC and CRP. Their stage-relative entries may be written as

$$X_C(s) \in \mathcal{X}_C, \quad \Delta_C^{\text{phys}}(s) \in \Xi_C, \quad \mathcal{C}_C^{\text{act}}(s) \neq \emptyset, \quad (168)$$

$$X_D(s) \in \mathcal{X}_D, \quad \Delta_D^{\text{phys}}(s) \in \Xi_D, \quad \mathcal{C}_D^{\text{act}}(s) \neq \emptyset. \quad (169)$$

By CMA (Eq. (74)), the complete then-realized qualified population containing C and D is co-present at s . Separately, UCC's complete actual-change burden requires actual physical change in every qualified system represented at that member; in this example it includes $\text{PhysReal}_C^+(s) \wedge \text{PhysReal}_D^+(s)$. Neither commitment requires $X_C(s) = X_D(s)$, identical change content, identical causal contributors, or identical later clock records. Distinct apparatus conditions, motion, gravitational environment, interrogation, and other independently specified physical dynamics may produce different mapped clock outputs while both physical clock systems remain members of the same common cosmic change stage. The example therefore instantiates the four profile roles without turning a clock output, proper-time functional, metric interval, or model parameter into the entity denoted by T_{TOF} . The quantitative clock branches in the later application sections supply the corresponding application-level laws and measurement maps.

The four components answer four distinct questions:

- (i) $\mathcal{S}_{\text{phys}}(s)$ identifies the complete qualified physical-system population whose numerical identities are realized at s ;
- (ii) $\mathfrak{X}_C(s)$ represents the system-specific physical states realized by that population;
- (iii) $\mathfrak{D}_C(s)$ represents the system-specific physical-change contents realized by that population under UCC;
- (iv) $\mathfrak{G}_C(s)$ represents the actual physical causal sets associated with those changes under CRP.

The profile is analytical and representational. It is not an additional physical substance existing alongside the systems.

Numerical-identity realization requires no fifth generic profile coordinate. At stage s , realization of numerical identity is already typed by $A \in \mathcal{S}_{\text{phys}}(s) \iff s \in I_A$, while formation, ending, and successor attribution are governed separately by the identity-history and lifecycle architecture. A universal $\text{IdentityStatus}_A(s)$ therefore does not follow from the foundational profile and would require an independently defined physical role.

9.5 Projection structure and conservative content

The four defining components are recoverable by canonical projections:

$$\pi_{\text{pop}}(\mathfrak{R}_C(s)) = \mathcal{S}_{\text{phys}}(s), \quad (170)$$

$$\pi_{\text{state}}(\mathfrak{R}_C(s)) = \mathfrak{X}_C(s), \quad (171)$$

$$\pi_{\text{change}}(\mathfrak{R}_C(s)) = \mathfrak{D}_C(s), \quad (172)$$

$$\pi_{\text{cause}}(\mathfrak{R}_C(s)) = \mathfrak{G}_C(s). \quad (173)$$

Accordingly, once the four components are fixed, the profile introduces no additional independent degree of freedom:

$$\text{ComponentsFixed}(\mathcal{S}_{\text{phys}}(s), \mathfrak{X}_C(s), \mathfrak{D}_C(s), \mathfrak{G}_C(s)) \implies \text{ProfileUniquelyFixed}(\mathfrak{R}_C(s)). \quad (174)$$

This is the formal sense in which the V37/F17 profile, retained and in V39/F19 is an integrating construction rather than an ontological primitive.

9.6 Relational augmentation without temporal enlargement

Population, state, change, and causal-set coverage do not exhaust every physically admissible relation among then-realized systems. For a declared physical model M , let

$$\mathcal{R}_M(s) \quad (175)$$

denote the independently warranted stage-relative family of additional physical relations used by that model, such as interaction, constraint, correlation, composition, or coupling relations. A model-relative augmentation is defined by

$$\mathfrak{R}_C^{[M]}(s) := (\mathfrak{R}_C(s), \mathcal{R}_M(s)). \quad (176)$$

The augmentation is application-level and is permitted only where the added relations are physically typed and independently warranted. It neither changes the population-completeness meaning of the foundational profile nor enlarges the temporal referent:

$$\mathfrak{R}_C^{[M]}(s) \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad \mathfrak{R}_C^{[M]}(s) \not\equiv_{\text{type}} \text{TemporalComponent}. \quad (177)$$

Different admissible physical models may therefore enrich the relational content associated with the same common cosmic change stage without generating different times or changing the V39/F19 definition of time.

9.7 Population completeness and representational scope

Completeness refers to the domain of qualified systems represented at the stage:

$$\text{ProfileDomain}(\mathfrak{R}_C(s)) = \mathcal{S}_{\text{phys}}(s). \quad (178)$$

It neither asserts physical uniformity nor exhausts every physically admissible relation among the systems:

$$\text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) \not\Rightarrow \text{ExhaustivePhysicalDescriptionAt}(s). \quad (179)$$

In particular:

$$\begin{aligned} \text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) &\not\Rightarrow \text{OneUniversalState}, \\ \text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) &\not\Rightarrow \text{OneUniversalChangeContent}, \\ \text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) &\not\Rightarrow \text{OneUniversalCausalSet}. \end{aligned} \quad (180)$$

The same non-entailment applies to a universal change magnitude, change rate, or physical mechanism. The relational augmentation of Eq. (176) supplies the model-level location for additional interaction, constraint, correlation, composition, or coupling relations. Stage unity, population completeness, physical multiplicity, and model-relative relational enrichment are therefore mutually consistent without altering temporal identity.

9.8 The realization profile is not time

The complete-population common-stage physical-realization profile is not a new temporal component:

$$\mathfrak{R}_C(s) \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (181)$$

Nor is:

$$\mathfrak{R}_C(s) \not\equiv_{\text{type}} s. \quad (182)$$

Nor does V39/F19 redefine time by adjoining the realization-profile family:

$$T_{\text{ITOF}} \not\equiv_{\text{def}} \left(\mathcal{S}_C^{\text{tot}}, \prec_C, \{\mathfrak{R}_C(s)\}_{s \in \mathcal{S}_C^{\text{tot}}} \right). \quad (183)$$

The governing time definition remains Eq. (11); the realization-profile family is not appended to that ordered pair.

The physical-realization profiles belong to the physical architecture associated with the common cosmic stages; they are not contents placed inside a temporal or cosmic container.

9.9 Population Completeness versus Epistemic Access

The complete profile is not claimed to be completely measurable or reconstructible by any observer.

Thus:

$$\text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) \not\Rightarrow \text{CompleteObservation}(\mathfrak{R}_C(s)). \quad (184)$$

And:

$$\text{CompletePopulationCoverage}(\mathfrak{R}_C(s)) \not\Rightarrow \text{CompleteScientificKnowledge}(\mathfrak{R}_C(s)). \quad (185)$$

The distinction is ontological–epistemic and does not depend on observational completeness.

9.10 Full-profile consequences under CMA, UCC, and CRP

The complete-population physical-realization profile is already defined by its population, state, change, and causal components. No additional realization predicate is required. Under temporal admissibility, CMA, UCC, and CRP, the governing stage-relative conditions are:

$$\begin{aligned} & \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{CMA} \wedge \text{UCC} \wedge \text{CRP} \\ & \implies \forall s \in \mathcal{S}_C^{\text{tot}}, \\ & \mathcal{S}_{\text{phys}}(s) \neq \emptyset \wedge \text{SCB}_C(s), \\ & \forall A \in \mathcal{S}_{\text{phys}}(s), \quad \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \end{aligned} \quad (186)$$

This is a derived consequence of already declared commitments, not a new layer or independent foundational predicate. The common formal cosmic-stage domain supplies the formal stage domain; CMA supplies objective common-stage co-presence; UCC supplies complete system-specific actual-change coverage; and CRP supplies nonempty physical causal realization for every actual-change pair.

10. Hierarchy, Composition, and Type Boundaries

The transition to composition is required by the scope of the realization commitments rather than by any claim that time itself is hierarchical. CSPP, CMA, and UCC quantify over qualified numerical physical-system identities, while many physical applications involve composites, constituents, and independently qualified subsystems sharing the same common cosmic stage. Before a universal population statement can

be applied across such levels, the framework must specify when two identified systems stand in a genuine physical constituent relation and which cross-level inferences are warranted. Without that discipline, mere co-membership in $\mathcal{S}_{\text{phys}}(s)$, spatial inclusion, or material overlap could be mistaken for numerical identity, composition, causal determination, or inherited change. Accordingly, the hierarchy module types the physical-system granularity needed by the realization architecture; it does not add a hierarchical component to T_{ITOF} .

10.1 Why composition requires an explicit physical criterion

Physical reality may support several scientifically legitimate system boundaries at different organizational levels. This level-relativity concerns system individuation, not the objectivity of physical realization. A subsystem and a composite can therefore both be qualified physical-system identities when each independently satisfies the appropriate physical criteria.

Simple and composite systems must be distinguished. A simple qualified system need not be decomposable into qualified subsystems. A composite qualified system requires a physically real relation among its elements: the governing criterion must establish both interconnection and coherence at the composite level. Accordingly, a composite criterion may be represented by

$$\kappa_{\text{comp}} = (\kappa_{\text{interconnection}}, \kappa_{\text{coherence}}). \quad (187)$$

Interconnection requires physically operative relations among the relevant constituents; mere spatial proximity is insufficient. Coherence requires that those relations support the composite as a distinguishable physical unity with system-level properties and persistence conditions; mere co-location or set membership is insufficient. The precise physical realization of these criteria is class-specific and may be structural, dynamical, organizational, or another scientifically warranted form.

A physical system may contain constituents, subsystems, components, organized substructures, or other independently identifiable physical-system identities. V39/F19 does not infer numerical identity or composition merely from linguistic description, material overlap, spatial inclusion, or analytical convenience. Composition therefore requires a declared physically warranted criterion κ consistent with the system class and granularity fixed for the application.

10.2 Stage-relative constituent relation

For $A, B \in \mathcal{U}_{\text{phys}}$, define:

$$A \triangleleft_{\kappa, s} B \quad (188)$$

to mean that, under declared physical composition criterion κ , the independently qualified numerical physical-system identity A is physically realized as a proper constituent or subsystem of numerical physical-system identity B at common cosmic change stage s .

The typing requirement is:

$$A \triangleleft_{\kappa, s} B \implies A, B \in \mathcal{S}_{\text{phys}}(s) \wedge A \neq B. \quad (189)$$

The relation concerns simultaneously realized physical identities. Ending or failure of a qualified constituent does not by itself end the composite identity:

$$A \triangleleft_{\kappa, s} B \wedge \text{End}_A(e_A) \not\Rightarrow \text{End}_B(e_B). \quad (190)$$

The composite ends only when the applicable composite identity criterion—in particular its required interconnection and coherence conditions—is no longer satisfied at the composite level.

It does not make a constituent a state of the composite:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow A \equiv_{\text{type}} X_B(s). \quad (191)$$

Nor does it erase the constituent's own identity history.

10.3 Composition profile

Define:

$$\mathfrak{R}_C(s) := \{(A, B, \kappa) \mid A \triangleleft_{\kappa,s} B\}. \quad (192)$$

This profile records declared stage-relative constituent relations among qualified physical-system identities.

The definition of the composition profile does not impose one unique hierarchy or one universal tree of systems:

$$\text{Defined}(\mathfrak{R}_C(s)) \not\Rightarrow \text{OneUniqueHierarchy}(s), \quad (193)$$

$$\text{Defined}(\mathfrak{R}_C(s)) \not\Rightarrow \text{OneUniversalTreeOfSystems}(s). \quad (194)$$

Likewise, V39/F19 does not universally postulate transitivity of $\triangleleft_{\kappa,s}$. From composition membership alone, without an additional closure condition on the declared criterion κ , the transitive conclusion is not a V39/F19 consequence:

$$A \triangleleft_{\kappa,s} B \wedge B \triangleleft_{\kappa,s} C \not\Rightarrow A \triangleleft_{\kappa,s} C. \quad (195)$$

A domain-specific composition criterion may independently impose transitivity. Where

$$\text{TransitiveCompositionCriterion}(\kappa; \mathcal{A}) \quad (196)$$

is independently warranted for system class $\mathcal{A}$, the corresponding application may infer the transitive relation within that declared domain. No framework-wide transitivity follows without that additional premise.

10.4 Constituents Are Not Automatically Systems

A physical component within the boundary of B need not automatically be a member of $\mathcal{U}_{\text{phys}}$.

Therefore:

$$\text{PhysicalConstituentOf}(x, B; s) \not\Rightarrow x \in \mathcal{U}_{\text{phys}}. \quad (197)$$

The relation

$$A \triangleleft_{\kappa,s} B \quad (198)$$

is reserved for a constituent that independently satisfies the qualified physical-system identity requirements.

This prevents arbitrary decomposition from producing an unlimited collection of nominal systems merely by description.

10.5 UCC at each independently qualified system level

If:

$$A \triangleleft_{\kappa,s} B, \quad (199)$$

then:

$$A, B \in \mathcal{S}_{\text{phys}}(s). \quad (200)$$

Under UCC:

$$A \triangleleft_{\kappa,s} B \wedge \text{UCC} \implies \text{PhysReal}_A^+(s) \wedge \text{PhysReal}_B^+(s). \quad (201)$$

These are two system-specific physical-change realizations.

The result does not imply:

$$A \triangleleft_{\kappa,s} B \wedge \text{UCC} \not\Rightarrow \Delta_A^{\text{phys}}(s) = \Delta_B^{\text{phys}}(s). \quad (202)$$

Nor does it imply:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow \Xi_A = \Xi_B. \quad (203)$$

10.6 Cross-Level Non-Transfer Principle

Principle 10.1 (Cross-Level Non-Transfer Principle). Physical composition does not by itself transfer a physical state, change content, causal description, or numerical identity from one qualified system level to another.

Formally:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow \text{PhysicallyDetermines}_{\kappa} \left(\Delta_A^{\text{phys}}(s); \Delta_B^{\text{phys}}(s) \right). \quad (204)$$

Likewise:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow \text{PhysicallyDetermines}_{\kappa} \left(\Delta_B^{\text{phys}}(s); \Delta_A^{\text{phys}}(s) \right). \quad (205)$$

Here $\text{PhysicallyDetermines}_{\kappa}$ is not a newly assumed physical relation. It denotes whatever specific cross-level physical dependence an application would need to establish.

The principle therefore states that composition alone supplies no such dependence.

10.7 Composite Change Is Not a Universal Sum

Even where qualified constituents

$$A_1, \dots, A_n$$

are physically realized within composite B , composition alone does not imply an additive change law:

$$\left[\bigwedge_{i=1}^n A_i \triangleleft_{\kappa_i,s} B \right] \not\Rightarrow \Delta_B^{\text{phys}}(s) = \sum_{i=1}^n \Delta_{A_i}^{\text{phys}}(s). \quad (206)$$

Such an expression may be mathematically ill typed because:

$$\Xi_{A_i} \neq \Xi_{A_j} \quad (207)$$

may hold and no universal addition operation is supplied.

A valid cross-level quantitative model requires its own physical variables, mapping rules, coupling relations, aggregation rules, and empirical warrant.

10.8 Hierarchical causation

Where $A \triangleleft_{\kappa,s} B$, A lies within the declared physical boundary of B under criterion κ .

A physically operative contribution associated with that constituent is therefore treated through the internal physical basis of B under the applicable causal attribution.

It is not converted into an influencing physical-system contribution merely because A also possesses an independently qualified physical-system identity.

Thus the causal classification depends jointly on:

$$\langle \text{NumericalIdentity}, \text{DeclaredSystemBoundary}, \text{PhysicalCausalRole} \rangle. \quad (208)$$

The same physical reality may therefore be described under distinct legitimate system boundaries without collapsing those boundaries or counting one contributor twice within one declared causal attribution.

10.9 Hierarchy does not divide the common cosmic stage

If:

$$A \triangleleft_{\kappa,s} B, \quad (209)$$

both identities are realized at the same common cosmic change stage s .

The constituent does not possess a lower-level time while the composite possesses a higher-level time.

Thus:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow \text{PrivateTime}(A) \vee \text{PrivateTime}(B). \quad (210)$$

Hierarchy belongs to physical organization, not to multiplication of temporal orders.

11. Numerical Identity and Formation Boundaries

11.1 Governing identity notion

Unless an application explicitly declares another domain-specific identity notion, V39/F19 uses numerical physical-system identity. Here *numerical identity* means identity of the physical system itself: whether two stage-indexed realizations concern one and the same physical system. It does not mean a numerical identifier, a stage number, a coordinate, a metric value, or an assigned ordinal.

The relevant question is:

$$\text{IsThisTheSamePhysicalSystem?} \quad (211)$$

rather than:

$$\text{DoesThisSystemHaveTheSameState?} \quad (212)$$

Accordingly:

$$\text{SameNumericalIdentity}_A(r, s) \not\Rightarrow X_A(r) = X_A(s). \quad (213)$$

Identity persistence is compatible with physical change.

11.2 Class-indexed physical-system identity qualification

V39/F19 does not postulate one universal empirical numerical-identity criterion for every physical-system class. For each declared class $\mathcal{K}$, define an application-level identity-qualification profile

$$\mathfrak{Q}_{\mathcal{K}}^{\text{id}} := (\kappa_{\text{sys}}, \kappa_{\text{boundary}}, \kappa_{\text{id}}, \kappa_{\text{persist}}, \kappa_{\text{form}}, \kappa_{\text{end}})_{\mathcal{K}}. \quad (214)$$

The components specify, respectively, physical-system qualification, system boundary, numerical identity, persistence, formation, and ending for the declared class and organizational granularity. Physical realization is objective; the selection and tracking of a system identity are level- and criterion-relative within that objective physical organization, not observer-subjective or arbitrary. For composite systems, κ_{sys} and the persistence and ending criteria must include the physically warranted interconnection and coherence conditions appropriate to the composite level. These are application-level physical criteria. They are not supplied by time, CMA, or UCC.

For an empirical or model-based protocol P , identity application is admissible only if the profile is fixed prospectively before outcome interpretation, internally consistent, physically warranted for the declared class, and applicable to the system under study:

$$\begin{aligned} & \text{IdentityApplicationAdmissible}(A; \mathcal{K}, P) \\ \implies & \text{PredeclaredAndFrozen}(\mathfrak{Q}_{\mathcal{K}}^{\text{id}}, P) \\ & \wedge \text{InternallyConsistent}(\mathfrak{Q}_{\mathcal{K}}^{\text{id}}) \\ & \wedge \text{PhysicallyWarrantedForClass}(\mathfrak{Q}_{\mathcal{K}}^{\text{id}}, \mathcal{K}) \\ & \wedge \text{DomainApplicable}(\mathfrak{Q}_{\mathcal{K}}^{\text{id}}, A, P). \end{aligned} \quad (215)$$

These are necessary admissibility conditions, not a universal sufficiency claim; a physical domain may require additional criteria.

Prospective freezing is protocol-relative rather than permanent. It forbids changing the system boundary or identity criterion after observing the outcome of P in order to manufacture or rescue an attribution. It does not forbid later science from adopting a better physically warranted profile in a new protocol P' :

$$\text{FrozenFor}(\mathfrak{Q}_{\mathcal{K}}^{\text{id}}, P) \not\Rightarrow \text{PermanentlyImmutableAcrossFutureProtocols}. \quad (216)$$

Application admissibility must also be distinguished from the admissibility of a specific identity attribution. For an attribution type $\chi \in \{\text{persistence, formation, ending, successor}\}$, require

$$\begin{aligned} & \text{IdentityAttributionAdmissible}(A; \mathcal{K}, P, \chi) \\ \implies & \text{IdentityApplicationAdmissible}(A; \mathcal{K}, P) \\ & \wedge \text{SatisfiesRelevantIdentityCriterion}(A; \mathcal{K}, P, \chi). \end{aligned} \quad (217)$$

A sound profile does not by itself establish that formation, persistence, ending, or successor production actually occurred; the relevant evidence or model output must satisfy the corresponding criterion.

11.3 Material continuity is not sufficient for numerical identity

A later system may:

$$\begin{aligned} &\text{contain earlier constituents,} \quad \text{contain transferred matter,} \quad \text{occupy a similar region,} \\ &\text{perform a similar function,} \quad \text{or resemble an earlier system} \end{aligned} \quad (218)$$

without being numerically identical to that earlier system.

Hence:

$$\text{MaterialOverlap}(A, B) \not\Rightarrow A = B. \quad (219)$$

And:

$$\text{FunctionalEquivalence}(A, B) \not\Rightarrow A = B. \quad (220)$$

The applicable physical identity criterion governs the attribution.

11.4 Identity-Realization Convexity

Postulate 11.1 (Identity-Realization Convexity). For every $A \in \mathcal{U}_{\text{phys}}$ and all $r, s, t \in \mathcal{S}_C^{\text{tot}}$:

$$\boxed{r \in I_A \wedge t \in I_A \wedge r \prec_C s \wedge s \prec_C t \implies s \in I_A.} \quad (221)$$

Identity-Realization Convexity is an independent foundational identity postulate. It prevents an internal gap in one numerical physical-system identity; with UCC it secures the uninterrupted change of every physical system of the universe (Eq. (86)).

Equivalently:

$$r, t \in I_A \wedge r \prec_C s \prec_C t \implies \neg(s \notin I_A). \quad (222)$$

Identity-Realization Convexity imposes no metric duration, stage count, equal-stage spacing, state constancy, or change-magnitude constancy. It constrains only membership continuity of one numerical identity in the universal order.

11.5 Actual Formation Boundary

Postulate 11.2 (Actual Formation Boundary (AFB)). For every qualified physical-system identity, its realized identity range $I_A \subseteq \mathcal{S}_C^{\text{tot}}$ has one unique least member with respect to the one common cosmic ordering $\prec_C$:

$$\boxed{\text{AFB} \iff \forall A \in \mathcal{U}_{\text{phys}} \exists! f \in I_A [\nexists r \in I_A (r \prec_C f)]}. \quad (223)$$

The member f_A is the formation boundary of numerical identity A inside the same universal cosmic-stage domain used by every qualified system. It is not a private first time for A , does not imply Cosmic Origin, and does not make the common stage a container in which the system is placed. Under UCC, A realizes actual system-specific physical change at its formation boundary f_A . Where independently warranted physics identifies a physical formation process at that boundary, that process may constitute or contribute to the realized formation change. AFB and UCC alone do not determine the formation mechanism or causal contributor. A prior member of the same numerical identity range is not required.

AFB is an independent identity-range postulate. Its universal quantification over $\mathcal{U}_{\text{phys}}$ is a foundational burden, not a consequence established by the temporal definition, CMA, UCC, or the non-termination

hypothesis. Empirical application to a declared system class still requires independently warranted identity-qualification criteria. AFB constrains only the lower boundary of each realized identity range within the one common cosmic-stage domain. The least member belongs to that same cosmic-stage domain. The incidence definitions identify the qualified population whose identity ranges contain that member; CMA, not incidence alone, supplies objective common-stage co-presence of that population. It is not a system-private stage, does not mark the beginning of physical change in the cosmic succession, and does not introduce any priority of one system's change over another system's change at the same common cosmic stage.

The asymmetry between AFB and optional UEIE is therefore an asymmetry of identity-range commitments, not of physical-change realization. AFB postulates a least member for every declared qualified identity range. UEIE would add the additional universal claim that every such identity range also possesses an ending member. Nothing in the temporal definition, CMA, UCC, or AFB entails that universal ending claim; UEIE accordingly remains an optional lifecycle postulate requiring independent physical warrant for the declared system domain.

Let the unique least member be:

$$f_A. \quad (224)$$

Define:

$$f : \mathcal{U}_{\text{phys}} \longrightarrow \mathcal{S}_C^{\text{tot}}, \quad f(A) = f_A. \quad (225)$$

Within AFB, formation denotes realization of the physical-system identity at the least member f_A of its identity range in the one common cosmic-stage domain. This is an identity-boundary statement. It neither introduces a private stage for A nor defines an onset of physical change in the cosmic succession.

For every $r \in \mathcal{S}_C^{\text{tot}}$:

$$r \prec_C f_A \implies \neg \text{ExistsAs}(A, r). \quad (226)$$

Equation (226) is an identity-incidence statement only: if $r \prec_C f_A$, then $r \notin I_A$. It does not imply absence of other qualified systems, influencing physical factors, or physical change at r . Other qualified physical systems realized at such stages may possess their own identity-bounded histories. Physical factors may be realized or influential there without thereby acquiring a system identity range or a system history.

11.6 Formation change

Formation change denotes the system-specific physical change realized at the common cosmic stage f_A at which the identity range of A has its least member. It is not a private or system-specific stage, is not the beginning of physical change in the common succession, and is not defined as a finite difference between two states of a pre-existing A .

Define:

$$\text{FormationChange}_A(s) \iff s = f_A \wedge \text{PhysReal}_A^+(s). \quad (227)$$

AFB and UCC give:

$$\{\text{AFB}, \text{UCC}\} \vdash \forall A \in \mathcal{U}_{\text{phys}}, \quad \text{FormationChange}_A(f_A). \quad (228)$$

This conclusion assigns no priority to formation change relative to changes of other qualified systems realized at f_A . By UCC, every $B \in \mathcal{S}_{\text{phys}}(f_A)$ satisfies $\text{PhysReal}_B^+(f_A)$ at that same common stage.

The causal contributors to formation change remain physical contributors in the sense of CRP; T_{TOF} , f_A ,

$\prec_C$, CMA, and UCC are not additional causal-source classes.

Under UCC and CRP:

$$\{\text{AFB}, \text{UCC}, \text{CRP}\} \vdash \forall A \in \mathcal{U}_{\text{phys}}, \quad \mathcal{C}_A^{\text{act}}(f_A) \neq \emptyset. \quad (229)$$

11.7 Formation does not imply cosmic origin

AFB concerns identity-range boundaries within the one common cosmic-stage domain. Different values of f_A and f_B , where they differ, are different members of that same domain; they are not private stages belonging to different systems.

Therefore:

$$\text{AFB} \not\Rightarrow \text{CosmicOrigin}. \quad (230)$$

The least common stage of $\mathcal{S}_C^{\text{tot}}$ is fixed by the Cosmic Origin postulate (Eq. (41)), not by the formation boundary of any system.

12. Identity-Bounded Physical Histories

12.1 History domain

Each qualified numerical physical-system identity has a physical history only over the common cosmic change stages at which that identity is realized:

$$I_A \subseteq \mathcal{S}_C^{\text{tot}}. \quad (231)$$

The restriction:

$$\prec_C|_{I_A} \quad (232)$$

does not create a new ordering relation. It is the restriction of the same one universal cosmic ordering to the identity-realization range of A .

Thus:

$$\text{OrderOfHistory}(A) = \prec_C|_{I_A}. \quad (233)$$

No independent private ordering is introduced for A .

12.2 Formal physical-history representation

In a governing V39/F19 realization, UCC gives:

$$I_A^\Delta = I_A. \quad (234)$$

Therefore the physical-change-content map is well typed throughout the realized identity range.

Define:

$$\mathcal{H}_A := \left(I_A, \prec_C|_{I_A}, X_A, \Delta_A^{\text{phys}} \right). \quad (235)$$

$\mathcal{H}_A$ is a formal representation of the actual physical history of A . It is not the actual physical system and is not the temporal referent.

Hence:

$$\mathcal{H}_A \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (236)$$

And:

$$\mathcal{H}_A \not\equiv_{\text{type}} A. \quad (237)$$

12.3 Many physical histories within one cosmic extension

V39/F19 assigns one system-indexed physical history representation $\mathcal{H}_A$ to each qualified physical-system identity $A \in \mathcal{U}_{\text{phys}}$. There is no single physical system-history that replaces this family: the physical histories are as system-specific as the identities that bear them, without any claim that their total cardinality is presently known. The framework does not assign a private temporal succession to any of them. Every history is restricted from the same universal ordering through its own identity range.

For distinct qualified systems:

$$A \neq B \Rightarrow \mathcal{H}_A = \mathcal{H}_B. \quad (238)$$

Their identity domains may overlap:

$$I_A \cap I_B \neq \emptyset. \quad (239)$$

At every shared member:

$$s \in I_A \cap I_B \quad (240)$$

the systems share the same common cosmic change stage s , while retaining distinct physical states, change contents, causal profiles, and numerical identities.

Thus:

$$\text{ManyPhysicalHistories} \Rightarrow \text{ManyTimes}. \quad (241)$$

12.4 Hierarchical histories

If:

$$A \triangleleft_{\kappa, s} B, \quad (242)$$

both A and B possess their own identity-bounded physical histories.

The history of the constituent is not established as a subhistory of the composite merely because the constituent lies physically within the composite at s . In particular, stage-relative composition alone does not entail containment of the constituent's entire identity range within the composite's identity range:

$$A \triangleleft_{\kappa, s} B \not\Rightarrow I_A \subseteq I_B. \quad (243)$$

The system histories may overlap in common cosmic change-stage domain while remaining numerically and physically distinct.

12.5 History recurrence and persistence

For $r, s \in I_A$ with:

$$r \prec_C s, \quad (244)$$

it is possible for a declared state criterion K_A to satisfy:

$$K_A(X_A(r), X_A(s)) = \text{Equivalent}. \quad (245)$$

The later physical realization remains later (Eq. (26)); state recurrence does not constitute historical reversal.

13. Historical Accumulation and Present Resultant

13.1 Strictly earlier identity history

For $A \in \mathcal{U}_{\text{phys}}$ and $s \in I_A$, define:

$$I_A^{<s} := \{r \in I_A \mid r \prec_C s\}. \quad (246)$$

Under UCC:

$$\text{UCC} \wedge I_A^{<s} \neq \emptyset \implies \forall r \in I_A^{<s}, \quad \text{PhysReal}_A^+(r). \quad (247)$$

This establishes actual earlier system-specific physical change without assigning a metric duration, stage count, or universal cumulative magnitude.

13.2 Historical Physical Accumulation

Definition 13.1 (Historical Physical Accumulation). For $A \in \mathcal{U}_{\text{phys}}$ and $s \in I_A$ with $I_A^{<s} \neq \emptyset$, the expression

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \quad (248)$$

designates the totality of system-specific physical change actually realized strictly earlier than s in the physical history of A .

The designation is historical.

It is not defined as:

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\text{def}} \sum_{r \in I_A^{<s}} \Delta_A^{\text{phys}}(r). \quad (249)$$

No universal addition operation across physical-change contents is assumed.

Historical accumulation is also not identical to the formal earlier-history representation:

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\text{def}} \mathcal{H}_A^{<s}. \quad (250)$$

13.3 The physical past is not a stored present object

Historical physical accumulation is not a present physical object:

$$\neg \text{PresentPhysicalObjectAt}(\text{HistoricalPhysicalAccumulation}_A^{<s}; s). \quad (251)$$

Nor is it an additional causal-source class:

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\text{type}} \text{PhysicalCausalContributor}. \quad (252)$$

This does not deny persistence of physical effects. It distinguishes an earlier physical occurrence from the present physical embodiment of an effect produced by that occurrence.

13.4 Persistence and transformation of earlier effects

Earlier physical change may produce effects that:

$$\begin{aligned} &\text{persist, transform, combine, diminish,} \\ &\text{intensify, be compensated, or cease to remain embodied.} \end{aligned} \quad (253)$$

Therefore:

$$\text{EarlierChangeOccurred}(A; r) \wedge r \prec_C s \not\Rightarrow \text{EarlierEffectStillEmbodied}(A; r; s). \quad (254)$$

Where an earlier effect remains physically embodied at s , that embodiment belongs to the present developed condition:

$$X_A(s). \quad (255)$$

Where it is presently causally operative, its present physical role belongs to the appropriate current causal-source class.

No past object acts from an earlier common cosmic change stage as an additional causal source at s .

13.5 Present cumulative physical resultant

Let:

$$\text{EmbodiedEarlierEffects}_A(X_A(s); s) \quad (256)$$

state that retained or transformed effects originating in earlier realized physical change remain physically embodied in the present condition $X_A(s)$.

Definition 13.2 (Present Cumulative Physical Resultant).

$$\text{CumulativePhysicalResultThrough}_A(s) \iff \text{EmbodiedEarlierEffects}_A(X_A(s); s). \quad (257)$$

This is a truth-valued statement about the present developed physical condition. It does not introduce a new physical object or state variable.

Thus:

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\text{def}} \text{CumulativePhysicalResultThrough}_A(s). \quad (258)$$

And:

$$\begin{aligned} &\text{PairwiseDefDistinct} \left(\mathcal{H}_A^{<s}, \text{HistoricalPhysicalAccumulation}_A^{<s}, \right. \\ &\quad \left. \text{CumulativePhysicalResultThrough}_A(s) \right). \end{aligned} \quad (259)$$

13.6 UCC does not imply retained effects

UCC requires actual physical change.

It does not require every effect of earlier physical change to remain physically embodied.

Therefore:

$$I_A^{<s} \neq \emptyset \wedge \text{UCC} \not\Rightarrow \text{CumulativePhysicalResultThrough}_A(s). \quad (260)$$

Likewise:

$$\text{UCC} \not\Rightarrow \text{MonotonicCumulativeGrowth}(A). \quad (261)$$

No universal accumulation scalar, common accumulation unit, or cross-system ranking follows from UCC.

14. Identity Ending as Final Transformation

14.1 Identity-ending transformation

Let:

$$\text{IdentityEndingTransformation}(A; e) \quad (262)$$

denote the local primitive physical classification that the transformation physically realized in A at e satisfies the applicable numerical physical-system identity-ending criterion.

This local predicate does not itself quantify over all later common cosmic change stages. Functional failure, last observation, loss of usefulness, loss of a selected property, or destruction of one constituent is not by itself an identity-ending transformation. Any such condition constitutes identity ending only where the applicable physical identity criterion establishes cessation of the numerical identity itself.

14.2 Definition of physical-system identity ending

Definition 14.1 (Physical-System Identity Ending). For $A \in \mathcal{U}_{\text{phys}}$ and $e \in \mathcal{S}_C^{\text{tot}}$:

$$\boxed{\text{End}_A(e) \iff e \in I_A \wedge \text{IdentityEndingTransformation}(A; e) \wedge \forall t \in \mathcal{S}_C^{\text{tot}} (e \prec_C t \implies t \notin I_A).} \quad (263)$$

The ending stage e is the final member of the identity-realization range of A .

It is not thereby a final stage of the cosmic extension; coincidence with a greatest cosmic stage, if one exists, is a separate cosmological possibility.

Thus:

$$\text{End}_A(e) \wedge \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \exists t \in \mathcal{S}_C^{\text{tot}}, \quad e \prec_C t. \quad (264)$$

14.3 UCC remains active at the ending boundary

From:

$$\text{End}_A(e) \implies e \in I_A, \quad (265)$$

UCC gives:

$$\text{End}_A(e) \wedge \text{UCC} \implies \text{PhysReal}_A^+(e). \quad (266)$$

The system does not first become physically static and then end outside its own physical development.

Define:

$$\Delta_A^{\text{end}}(e) := \Delta_A^{\text{phys}}(e), \quad \text{when } \text{End}_A(e) \wedge \text{UCC}. \quad (267)$$

The superscript end classifies the system-specific physical-change content relative to the identity boundary.

It does not introduce a separate type of change:

$$\Delta_A^{\text{end}}(e) \not\equiv_{\text{type}} \text{IndependentTerminalProcess}. \quad (268)$$

14.4 Uniqueness of ending

Proposition 14.2 (Uniqueness of Identity Ending). Under Strict Cosmic Ordering:

$$\begin{aligned} \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \vdash \forall A \in \mathcal{U}_{\text{phys}} \forall e_1, e_2 \in \mathcal{S}_C^{\text{tot}}, \\ \text{End}_A(e_1) \wedge \text{End}_A(e_2) \implies e_1 = e_2. \end{aligned} \quad (269)$$

If two distinct ending members were assumed, strict total ordering would place one earlier than the other. The earlier ending condition would then exclude the same numerical identity from the later member.

14.5 Functional failure remains distinct from ending

For any declared functional criterion Γ :

$$\text{FunctionalFailure}_{\Gamma}(A; s) \not\Rightarrow \text{End}_A(s). \quad (270)$$

Conversely:

$$\text{End}_A(e) \not\Rightarrow \text{FunctionalFailure}_{\Gamma}(A; e). \quad (271)$$

A system may retain its numerical identity while damaged, inactive, diseased, inefficient, or non-operational.

An identity may also end through transformation, division, fusion, merger, absorption, dissolution, or reorganization without an independently identified earlier functional-failure stage.

14.6 Ending and earlier physical history

Where:

$$I_A^{<e} \neq \emptyset \quad (272)$$

and:

$$\text{End}_A(e) \wedge \text{UCC}, \quad (273)$$

the earlier and ending changes belong to one identity-bounded development:

$$[\forall r \in I_A^{<e}, \quad \text{PhysReal}_A^+(r)] \wedge \text{PhysReal}_A^+(e). \quad (274)$$

This is UCC applied to the ending stage: the ending system changes at every member of its identity range, including the last.

It is not mathematical continuity, differentiability, a metric trajectory, or an infinitesimal-change claim.

14.7 Ending configuration

For an actual ending define:

$$\mathfrak{R}_A^{\text{end}}(e) := \left(X_A(e), \Delta_A^{\text{end}}(e), \mathfrak{C}_A(e) \right). \quad (275)$$

The components distinguish:

- (i) the developed physical state at ending;
- (ii) the system-specific physical-change content classified relative to the identity-ending boundary;
- (iii) the actual causal profile operative at that same ending stage.

The tuple is not chronological:

$$\text{Defined}\left(\mathfrak{R}_A^{\text{end}}(e)\right) \not\Rightarrow \text{SequentialThreeStepEnding}. \quad (276)$$

All three terms concern one common cosmic change stage and are analytically distinguished by role. At the ending stage, the final system-specific change and the developed physical state of the ending identity are realized together at that same common cosmic change stage. The strictly earlier changes remain the identity's historical physical accumulation; they are not converted into a second present object. Whatever retained or transformed physical result of that history remains embodied at ending is present through $X_A(e)$, together with the final change $\Delta_A^{\text{end}}(e)$, and any presently operative effects enter the already governed causal-source classes. This preserves the cumulative physical development of the system without treating its past occurrences as co-present causal objects.

14.8 Physical Identity-Ending Causation Principle

Postulate 14.3 (Physical Identity-Ending Causation Principle (PIECP)). Every actual numerical physical-system identity ending has at least one physically admissible contributor from the already governed actual causal set at the ending stage that physically contributes specifically to the identity-ending transformation:

$$\begin{aligned} \text{PIECP} &\iff \forall A \in \mathcal{U}_{\text{phys}} \forall e \in \mathcal{S}_{\text{C}}^{\text{tot}}, \\ &\quad \text{End}_A(e) \implies \exists c \in \mathcal{C}_A^{\text{act}}(e) : \\ &\quad \text{PhysicallyContributes}(c; \text{IdentityEndingTransformation}(A; e)). \end{aligned} \quad (277)$$

The ending transformation is the final system-specific change of that numerical identity at the common stage e . The earlier physical history of A remains its own historical sequence of realized changes; it is not converted into an additional causal substance at ending. Only effects of earlier change that are still physically retained or transformed in the present condition of A , together with other actually operative contributors, can enter the ending-stage causal account. Identity ending does not by itself terminate the cosmic succession or require production of a successor.

PIECP is an independent ending-specific causal postulate with a narrower role than CRP.

CRP establishes nonempty causal realization of actual physical change.

PIECP requires at least one already admissible causal contributor to be physically implicated specifically in the identity-ending transformation.

Thus:

$$\text{CRP} \wedge \text{End}_A(e) \not\Rightarrow \text{PIECP}. \quad (278)$$

PIECP introduces no additional causal-source class.

14.9 Accumulation is not an independent ending cause

Neither historical physical accumulation nor the present cumulative physical resultant is an independently acting ending cause. Historical accumulation is a historical designation rather than a present causal object. For the present cumulative-resultant predicate:

$$\text{CumulativePhysicalResultThrough}_A(e) \not\Rightarrow \text{IdentityEndingTransformation}(A; e). \quad (279)$$

And:

$$I_A^{<e} \neq \emptyset \not\Rightarrow \text{End}_A(e). \quad (280)$$

Where earlier effects remain embodied and causally operative at ending, their present causal role is classified through the existing physical causal-source architecture.

15. Lifecycle Boundaries and Conditional Successors

15.1 Completed numerical identity

Define:

$$\text{HistoryComplete}(A) \iff \exists e \in I_A \text{ End}_A(e). \quad (281)$$

Let:

$$\mathcal{U}_{\text{phys}}^{\text{end}} := \{A \in \mathcal{U}_{\text{phys}} \mid \text{HistoryComplete}(A)\}. \quad (282)$$

For ended identities:

$$e : \mathcal{U}_{\text{phys}}^{\text{end}} \longrightarrow \mathcal{S}_C^{\text{tot}}, \quad e(A) = e_A. \quad (283)$$

The map remains partial relative to $\mathcal{U}_{\text{phys}}$ unless a universal ending postulate is separately adopted.

15.2 Optional Universal Eventual Identity Ending

Postulate 15.1 (Optional Universal Eventual Identity Ending (UEIE)). If the optional UEIE lifecycle module is adopted, every qualified realized physical-system identity has an ending and a nonempty strict pre-ending identity history:

$$\boxed{\text{UEIE} \iff \forall A \in \mathcal{U}_{\text{phys}} \exists e_A \in I_A [\text{End}_A(e_A) \wedge \exists r_A \in I_A (r_A \prec_C e_A)]}. \quad (284)$$

UEIE concerns identity-bounded physical histories, not the extent of the cosmic stage domain. It does not follow from CMA or UCC, does not imply that the cosmic succession ends, and does not require an ending system to produce a successor.

UEIE is an optional lifecycle postulate, not a governing requirement of the foundational temporal, CMA, and UCC core. It is adopted only in a model or application that explicitly assumes universal eventual ending. Its universal quantifier ranges only over the governing ontic physical-system domain $\mathcal{U}_{\text{phys}}$ and

therefore over numerical physical-system identities. It does not quantify over the cosmic physical totality $\mathcal{U}_C^{\text{phys}}$, which is not a member of $\mathcal{U}_{\text{phys}}$, nor does it retype physical factors as system identities. It therefore carries an independent physical lifecycle burden: arbitrary mathematical subsystems, merely convenient decompositions, or entities not admitted to $\mathcal{U}_{\text{phys}}$ are not silently included. Its adoption must not be inferred from UCC, CRP, non-termination, or from the mere availability of an identity decomposition. Empirical application of UEIE to a declared system class also presupposes a domain-specific numerical-identity criterion adequate to determine formation, persistence, and ending for that class; V39/F19 does not supply one universal empirical identity criterion for all physical-system classes.

It is not derived from:

$$\left\{ \begin{array}{l} T_{\text{TOF}}, \text{ StrictTotalOrder}, \text{ NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \\ \text{CSPP}, \text{ CMA}, \text{ CRP}, \text{ AFB} \end{array} \right\}. \quad (285)$$

In particular:

$$\text{CMA} \not\Rightarrow \text{UEIE}, \quad \text{UCC} \not\Rightarrow \text{UEIE}. \quad (286)$$

UEIE requires a nonempty strict pre-ending identity history:

$$\text{UEIE} \implies \forall A \in \mathcal{U}_{\text{phys}}, \quad I_A^{<e_A} \neq \emptyset. \quad (287)$$

UEIE does not by itself determine a metric lifetime, a number of realized stages, a universal ending mechanism, a universal ending threshold, or a universal ending magnitude.

15.3 Identity Cardinality under Non-Termination

The following result is mathematical and conditional. If the complete cosmic succession is additionally assumed to be non-terminating and UEIE is adopted for every identity in the governing physical-system totality, then the total number of distinct numerical physical-system identities across the complete succession cannot be finite. In the notation $|X| = \infty$ used here, ∞ means only that X is infinite; no particular infinite cardinal or countability assumption is implied.

Proposition 15.2 (Conditional infinite identity totality).

$$\left. \begin{array}{l} \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \\ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \quad \text{UEIE} \end{array} \right\} \vdash |\mathcal{U}_{\text{phys}}| = \infty. \quad (288)$$

Proof. Because $\mathcal{S}_C^{\text{tot}} \neq \emptyset$, choose $s_0 \in \mathcal{S}_C^{\text{tot}}$. By the CSPP consequence of temporal admissibility, the population realized at s_0 is nonempty. Assume for contradiction that $\mathcal{U}_{\text{phys}}$ is finite. UEIE supplies an ending member $e_A \in I_A$ for every $A \in \mathcal{U}_{\text{phys}}$. The finite nonempty set

$$E := \{e_A \mid A \in \mathcal{U}_{\text{phys}}\} \quad (289)$$

has a greatest member e_* under the strict total order. Conditional non-termination supplies $t \in \mathcal{S}_C^{\text{tot}}$ with $e_* \prec_C t$. Common-stage admission gives a nonempty population at t ; let B be a member. Its UEIE ending member $e_B \in E$ cannot be later than e_* , so $e_B \prec_C t$, contradicting realization of B at t after its identity ending. Hence $\mathcal{U}_{\text{phys}}$ is infinite under the stated premises.

The result is not an unconditional prediction that the actual cosmic physical totality has an infinite system-

identity component. The non-termination premise is an open cosmological condition in V39/F19, and UEIE is a separately declared lifecycle postulate. Nor does the result assert infinitely many simultaneously realized systems at any stage. Its exact content is

$$\begin{aligned} \mathfrak{T}_C \wedge \text{NTCS}_C \wedge \text{UEIE} \\ \implies |\mathcal{U}_{\text{phys}}| = \infty. \end{aligned} \quad (290)$$

Application-level counting inside a selected class or granularity still requires an independently fixed physically warranted qualification and identity criterion; the theorem itself concerns the governing ontic totality quantified by UEIE.

15.4 Direct successor relation

Identity ending does not by itself entail production of a new numerical physical-system identity. A direct successor is admitted only where the ending transformation independently warrants formation of a genuinely new numerical identity. Define:

$$\text{SuccAt}(A, B; e) \iff \text{End}_A(e) \wedge A \neq B \wedge f_B = e \wedge \text{PhysicalProductionLink}(A, B; e). \quad (291)$$

The relation therefore requires:

- (i) actual ending of A ;
- (ii) numerical distinction between predecessor and successor;
- (iii) formation of B at the same common cosmic stage e ; and
- (iv) an independently warranted physical-production relation linking the ending transformation of A to formation of B .

A pre-existing qualified system does not become a direct successor merely by receiving matter or energy, absorbing constituents, interacting with the ending system, or remaining realized after that ending. In particular, if B is already realized before e and retains its numerical identity while incorporating material or other physical contributions from A , then $f_B \prec_C e$ and B is not a direct successor of A under Eq. (291). Absorption can therefore terminate A without producing any new qualified identity. The absorbing system may thereby change its physical character — composition, structure, or properties — or retain it within its identity criterion; in either case it keeps its numerical identity and is not a successor. If the incorporation instead ends the identity of B , the case falls under the ending and successor conditions above.

15.5 Conditional Successors and No Universal Closure

Define the direct successor family by

$$\mathfrak{S}^+(A, e) := \{B \in \mathcal{U}_{\text{phys}} \mid \text{SuccAt}(A, B; e)\}. \quad (292)$$

No universal nonemptiness condition is imposed:

$$\text{End}_A(e) \not\Rightarrow \mathfrak{S}^+(A, e) \neq \emptyset. \quad (293)$$

Accordingly, an ending transformation may physically produce no new qualified identity, one direct successor, or a plurality of direct successors. Which case obtains is fixed by independently warranted physical production and numerical identity criteria. Failure of one proposed successor candidate says

nothing about other candidates; absence of every direct successor is admissible when no new identity is physically produced.

15.6 Successor identity is new even under state resemblance

Every $B \in \mathfrak{S}^+(A, e)$ is numerically distinct from A . This remains true even if a declared cross-system comparison regards the successor's formation state as physically equal or equivalent to a state of A realized before its ending. Here $\text{StateEquivalent}_\Gamma$ denotes only a declared, physically warranted cross-system state-comparison relation under criterion Γ ; it is not an identity relation. For any $r \in I_A$ with $r \prec_C e$,

$$\text{SuccAt}(A, B; e) \wedge \text{StateEquivalent}_\Gamma(X_B(e), X_A(r)) \implies A \neq B. \quad (294)$$

The same conclusion holds for resemblance in composition, organization, function, location, records, or naming. State resemblance is therefore a cross-identity physical comparison; it does not restore the ended numerical identity.

15.7 Successor history remains numerically distinct

Where $\text{SuccAt}(A, B; e)$, the successor forms at $f_B = e$, has its own identity range

$$I_B = \{s \in \mathcal{S}_C^{\text{tot}} \mid \text{ExistsAs}(B, s)\}, \quad (295)$$

and, under UCC, its own physical-history representation

$$\mathcal{H}_B = (I_B, \prec_C|_{I_B}, X_B, \Delta_B^{\text{phys}}). \quad (296)$$

Thus

$$\text{SuccAt}(A, B; e) \implies A \neq B, \quad \text{SuccAt}(A, B; e) \not\Rightarrow \mathcal{H}_B = \mathcal{H}_A. \quad (297)$$

Physical production links predecessor and successor causally without merging their numerical identities or histories.

15.8 Successor attribution and cosmic extent remain distinct

Conditional successor production does not supply a no-greatest-stage commitment. Whether an ending has zero, one, or several direct successors is an identity-production question at that ending transformation. Whether every admitted cosmic stage has a later member is the separate revisable cosmological hypothesis $\text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C)$. Neither identity ending nor direct-successor attribution, separately or together, establishes that condition.

16. Population Change Across Cosmic Order

16.1 Population-level extension

V36/F16 provides a complete stage-relative qualified population:

$$\mathcal{S}_{\text{phys}}(s). \quad (298)$$

It also provides identity-realization ranges:

$$I_A. \quad (299)$$

These existing objects represent how the qualified population may differ between arbitrary ordered common cosmic change stages without introducing:

$$\left\{ \begin{array}{l} \text{AdjacentStages, MovingPopulation, PopulationTransportSubstrate,} \\ \text{OneToOneSuccessorConservationLaw, PopulationConservationLaw} \end{array} \right\}. \quad (300)$$

Let:

$$r, s \in \mathcal{S}_C^{\text{tot}}, \quad r \prec_C s. \quad (301)$$

No assumption is made that r and s are adjacent.

16.2 Endpoint-persistent population

Define:

$$\mathcal{P}_{r,s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \in I_A \wedge s \in I_A\}. \quad (302)$$

Every member belongs to both endpoint populations:

$$\mathcal{P}_{r,s} = \mathcal{S}_{\text{phys}}(r) \cap \mathcal{S}_{\text{phys}}(s). \quad (303)$$

Under Identity-Realization Convexity:

$$A \in \mathcal{P}_{r,s} \wedge r \prec_C u \prec_C s \implies u \in I_A. \quad (304)$$

Thus endpoint persistence implies realization of the same numerical identity at every intermediate common cosmic change stage.

This is an order-theoretic identity result, not a metric continuity claim.

16.3 Later-endpoint entrant population

Define:

$$\mathcal{N}_{r \rightarrow s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \notin I_A \wedge s \in I_A\}. \quad (305)$$

The term *entrant* or *later-endpoint entrant* is population-relative. It does not mean that a system is created by time or transported into the cosmic extension.

Under AFB and Identity-Realization Convexity:

$$A \in \mathcal{N}_{r \rightarrow s} \implies r \prec_C f_A \vee f_A = s. \quad (306)$$

Since $f_A \in I_A$ and $s \in I_A$, the least-member property also gives:

$$A \in \mathcal{N}_{r \rightarrow s} \implies \neg(s \prec_C f_A). \quad (307)$$

Thus formation occurs after r and no later than s , without requiring identification of a stage immediately following r .

16.4 Earlier-endpoint departing population

Define:

$$\mathcal{L}_{r \rightarrow s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \in I_A \wedge s \notin I_A\}. \quad (308)$$

Again, *departing* is population-relative. It does not mean that the system moves outside time or leaves the cosmic extension.

If optional UEIE is adopted together with Identity-Realization Convexity and $A \in \mathcal{L}_{r \rightarrow s}$, its ending member must occur before s .

Thus:

$$\{\text{UEIE}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{L}_{r \rightarrow s} \implies e_A \prec_C s. \quad (309)$$

Because $r \in I_A$ and $e_A \in I_A$, strict ordering and ending uniqueness permit:

$$r = e_A \quad \text{or} \quad r \prec_C e_A. \quad (310)$$

No metric lifetime is inferred.

16.5 Endpoint population decomposition

The later endpoint population decomposes exactly as:

$$\mathcal{S}_{\text{phys}}(s) = \mathcal{P}_{r,s} \dot{\cup} \mathcal{N}_{r \rightarrow s}. \quad (311)$$

The earlier endpoint population decomposes exactly as:

$$\mathcal{S}_{\text{phys}}(r) = \mathcal{P}_{r,s} \dot{\cup} \mathcal{L}_{r \rightarrow s}. \quad (312)$$

Here $\dot{\cup}$ denotes disjoint union.

The decompositions follow directly from identity-domain membership and do not assert any physical conservation equation.

In particular:

$$|\mathcal{S}_{\text{phys}}(r)| - |\mathcal{L}_{r \rightarrow s}| + |\mathcal{N}_{r \rightarrow s}| = |\mathcal{S}_{\text{phys}}(s)| \quad (313)$$

is not adopted as a universal numerical law without the additional assumptions required for the relevant cardinal arithmetic and finite-population context.

The set decompositions, not a scalar population equation, are fundamental here.

16.6 Intermediate-only identities

Endpoint comparison does not capture every numerical physical-system identity realized between r and s .

Define:

$$\mathcal{T}_{r,s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \notin I_A \wedge s \notin I_A \wedge \exists u \in I_A (r \prec_C u \prec_C s)\}. \quad (314)$$

Members of $\mathcal{T}_{r,s}$ are absent from both endpoint populations while possessing a realized identity history somewhere strictly between the two endpoints.

Therefore:

$$\mathcal{T}_{r,s} \cap (\mathcal{S}_{\text{phys}}(r) \cup \mathcal{S}_{\text{phys}}(s)) = \emptyset. \quad (315)$$

This class is essential for a logically complete population comparison.

Without it, a pairwise comparison of endpoint populations could incorrectly suggest that no system formed and ended between r and s .

16.7 Formation and ending of intermediate-only identities

Under AFB and Identity-Realization Convexity, every $A \in \mathcal{T}_{r,s}$ has its formation boundary strictly between the selected endpoints. Because f_A is the least member of I_A , at least one member of I_A lies strictly between r and s , while both endpoints are absent from I_A . Hence:

$$\{\text{AFB}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{T}_{r,s} \implies r \prec_C f_A \prec_C s. \quad (316)$$

If UEIE is also adopted, its strict pre-ending-history requirement, together with AFB and Identity-Realization Convexity, places both formation and ending strictly between the selected endpoints:

$$\{\text{AFB}, \text{UEIE}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{T}_{r,s} \implies r \prec_C f_A \prec_C e_A \prec_C s. \quad (317)$$

Thus an identity may be physically formed, undergo its own UCC-governed development, and end entirely between two arbitrarily selected endpoint stages.

16.8 Population-transition representation

Define the pairwise population-transition descriptor:

$$\mathfrak{P}_C^{\text{pop}}(r, s) := (\mathcal{S}_{\text{phys}}(r), \mathcal{P}_{r,s}, \mathcal{N}_{r \rightarrow s}, \mathcal{L}_{r \rightarrow s}, \mathcal{T}_{r,s}, \mathcal{S}_{\text{phys}}(s)), \quad r \prec_C s. \quad (318)$$

This is a defined representation:

$$\text{Status}(\mathfrak{P}_C^{\text{pop}}(r, s)) = \text{DefinedPopulationMembershipProfile}. \quad (319)$$

It does not represent a moving population, a flow of time, a temporal transport mechanism, or a universal successor chain. The descriptor compares identity-domain membership across two ordered common cosmic change stages.

16.9 Population transformation does not alter temporal identity

Population change may be extensive:

$$\mathcal{S}_{\text{phys}}(r) \neq \mathcal{S}_{\text{phys}}(s). \quad (320)$$

Population difference does not generate stage-specific temporal extensions:

$$\mathcal{S}_{\text{phys}}(r) \neq \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{DifferentTemporalExtensions}(r, s). \quad (321)$$

The one temporal referent remains Eq. (11).

Population transformation belongs to the physical histories realized within that extension.

16.10 Population transformation and complete physical realization

The endpoint profiles $\mathfrak{R}_C(r)$ and $\mathfrak{R}_C(s)$ are indexed by their respective complete then-realized qualified populations. If $\mathcal{S}_{\text{phys}}(r) \neq \mathcal{S}_{\text{phys}}(s)$, their profile domains differ.

No universal deterministic profile-to-profile map is implied. Therefore:

$$r \prec_C s \not\Rightarrow \exists F_{\text{univ}} : \mathfrak{R}_C(s) = F_{\text{univ}}(\mathfrak{R}_C(r)). \quad (322)$$

The invariant cosmic ordering fixes earlier and later.

It does not itself supply one universal physical dynamics.

Physical comparison maps, mathematical-form-neutral dynamics, operational metrics, clocks, observation, signal access, and model-to-record bridges therefore remain downstream physical or representational constructions whose parameters and outputs are type-distinct from time.

17. Cross-System Physical Comparison

17.1 Comparison requires an independently declared common space

Let $A, B \in \mathcal{S}_{\text{phys}}(s)$ in a governing realization satisfying UCC. Then both system-specific change-content terms are well typed:

$$\Delta_A^{\text{phys}}(s) \in \Xi_A, \quad \Delta_B^{\text{phys}}(s) \in \Xi_B, \quad (323)$$

without requiring

$$\Xi_A = \Xi_B. \quad (324)$$

Consequently, a mathematical comparison between the physical-change contents of distinct systems is not automatically well typed.

For a declared comparison protocol P , let

$$\mathcal{Y}_{AB,P} \quad (325)$$

be a comparison space whose physical interpretation, units or normalization, domain of validity, and uncertainty structure are explicitly declared.

Introduce independently supplied maps

$$\phi_{A \rightarrow AB}^P : \Xi_A \longrightarrow \mathcal{Y}_{AB,P}, \quad (326)$$

$$\phi_{B \rightarrow AB}^P : \Xi_B \longrightarrow \mathcal{Y}_{AB,P}. \quad (327)$$

Only after these maps are physically and mathematically warranted may mapped change contents be compared within the common comparison space.

17.2 Mapped comparison is not physical identity

Define:

$$\text{MappedChange}_{A|AB,P}(s) := \phi_{A \rightarrow AB}^P \left(\Delta_A^{\text{phys}}(s) \right) \quad (328)$$

and similarly

$$\text{MappedChange}_{B|AB,P}(s) := \phi_{B \rightarrow AB}^P \left(\Delta_B^{\text{phys}}(s) \right). \quad (329)$$

Even if:

$$\text{MappedChange}_{A|AB,P}(s) = \text{MappedChange}_{B|AB,P}(s), \quad (330)$$

it does not follow that:

$$\text{MappedChange}_{A|AB,P}(s) = \text{MappedChange}_{B|AB,P}(s) \not\Rightarrow \Delta_A^{\text{phys}}(s) \equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \quad (331)$$

Mapped equality is equality under the declared comparison representation.

It is not physical system identity.

17.3 General comparison operator

Let:

$$\Psi_{AB,P} : \mathcal{Y}_{AB,P} \times \mathcal{Y}_{AB,P} \longrightarrow \mathcal{Z}_{AB,P} \quad (332)$$

be a declared comparison operator.

Define:

$$\begin{aligned} \text{Cmp}_{AB,P}(s) := \Psi_{AB,P} \Big(& \phi_{A \rightarrow AB}^P(\Delta_A^{\text{phys}}(s)), \\ & \phi_{B \rightarrow AB}^P(\Delta_B^{\text{phys}}(s)) \Big). \end{aligned} \quad (333)$$

The output belongs to the comparison codomain:

$$\text{Cmp}_{AB,P}(s) \in \mathcal{Z}_{AB,P}. \quad (334)$$

It is not:

$$\text{Cmp}_{AB,P}(s) \not\equiv_{\text{type}} T_{\text{TOF}}. \quad (335)$$

This excludes any identification of the comparison output with time.

Nor is it:

$$\text{Cmp}_{AB,P}(s) \not\equiv_{\text{type}} s. \quad (336)$$

These two exclusions state that a comparison output is an application-level quantity, neither time nor a cosmic-stage member.

17.4 Admissibility of a physical comparison

A comparison is scientifically admissible only where its construction is independently specified.

Define:

$$\begin{aligned}
\text{AdmissibleComparison}(A, B; P) \implies & \text{PhysicalTargetDeclared}(A, B; P) \\
& \wedge \text{ComparisonMapsDeclared}(A, B; P) \\
& \wedge \text{ComparisonCodomainDeclared}(P) \\
& \wedge \text{UnitsOrNormalizationDeclared}(P) \\
& \wedge \text{ParameterProvenanceDeclared}(P) \\
& \wedge \text{UncertaintyStructureDeclared}(P) \\
& \wedge \text{DomainOfValidityDeclared}(P).
\end{aligned} \tag{337}$$

The condition is methodological.

It does not state that every pair of systems must admit a physically meaningful comparison.

Thus:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \exists P \text{ AdmissibleComparison}(A, B; P). \tag{338}$$

Shared membership in $\mathcal{S}_{\text{phys}}(s)$ identifies the represented population at that member of the formal cosmic-stage domain; neither population membership, CMA common-stage co-presence, nor UCC supplies quantitative comparability by itself.

17.5 No universal scalar amount of change

V39/F19 does not infer:

$$\exists \mu_{\Delta} : \bigcup_{A \in \mathcal{Z}_{\text{phys}}} \Xi_A \longrightarrow \mathbb{R} \tag{339}$$

as a foundational requirement.

Accordingly:

$$\text{UCC} \not\Rightarrow \text{UniversalScalarAmountOfChange}. \tag{340}$$

The complete-population physical-realization architecture likewise supplies no universal cross-system ranking of change.

Statements such as

$$\text{“}A \text{ changed more than } B\text{”} \tag{341}$$

require a declared comparison construction.

They do not follow from the cosmic ordering itself.

17.6 Cross-level comparison under hierarchical composition

If:

$$A \triangleleft_{\kappa, s} B, \tag{342}$$

a comparison between constituent and composite change remains subject to the same mapping discipline.

Thus:

$$A \triangleleft_{\kappa, s} B \not\Rightarrow \text{Cmp}_{AB, P}(s) \text{ is defined.} \tag{343}$$

A physical composition model may independently supply the necessary maps.
Composition itself does not.

18. Physical Dynamics and Temporal Order

18.1 Foundational neutrality toward the form of physical dynamics

The temporal definition (Eq. (11)) does not select one universal mathematical form for physical dynamics. No single deterministic, stochastic, quantum, field-theoretic, Hamiltonian, or relativistic-geometrical form is imposed as the universal dynamics of all physical systems. The neutrality asserted here concerns mathematical form and representation; it does not suspend CRP or the framework's declared physical-causal ontology. The foundational temporal architecture and application-level physical dynamics remain distinct. Accordingly, governing CMA remains type-distinct from every application-level physical-dynamics descriptor:

$$\text{CMA} \not\equiv_{\text{type}} \mathfrak{D}\eta\mathfrak{n}_{M;\mathcal{A}}. \quad (344)$$

The left-hand side states CMA; the right-hand side specifies a declared physical model. Complete qualified-system actual-change coverage belongs separately to UCC. Neither common-stage co-presence nor physical-change coverage is supplied by this type-nonidentity statement. Neither side supplies a dynamical law for time.

18.2 Admissible physical-dynamics descriptor

For a declared physical-system class $\mathcal{A}$, let application model M possess the internal physical-dynamics descriptor

$$\mathfrak{D}\eta\mathfrak{n}_{M;\mathcal{A}} := (\mathcal{Z}_M, \Theta_M, \mathcal{L}_M, D_M, \text{Sol}_M). \quad (345)$$

Here $\mathcal{Z}_M$ is the declared space or class of model realizations, Θ_M the model-parameter family, $\mathcal{L}_M$ the declared physical law, evolution relation, stochastic rule, Hamiltonian structure, field equation, constraint family, or other governing model structure, D_M the physical and mathematical domain of validity, and Sol_M the declared solution or admissible-realization rule. Physical encoding and measurement are excluded from this descriptor because they belong to separately typed bridge layers.

A mathematical-form-neutral solution family may be written schematically as

$$\text{Sol}_M(D_M, \Theta_M) := \{z \in \mathcal{Z}_M(D_M) \mid \text{LawSatisfied}_M(z; \mathcal{L}_M, \Theta_M, D_M)\}. \quad (346)$$

Here LawSatisfied_M is the satisfaction predicate induced by the declared governing structure $\mathcal{L}_M$ on the stated parameter family and validity domain. This notation does not require every model to share the same mathematical ontology or to be representable as a deterministic differential equation.

18.3 Admissibility condition

A physical model may enter an ITOF application only where its role is explicit.

Admissibility requires the following declared conditions:

$$\begin{aligned}
\text{AdmissiblePhysicalModel}(M; \mathcal{A}) \implies & \text{PhysicalTargetDeclared}(M; \mathcal{A}) \\
& \wedge \text{ModelRealizationSpaceTyped}(M) \\
& \wedge \text{PhysicalSystemBoundariesDeclared}(M) \\
& \wedge \text{IdentityCriterionDeclaredWhereApplicable}(M) \\
& \wedge \text{ParameterProvenanceDeclared}(M) \\
& \wedge \text{DynamicsFormDeclared}(M) \\
& \wedge \text{SolutionRuleDeclared}(M) \\
& \wedge \text{ModelInputBridgeDeclared}(M) \\
& \wedge \text{ModelOutputBridgeDeclared}(M) \\
& \wedge \text{DomainOfValidityDeclared}(M) \\
& \wedge \text{ApproximationStatusDeclared}(M) \\
& \wedge \text{ObservationBridgeDeclaredWhereNeeded}(M).
\end{aligned} \tag{347}$$

These are necessary methodological conditions for admission of the declared model into an ITOF application; they are not claimed to be universally sufficient for every possible physical-model class.

It does not convert the chosen dynamics into a foundational ITOF axiom.

18.4 Model evolution parameters

A model may employ one or more parameters that index mathematical evolution, solution families, record order, path position, iteration, phase, or another representation.

Let:

$$\lambda_M \tag{348}$$

be such a parameter.

Then:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}. \tag{349}$$

Even where:

$$\lambda_M \mapsto X_A^M(\lambda_M) \tag{350}$$

accurately predicts physical records, the parameter remains a model parameter.

Thus:

$$\begin{aligned}
& \text{ModelEvolutionParameter}(\lambda_M; M) \\
& \wedge \text{OperationalSuccess}_{P,M,D}(\lambda_M) \\
& \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}.
\end{aligned} \tag{351}$$

18.5 Model Parameter Is Not a Cosmic-Stage Index

No global numerical map $\iota : \mathcal{S}_C^{\text{tot}} \rightarrow \mathbb{R}$ is required by the temporal definition. An application may introduce an index only with an independently declared representational role. Therefore:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \not\Rightarrow \text{ExactCommonCosmicChangeStageIndex}(\lambda_M). \quad (352)$$

A model may parameterize a reconstructed or predicted physical history without enumerating the members of $\mathcal{S}_C^{\text{tot}}$.

18.6 Physical Laws and Non-Causal Time

The mathematical-form-neutral requirement is that a declared realization $z \in \mathcal{L}_M$ satisfy the independently specified governing rule:

$$\text{LawSatisfied}_M(z; \mathcal{L}_M, \Theta_M, D_M). \quad (353)$$

A residual equation such as $\mathcal{L}_M(\mathcal{V}_M, \Theta_M) = 0$ is one admissible special case, not the universal form of physical dynamics. The physical interpretation belongs to the declared systems, fields, interactions, constraints, and physical quantities represented by the particular model.

The occurrence of an evolution parameter in the equation does not make the parameter a causal source.

Thus:

$$\text{AppearsAsEvolutionParameter}(\lambda_M) \not\Rightarrow \text{PhysicalCause}(\lambda_M). \quad (354)$$

Likewise, time is not a member of the physical causal-source domain:

$$T_{\text{ITOF}} \not\equiv_{\text{type}} \text{PhysicalCausalContributor}. \quad (355)$$

18.7 Model-to-history association

An application may associate a model trajectory, state family, stochastic family, field configuration, or other mathematical object with part of a physical-system history.

Represent that association by:

$$\Psi_{M,A}^{\text{hist}} : \text{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}_A^M. \quad (356)$$

where $\mathcal{H}_A^M$ denotes only the model-represented aspects of the physical history of A . The source is the declared family of model realizations, not the domain-of-validity statement itself.

The existence of such an association alone does not establish complete representational identity:

$$\left[\Psi_{M,A}^{\text{hist}} : \text{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}_A^M \right] \not\Rightarrow \mathcal{H}_A^M = \mathcal{H}_A. \quad (357)$$

Equality would require an independent argument for complete representational adequacy over every component relevant to the claim. Likewise,

$$\left[\Psi_{M,A}^{\text{hist}} : \text{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}_A^M \right] \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}. \quad (358)$$

18.8 Valid Models Need Not Share One Parameter

Two physical models may successfully represent different aspects of the same physical system or different systems:

$$M_1, \quad M_2. \quad (359)$$

Their parameters may satisfy:

$$\lambda_{M_1} \neq \lambda_{M_2}. \quad (360)$$

Distinct model parameters do not imply distinct temporal referents:

$$\lambda_{M_1} \neq \lambda_{M_2} \not\Rightarrow \text{DistinctTemporalReferents}(M_1, M_2). \quad (361)$$

It indicates different representational constructions.

18.9 Formal reversibility does not reverse cosmic ordering

A physical model may admit:

$$\lambda_M \mapsto -\lambda_M. \quad (362)$$

This mathematical transformation does not reverse:

$$\prec_C. \quad (363)$$

Therefore:

$$\text{ModelInvariantUnder}(\lambda_M \mapsto -\lambda_M) \not\Rightarrow \text{CosmicOrderingReversed}. \quad (364)$$

Mathematical reversibility, physical recurrence, and non-reversal of the governing cosmic order remain distinct.

18.10 System-specific physical directionalities

A physical-system history may exhibit a directional pattern relative to a declared physical criterion without generating an additional temporal order. For qualified system A and criterion α , let

$$Y_{A,\alpha} : I_A \longrightarrow \mathcal{Y}_{A,\alpha} \quad (365)$$

be a declared physical or model-supported descriptor, and let

$$\preceq_{A,\alpha} \subseteq \mathcal{Y}_{A,\alpha} \times \mathcal{Y}_{A,\alpha} \quad (366)$$

be the comparison relation warranted for that criterion. No totality, metric, linearity, or universal cross-system meaning is assumed for $\preceq_{A,\alpha}$.

Define the criterion-indexed directionality descriptor:

$$\mathfrak{A}_{A,\alpha} := (\mathcal{Y}_{A,\alpha}, Y_{A,\alpha}, \preceq_{A,\alpha}). \quad (367)$$

For $J \subseteq I_A$, define alignment with the universal cosmic ordering on that domain by:

$$\text{ArrowAligned}_{A,\alpha}(J) \iff \forall r, s \in J, \quad r \prec_C s \implies Y_{A,\alpha}(r) \preceq_{A,\alpha} Y_{A,\alpha}(s). \quad (368)$$

Where the strict part of the criterion relation is needed, define:

$$u \prec_{A,\alpha}^{\text{phys}} v \iff u \preceq_{A,\alpha} v \wedge \neg (v \preceq_{A,\alpha} u). \quad (369)$$

A criterion-relative reversal over an ordered pair may then be represented by:

$$\text{CriterionReversal}_{A,\alpha}(r, s) \iff r \prec_C s \wedge Y_{A,\alpha}(s) \prec_{A,\alpha}^{\text{phys}} Y_{A,\alpha}(r). \quad (370)$$

Such a reversal concerns the selected physical criterion. It does not reverse the cosmic order:

$$\text{CriterionReversal}_{A,\alpha}(r, s) \not\Rightarrow s \prec_C r. \quad (371)$$

A conventional physical “arrow” is therefore admissible only as a criterion-indexed physical regularity:

$$\text{PhysicalArrow}_{A,\alpha}(J) \iff \text{ArrowAligned}_{A,\alpha}(J). \quad (372)$$

The designation is not a second meaning of time. The physical comparison relation and the universal cosmic order have different types:

$$\preceq_{A,\alpha} \not\equiv_{\text{type}} \prec_C. \quad (373)$$

Even perfect alignment over a declared domain does not transfer temporal identity:

$$\text{PhysicalArrow}_{A,\alpha}(J) \not\Rightarrow \preceq_{A,\alpha} \equiv_{\text{type}} \prec_C. \quad (374)$$

UCC requires actual system-specific physical change; it does not require one criterion to be monotonic for every system:

$$\text{UCC} \not\Rightarrow \exists \alpha \forall A \in \mathcal{U}_{\text{phys}}, \quad \text{PhysicalArrow}_{A,\alpha}(I_A). \quad (375)$$

Nor does a physical arrow require a metric on the identity range:

$$\text{PhysicalArrow}_{A,\alpha}(J) \not\Rightarrow \text{MetricOn}(J). \quad (376)$$

Thermodynamic, developmental, decay-statistical, memory- or record-related, computational, and other physical directionalities may be represented through $\mathfrak{A}_{A,\alpha}$ when the relevant physical model supplies a defined criterion and evidential support. Different directionalities may align, recur, plateau, or reverse relative to their own criteria while the universal earlier–later ordering remains fixed. The directionality descriptor is a defined application-level construction, not a new foundational temporal postulate.

19. Operational Metrics and Time

19.1 Operational metric layer

V39/F19 moves beyond the statement that a clock output is not time.

It asks how numerical quantities conventionally used to represent:

$$\begin{aligned} &\text{duration, elapsed units, frequency ratios, rates,} \\ &\text{synchronization differences, path-dependent intervals, and related metric outputs} \end{aligned} \quad (377)$$

are physically or mathematically constructed.

The governing answer is that such quantities require declared physical records, model quantities, calibration structures, comparison rules, or combinations of those ingredients.

They are not extracted as a metric already contained in $(\mathcal{S}_C^{\text{tot}}, \prec_C)$.

19.2 Non-Metricity as a Type Boundary

V39/F19 does not claim that bare earlier–later order generates differential equations, Hamiltonians, stochastic kernels, clock-response laws, or numerical intervals. Those belong to independently warranted physical-model layers. The connection to quantitative practice is instead typed: physical inputs are encoded into a declared model, the model dynamics constrain or generate admissible realizations, predicted physical quantities are mapped to records, and an operational construction maps those records together with calibration and comparison information to numerical outputs. Thus the absence of a canonical metric in T_{ITOF} is not repaired by silently inserting one into the temporal definition; quantitative scale enters only through the declared physical and operational architecture.

Accordingly,

$$\text{TemporalDefinition}_{\text{ITOF}} \not\Rightarrow \text{DynamicsDescriptorSpecified}(M; \mathcal{A}). \quad (378)$$

and successful application dynamics do not convert their evolution parameter or metric output into time.

Operational metric denotes a protocol-defined quantitative output used to express an interval, rate, ratio, synchronization difference, or related metric quantity. The term does not by itself assert that $\mathcal{Y}_P$ or $\mathcal{M}_P^{\text{op}}$ satisfies the axioms of a metric space. Where a genuine metric-space distance is required, non-negativity, separation, symmetry, the triangle inequality, the applicable domain, and the physical interpretation must be supplied independently.

19.3 General operational metric map

Let:

$$\mathfrak{R}_P \quad (379)$$

be a declared physical record domain associated with protocol P .

Let:

$$\mathcal{K}_P \quad (380)$$

contain the calibration, reference, normalization, unit, alignment, and comparison information required by the declared operational construction.

Define:

$$\mathcal{M}_P^{\text{op}} : \mathfrak{R}_P^n \times \mathcal{K}_P \longrightarrow \mathcal{Y}_P. \quad (381)$$

For records:

$$r_1, \dots, r_n \in \mathfrak{R}_P \quad (382)$$

and declared calibration bundle $\kappa_P \in \mathcal{K}_P$, define:

$$m_P := \mathcal{M}_P^{\text{op}}(r_1, \dots, r_n; \kappa_P). \quad (383)$$

The output:

$$m_P \in \mathcal{Y}_P \quad (384)$$

is an operational quantity.

It is not time:

$$m_P \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (385)$$

19.4 Operational metric output is not an order magnitude

The ordered pair

$$(\mathcal{S}_C^{\text{tot}}, \prec_C) \quad (386)$$

contains no foundationally defined numerical distance function. This is the application-level consequence of the order-representation non-metricity result in Eq. (39). A map of the form $d_C : \mathcal{S}_C^{\text{tot}} \times \mathcal{S}_C^{\text{tot}} \rightarrow \mathbb{R}$ may be introduced only as an additional mathematical or physical-model construction; it is not part of the definition of time.

Accordingly, an operational metric output does not by itself define a magnitude on the cosmic-stage order:

$$\text{OperationalMetricOutput}(m_P) \not\Rightarrow \text{CosmicStageSeparationMagnitudeDefined}(m_P). \quad (387)$$

A numerical difference between records belongs to the declared operational scale.

19.5 Model-derived metric quantities

Some scientifically useful metric quantities are obtained primarily from a mathematical or physical model rather than directly from record arithmetic.

Let:

$$\mu_M = \mathcal{G}_M(\mathcal{V}_M, \Theta_M) \quad (388)$$

be such a model-derived metric quantity.

Then:

$$\mu_M \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (389)$$

Where:

$$m_P \approx K_{P,M}(\mu_M) \quad (390)$$

successfully connects model quantity and operational output, the agreement warrants the declared quantitative association.

It does not establish:

$$m_P \approx K_{P,M}(\mu_M) \not\Rightarrow \mu_M \equiv_{\text{type}} T_{\text{ITOF}}. \quad (391)$$

19.6 Operational interval

For two ordered records r_1, r_2 , let:

$$N_P : \mathfrak{R}_P \longrightarrow \mathbb{R}_P \quad (392)$$

be a declared numerical reading map.

Define:

$$\Delta N_P := N_P(r_2) - N_P(r_1). \quad (393)$$

The quantity may conventionally be described as elapsed time or duration.

Within ITOF it remains:

$$\Delta N_P \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (394)$$

Nor does a numerical interval establish an exact count of common cosmic stages. From $\Delta N_P = n$ alone, no finite cardinality of intervening or endpoint common stages follows. V39/F19 supplies no stage-count function, adjacency rule, or independently warranted stage-identification-and-counting procedure from the bare strict order $(\mathcal{S}_C^{\text{tot}}, \prec_C)$. This Non-Transfer statement is kept in prose rather than introducing an otherwise unused stage-count predicate.

19.7 Operational physical rate

For measured physical quantity Q_A , define:

$$\Delta_P Q_A := \widehat{Q}_{A;P,M}(r_{A,2}) - \widehat{Q}_{A;P,M}(r_{A,1}). \quad (395)$$

Where:

$$\Delta N_P \neq 0, \quad (396)$$

define:

$$\bar{v}_{Q_A|N}^P := \frac{\Delta_P Q_A}{\Delta N_P}. \quad (397)$$

This is a relation between a measured physical difference and a declared operational numerical interval.

It is not:

$$\bar{v}_{Q_A|N}^P \not\equiv_{\text{type}} \text{RateOfTime}. \quad (398)$$

19.8 Operational synchronization

Let two physical standard systems produce mapped outputs:

$$n_1, \quad n_2. \quad (399)$$

Define:

$$d_{12}^P := \Gamma_{1,P}(n_1) - \Gamma_{2,P}(n_2). \quad (400)$$

For declared synchronization tolerance ϵ_{sync} :

$$\text{Synchronized}_{P,\epsilon_{\text{sync}}}(1,2) \iff |d_{12}^P| \leq \epsilon_{\text{sync}}. \quad (401)$$

This is an operational relation.

It neither creates nor defines CMA:

$$\text{Synchronized}_{P, \varepsilon_{\text{sync}}}(1, 2) \not\Rightarrow \text{CMA}. \quad (402)$$

Nor does failure of synchronization negate CMA:

$$\neg \text{Synchronized}_{P, \varepsilon_{\text{sync}}}(1, 2) \not\Rightarrow \neg \text{CMA}. \quad (403)$$

Clock-output agreement and common cosmic-stage unity remain different claims.

20. Signals, Records, and Observation

20.1 Physical actuality and observational access

A system-specific physical change may be actual whether or not it is accessible to a declared observer or apparatus.

For physical manifestation χ , record r , protocol P , model M , and threshold ε :

$$\text{PairwiseTypeDistinct}(\text{PhysReal}_A^+(s), \text{ManifestationAt}(A, \chi; s), \text{Detected}_{P, M, \varepsilon}(A, \chi; r)). \quad (404)$$

Hence:

$$\text{PhysReal}_A^+(s) \Rightarrow \text{Detected}_{P, M, \varepsilon}(A, \chi; r). \quad (405)$$

And:

$$\neg \text{Detected}_{P, M, \varepsilon}(A, \chi; r) \Rightarrow \text{NC}_A^{\text{phys}}(s). \quad (406)$$

20.2 Access Relations and Common-Stage Realization

For $A, B \in \mathcal{S}_{\text{phys}}(s)$, CMA supplies objective common-stage co-presence. Under the independent UCC postulate, $\text{PhysReal}_A^+(s)$ and $\text{PhysReal}_B^+(s)$ also hold. The physical relations of interaction, signal accessibility, and observational accessibility remain separately typed:

$$\text{PhysicalInteraction}(A, B; s), \quad (407)$$

$$\text{SignalAccessible}(A, B; s), \quad (408)$$

and:

$$\text{ObservationallyAccessible}_{P, M}(B; A, s). \quad (409)$$

The first two non-entailments are fixed in Eqs. (77) and (78). Observational accessibility is likewise not supplied by CMA:

$$\text{CMA} \not\Rightarrow \forall s \in \mathcal{S}_C^{\text{tot}} \forall A, B \in \mathcal{S}_{\text{phys}}(s), \quad \text{ObservationallyAccessible}_{P, M}(B; A, s). \quad (410)$$

20.3 Signal delay does not divide the common cosmic change stage

If a signal originating from system B is not yet physically received by system A at s , this does not imply that B is absent from the common stage.

Thus:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \wedge \text{SignalNotYetReceived}(A, B; s) \not\Rightarrow B \notin \mathcal{S}_{\text{phys}}(s). \quad (411)$$

Under UCC, delayed reception leaves system-specific change intact:

$$\text{UCC} \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \wedge \text{SignalNotYetReceived}(A, B; s) \implies \text{PhysReal}_B^+(s). \quad (412)$$

Spatial and causal accessibility affect physical interaction and knowledge.

They do not partition the common cosmic change stage.

20.4 Observation remains physical

An observational arrangement consists of physical systems and physically realized factors.

Let:

$$\mathcal{L}_P \quad (413)$$

denote the declared family of target, apparatus, detector, record-bearing, observer, reference, calibration, communication, processing, and environmental systems entering protocol P .

For every member of that physical-system family that is realized at s , UCC gives

$$\text{UCC} \wedge X \in \mathcal{L}_P \cap \mathcal{S}_{\text{phys}}(s) \implies \text{PhysReal}_X^+(s). \quad (414)$$

A sample or target, apparatus, detector, record-bearing system, observer, and laboratory, where each satisfies the governing physical-system criteria, are therefore all inside the same changing physical domain. A laboratory may itself be a qualified composite system while its constituents retain their own qualified histories. Selection of any of these systems as a reference, standard, or observer does not exempt it from UCC.

Thus no sample, observer, apparatus, or laboratory supplies a changeless standpoint outside the common cosmic extension.

20.5 Source-to-record physical chain

A physical observation may be schematically represented by:

$$\begin{aligned} \text{SourceManifestation} &\rightsquigarrow_{\text{phys}} \text{AccessiblePhysicalEffect} \\ &\rightsquigarrow_{\text{phys}} \text{ApparatusDetectorInteraction} \\ &\rightsquigarrow_{\text{phys}} \text{RecordFormation} \\ &\rightsquigarrow_{\text{phys}} \text{PhysicalRecordAccess}. \end{aligned} \quad (415)$$

The physical links are changes and interactions of systems within the same cosmic succession; none is an operation performed from outside that succession. The source, apparatus, record-bearing system, observer, and relevant laboratory or environmental systems may contribute at different members of $\mathcal{S}_C^{\text{tot}}$, as represented by the physical support set below.

A subsequent operational reading and scientific inference may be represented by

$$\text{PhysicalRecordAccess} \longrightarrow \text{Reading} \longrightarrow \text{RestrictedScientificConclusion}. \quad (416)$$

The availability and access of a record are physical; numerical representation and scientific inference add model-dependent and inferential operations. No arrow or physical arrow in these chains denotes identity of source, record, stage, reading, or time.

20.6 Record type

For physical record r :

$$r \not\equiv_{\text{type}} \text{SourceManifestation}. \quad (417)$$

Also:

$$r \not\equiv_{\text{type}} s. \quad (418)$$

And:

$$r \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (419)$$

A record may physically encode information about a source.

Information carriage does not erase the type distinction between:

$$\text{source}, \quad \text{record}, \quad \text{stage}, \quad \text{time}. \quad (420)$$

20.7 Physical acquisition support

For record $r \in \mathfrak{R}_P$, define:

$$J_r^{\text{phys}} := \{s \in \mathcal{S}_C^{\text{tot}} \mid \exists X \in \mathcal{L}_P \text{ PhysicalContributionToRecord}(X, s; r)\}. \quad (421)$$

A physically produced record satisfies:

$$\text{PhysicallyProducedRecord}(r) \implies J_r^{\text{phys}} \neq \emptyset. \quad (422)$$

The support need not be a singleton:

$$|J_r^{\text{phys}}| > 1 \quad (423)$$

is admissible.

Therefore:

$$\text{ReadableAt}(r; s_d) \not\Rightarrow J_r^{\text{phys}} = \{s_d\}. \quad (424)$$

20.8 Observation as a physically restricted projection

Let:

$$\mathfrak{A}_C^{P,M} \subseteq \{\mathfrak{R}_C(s) \mid s \in \mathcal{S}_C^{\text{tot}}\} \quad (425)$$

denote only the physically accessible part of the common-stage physical-realization architecture relevant to protocol P and model M .

Define schematically:

$$\mathcal{O}_{P,M} : \mathfrak{A}_C^{P,M} \times \Theta_{P,M} \longrightarrow \mathfrak{R}_P. \quad (426)$$

Here $\Theta_{P,M}$ denotes the declared physical acquisition, transformation, calibration, and record-production conditions.

The definition of the observation map does not entail injectivity, observational completeness, or invertibility to exact common cosmic change stages. Let $\text{ObservationMapSpecified}_{P,M}$ denote that the declared map is well defined for the stated protocol and model. Then:

$$\text{ObservationMapSpecified}_{P,M} \not\Rightarrow \text{Injective}(\mathcal{O}_{P,M}), \quad (427)$$

$$\text{ObservationMapSpecified}_{P,M} \not\Rightarrow \text{SurjectiveOntoCompletePhysicalReality}(\mathcal{O}_{P,M}). \quad (428)$$

Thus:

$$\text{ObservationMapSpecified}_{P,M} \not\Rightarrow \text{RecordToExactCosmicChangeStageInverse}. \quad (429)$$

This construction formalizes the distinction between ontological population completeness and physically restricted observational access.

21. Exact-Stage Restraint

21.1 Stage designation and epistemic identification

Each admitted $s \in \mathcal{S}_C^{\text{tot}}$ is a formal stage expression of realized physical change within the common cosmic earlier–later succession. The physical realization and the earlier–later relation are objective within the governing theory; no additional stage entity or independently existing ordering-position entity is required.

Yet:

$$s \in \mathcal{S}_C^{\text{tot}} \not\Rightarrow \text{ExactCosmicChangeStageObservationallyIdentified}(s). \quad (430)$$

The distinction is epistemic and does not make the cosmic ordering observer-dependent.

21.2 Positive observational warrant

Define:

$$\begin{aligned} \text{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi; r) &\iff \text{Detected}_{P,M,\varepsilon}(A, \chi; r) \\ &\quad \wedge \text{ValidSystemAttribution}_{P,M}(r; A) \\ &\quad \wedge \text{PhysicalSourceRecordLink}_{P,M}(A, \chi; r) \\ &\quad \wedge \text{AcceptedDifference}_{P,M,\varepsilon}(r). \end{aligned} \quad (431)$$

Then:

$$\begin{aligned} &\text{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi; r) \\ &\implies \text{Warrant}_{P,M} [\exists s \in I_A (\text{ManifestationAt}(A, \chi; s) \wedge \text{PhysReal}_A^+(s))]. \end{aligned} \quad (432)$$

The existential witness is physically actual.

The record does not thereby identify which member of I_A it is. Under UCC, the investigated system continues to realize physical change at every admitted member of its identity range, while the sample, detector, apparatus, record-bearing systems, observer, and laboratory — all physical systems of the universe — also continue to change. A reference frame that is only a coordinate construction is not a physical system and bears no record. This makes first noticeability a threshold within ongoing physical change rather than its onset. The stronger claim that an exact stage member cannot be identified is not derived from UCC alone; it also depends on the source–record architecture, finite physical access, and the absence of an independently warranted unique stage-identification inverse.

21.3 Formal Exact-Change-Stage Restraint

Principle 21.1 (Exact-Change-Stage Restraint). A valid physical observation may warrant that a manifestation, physical difference, threshold crossing, recurrence, formation-related manifestation, ending-related manifestation, or ordered physical development is realized at some common cosmic change stage in a physical-system history.

The observation does not thereby identify that exact common cosmic change stage or its exact position in the complete universal ordering. The restraint is epistemic rather than ontological: the source, sample, detector, apparatus, record-bearing systems, observer, and laboratory are physical systems of the universe and are themselves changing under UCC, so no changeless external observer or record is available as a cosmic-stage label.

The positive existential warrant is already fixed by Eq. (432). The restraint concerns what that same validated witness does not identify:

$$\text{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi;r) \not\Rightarrow \text{ExactCosmicChangeStageIdentified}_{P,M}(A,\chi), \quad (433)$$

and:

$$\text{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi;r) \not\Rightarrow \text{ExactCosmicOrderPositionIdentified}_{P,M}(A,\chi). \quad (434)$$

21.4 Exact-stage restraint is not derived from UCC alone

The UCC condition states universal system-specific physical-change actuality and excludes treating the sample, apparatus, observer, or laboratory — all physical systems of the universe — as a changeless external temporal anchor. It does not by itself establish observational non-identifiability.

Therefore:

$$\text{UCC} \not\Rightarrow \text{ExactChangeStageNonidentifiabilityAsLogicalTheorem}. \quad (435)$$

The restraint additionally depends on:

$$\begin{aligned}
& \text{source--record separation,} \quad \text{finite physical access,} \\
& \text{absence of an external changeless measurement anchor,} \\
& \text{changing acquisition and record-bearing systems,} \\
& \text{possibly non-singleton record support,} \quad \text{model dependence,} \\
& \text{and stage--record type distinction.}
\end{aligned} \tag{436}$$

21.5 First notice is not first change

Under UCC, every earlier admitted member of the same identity range already expresses actual physical change realized in that physical system:

$$\text{UCC} \wedge s \in I_A \wedge I_A^{<s} \neq \emptyset \implies \forall q \in I_A^{<s}, \quad \text{PhysReal}_A^+(q). \tag{437}$$

Let $\text{FirstResolvedManifestation}_{P,M,\varepsilon}(A, \chi; r)$ mean only that r is the earliest record in the declared protocol order that resolves manifestation χ as attributable to A above the stated criterion. It does not encode a minimum of the physical-change history. Hence

$$\begin{aligned}
& \text{FirstResolvedManifestation}_{P,M,\varepsilon}(A, \chi; r) \\
& \not\Rightarrow \exists s \in I_A \left[\text{ManifestationAt}(A, \chi; s) \right. \\
& \quad \left. \wedge \forall q \in I_A (q \prec_C s \Rightarrow \neg \text{PhysReal}_A^+(q)) \right].
\end{aligned} \tag{438}$$

A detection threshold concerns the changing source--acquisition--record system and the declared criterion. It does not establish a transition from physical stasis to physical change. A resolved manifestation warrants that the relevant physical condition was realized at some common cosmic change stage, but neither the exact member of $\mathcal{S}_C^{\text{tot}}$ nor its exact position in the universal ordering is thereby identified. The first resolved observation is therefore an observational threshold event, not an ontological onset marker for change.

21.6 Record order and source-development order

Let:

$$r_1 \prec_P r_2 \tag{439}$$

be an order relation in a declared record domain.

Then:

$$r_1 \prec_P r_2 \not\Rightarrow \text{SourceDevelopmentEarlier}(A, \chi_1, \chi_2). \tag{440}$$

A physical source-order bridge is required.

Let:

$$\text{OrderBridge}_{A;P,M}(r_1, r_2; \chi_1, \chi_2) \tag{441}$$

denote such a warranted relation.

Then a record comparison may support:

$$\begin{aligned} \text{Warrant}_{P,M} \left[\exists s_1, s_2 \in I_A : s_1 \prec_C s_2 \right. \\ \left. \wedge \text{ManifestationAt}(A, \chi_1; s_1) \right. \\ \left. \wedge \text{ManifestationAt}(A, \chi_2; s_2) \right]. \end{aligned} \quad (442)$$

This still does not identify the exact pair:

$$\text{Warrant}_{P,M}[\exists s_1, s_2 (\dots)] \not\Rightarrow \text{ExactCosmicChangeStagePairIdentified}_{P,M}(A, \chi_1, \chi_2). \quad (443)$$

22. Clocks as Physical Systems and Standards

22.1 Physical status of a clock

A clock is a physical system selected because a sufficiently reproducible, stable, controllable, or modelable part of its physical operation can generate ordered records and standardized numerical outputs. Modern atomic-clock comparisons provide high-precision physical record domains for such response analysis [32, 33, 43, 44, 45].

Thus:

$$\text{Clock}(C) \implies \text{PhysicalSystem}(C). \quad (444)$$

The clock possesses:

$$I_C = \{s \in \mathcal{S}_C^{\text{tot}} \mid \text{ExistsAs}(C, s)\}, \quad (445)$$

and under UCC:

$$C \in \mathcal{S}_{\text{phys}}(s) \implies \text{PhysReal}_C^+(s). \quad (446)$$

Under CRP:

$$\text{PhysReal}_C^+(s) \implies \mathcal{C}_C^{\text{act}}(s) \neq \emptyset. \quad (447)$$

Selection of a physical system as a standard does not remove it from physical change or causal realization.

22.2 Clock process, record, and reading

A clock involves at least three analytically distinct levels:

$$\text{ClockProcess}, \quad \text{ClockRecord}, \quad \text{ClockReading}. \quad (448)$$

Each remains type-distinct from time:

$$\text{ClockProcess} \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (449)$$

$$\text{ClockRecord} \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (450)$$

A clock record is a physical record produced by the clock process; it is not time. and:

$$\text{ClockReading} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (451)$$

The three objects are physical or operational parts of a clock model. None is the temporal referent T_{ITOF} .

22.3 Clock-record map

Let $J \subseteq I_C$ denote a portion of the clock's physical history relevant to record production.

Let $\Theta_{C,P}$ contain declared operating, environmental, interrogation, control, detector, transfer, and record-production conditions.

Define:

$$\mathcal{R}_{C,P} : (\mathcal{H}_C|_J, \Theta_{C,P}) \mapsto r_C. \quad (452)$$

This map is a physical/operational construction.

It does not assign a rate to time.

22.4 Numerical clock reading

Define:

$$N_{C,P} : \mathfrak{R}_{C,P} \longrightarrow \mathbb{R}_P. \quad (453)$$

For:

$$r_C \in \mathfrak{R}_{C,P}, \quad (454)$$

the protocol assigns the numerical reading

$$n_C = N_{C,P}(r_C). \quad (455)$$

This equation defines the reading as an output of the record map; it does not identify the reading with time.

Then:

$$n_C \not\equiv_{\text{type}} r_C, \quad (456)$$

and:

$$n_C \not\equiv_{\text{type}} s, \quad n_C \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (457)$$

22.5 Clock interval as a special operational metric

For two records:

$$r_{C,1} \triangleleft_P r_{C,2}, \quad (458)$$

define:

$$\Delta N_{C,P} := N_{C,P}(r_{C,2}) - N_{C,P}(r_{C,1}). \quad (459)$$

Then:

$$\Delta N_{C,P} \not\equiv_{\text{type}} \text{MagnitudeOf}(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (460)$$

The quantity is a special case of the operational metric architecture developed in Section 19.

22.6 Clock comparison

For clocks C_1, C_2 , map their readings into a declared comparison codomain:

$$d_{12}^{\text{obs}} := \Gamma_{1,12}(N_{C_1,P_1}(r_1)) - \Gamma_{2,12}(N_{C_2,P_2}(r_2)). \quad (461)$$

A resolved:

$$d_{12}^{\text{obs}} \neq 0 \quad (462)$$

warrants a physical/operational difference under the declared comparison conditions.

It does not establish:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{DifferentCosmicExtensions}(C_1, C_2). \quad (463)$$

Nor:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{CosmicOrderingDeformed}. \quad (464)$$

Nor:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{DifferentRatesOfTime}(C_1, C_2). \quad (465)$$

22.7 Clock Synchronization and Global-Stage Co-Presence

Clock synchronization remains operational:

$$\text{Synchronized}_{P,\varepsilon}(C_1, C_2). \quad (466)$$

Objective co-presence at a stage is supplied by CMA (Eq. (74)). The two are distinct in type:

$$\text{Synchronized}_{P,\varepsilon} \not\equiv_{\text{type}} \text{CosmicCoPresence}_C. \quad (467)$$

Common-stage unity is not constructed by clock agreement.

22.8 Clock failure

Functional clock failure need not terminate numerical identity:

$$\text{ClockFailure}_P(C; s) \not\Rightarrow \text{End}_C(s). \quad (468)$$

If:

$$s \in I_C, \quad (469)$$

then under UCC:

$$\text{ClockFailure}_P(C; s) \wedge s \in I_C \implies \text{PhysReal}_C^+(s). \quad (470)$$

Likewise:

$$\text{NoClockOutputAfter}_P(C; s) \not\Rightarrow \text{CosmicSuccessionStopsAt}(s). \quad (471)$$

22.9 Clock records under mechanical vibration

A clock is a physical system, not time; strong or sustained mechanical vibration can therefore alter its record. For an atomic or optical clock C , the record-producing chain comprises

$$\mathcal{K}_C = \{\text{atom or ion, interrogation laser, reference cavity, trap or lattice,} \\ \text{servo lock, detector, electronics, comparison link}\}. \quad (472)$$

Vibration acts on members of $\mathcal{K}_C$: on the length and therefore the resonance of the reference cavity that stabilizes the interrogation laser; on the position, motion, and confinement of the atoms or ions in the trap or lattice; on the servo lock; on the detector and readout; on connections and electronics; and on the signal path of a comparison between clocks. Each effect is a physical response of the bearer to a mechanical factor of the kind listed in Section 8. A declared vibration condition is

$$V = (S_a(f), [f_1, f_2], \hat{\mathbf{n}}, \text{CouplingPath}), \quad (473)$$

with acceleration spectral density S_a , frequency band, axis, and coupling path into C . The clock record under V is modelled as

$$y_C^{\text{obs}} = y_C^0 + \sum_k s_{k,C} + s_C^{\text{vib}}(V; \mathbf{\kappa}_C) + \varepsilon_C, \quad (474)$$

where s_C^{vib} is the vibration contribution predicted by a declared response model with sensitivity coefficients $\mathbf{\kappa}_C$ for the members of $\mathcal{K}_C$ (for example, the fractional frequency shift of the cavity per unit acceleration along $\hat{\mathbf{n}}$), and the remaining terms are as in Eq. (919).

Definition 22.1 (Clock vibration-condition protocol). A test of clock C under vibration condition V and protocol P satisfies

$$\begin{aligned} &\text{VibrationClockProtocol}(C, V, P) \\ &\implies \text{ConditionDeclared}(V) \wedge \text{ChainDeclared}(\mathcal{K}_C) \\ &\quad \wedge \text{SensitivityModelDeclared}(\mathbf{\kappa}_C) \\ &\quad \wedge \text{IndependentMotionRecord}(V) \wedge \text{InterleavedControl}(P) \\ &\quad \wedge \text{ProtocolFrozen}(P) \wedge \text{NoPostHocContributor}(P). \end{aligned} \quad (475)$$

Here the motion record is taken by an accelerometer or equivalent sensor independent of C ; interleaved control alternates vibration-on and vibration-off intervals or compares C with an isolated reference clock; and no contributor is added to the record model after the result is inspected.

A record shift observed under V is attributed first to the response of the bearer and of its record-producing chain:

$$\text{VibrationRecordShift}(C; V, P) \not\Rightarrow \text{TimeChanged}, \quad (476)$$

consistent with the Generalized Non-Transfer Principle (Section 27). If the shift agrees with $s_C^{\text{vib}}(V; \mathbf{\kappa}_C)$ within declared uncertainty, the response model is supported on the tested domain. If a residual remains, the response model is restricted, and a further physical contributor may be proposed only with a new predeclared test; the residual is not assigned to time. If vibration breaks the lock or interrupts output, the case is clock failure (Eq. (468)): the clock continues to change under UCC, and absence of output does not mark a cosmic stage (Eq. (471)). The same reading applies to pressure, heat and direct solar exposure,

shock, motion, and gravitational conditions: each acts on the physical bearer and its record chain, and a difference between clock records is a physical result in a physical bearer under declared conditions, not a transfer, change, or deformation of time.

23. Physical Response and Records

23.1 From clock response to typed application

V36/F16 developed clock-response modeling as an application-level construction. V39/F19 generalizes the same discipline to arbitrary admissible physical-system classes without promoting any application model into the temporal core. In this application vocabulary, a physical or operational “response” is a predicted or measured characterization of a realized or model-predicted physical effect; it is not a foundational intermediate entity between cause and change.

The governing typed chain is Eq. (115). For a declared system A , its independently warranted physical conditions, causal contributors, boundaries, and preparations enter the physical-input domain; the model-input bridge encodes them, the declared dynamical rule constrains or generates admissible model realizations according to its stated mathematical type, the model-output bridge yields predicted physical quantities, and the measurement bridge connects those quantities to records. Every step requires an independently specified relation of the correct type. No step is supplied by the definition of time, CMA, or UCC alone.

23.2 Application-level status

The distinction is:

$$\text{TemporalTypeClaim} \not\equiv_{\text{def}} \text{PhysicalResponseModel}. \quad (477)$$

And:

$$\text{SuccessfulPhysicalPrediction} \not\Rightarrow \text{ModelOutput} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (478)$$

23.3 Physical-condition bundle

For system A_i and accepted comparison index k , let:

$$\mathcal{B}_{i,k} := \left(\hat{X}_{i,k}, \hat{Z}_{i,k}, \hat{R}_{i,k}, \hat{\Pi}_{i,k} \right), \quad (479)$$

where:

- (i) $\hat{X}_{i,k}$ is the reconstructed system state relevant to the declared model;
- (ii) $\hat{Z}_{i,k}$ is the declared local or environmental physical-condition bundle;
- (iii) $\hat{R}_{i,k}$ contains relevant physical relations to other systems or reference structures;
- (iv) $\hat{\Pi}_{i,k}$ contains applicable physical propagation, transfer, interaction- path, or comparison-path conditions that belong to the declared model-input specification. Acquisition, calibration, and record-alignment conditions belong to the separately typed measurement layer.

Additional model-specific variables may be introduced only where physically required.

No component is automatically a coordinate of $\mathcal{S}_C^{\text{tot}}$.

23.4 Physical response function

Let:

$$\hat{q}_{i,k}^M = \mathcal{Q}_{i,M}(\mathcal{B}_{i,k}; \theta_i) \quad (480)$$

be a predicted physical or operational response. Where atomic or optical physical-system models are used, independently derived sensitivity calculations can supply application-level coefficient provenance when physically warranted [46].

The model parameters:

$$\theta_i = (\theta_{i,1}, \dots, \theta_{i,p_i}) \quad (481)$$

must possess declared provenance:

$$\text{Prov}(\theta_{i,j}) = \mathcal{P}_{i,j}. \quad (482)$$

Admissible provenance may include:

$$\begin{aligned} &\text{independent physical derivation, independent measurement,} \\ &\text{construction specification, independent calibration,} \\ &\text{external physical constraint, or declared derivation-domain estimation.} \end{aligned} \quad (483)$$

23.5 Benchmark recovery is not independent prediction

If:

$$\text{Prov}(\theta) = \text{BenchmarkAssigned}, \quad (484)$$

then:

$$\text{Prov}(\theta) = \text{BenchmarkAssigned} \not\Rightarrow \text{IndependentPrediction}(\theta). \quad (485)$$

Likewise:

$$\theta = \Theta(D_{\text{eval}}) \not\Rightarrow \text{IndependentPrediction}(D_{\text{eval}}). \quad (486)$$

A model may successfully recover an existing benchmark.

Recovery and advance prediction remain distinct inferential statuses.

24. Predeclared Physical Tests

24.1 Four inferential levels

V39/F19 retains the hierarchy:

$$\text{Recovery} \longrightarrow \text{AdvancePrediction} \longrightarrow \text{ModelDiscrimination} \longrightarrow \text{FoundationalAssessment}. \quad (487)$$

The arrows indicate increasing inferential burden.

They do not state automatic entailment.

Recovery concerns whether a declared application model represents known records adequately within a specified domain.

Advance prediction requires model form, parameter values or derivation rules, controls, uncertainty, and

acceptance criteria to be fixed independently before the evaluation outcome is known.

Model discrimination requires sufficiently separated rival predictions.

Foundational assessment additionally requires identifiable logical attribution to the foundational commitments under test.

24.2 Protocol freeze

Let:

$$\mathfrak{P}^* := (\mathcal{S}, \mathcal{B}, \mathcal{Q}, \mathcal{M}, \Theta, \mathcal{C}, \Sigma, \mathcal{E}, \mathcal{A}, \mathcal{F}, \mathcal{R}). \quad (488)$$

The components specify:

- (i) physical systems and system classes;
- (ii) physical-system boundaries and identity criteria;
- (iii) controlled and measured physical-condition bundles;
- (iv) application model and declared rival models;
- (v) model form and parameter provenance;
- (vi) positive and null-control channels;
- (vii) covariance, uncertainty, and bounded remainder structure;
- (viii) exclusions and data-quality rules;
- (ix) acceptance criteria;
- (x) failure criteria;
- (xi) replication specification.

Predictive status requires:

$$\text{ProtocolFrozen}(\mathfrak{P}^*) \implies \text{NoEvaluationOutcomeDependence}(\mathfrak{P}^*). \quad (489)$$

For any application whose claims depend on numerical physical-system identity, the system class, declared system boundary, and applicable identity criterion are part of the frozen protocol rather than post-evaluation interpretive choices:

$$\begin{aligned} & \text{ProtocolFrozen}(\mathfrak{P}^*) \wedge \text{IdentitySensitiveApplication}(\mathfrak{P}^*) \\ & \implies \text{OutcomeIndependentSystemClass}(\mathfrak{P}^*) \\ & \quad \wedge \text{OutcomeIndependentSystemBoundary}(\mathfrak{P}^*) \\ & \quad \wedge \text{OutcomeIndependentIdentityCriterion}(\mathfrak{P}^*). \end{aligned} \quad (490)$$

Where formation, ending, or successor attribution is part of the tested claim, the corresponding formation, ending, and successor criteria must likewise be declared before evaluation. A post-evaluation revision of any such criterion is a revised protocol, not a retroactive rescue of the original test:

$$\text{PostEvaluationIdentityOrBoundaryRevision} \not\Rightarrow \text{OriginalProtocolPredictionSucceeded}. \quad (491)$$

The revised identity or boundary specification requires independent evaluation under a newly declared protocol. This constraint does not impose one universal identity criterion on all physical-system classes; it prevents outcome-dependent reclassification within a specific test.

24.3 Derivation and evaluation separation

Let:

$$D_{\text{der}} \quad (492)$$

be the derivation domain and:

$$D_{\text{eval}} \quad (493)$$

the evaluation domain.

Require:

$$D_{\text{der}} \cap D_{\text{eval}} = \emptyset. \quad (494)$$

But:

$$D_{\text{der}} \cap D_{\text{eval}} = \emptyset \not\Rightarrow \text{NoEvaluationLeakage}. \quad (495)$$

Outcome-sensitive model form, preprocessing, exclusions, covariance choices, thresholds, controls, remainder bounds, or model-selection rules can still produce leakage despite record-level separation.

24.4 Prediction separation

For rival models M_1, M_2 , let:

$$\hat{\mathbf{y}}^{M_1}, \quad \hat{\mathbf{y}}^{M_2} \quad (496)$$

be their predeclared evaluation predictions.

Define:

$$\Delta \hat{\mathbf{y}}_{12} := \hat{\mathbf{y}}^{M_1} - \hat{\mathbf{y}}^{M_2}. \quad (497)$$

A meaningful discrimination claim requires that the predicted separation be resolved relative to the declared combined uncertainty structure. Using the short predicate $\text{ResolvedSep}_{\Sigma_{12}}$ for that declared criterion:

$$\text{PredictionSeparation}(M_1, M_2; P, D) \implies \text{ResolvedSep}_{\Sigma_{12}}(\Delta \hat{\mathbf{y}}_{12}). \quad (498)$$

No universal numerical threshold is imposed by the foundation.

The criterion belongs to the predeclared protocol.

24.5 Identifiability

A fitted model does not acquire predictive force merely because one parameter choice reproduces the observations.

Let:

$$J_D = \left[\frac{\partial \hat{y}_k^M}{\partial \theta_j} \right]_{k \in D} \quad (499)$$

be the local sensitivity matrix.

For positive-definite covariance:

$$\mathbf{W}_D^T \mathbf{W}_D = \Sigma_D^{-1}, \quad (500)$$

define:

$$\mathbf{X}_D = \mathbf{W}_D J_D. \quad (501)$$

A local identifiability criterion may require:

$$\text{Identifiable}_D(M) \iff \text{rank}(X_D) = p_M \wedge \kappa_2(X_D) \leq \kappa_{\max}, \quad (502)$$

where the conditioning bound is declared before evaluation.

This is an application-level statistical criterion.

It is not part of the definition of time.

25. Foundation-to-Observable Bridges

25.1 Foundational and Empirical Bridges Differ

The local stage-change condition remains:

$$\text{SCB}_C(s). \quad (503)$$

It records the local conjunction of CMA common-stage co-presence and UCC complete system-specific actual-change coverage at member s . It is a foundational representation only and is not an empirical bridge.

A foundational empirical bridge instead records the additional physical and observational premises required to derive a measurable consequence.

Therefore:

$$\text{SCB}_C \not\equiv_{\text{type}} \text{FoundationalEmpiricalBridge}. \quad (504)$$

The distinction is central to V39/F19.

25.2 Empirical bridge tuple

For foundational claim F , protocol P , and evaluation domain D , with any declared application-model family represented within B_F^{phys} by its physical-encoding, dynamical, and model-to-prediction premises, define the full empirical assessment tuple by:

$$\mathfrak{B}_F^{P,D} := \left(B_F^{\text{phys}}, B_F^{\text{obs}}, \mathcal{P}_F^{\text{aux}}, \Sigma_F, \mathcal{A}_F \right). \quad (505)$$

Here:

- (i) B_F^{phys} contains independently specified physical-encoding, dynamical, and model-to-prediction premises;
- (ii) B_F^{obs} contains independently specified acquisition, source-record, measurement, and reconstruction premises;
- (iii) $\mathcal{P}_F^{\text{aux}}$ contains additional independently warranted auxiliary assumptions;
- (iv) Σ_F contains the declared uncertainty and covariance architecture;
- (v) $\mathcal{A}_F$ contains the attribution conditions required to determine which premise class is actually challenged by an observed failure.

The tuple is methodological. Its first three entries refine the derivational core stated in Eq. (506); Σ_F and $\mathcal{A}_F$ govern evaluation and attribution rather than the logical content of the predicted observable itself.

When B_F^{phys} , B_F^{obs} , or $\mathcal{P}_F^{\text{aux}}$ appears in a conjunction or entailment, the symbol denotes the conjunction of its declared propositional premises. The tuple $\mathfrak{B}_F^{P,D}$ itself is never used as a proposition.

It is not a physical object and not a component of time.

25.3 Foundational-to-observable derivation

A claimed observable consequence O_F must satisfy:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F. \quad (506)$$

The derivation itself must not be reconstructed after observing the outcome if advance predictive status is claimed.

Thus:

$$\text{AdvanceFoundationalPrediction} \implies \text{OutcomeIndependentSpecification}(\mathfrak{B}_F^{P,D}, O_F). \quad (507)$$

25.4 Observable Failure and Foundational Scope

If the derivation of Eq. (506) holds and $\neg O_F$ is observed, then

$$\neg O_F \not\Rightarrow \neg F. \quad (508)$$

The failure may instead lie in:

$$B_F^{\text{phys}}, \quad B_F^{\text{obs}}, \quad \mathcal{P}_F^{\text{aux}}, \quad \Sigma_F, \quad \text{or their declared domain.} \quad (509)$$

25.5 Foundational Attribution Principle

Principle 25.1 (Foundational Empirical Attribution Principle). A failed or successful application-level observable warrants a conclusion about a foundational commitment only where the derivational path from foundation to observable is independently specified and the attribution of the result to the foundational difference is identifiable against bridge, auxiliary, acquisition, and uncertainty alternatives.

Formally:

$$\begin{aligned}
\text{FoundationalAttribution}(F; O, P, D) \implies & \text{FoundationToObservableDerivationDeclared} \\
& \wedge \text{OutcomeIndependentBridges} \\
& \wedge \text{ProtocolFrozen}(P) \\
& \wedge \text{NoEvaluationLeakage}(P, D) \\
& \wedge \text{ValidPhysicalSystemBoundaries} \\
& \wedge \text{ValidIdentityCriteriaWhereApplicable} \\
& \wedge \text{ValidAcquisitionSupport} \\
& \wedge \text{ValidCovariance} \\
& \wedge \text{PredictionSeparationIdentifiable} \\
& \wedge \text{AlternativeAttributionControlled}.
\end{aligned} \tag{510}$$

These conditions are necessary.

They are not claimed to be universally sufficient for every possible experimental domain. The principle is methodological and evidential: it constrains what may be warranted from a foundation-to-observable derivation. It adds no temporal component, ontological realization commitment, physical causal law, or independent empirical postulate.

25.6 Current empirical status and foundation-specific prediction criterion

The existence of formal counterconditions to CMA, the UCC continuity condition, or other foundational commitments is distinct from the existence of a presently available finite experiment that uniquely identifies those counterconditions. Likewise, a foundational conflict with a rival temporal ontology is not by itself an experimental preference relation.

Therefore, where no independently warranted physical branch produces a resolved prediction separation attributable to the foundational difference, V39/F19 does not claim that experiment has already established empirical preference for ITOF over that rival ontology:

$$\neg \text{FoundationSpecificSeparation}_{P,D} \implies \neg \text{ExperimentalPreferenceEstablished}_{P,D}(I, R). \tag{511}$$

This is an epistemic-status statement, not a retreat from the formal contrary conditions. The current scientific burden is to construct an independently warranted physical bridge for which prediction separation and foundational attribution survive the declared uncertainty and bridge freedom.

At the present V39/F19 stage, the framework does not claim a unique quantitative observable residual derived from the temporal foundation alone. This limitation is stated explicitly because a foundation-specific prediction cannot be created by stipulation without adding prediction-relevant physical content. Any future claim of an ITOF-specific prediction must identify the responsible foundational premise, derive the physical consequence through independently warranted application physics, fix the measurement bridge before outcome-sensitive evaluation, compare the relevant rival on matched shared inputs, and show that the resulting observable separation survives uncertainty and admissible bridge freedom. A candidate effect that is merely appended as an optional interaction is a test of that interaction, not yet a test of ITOF's temporal ontology.

25.7 Foundational discrimination between two alternatives

For foundational alternatives:

$$F, \quad F^*, \quad (512)$$

a warranted discrimination claim requires independently specified observable consequences:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F, \quad (513)$$

$$F^* \wedge B_{F^*}^{\text{phys}} \wedge B_{F^*}^{\text{obs}} \wedge \mathcal{P}_{F^*}^{\text{aux}} \vdash O_{F^*}. \quad (514)$$

A necessary condition is:

$$\begin{aligned} & \text{Warrant}_{P,D} [\text{FoundationalDiscrimination}(F, F^*)] \\ \implies & \text{OutcomeIndependentSpecification} \left(\mathfrak{B}_F^{P,D}, \mathfrak{B}_{F^*}^{P,D} \right) \\ & \wedge \text{ProtocolFrozen}(P) \\ & \wedge \text{NoEvaluationLeakage}(P, D) \\ & \wedge \text{PredictionSeparationBeyondCombinedUncertainty} (O_F, O_{F^*}; P, D) \\ & \wedge \text{FoundationalAttributionIdentifiable} (F, F^*; P, D). \end{aligned} \quad (515)$$

Shared calibrations or systematic inputs are not prohibited where their dependence is explicitly represented in provenance and covariance.

25.8 Application-model vs foundational discrimination

If two application models differ:

$$M_1 \neq M_2, \quad (516)$$

and observation favours one:

$$\text{DiscriminationFavours}(M_1), \quad (517)$$

the warranted conclusion is initially:

$$\text{Warrant} [\text{ApplicationModelSupportedOn}(M_1; D)]. \quad (518)$$

It does not automatically follow that:

$$\text{DiscriminationFavours}(M_1) \not\Rightarrow \text{FoundationalTheoryEstablished}. \quad (519)$$

Application models may differ for reasons downstream of their foundations.

25.9 No post-hoc immunity

Suppose model M_1 makes a predeclared advance prediction and fails.

A later model:

$$M_2 \quad (520)$$

may legitimately introduce a newly established physical contributor, improved response law, corrected

boundary condition, or revised uncertainty structure.

That scientific revision does not alter the historical status of the original test:

$$\text{PostEvaluationRevision}(M_1 \rightarrow M_2) \not\Rightarrow \text{OriginalAdvancePredictionSucceeded}. \quad (521)$$

The revised model requires:

$$M_2 \longrightarrow D_{\text{new}} \quad (522)$$

for new predictive evaluation.

This prevents unrestricted auxiliary modification from making an application model empirically immune to failure.

25.10 Direct UCC countercondition

The direct physical contrary to UCC is $\neg \text{UCC}$ (Eq. (905)); by Eq. (89), it is exactly $\exists A \in \mathcal{U}_{\text{phys}} \exists s \in I_A : \neg \text{PhysReal}_A^+(s)$.

A null difference:

$$D^{\text{obs}} = 0 \quad (523)$$

does not establish that contrary:

$$D^{\text{obs}} = 0 \not\Rightarrow \exists A \in \mathcal{U}_{\text{phys}} \exists s \in I_A, \quad \text{NC}_A^{\text{phys}}(s). \quad (524)$$

Positive physical warrant for $\text{NC}_A^{\text{phys}}(s)$ of the qualified persisting system at an admitted stage would be required. A zero selected-variable result, criterion-relative stability, or failure to resolve change is not the same proposition.

25.11 CMA challenge condition

The governing contrary to CMA is a qualified system with a private stage or a private ordering of stages (Eq. (904)). Complete physical non-change of a realized qualified system is instead the direct contrary to UCC.

Different physical states, different clock outputs, spatial separation, delayed signals, or different observational access do not themselves establish either kind of challenge.

Thus:

$$\text{DifferentPhysicalOutputs}(A, B) \not\Rightarrow \neg \text{CMA}. \quad (525)$$

Likewise:

$$\text{SignalDelay}(A, B) \not\Rightarrow \neg \text{CMA}. \quad (526)$$

A challenge to CMA must warrant a private stage or private ordering. A challenge to UCC must establish complete physical non-change of at least one realized qualified system at an admitted member. These evidential targets are distinct.

25.12 Strong test condition

A strong discriminating application satisfies:

$$\begin{aligned}
 \text{StrongDiscriminatingTest} \implies & \text{ProtocolFrozen} \\
 & \wedge \text{IndependentPhysicalBridge} \\
 & \wedge \text{IndependentParameterProvenance} \\
 & \wedge \text{ValidPhysicalSystemBoundaries} \\
 & \wedge \text{ValidAcquisitionSupport} \\
 & \wedge \text{ValidCovariance} \\
 & \wedge \text{NoEvaluationLeakage} \\
 & \wedge \text{IdentifiableModel} \\
 & \wedge \text{PositiveDiscriminatingChannels} \\
 & \wedge \text{NullControlChannels} \\
 & \wedge \text{RivalPredictionSeparation} \\
 & \wedge \text{IndependentEvaluation} .
 \end{aligned} \tag{527}$$

Where replication is physically appropriate and claimed:

$$\text{IndependentReplication} \tag{528}$$

is added as a further condition.

The distinction between a formal contrary and a finite experimental procedure, and the limits of finite evidence for universal commitments, are stated in Appendix F.

26. Application Bridge Structure

26.1 Five distinct levels

The V39/F19 bridge architecture consists of five distinct levels without collapsing their roles.

$$\begin{aligned}
 \text{Level I:} & \quad \text{FoundationalCommitment,} \\
 \text{Level II:} & \quad \text{FoundationalDefinedRepresentation,} \\
 \text{Level III:} & \quad \text{PhysicalEncodingDynamicsAndPrediction,} \\
 \text{Level IV:} & \quad \text{MeasurementAndRecordBridge,} \\
 \text{Level V:} & \quad \text{EmpiricalComparisonAndAttribution.}
 \end{aligned} \tag{529}$$

For example:

$$\text{CMA} \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}} \text{ SCB}_C(s) . \tag{530}$$

belongs to the foundational and defined-representation levels. The converse at each admitted stage is only the local unpacking of the defined bridge into its CMA and UCC components; the bridge is not an independent foundational commitment.

Level III is the typed physical application chain formed by the model-input bridge, the declared dynamics, and the model-output bridge in Eq. (115). Level IV begins only when predicted physical quantities enter the measurement or observation bridge and are connected to records under a declared protocol. Thus a physical response law belongs to Level III, whereas a source–record or acquisition relation belongs to Level IV.

A model-discrimination or foundational-attribution claim belongs to Level V.

26.2 Worked instantiation: the no-asymptotic-closure expectation

The currently-complete-isolation criterion and its associated expectation (Section 5.7, Proposition 5.3) are a qualitative empirical commitment, not a numeric discriminant, and fall under the same level discipline:

- Level I: UCC,
- Level II: $\text{CCPI}_{M,G}(A,s)$ and the stagewise form of UCC (Eq. (87)),
- Level III: the declared M fixing which channels count as closed, at boundary and granularity G (Definition 5.2),
- Level IV: a certification protocol P for a named system, reporting either an identified channel or an upper bound on residual change, (531)
- Level V: treatment of a decreasing sequence of Level-IV bounds as adverse evidence against UCC, only where the Level-III and Level-IV premises are independently defended.

UCC does not determine which channel a Level-III model names (Eq. (535)). A Level-IV result bears on UCC only through Level V. Level IV can be executed on existing isolation experiments.

26.3 No upward identity transfer

No successful lower-level construction changes the logical type of the foundation.

Thus:

$$\text{SuccessfulApplicationChain} \not\Rightarrow \text{ApplicationOutput} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (532)$$

And:

$$\text{SuccessfulMeasurementBridge} \not\Rightarrow \text{Record} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (533)$$

The same type boundary applies to successful measurement: a record does not become time.

Likewise:

$$\text{SuccessfulEmpiricalRecovery} \not\Rightarrow \text{ModelParameter} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (534)$$

These non-transfer results are instances of the generalized Non-Transfer Principle.

26.4 No downward automatic derivation

The temporal definition $T_{\text{TOF}} = (\mathcal{S}_C^{\text{tot}}, \prec_C)$ does not by itself determine any specific physical dynamics, clock response, metric output, signal law, observation model, or experimental prediction:

$$\text{TemporalDefinition}_{\text{TOF}} \not\Rightarrow \text{SpecificApplicationPhysics}. \quad (535)$$

Likewise:

$$\text{CMA} \not\Rightarrow \text{SpecificClockDifference}, \quad (536)$$

and:

$$\text{UCC} \not\Rightarrow \text{SpecificNonzeroSystemDifferential}. \quad (537)$$

System specificity permits physically different responses.

It does not manufacture a quantitative difference without an independently specified physical law.

26.5 Bridge closure before external-theory confrontation

Quantitative confrontation with an external physical theory requires the dependency chain:

$$\begin{aligned} \text{FoundationalDifference} &\longrightarrow \text{IndependentlySpecifiedPhysicalBridge} \\ &\longrightarrow \text{DistinctAdvancePrediction} \\ &\longrightarrow \text{PhysicalRecord} \\ &\longrightarrow \text{ControlledComparison} \\ &\longrightarrow \text{IdentifiableAttribution}. \end{aligned} \quad (538)$$

Without the second and third steps, foundational disagreement remains foundational disagreement.

It does not become an empirical success merely by declaration.

The generalized Non-Transfer Principle fixes the type boundary governing such external-theory comparisons.

27. Generalized Non-Transfer Principle

27.1 Scope

The Non-Transfer Principle prevents mathematical, representational, physical, and operational success from being converted into temporal identity without an independent identity argument.

V39/F19 generalizes that discipline beyond clocks and relativistic quantities.

Let q denote any mathematical, physical-model, operational, representational, geometrical, statistical, coordinate, record-derived, or comparison quantity.

Let:

$$\text{MathematicallyConsistent}_M(q) \quad (539)$$

state that q belongs to a mathematically consistent declared model M .

Let:

$$\text{OperationalSuccess}_{P,M,D}(q) \quad (540)$$

state that use of q contributes successfully to prediction, reconstruction, measurement, comparison, or calculation under protocol P , model M , and physical domain D .

Principle 27.1 (Generalized Non-Transfer Principle (NTP)). Mathematical consistency, physical applicability, and operational or predictive success do not transfer temporal identity to the object, parameter, relation, or quantity possessing those properties:

$$\boxed{\text{NTP : } \text{MathematicallyConsistent}_M(q) \wedge \text{OperationalSuccess}_{P,M,D}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}.} \quad (541)$$

The principle protects the governing definition in Eq. (11).

27.2 Three separate transfers are prohibited

V39/F19 distinguishes three logically different transfer errors.

First:

$$\text{MathematicallyConsistent}_M(q) \not\Rightarrow \text{ActuallyPhysicallyRealized}(q). \quad (542)$$

Second:

$$\text{ActuallyPhysicallyRealized}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (543)$$

Third:

$$\text{OperationalSuccess}_{P,M,D}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (544)$$

These statements are not one transitive argument.

They block different unjustified inferences.

A mathematical object may lack physical realization.

A physically real object may remain non-temporal.

A predictively successful quantity may remain only the quantity defined by its model or measurement procedure.

27.3 Naming does not determine type

A quantity may historically contain the word “time” in its conventional name.

That linguistic fact does not determine its ontological type:

$$\text{NameContainsTime}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (545)$$

Temporal classification depends on the construction and role of q and on an independent identity argument relative to the governing definition of T_{ITOF} . Terminological convention cannot supply that identity argument.

27.4 Model-parameter Non-Transfer

The basic model-parameter non-transfer statement is already fixed in Eq. (349). Even predictive success does not supply temporal identity:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \wedge \text{OperationalSuccess}_{P,M,D}(\lambda_M) \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}. \quad (546)$$

A parameter may successfully order a solution, label model states, parameterize a path, or predict physical records.

Those roles do not make it the universal cosmic extension.

27.5 Operational-metric Non-Transfer

For operational metric quantity m_P :

$$m_P = \mathcal{M}_P^{\text{op}}(r_1, \dots, r_n; \kappa_P) \not\Rightarrow m_P \equiv_{\text{type}} T_{\text{ITOF}}. \quad (547)$$

Higher precision likewise does not transfer type:

$$\text{Precision}(m_P) \rightarrow \text{VeryHigh} \not\Rightarrow m_P \equiv_{\text{type}} T_{\text{ITOF}}. \quad (548)$$

27.6 Coordinate Non-Transfer

For coordinate map:

$$\chi : \mathcal{E}_{\text{phys}} \longrightarrow \mathbb{R}^n, \quad (549)$$

the coordinate representation of event e is not the event:

$$e \not\equiv_{\text{type}} \chi(e). \quad (550)$$

Likewise, a coordinate component used to label model evolution remains type-distinct from time:

$$x^0 \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (551)$$

27.7 Geometrical Non-Transfer

Let:

$$(\mathcal{M}, g) \quad (552)$$

be a mathematical manifold–metric structure used in an external or application model.

Then:

$$\text{GeometricalRepresentation}(\mathcal{M}, g) \not\Rightarrow (\mathcal{M}, g) \equiv_{\text{type}} T_{\text{ITOF}}. \quad (553)$$

Even if the geometrical model successfully predicts physical records:

$$\text{OperationalSuccess}_{P,M,D}(\mathcal{M}, g) \not\Rightarrow (\mathcal{M}, g) \equiv_{\text{type}} T_{\text{ITOF}}. \quad (554)$$

27.8 Physical-history Non-Transfer

A physical history is not time (Eq. (236)). The restricted ordering $\prec_C|_{I_A}$ is the order component of the physical history and does not create an independent private time. In the governing ontology:

$$\forall A \in \mathcal{U}_{\text{phys}}, \quad \neg \text{PrivateTimeOf}(A). \quad (555)$$

27.9 Physical-realization-profile Non-Transfer

The complete-population common-stage physical-realization profile remains outside the definition of time by Eq. (181).

The restriction remains necessary because V39/F19 expands the theory of physical realization.

The expanded realization architecture does not identify time with the cosmic physical totality or with any complete physical-reality profile:

$$T_{\text{ITOF}} \not\equiv_{\text{type}} \mathcal{U}_C^{\text{phys}}, \quad T_{\text{ITOF}} \not\equiv_{\text{type}} \text{CompletePhysicalRealityProfile}. \quad (556)$$

The cosmic physical totality is physical ontology; a realization profile is a typed physical representation; time denotes the ordered extension of realized change. None is retyped as another.

The temporal architecture and the physical-realization architecture remain integrated but type-distinct.

28. Relativistic Temporal Identifications

28.1 Foundational point of disagreement

Relativistic theories possess substantial calculational and predictive success in experimentally tested physical domains [4, 5, 26, 27]. V39/F19 treats those successes as successes of the corresponding physical and geometrical models within the domains in which their empirical warrant is established; the associated foundational questions concerning time remain separate [28, 29].

This acknowledgment does not alter the foundational issue.

ITOF rejects identification of time with coordinate time, metric interval, proper-time functional, frame-dependent simultaneity relation, spacetime metric, foliation parameter, cosmological coordinate parameter, or clock output.

The disagreement concerns temporal identity.

It is therefore direct and foundational.

Two questions must remain separate:

$$\text{DoesRelativisticModelPredictPhysicalRecordsSuccessfully?} \quad (557)$$

and:

$$\text{IsRelativisticModelQuantityIdenticalWithITOFTime?} \quad (558)$$

The first is an empirical and quantitative question.

The second is definitional and ontological.

Hence:

$$\text{RelativisticPredictionSuccessful} \not\Rightarrow \text{RelativisticTemporalQuantity} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (559)$$

28.2 Foliation and the common stage domain

A relativistic spacetime model may employ a foliation $\{\Sigma_\lambda\}_{\lambda \in L}$ when such a construction is independently admissible for the declared model and domain. V39/F19 does not identify any leaf Σ_λ , foliation parameter λ , coordinate-time function, or Cauchy slicing with a common cosmic change stage merely because that mathematical structure is useful. A foliation is a structure inside a declared spacetime representation. By contrast, $\mathcal{S}_C^{\text{tot}}$ is one cosmic-stage domain for all qualified physical-system identities, and CMA makes every system's realization succession a segment of it. Neither is constructed from a foliation, coordinate chart, or synchronization convention.

Accordingly, relating a relativistic spacetime representation to ITOF cosmic-stage expressions requires an independently declared cross-representation bridge assigning the relevant physically realized manifestations to members of $\mathcal{S}_C^{\text{tot}}$. Such a bridge is not supplied by a Lorentz transformation, coordinate convention, synchronization rule, metric tensor, or foliation alone, and it is not inferred from the empirical success of those constructions. The existence of a usable foliation in a particular relativistic model therefore neither establishes CMA nor turns that foliation into $\mathcal{S}_C^{\text{tot}}$. CMA supplies neither a spacetime-to-stage map nor a physical-change requirement; UCC separately supplies complete system-specific actual-change continuity.

This architecture does not convert ITOF into presentism. The derived reference-stage prefix introduced earlier is only an order-relative subset of the full admitted stage totality; it does not define a moving present, generated frontier, second mode of stage existence, or privileged hypersurface. Neither the definition of time nor CMA postulates a temporal ether, rest medium, preferred inertial frame, velocity field, or material carrier.

The foundational conflict with CMA is stated in Section 31.4; it concerns temporal ontology, cannot be removed by a change of coordinates or synchronization convention, and is distinct from UCC's actual-change burden. Relativistic equations may nevertheless be used as independently warranted application-level physical models; their calculational or empirical success does not transfer temporal identity to a coordinate, metric quantity, proper-time functional, or spacetime foliation.

28.3 Relativistic quantity family

Let:

$$\mathcal{Q}_{\text{rel}} := \left\{ \begin{array}{l} x_F^\mu, t_F, g_{\mu\nu}, ds^2, \tau[\gamma, g], \Sigma_\lambda, \sim_F, \\ J^+(p), J^-(p), t_{\text{cos}}, t_{\text{age}}, \\ \text{ClockOutput}, \text{SynchronizationOutput} \end{array} \right\}. \quad (560)$$

These objects perform different mathematical, geometrical, physical-model, or operational roles.

Their common inclusion in $\mathcal{Q}_{\text{rel}}$ does not make them one type.

The governing ITOF conclusion is:

$$\forall q \in \mathcal{Q}_{\text{rel}}, \quad q \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (561)$$

In particular:

$$t_F \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (562)$$

$$g_{\mu\nu} \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (563)$$

$$ds^2 \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (564)$$

$$\tau[\gamma, g] \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (565)$$

$$\Sigma_\lambda \not\equiv_{\text{type}} s, \quad s \in \mathcal{S}_C^{\text{tot}}, \quad (566)$$

$$\sim_F \not\equiv_{\text{type}} \text{CosmicCoPresence}_C, \quad (567)$$

$$\text{ClockOutput} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (568)$$

No successful calculation changes these type relations.

28.4 Relativistic Non-Transfer

For $q \in \mathcal{Q}_{\text{rel}}$, the generalized Non-Transfer Principle of Eq. (541) applies without a relativistic exception.

Even physical realization of a quantity's referent does not transfer temporal identity:

$$\text{ActuallyPhysicallyRealizedReferent}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (569)$$

For example, physical gravitational systems, paths, clocks, signals, and matter distributions may be real while the mathematical metric used to represent their relations remains a model quantity.

28.5 No semantic transfer from successful terminology

The conventional use of terms such as:

$$\begin{aligned} &\text{coordinate time, proper time, time dilation, cosmic time,} \\ &\text{time coordinate, time function} \end{aligned} \quad (570)$$

does not settle the ontological question posed by ITOF.

Thus:

$$\text{StandardTerminology}(q, \text{"time"}) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (571)$$

The ITOF classification follows the construction and role of the quantity, not its conventional label.

29. Coordinates and Temporal Invariance

29.1 Physical event and coordinate assignment

Let:

$$\mathcal{E}_{\text{phys}} \quad (572)$$

be a declared family of physically realized events or manifestations.

For chart or frame F , let:

$$\chi_F : \mathcal{E}_{\text{phys}} \longrightarrow \mathbb{R}^4. \quad (573)$$

For:

$$e \in \mathcal{E}_{\text{phys}}, \quad (574)$$

the coordinate tuple is:

$$x_F^\mu(e) = \chi_F(e). \quad (575)$$

The physical manifestation is not its coordinates:

$$e \not\equiv_{\text{type}} \chi_F(e). \quad (576)$$

Likewise:

$$\mathcal{L}_C^{\text{phys}} \not\equiv_{\text{type}} (\mathcal{M}, g). \quad (577)$$

A spacetime manifold and metric may represent physical relations in an application model; they are not identical with the cosmic physical totality represented.

29.2 Coordinates Do Not Create Common Stages

Suppose:

$$\text{ManifestationAt}(A, \chi; s), \quad s \in I_A. \quad (578)$$

A relativistic model may assign:

$$\chi_F(e) = (x_F^0, x_F^1, x_F^2, x_F^3). \quad (579)$$

Accordingly, the coordinate component remains type-distinct from both the common cosmic-stage member and the ITOF temporal referent:

$$x_F^0 \not\equiv_{\text{type}} s. \quad (580)$$

$$x_F^0 \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (581)$$

A coordinate value may be operationally associated with a physical event. Even when a coordinate component is chosen so that its ordering agrees with $\prec_C$ on a declared domain, it remains an order representation in the sense of Eq. (38). Its numerical intervals are therefore not fixed by the bare cosmic order.

It does not become the common cosmic-stage designation or the ordering position that designation represents.

29.3 Different meanings of invariance

V39/F19 explicitly distinguishes:

$$\text{PairwiseDefDistinct}(\text{InvariantCosmicOrdering}, \text{LorentzInvariance}, \text{GeneralCovariance}). \quad (582)$$

Invariant Cosmic Ordering means that:

$$\prec_C \quad (583)$$

is the one universal earlier–later ordering of the common stages of change, invariant in the sense of Definition 2.1: a non-metric succession that is non-reversed, with no stage empty of change or static.

Lorentz invariance concerns transformation properties under Lorentz transformations.

General covariance concerns admissible coordinate representation of physical laws.

Neither defines:

$$T_{\text{ITOF}}. \quad (584)$$

Therefore:

$$\text{LorentzInvariant}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}, \quad (585)$$

and:

$$\text{GenerallyCovariant}(M) \not\Rightarrow \text{TimeDefinedBy}(M). \quad (586)$$

29.4 Coordinates Do Not Transform Cosmic Order

A special-relativistic transformation may contain:

$$t' = \gamma \left(t - \frac{vx}{c^2} \right), \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}. \quad (587)$$

The transformation relates coordinate assignments.

It does not transform:

$$(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (588)$$

Thus:

$$t \neq t' \not\Rightarrow \text{ITOFTimeTransformed}. \quad (589)$$

More generally:

$$\text{CoordinateTransform}(F \rightarrow F') \not\Rightarrow \text{Transform}(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (590)$$

Different coordinate assignments do not generate different cosmic extensions.

30. Metric Geometry and Proper Time

30.1 Metric interval

In a relativistic model:

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu. \quad (591)$$

The expression defines a geometrical model quantity under the adopted metric structure.

It is not:

$$ds^2 \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (592)$$

Nor is:

$$g_{\mu\nu} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (593)$$

Metric success therefore does not establish temporal identity:

$$\text{MetricPredictionSuccessful} \not\Rightarrow g_{\mu\nu} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (594)$$

30.2 Metric dependence on physical or coordinate variables

A metric may be represented as:

$$g_{\mu\nu} = g_{\mu\nu}(x). \quad (595)$$

It does not follow that:

$$g_{\mu\nu} = g_{\mu\nu}(x) \not\Rightarrow T_{\text{ITOF}} = T_{\text{ITOF}}(x). \quad (596)$$

ITOF does not define time as a field whose value changes from one spacetime location to another.

30.3 Curvature

General-relativistic geometry may possess:

$$R^{\rho}{}_{\sigma\mu\nu} \neq 0. \quad (597)$$

This geometrical result does not imply:

$$R^{\rho}{}_{\sigma\mu\nu} \neq 0 \not\Rightarrow \text{ITOFTimeCurved}. \quad (598)$$

The ordered pair:

$$(\mathcal{S}_C^{\text{tot}}, \prec_C) \quad (599)$$

is not assigned a curvature tensor by the definition of time.

30.4 Einstein field equation

A general-relativistic application may employ:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}. \quad (600)$$

V39/F19 does not deny the mathematical content or empirically warranted physical use of such equations [5, 26].

The relevant type conclusion remains:

$$\text{EinsteinFieldEquationSuccessfulOn}(D) \not\Rightarrow g_{\mu\nu} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (601)$$

The equation relates geometrical and matter-energy model quantities.

It does not define the ITOF temporal referent.

30.5 Proper-time functional

For timelike path γ :

$$\tau[\gamma, g] = \frac{1}{c} \int_{\gamma} \sqrt{-g_{\mu\nu} dx^{\mu} dx^{\nu}}. \quad (602)$$

The quantity depends on:

$$\gamma \quad \text{and} \quad g. \quad (603)$$

Therefore:

$$\tau = \tau[\gamma, g]. \quad (604)$$

ITOF therefore assigns the direct type relation:

$$\tau[\gamma, g] \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (605)$$

Different path-dependent values satisfy:

$$\tau[\gamma_1, g] \neq \tau[\gamma_2, g]. \quad (606)$$

That difference does not establish different temporal extensions:

$$\tau[\gamma_1, g] \neq \tau[\gamma_2, g] \not\Rightarrow \text{DistinctTemporalReferents}(\gamma_1, \gamma_2). \quad (607)$$

They establish different values of the declared metric functional.

30.6 Proper time is not a private physical-system time

For physical system A represented by a worldline or path γ_A :

$$\tau[\gamma_A, g] \quad (608)$$

is not the restriction:

$$\prec_C|_{I_A}. \quad (609)$$

Thus:

$$\tau[\gamma_A, g] \not\equiv_{\text{type}} \prec_C|_{I_A}. \quad (610)$$

Accordingly, the proper-time functional is not a private temporal extension belonging to the system:

$$\tau[\gamma_A, g] \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (611)$$

The system has a physical history within the one common cosmic ordering.

It does not possess a separate temporal extension.

30.7 Clock agreement with proper-time calculation

A physical clock output may satisfy:

$$N_{C,P} \approx K_{P,M}(\tau[\gamma, g]) \quad (612)$$

within the warranted domain of a relativistic model.

The conclusion is:

$$\text{QuantitativeAssociationSupported}(N_{C,P}, \tau[\gamma, g]). \quad (613)$$

It is not:

$$N_{C,P} \approx K_{P,M}(\tau[\gamma, g]) \not\Rightarrow \tau[\gamma, g] \equiv_{\text{type}} T_{\text{ITOF}}. \quad (614)$$

The relation is therefore an example of successful model-to-record association without ontological transfer.

31. Relativity of Simultaneity, Lorentzian Structure, and Common Stages

31.1 Frame-dependent simultaneity

Let:

$$e_1 \sim_F e_2 \quad (615)$$

denote simultaneity assigned according to relativistic frame, chart, and synchronization structure F .

Different admissible frames may satisfy:

$$\exists e_1, e_2, F, F', \quad e_1 \sim_F e_2 \wedge \neg(e_1 \sim_{F'} e_2). \quad (616)$$

For the standard Lorentz transformation along one spatial axis,

$$\Delta t' = \gamma \left(\Delta t - \frac{v \Delta x}{c^2} \right). \quad (617)$$

Hence two spatially separated events satisfying $\Delta t = 0$ in one inertial coordinate system generally satisfy

$$\Delta t' = -\gamma \frac{v \Delta x}{c^2} \neq 0 \quad (618)$$

when $v \Delta x \neq 0$. V39/F19 therefore does not dispute the frame-dependence of relativistic coordinate simultaneity. The foundational issue is instead whether that representational fact exhausts the ontology of temporal ordering and co-realization.

The relation:

$$\sim_F \quad (619)$$

is a relativistic representational relation.

It is not:

$$\sim_F \not\equiv_{\text{type}} \text{CosmicCoPresence}_C. \quad (620)$$

31.2 Global-stage co-presence is not synchronization

Clock synchronization neither creates nor replaces the formal cosmic-stage domain, and co-presence is not obtained from that domain alone. It follows from CMA (Eq. (74)), which is stated through realization successions, not through signal exchange, clock agreement, coordinate equality, Einstein synchronization, frame choice, or hypersurface construction. UCC separately requires each co-present system to realize its own physical change.

Thus:

$$\text{SynchronizationConventionChanged} \not\Rightarrow \text{CosmicCoPresenceChanged}. \quad (621)$$

And:

$$\text{CoordinateAssignmentChanged} \not\Rightarrow \text{CommonCosmicChangeStageRealizationChanged}. \quad (622)$$

31.3 Lorentz Domain and No Temporal Ether

In a Minkowski representation a Lorentz transformation acts on spacetime coordinates or event representations, for example

$$x'^{\mu} = \Lambda^{\mu}_{\nu} x^{\nu}, \quad \Lambda^{\top} \eta \Lambda = \eta. \quad (623)$$

No ITOF rule identifies this matrix action with an action on the formal cosmic-stage domain $\mathcal{S}_C^{\text{tot}}$ or derives from it a map that replaces the governing order $\prec_C$. The Lorentz transformation changes the relativistic representation assigned to events; it does not, by type alone, transform the ITOF ordered pair. This is the domain distinction already expressed by Eq. (590).

The common-stage ontology also introduces no material or spatial ether. T_{ITOF} contains no spatial coordinate, velocity field, rest-medium variable, or dynamical substrate. Neither $\mathcal{S}_C^{\text{tot}}$ nor CMA selects a preferred inertial frame (Eqs. (658) and (659)). Any preferred-frame dynamics, measurable anisotropy, or velocity-dependent new coupling must therefore enter as an additional physical hypothesis with its own empirical burden; it is not contained in CMA or in the definition of time.

Consequently V39/F19 does not attempt to evade the foundational disagreement by recasting common-stage identity as Einstein synchronization or by introducing a hidden rest medium. It localizes the disagreement: Lorentz covariance and relativity of coordinate simultaneity remain model facts, whereas denial of every objective universal common stage is the stronger ontological claim treated in Section 31.4.

31.4 Direct foundational conflict

A relativistic representation containing frame-dependent simultaneity does not by that mathematical fact alone negate the definition of time or CMA.

The direct foundational conflict is exact and is not softened by coordinate terminology: any ontological interpretation that denies a frame-independent universal common cosmic-stage co-realization for the complete then-realized qualified physical-system population is incompatible with CMA. In ITOF terms, such an interpretation assigns the qualified systems frame- or worldline-relative orderings of their realizations, that is, private orderings in the sense of Eq. (904). The contradiction is supplied by CMA, not by the definition of $\mathcal{S}_C^{\text{tot}}$ or by UCC. This ontological incompatibility does not by itself negate the mathematical consistency, Lorentz covariance, or empirical success of relativistic physical models; empirical discrimination requires an independently warranted physical-to-observable difference.

Let:

$$\text{NoUniversalCommonStageOntology} \quad (624)$$

denote that stronger claim.

Then the conflict is with CMA:

$$\begin{aligned} & [\forall s \in \mathcal{S}_C^{\text{tot}}, \quad \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s)] \wedge \text{NoUniversalCommonStageOntology} \\ & \implies \perp. \end{aligned} \quad (625)$$

Equivalently, at stage-relative level, the fixed global-stage consequence cannot coexist with its denial:

$$\begin{aligned} & [\forall s \in \mathcal{S}_C^{\text{tot}} : \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s)] \\ & \wedge [\exists s \in \mathcal{S}_C^{\text{tot}} : \neg \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s)] \implies \perp. \end{aligned} \quad (626)$$

This is a genuine foundational incompatibility of the two asserted ontologies. It is not removed by

reinterpreting common-stage identity as an operational synchronization convention, because CMA is an ontological common-stage co-presence commitment within ITOF, not a clock procedure.

31.5 The conflict is not yet an empirical discriminant

Foundational contradiction does not by itself produce a measurable separation:

$$\text{FoundationalConflict} \not\Rightarrow \text{EmpiricalDiscrimination}. \quad (627)$$

Empirical discrimination requires the bridge architecture established earlier:

$$\begin{aligned} &\text{FoundationalConflict} \wedge \text{IndependentPhysicalBridges} \wedge \text{SeparatedPredictions} \\ &\quad \wedge \text{ValidObservation} \wedge \text{IdentifiableAttribution}. \end{aligned} \quad (628)$$

Conceptual disagreement alone therefore does not constitute experimental refutation.

31.6 The Rietdijk–Putnam argument

The Rietdijk–Putnam argument [22, 23] runs as follows. (R1) For an observer, the events simultaneous with the observer’s here-now in the observer’s rest frame are real for that observer. (R2) The relation “real for” is transitive and is the same for every observer. (R3) Two co-located observers in relative motion have different simultaneity hypersurfaces. From (R1)–(R3) it follows that every event, including events in an observer’s causal future, is real for that observer.

ITOF denies (R1). Co-presence is fixed by CMA through realization successions (Eq. (74)); it is not fixed by any observer’s coordinate simultaneity (Eqs. (616) and (467)):

$$x_F^0(e_1) = x_F^0(e_2) \not\Rightarrow \exists s \in \mathcal{S}_C^{\text{tot}} : e_1, e_2 \text{ are realized at } s. \quad (629)$$

Without (R1) the argument has no premise connecting the relativity of simultaneity to co-presence. ITOF does not adopt presentism either: $\mathcal{S}_C^{\text{tot}}$ is one completed ordered domain, and the argument’s conclusion is not a thesis ITOF must refute. What ITOF asserts — one common succession, strictly ordered and never reversed — is not addressed by (R1)–(R3), because the argument contains no premise about the order of realization. The cost of this position is stated in Section 31.4: the common stage is not identified with any foliation, and no record selects it.

32. Common Stages and Signal Access

Relativistic causal domains represent causal accessibility within the declared spacetime model. They remain distinct from common-stage incidence and co-presence under CMA and from the general physical source–signal–record architecture of Section 40.

32.1 Common-stage realization is not instantaneous causation

For:

$$A, B \in \mathcal{S}_{\text{phys}}(s), \quad (630)$$

CMA gives objective common-stage co-presence for the complete stage population.

That co-realization does not give:

$$\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{InstantaneousCausalInfluence}(A, B; s). \quad (631)$$

Nor:

$$\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{InstantaneousSignalTransfer}(A, B; s). \quad (632)$$

Common-stage co-realization therefore does not imply instantaneous signal transfer.

Nor:

$$\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{MutualObservationalAccess}(A, B; s). \quad (633)$$

These three non-implications separate common-stage co-realization from causation, signalling, and observational access.

CMA is not a hidden superluminal interaction postulate.

32.2 Relativistic causal domains

For modeled event p :

$$J^+(p), \quad J^-(p) \quad (634)$$

represent causal-accessibility domains within the adopted spacetime model.

They are not:

$$J^\pm(p) \not\equiv_{\text{type}} \mathcal{S}_C^{\text{tot}}. \quad (635)$$

Nor:

$$J^\pm(p) \not\equiv_{\text{type}} \mathcal{C}_C. \quad (636)$$

Causal accessibility and universal ordering therefore remain distinct:

$$\text{CausallyAccessible}(e_1, e_2) \not\equiv_{\text{def}} \text{CosmicallyOrdered}(e_1, e_2). \quad (637)$$

32.3 No signal requirement for common-stage membership

Let:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \quad (638)$$

while:

$$\text{SignalNotYetReceived}(A, B; s). \quad (639)$$

Then:

$$\text{SignalNotYetReceived}(A, B; s) \not\Rightarrow B \notin \mathcal{S}_{\text{phys}}(s). \quad (640)$$

Under UCC and the stated common-stage membership of B , delayed reception cannot suspend B 's physical change:

$$\text{UCC} \wedge B \in \mathcal{S}_{\text{phys}}(s) \wedge \text{SignalNotYetReceived}(A, B; s) \implies \text{PhysReal}_B^+(s). \quad (641)$$

A distant system does not wait for its signal to reach another system before participating in the common cosmic change stage.

32.4 Signal propagation does not transport time

A physical signal chain:

$$\text{Emission} \rightsquigarrow_{\text{phys}} \text{Propagation} \rightsquigarrow_{\text{phys}} \text{Reception} \rightsquigarrow_{\text{phys}} \text{RecordFormation} \quad (642)$$

contains changing physical systems, fields, interactions, and records.

It does not transport:

$$T_{\text{ITOF}}. \quad (643)$$

Thus:

$$\text{SignalPropagation}(A \rightarrow B) \not\Rightarrow \text{TimeTransported}(A \rightarrow B). \quad (644)$$

A finite record delay is a physical/operational property of the signal and acquisition chain.

It is not evidence of multiple temporal extensions.

33. Foliations and Global-Stage Interpretation

33.1 Mathematical foliation

Let:

$$\mathfrak{F} = \{\Sigma_\lambda\}_{\lambda \in \Lambda} \quad (645)$$

be a mathematical foliation where such a construction is defined [26, 30].

A hypersurface:

$$\Sigma_\lambda \quad (646)$$

is not automatically a common cosmic change stage:

$$\Sigma_\lambda \not\equiv_{\text{type}} s, \quad s \in \mathcal{S}_C^{\text{tot}}. \quad (647)$$

Likewise:

$$\lambda \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (648)$$

33.2 A global time function does not establish ITOF ontology

If a mathematical or relativistic model possesses:

$$t_{\text{glob}} : \mathcal{M} \longrightarrow \mathbb{R}, \quad (649)$$

its existence does not establish:

$$\exists t_{\text{glob}} : \mathcal{M} \rightarrow \mathbb{R} \not\Rightarrow \text{ActuallyPhysicallyRealized}(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (650)$$

The model construction and ITOF temporal ontology remain different claims.

33.3 CMA does not select a unique relativistic foliation

Conversely:

$$\text{CMA} \not\Rightarrow \exists! \mathfrak{F} \text{ ExactlyRepresents } (\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (651)$$

V39/F19 does not identify a coordinate foliation with the common cosmic change-stage totality.

Any proposed association

$$\Sigma_\lambda \leftrightarrow s \quad (652)$$

is an additional model-level hypothesis requiring independent physical justification; CMA does not supply that association.

33.4 Cross-representation burden and Lorentzian extra structure

Special relativity makes simultaneity of spatially separated events frame-dependent under Lorentz transformations [4, 26]. V39/F19 does not deny that result and does not derive CMA from Lorentzian geometry. To compare CMA with a relativistic spacetime $(\mathcal{M}, g)$, an application must introduce an additional association

$$\Phi_M : \mathcal{S}_C^{\text{tot}} \rightarrow \mathcal{P}(\mathcal{M}), \quad s \mapsto \Phi_M(s), \quad (653)$$

where $\Phi_M(s)$ denotes the event set, hypersurface, or other spacetime representation proposed for stage s . Neither the Lorentzian metric nor CMA alone supplies Φ_M . This is a cross-type representation bridge, not a type identity: the ITOF stage remains a member of the formal cosmic-stage domain, while its image is a geometric object inside the declared spacetime model. In particular,

$$s \not\equiv_{\text{type}} \Phi_M(s), \quad T_{\text{ITOF}} \not\equiv_{\text{type}} (\mathcal{M}, g), \quad t_F \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (654)$$

Equality of a coordinate-time label inside a chart is therefore not a definition of common-stage co-presence, and common-stage co-presence does not require equal spatial coordinates for distinct systems.

If the images $\Phi_M(s)$ are taken to form physically distinguished hypersurfaces, the application has added structure beyond the bare Lorentzian model:

$$(\mathcal{M}, g) \mapsto (\mathcal{M}, g, \Phi_M). \quad (655)$$

Globally hyperbolic spacetimes can admit smooth Cauchy foliations, but the existence of such foliations does not select one as the physically realized ITOF stage representation [30]. A physically distinguished slicing can therefore not be smuggled into the framework as a consequence of Lorentzian geometry.

The empirical burden is explicit. If observable predictions depend on the added association, its symmetry properties and consequences require independent testing:

$$\text{PredictionDependsOn}(\Phi_M) \implies \text{IndependentEmpiricalTestRequired}(\Phi_M). \quad (656)$$

If observable predictions do not depend on it, CMA alone supplies no empirical discrimination from the relativistic application:

$$\neg \text{PredictionDependsOn}(\Phi_M) \implies \neg \text{EmpiricalDiscriminationFromCMAAlone}. \quad (657)$$

The resulting position is deliberately non-evasive. CMA is an additional ontological commitment relative to standard Lorentzian spacetime structure; it is not a theorem of special or general relativity and is not made compatible by renaming a coordinate slicing. Observational compatibility in a declared domain means only that the complete application, including any Φ_M , preserves the tested relativistic predictions within their empirical warrant. A future bridge that makes the common-stage association physically discriminating must face the corresponding Lorentz-symmetry and experimental constraints.

33.5 No automatic preferred inertial frame

Co-presence under CMA does not itself define a preferred inertial frame:

$$[\forall s \in \mathcal{S}_C^{\text{tot}}, \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s)] \not\Rightarrow \text{PreferredInertialFrame}. \quad (658)$$

Likewise:

$$T_{\text{ITOF}} \not\equiv_{\text{type}} \text{PreferredVelocityField}. \quad (659)$$

Any claim of:

$$\begin{aligned} &\text{preferred motion, measurable anisotropy, modified propagation,} \\ &\text{preferred dynamical frame, or frame-specific physical law} \end{aligned} \quad (660)$$

would be an additional physical hypothesis.

Such a hypothesis requires:

$$\text{IndependentPhysicalModel} \wedge \text{IndependentObservableConsequences} \wedge \text{EmpiricalEvaluation}. \quad (661)$$

It cannot be inferred merely from the existence of CMA.

34. Relativistic Clock Records and Temporal Identity

34.1 Special-relativistic interval relation

A standard special-relativistic relation may be represented as:

$$\Delta\tau = \frac{\Delta t}{\gamma}. \quad (662)$$

Within V39/F19, this equation relates declared relativistic model quantities; it is not an equation for deformation or dilation of the ITOF temporal referent. Thus:

$$\Delta\tau \neq \Delta t \not\Rightarrow \text{ITOFTimeDilated}. \quad (663)$$

The conventional phrase “time dilation” may continue to identify this standard relativistic class of calculation.

ITOF rejects only the ontological inference that the entity denoted by time is literally dilated.

34.2 Separated-clock histories

Let:

$$C_A, \quad C_B \quad (664)$$

be two physical clock systems with:

$$\mathcal{H}_{C_A} = \left(I_{C_A}, \prec_C|_{I_{C_A}}, X_{C_A}, \Delta_{C_A}^{\text{phys}} \right), \quad (665)$$

$$\mathcal{H}_{C_B} = \left(I_{C_B}, \prec_C|_{I_{C_B}}, X_{C_B}, \Delta_{C_B}^{\text{phys}} \right). \quad (666)$$

Their physical histories may differ in:

$$\begin{aligned} & \text{motion,} \quad \text{gravitational environment,} \quad \text{thermal conditions,} \\ & \text{electromagnetic interactions,} \quad \text{mechanical conditions,} \quad \text{control,} \\ & \text{interrogation,} \quad \text{signal transfer,} \quad \text{and other physical variables.} \end{aligned} \quad (667)$$

A later comparison may yield:

$$d_{AB}^{\text{obs}} = \Gamma_A(N_A) - \Gamma_B(N_B) \neq 0. \quad (668)$$

The warranted direct conclusion is:

$$\text{DifferentPhysicalClockRecords}(C_A, C_B). \quad (669)$$

The record difference does not establish unequal amounts of ITOF time:

$$d_{AB}^{\text{obs}} \neq 0 \not\Rightarrow [\text{LessTimeFor}(C_A) \vee \text{MoreTimeFor}(C_B)]. \quad (670)$$

34.3 CMA and UCC in the separated-clock case

Where:

$$C_A, C_B \in \mathcal{S}_{\text{phys}}(s), \quad (671)$$

CMA gives objective common-stage co-presence:

$$\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s), \quad (672)$$

Under UCC,

$$\text{PhysReal}_{C_A}^+(s) \wedge \text{PhysReal}_{C_B}^+(s). \quad (673)$$

UCC expresses the uninterrupted continuity of those system-specific changes throughout the respective realized identity ranges.

The clocks therefore share one common cosmic change stage while realizing different system-specific physical histories and possibly different clock outputs.

34.4 Gravitational clock comparison

A weak-field benchmark may contain:

$$\frac{\Delta v}{v} \simeq \frac{\Delta \Psi}{c^2}. \quad (674)$$

Within its warranted approximation domain, this is a relation among physical or model quantities associated with clock response under different gravitational conditions.

It does not establish:

$$\frac{\Delta v}{v} \neq 0 \not\Rightarrow \text{ITOFGravitationalTimeDilation}. \quad (675)$$

V39/F19 classifies:

$$\frac{\Delta v}{v} \quad (676)$$

as a physical or operational clock-response difference.

The model used to predict that difference may be relativistic or another independently specified physical response model.

Neither model acquires temporal identity through successful recovery.

34.5 GPS and integrated relativistic operations

Navigation systems, including GPS-class systems, may combine [31]:

$$\begin{aligned} &\text{satellite systems, physical clocks, orbital models, signal propagation,} \\ &\text{receivers, coordinate assignments, synchronization conventions,} \\ &\text{relativistic corrections, calibration, and record processing.} \end{aligned} \quad (677)$$

If:

$$\text{NavigationError} \leq \epsilon_{\text{nav}}, \quad (678)$$

then:

$$\text{GPSOperationalSuccess} \quad (679)$$

may be warranted within the declared domain.

It does not follow that:

$$\text{GPSOperationalSuccess} \not\Rightarrow t_{\text{GPS}} \equiv_{\text{type}} T_{\text{ITOF}}. \quad (680)$$

GPS success is evidence for the adequacy of the integrated physical, geometrical, signal, coordinate, clock, correction, and record architecture within its validated application domain.

It does not determine the ontological definition of time.

35. Cosmological Parameters and Temporal Identity

35.1 Cosmological coordinate parameter

A relativistic cosmological model may employ:

$$ds^2 = -c^2 dt_{\text{cos}}^2 + a^2(t_{\text{cos}}) d\Sigma_k^2. \quad (681)$$

The parameter:

$$t_{\text{cos}} \quad (682)$$

belongs to the declared cosmological model.

Even where it orders a useful family of model hypersurfaces:

$$t_{\text{cos}} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (683)$$

35.2 Model-derived cosmological age

A cosmological model may calculate:

$$t_{\text{age}} = \int_{a_i}^{a_0} \frac{da}{aH(a; \Omega_i, \dots)}. \quad (684)$$

This is a model-derived quantitative magnitude.

It does not enumerate the members of:

$$\mathcal{S}_C^{\text{tot}}. \quad (685)$$

Therefore:

$$\text{CosmologicalAgeComputed}(t_{\text{age}}) \not\Rightarrow \text{CommonCosmicChangeStagesCounted}. \quad (686)$$

Nor:

$$t_{\text{age}} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (687)$$

35.3 Cosmic origin and cosmological model origin

The Cosmic Origin commitment,

$$\text{CosmicOrigin}, \quad (688)$$

it remains logically distinct from:

$$\text{RelativisticModelOriginParameter}. \quad (689)$$

Thus:

$$\text{CosmicOrigin} \not\equiv_{\text{def}} \text{RelativisticCosmologicalBoundary}. \quad (690)$$

Agreement or disagreement between a physical cosmological model and the foundational origin postulate requires an independently developed bridge.

No identity follows from similar language such as “beginning”, “age”, or “cosmic time”.

36. ITOF–Relativity Physical Bridges

36.1 Ontological difference and empirical comparison

The foundational disagreement between ITOF and relativistic temporal identification must not be weakened by an ontological merger.

At the same time, a physical theory cannot obtain quantitative force merely by declaring a different ontology.

V39/F19 therefore distinguishes:

$$\text{OntologicalIdentification} \not\equiv_{\text{def}} \text{EmpiricalComparison}. \quad (691)$$

The bridge is an empirical-comparison architecture, not an ontological merger of temporal definitions.

36.2 No projection into spacetime geometry

The definition:

$$T_{\text{ITOF}} = (\mathcal{S}_C^{\text{tot}}, \prec_C) \quad (692)$$

does not itself derive:

$$g_{\mu\nu}, \quad ds^2, \quad \tau[\gamma, g], \quad J^\pm(p), \quad \Sigma_\lambda. \quad (693)$$

Therefore:

$$\text{TemporalDefinition}_{\text{ITOF}} \not\Rightarrow \text{RelativisticSpacetimeGeometry}. \quad (694)$$

Likewise, neither foundational commitment supplies the corresponding relativistic mathematical structure:

$$\text{CMA} \not\Rightarrow \text{RelativisticMetricStructureSpecified}, \quad (695)$$

$$\text{UCC} \not\Rightarrow \text{ProperTimeFunctionalSpecified}. \quad (696)$$

No mathematical projection from the temporal definition to relativistic geometry is part of the definition of time.

36.3 No requirement of ontological recovery

Validity of ITOF does not entail recovery of a relativistic temporal ontology:

$$\text{ValidITOF} \not\Rightarrow \text{RelativisticTemporalOntologyRecovered}. \quad (697)$$

Such a requirement would erase the foundational disagreement before testing it.

What may be required in a physical domain is empirical recovery or discrimination of observed physical records.

Thus:

$$\text{PhysicalCompetitionOn}(D) \implies \text{ObservableRecoveryOrDiscriminationOn}(D), \quad (698)$$

not:

$$\text{TemporalOntologyIdentity} . \quad (699)$$

Observable model discrimination therefore does not by itself establish an identity claim about the temporal ontology.

36.4 Two independent application branches

Let:

$$F_I \quad (700)$$

denote the relevant ITOF foundational commitments.

Let:

$$M_I \quad (701)$$

be an independently specified physical application model consistent with those commitments.

Let:

$$M_R \quad (702)$$

be the declared relativistic comparison model.

The ITOF branch is:

$$F_I \wedge M_I \wedge B_I^{\text{phys}} \wedge \mathcal{P}_I \vdash \hat{\mathbf{y}}^I. \quad (703)$$

The relativistic branch is:

$$M_R \wedge B_R^{\text{phys}} \wedge \mathcal{P}_R \vdash \hat{\mathbf{y}}^R. \quad (704)$$

Both predictions must then be related to one declared empirical comparison space through their own warranted observation and acquisition bridges.

36.5 Common observable space

For the vector-valued comparison developed below, let

$$\mathcal{Y}_{\text{obs}}^{P,D} \subseteq \mathbb{R}^{m_{P,D}}, \quad m_{P,D} \in \mathbb{N}_{>0}, \quad (705)$$

be the common empirical output space in which the rival predictions are actually compared. Vector subtraction is therefore defined in the ambient space $\mathbb{R}^{m_{P,D}}$. Where a protocol has non-vector-valued outputs, it must supply a separately declared comparison functional; the vector and inverse-covariance formulas below then apply only after a warranted embedding into such a numerical comparison space.

Define:

$$\Pi_I^{P,D} : \widehat{\mathcal{Y}}_I \longrightarrow \mathcal{Y}_{\text{obs}}^{P,D}, \quad (706)$$

$$\Pi_R^{P,D} : \widehat{\mathcal{Y}}_R \longrightarrow \mathcal{Y}_{\text{obs}}^{P,D}. \quad (707)$$

Then:

$$\mathbf{y}_I^{P,D} = \Pi_I^{P,D}(\hat{\mathbf{y}}^I), \quad (708)$$

$$\mathbf{y}_R^{P,D} = \Pi_R^{P,D}(\hat{\mathbf{y}}^R). \quad (709)$$

The common empirical codomain permits comparison.

It does not create ontological identity between the theories.

36.6 Observable comparison bridge

Define the comparison architecture:

$$\mathfrak{B}_{I:R}^{P,D} := \left(B_I^{\text{phys}}, B_R^{\text{phys}}, \Pi_I^{P,D}, \Pi_R^{P,D}, \mathcal{P}_I, \mathcal{P}_R, \Sigma_{I:R} \right). \quad (710)$$

This is the V39/F19 ITOF–relativistic observable comparison bridge.

Its status is:

$$\text{Status}(\mathfrak{B}_{I:R}^{P,D}) = \text{ApplicationLevelEmpiricalComparisonArchitecture}. \quad (711)$$

The bridge compares physical predictions. It is not a temporal-identity merger, an ontological merger, a definition of time, or an identity map between ITOF time and a relativistic temporal quantity.

36.7 No bridge by coordinate naming alone

Coordinate assignment alone does not supply a physical association with a common cosmic change stage:

$$\text{CoordinateAssigned}_F(e) \not\Rightarrow \text{PhysicalAssociationWithCommonCosmicChangeStage}(e). \quad (712)$$

Likewise:

$$t_F(e) = t_0 \quad (713)$$

does not establish:

$$t_F(e) = t_0 \not\Rightarrow \text{ExactCosmicChangeStageIdentified}(e). \quad (714)$$

Any claimed physical association between observable data and common cosmic change-stage realization requires a separately declared association bridge.

36.8 Physical association burden

For protocol P and model M :

$$\text{CommonCosmicChangeStageDataClaim}_{P,M} \implies \text{DeclaredPhysicalAssociationBridge}_{P,M}. \quad (715)$$

Let:

$$\mathcal{Q}_{P,M}^{\text{assoc}} \quad (716)$$

be the set of physically applicable association components selected from:

$$\begin{aligned} &\text{source attribution,} \quad \text{propagation/path model,} \quad \text{detector interaction,} \\ &\quad \text{record formation,} \quad \text{reconstruction,} \quad \text{calibration,} \\ &\text{system identification,} \quad \text{uncertainty characterization.} \end{aligned} \quad (717)$$

Then:

$$\begin{aligned} \text{DeclaredPhysicalAssociationBridge}_{P,M} \implies \text{ApplicabilitySetFixedIndependently}_{P,M} (\mathcal{Q}_{P,M}^{\text{assoc}}) \\ \wedge \forall q \in \mathcal{Q}_{P,M}^{\text{assoc}}, \quad \text{DeclaredAndWarranted}_{P,M}(q). \end{aligned} \quad (718)$$

A component may be omitted where it is physically inapplicable.

Its omission must not be chosen post hoc to absorb a failed prediction or unresolved attribution.

36.9 Recovery bridge

Suppose the ITOF application model is constructed to recover an established relativistic prediction on benchmark domain D_{rec} .

Let the two application branches be projected through their independently specified observation maps into the common benchmark observable space:

$$\mathbf{y}_{I,\text{rec}}^{P,D_{\text{rec}}} = \Pi_I^{P,D_{\text{rec}}} (\hat{\mathbf{y}}_{\text{rec}}^I), \quad (719)$$

$$\mathbf{y}_{R,\text{rec}}^{P,D_{\text{rec}}} = \Pi_R^{P,D_{\text{rec}}} (\hat{\mathbf{y}}_{\text{rec}}^R). \quad (720)$$

A recovery condition may then be stated in that common empirical codomain:

$$\left\| \mathbf{y}_{I,\text{rec}}^{P,D_{\text{rec}}} - \mathbf{y}_{R,\text{rec}}^{P,D_{\text{rec}}} \right\|_{\Sigma_{I,R}^{-1}} \leq \epsilon_{\text{rec}}. \quad (721)$$

The comparison norm, covariance, and threshold must be declared in advance.

Successful recovery warrants:

$$\text{ITOFApplicationRecoversBenchmarkOn}(D_{\text{rec}}). \quad (722)$$

It does not establish:

$$\begin{aligned} \text{ITOFApplicationRecoversBenchmarkOn}(D_{\text{rec}}) \\ \not\Rightarrow \text{ITOFTemporalOntology} = \text{RelativisticTemporalOntology}. \end{aligned} \quad (723)$$

36.10 Recovery is not discrimination

If the common-observable predictions satisfy:

$$\mathbf{y}_I^{P,D} \approx \mathbf{y}_R^{P,D} \quad (724)$$

within the declared combined uncertainty, the two application models may be empirically indistinguishable on that domain.

Thus:

$$\text{BenchmarkRecovered} \not\Rightarrow \text{ITOFFoundationallyConfirmed}. \quad (725)$$

And:

$$\text{BenchmarkRecovered} \not\Rightarrow \text{RelativisticTemporalIdentityAccepted}. \quad (726)$$

Recovery establishes quantitative adequacy of the tested application chain on the declared benchmark domain.

Nothing more follows automatically.

36.11 Discriminating prediction

For a genuine quantitative confrontation, define:

$$\Delta_{I:R}^{P,D} := \mathbf{y}_I^{P,D} - \mathbf{y}_R^{P,D}. \quad (727)$$

A necessary discrimination condition is:

$$\text{ResolvedPredictionSeparation}_{I:R} \implies \left\| \Delta_{I:R}^{P,D} \right\|_{\Sigma_{I:R}^{-1}} > \eta_*, \quad (728)$$

where:

$$\eta_* > 0 \quad (729)$$

is a predeclared protocol threshold appropriate to the comparison.

The foundation does not assign one universal numerical value to η_* .

36.12 Prediction separation must precede outcome inspection

Define the predeclared comparison specification:

$$\mathcal{Q}_{I:R}^{P,D} := \left(\mathbf{y}_I^{P,D}, \mathbf{y}_R^{P,D}, \Sigma_{I:R}, \eta_* \right). \quad (730)$$

A prediction difference has genuine advance-discrimination status only if:

$$\text{AdvanceRelativityDiscrimination} \implies \text{OutcomeIndependentSpecification} \left(\mathcal{Q}_{I:R}^{P,D} \right). \quad (731)$$

A difference manufactured after viewing the data is not an independent prediction.

36.13 Bridge symmetry at the comparison level

Empirical comparison should not permit one model to receive unexamined bridge freedom denied to the other.

Thus:

$$\text{FairModelComparison}_{I:R} \implies \text{BridgeRequirementsAppliedByDeclaredRole}. \quad (732)$$

This does not require identical physical premises for two different models.

It requires that:

$$\begin{aligned}
& \text{each necessary bridge be declared,} \\
& \text{each parameter have provenance,} \\
& \text{each uncertainty contribution be represented,} \\
& \text{and no model receive outcome-dependent auxiliary freedom.}
\end{aligned} \tag{733}$$

36.14 Bridge-robust prediction separation

A single pair of bridge choices can display prediction separation while other independently admissible bridge choices remove it. Foundation-sensitive comparison therefore requires the residual bridge freedom to be represented explicitly rather than absorbed into one preferred application map.

Let

$$\mathbb{B}_I^{P,D} \neq \emptyset, \quad \mathbb{B}_R^{P,D} \neq \emptyset \tag{734}$$

be the independently specified admissible bridge classes for the ITOF and relativistic application branches. Membership in those classes must be fixed by outcome-independent admissibility conditions:

$$\text{AdmissibleBridgeClasses}_{I:R}(P,D) \implies \text{OutcomeIndependentMembershipRule} \left(\mathbb{B}_I^{P,D}, \mathbb{B}_R^{P,D} \right). \tag{735}$$

Residual bridge freedom is present when at least one branch admits more than one independently acceptable bridge realization:

$$\text{ResidualBridgeFreedom}_{I:R}(P,D) \iff \left| \mathbb{B}_I^{P,D} \right| > 1 \vee \left| \mathbb{B}_R^{P,D} \right| > 1. \tag{736}$$

For $b_I \in \mathbb{B}_I^{P,D}$ and $b_R \in \mathbb{B}_R^{P,D}$, let

$$d_{I:R}^{P,D}(b_I, b_R) := \left\| \mathbf{y}_I^{P,D}(b_I) - \mathbf{y}_R^{P,D}(b_R) \right\|_{\Sigma^{-1}(b_I, b_R)}. \tag{737}$$

The covariance entering the norm must include the declared shared and branch-specific uncertainty contributions applicable to that bridge pair. Where the inverse-covariance norm in Eq. (737) is used, the applicable covariance must be positive definite on the evaluated observable subspace:

$$\forall b_I \in \mathbb{B}_I^{P,D} \forall b_R \in \mathbb{B}_R^{P,D}, \quad \Sigma(b_I, b_R) \succ 0. \tag{738}$$

If a domain requires a singular covariance treatment, the protocol must replace the inverse norm by a predeclared mathematically valid alternative rather than silently applying an undefined inverse.

Define the bridge-robust separation margin:

$$\delta_{I:R}^{P,D} := \inf_{\substack{b_I \in \mathbb{B}_I^{P,D} \\ b_R \in \mathbb{B}_R^{P,D}}} d_{I:R}^{P,D}(b_I, b_R). \tag{739}$$

For a predeclared threshold $\eta_\star > 0$, define:

$$\text{RobustBridgeSeparation}_{I:R}(P,D; \eta_\star) \iff \delta_{I:R}^{P,D} > \eta_\star. \tag{740}$$

This condition states that every independently admissible bridge pair preserves a resolved prediction separation. It is stronger than separation obtained from one selected bridge pair and remains a necessary, not sufficient, condition for a foundation-sensitive inference whenever unresolved bridge freedom is present.

Accordingly:

$$\begin{aligned} & \text{ResidualBridgeFreedom}_{I:R}(P, D) \wedge \text{Warrant}_{P,D} [\text{FoundationalDiscrimination}(F_I, F_R)] \\ & \implies \text{RobustBridgeSeparation}_{I:R}(P, D; \eta_\star). \end{aligned} \quad (741)$$

If

$$\delta_{I:R}^{P,D} \leq \eta_\star, \quad (742)$$

then admissible bridge freedom can eliminate the predeclared separation. The comparison may still discriminate particular application realizations, but that separation alone does not isolate the foundational difference.

36.15 Attribution of a discriminating result

Suppose observation favours:

$$M_I \quad (743)$$

over:

$$M_R. \quad (744)$$

The immediate warranted claim is:

$$\text{DiscriminationFavours}(M_I) \implies \text{Warrant} [\text{ITOFApplicationModelSupportedOn}(D)]. \quad (745)$$

It does not automatically establish:

$$\text{DiscriminationFavours}(M_I) \not\Rightarrow \text{CMAEmpiricallyEstablished}. \quad (746)$$

Nor:

$$\text{DiscriminationFavours}(M_I) \not\Rightarrow \text{UCCEmpiricallyEstablished}. \quad (747)$$

A foundational conclusion requires identifiable dependence of the prediction difference on the relevant foundational difference.

36.16 Relativistic Success and ITOF Type Claims

Conversely, suppose:

$$\text{DiscriminationFavours}(M_R). \quad (748)$$

The direct conclusion concerns the compared application models:

$$\text{DiscriminationFavours}(M_R) \implies \text{ITOFApplicationModelRejectedOrRestrictedOn}(D) \quad (749)$$

where the comparison satisfies the declared protocol.

The result does not license replacement of the V39/F19 type assignments. They remain:

$$t_F \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad \tau[\gamma, g] \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (750)$$

Empirical success of a physical representation and the definition of time remain logically different questions.

36.17 Condition for genuinely foundational discrimination

Let:

$$F_I \quad (751)$$

contain an ITOF foundational commitment and:

$$F_R \quad (752)$$

the explicitly declared rival foundational proposition.

A genuine foundational comparison requires:

$$F_I \wedge B_I \wedge \mathcal{P}_I \vdash O_I, \quad (753)$$

$$F_R \wedge B_R \wedge \mathcal{P}_R \vdash O_R. \quad (754)$$

Then:

$$\begin{aligned} & \text{Warrant}_{P,D} [\text{FoundationalDiscrimination}(F_I, F_R)] \\ & \implies \text{OutcomeIndependentSpecification}(B_I, B_R, \mathcal{P}_I, \mathcal{P}_R) \\ & \quad \wedge \text{ProtocolFrozen}(P) \\ & \quad \wedge \text{NoEvaluationLeakage}(P, D) \\ & \quad \wedge \text{PredictionSeparationBeyondCombinedUncertainty}(O_I, O_R; P, D) \\ & \quad \wedge \text{FoundationalAttributionIdentifiable}(F_I, F_R; B_I, B_R, \mathcal{P}_I, \mathcal{P}_R; P, D). \end{aligned} \quad (755)$$

Where residual bridge freedom remains, Eq. (741) adds the bridge-robust separation requirement to this burden. If the observable separation can be removed by an independently admissible bridge variation while the foundational commitments are held fixed, the result does not isolate the foundational difference.

36.18 The bridge cannot establish ontological identity

Suppose:

$$\mathbf{y}_I^{P,D} \approx \mathbf{y}_R^{P,D} \approx \mathbf{y}_{\text{obs}}. \quad (756)$$

Then:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \quad (757)$$

may be warranted.

It does not follow that:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \not\Rightarrow T_{\text{ITOF}} \equiv_{\text{type}} \tau[\gamma, g]. \quad (758)$$

or:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \not\Rightarrow \text{CosmicCoPresence}_C \equiv_{\text{type}} \sim_F. \quad (759)$$

Empirical equivalence on a finite domain is not ontological identity.

36.19 Application Tests Do Not Automatically Refute the Core

Likewise, if:

$$\mathbf{y}_I^{P,D} \not\approx \mathbf{y}_{\text{obs}}, \quad (760)$$

the tested application chain may be inadequate on that domain.

It does not automatically follow that:

$$\text{TemporalDefinitionRejected}_{\text{ITOF}} \quad \neg \text{CMA}, \quad \text{or} \quad \neg \text{UCC}. \quad (761)$$

The foundational consequence must be derived, not presumed.

36.20 Bridge claim boundary

The admissible V39/F19 bridge claim is:

ITOF and a relativistic physical model may be brought into direct quantitative comparison only after each has been connected independently to the same observable domain through explicit physical, acquisition, calibration, and uncertainty structures. Agreement establishes bounded empirical adequacy of the respective application model; disagreement establishes model-level discrimination where resolved. A foundational conclusion requires the observed separation to be independently traceable to the foundational difference itself; where residual bridge freedom exists, that separation must remain resolved across the independently admissible bridge classes. The comparison bridge does not identify coordinate time, metric interval, proper time, simultaneity convention, spacetime geometry, or clock output with the entity denoted by time in ITOF.

This is a bridge of empirical confrontation.

It is not a bridge that identifies the temporal referents.

37. Special- and General-Relativistic Phenomena

This section states, phenomenon by phenomenon, what ITOF retains from special and general relativity and what it denies. Every quantitative relativistic result is retained. What is denied is only the identification of a relativistic model quantity with time and the attribution of a physical effect to time.

37.1 The relativistic phenomenon bridge

Definition 37.1 (Relativistic phenomenon bridge). For a relativistic phenomenon Φ observed under protocol P ,

$$\mathfrak{B}_\Phi := (\mathcal{K}_\Phi, \mathcal{C}_\Phi, M_\Phi, q_\Phi, \Pi_\Phi, \text{Rec}_\Phi), \quad (762)$$

where $\mathcal{K}_\Phi \subseteq \mathcal{U}_{\text{phys}}$ is the set of physical bearers whose records constitute the data (clocks, unstable particles, sources, receivers, detectors, links, test masses, gyroscopes); $\mathcal{C}_\Phi$ is the declared set of physical conditions and causal contributors (motion relative to the apparatus, gravitational relation, medium, link and environmental conditions); M_Φ is the relativistic model (Lorentz-covariant dynamics, or the Einstein field equations with a matter model); q_Φ is the model quantity used (x^0 , $\tau[\gamma, g]$, $g_{\mu\nu}$, ds^2 , a redshift, or a strain); Π_Φ maps model quantities and conditions to predicted records; and Rec_Φ is the set of records obtained.

The bridge is required to be inclusive, so that nothing in the data falls outside it, and exclusive, so that nothing outside physics enters it.

Inclusion conditions: record closure (J1), contributor closure (J2), and quantitative retention (J3).

$$(J1) \quad \text{Data}_\Phi \subseteq \text{Records}(\mathcal{K}_\Phi), \quad (763)$$

$$(J2) \quad \text{Contributors}(\text{Rec}_\Phi) \subseteq \mathcal{K}_\Phi \cup \mathcal{C}_\Phi, \quad (764)$$

$$(J3) \quad \text{Rec}_\Phi \approx_{\sigma_P} \Pi_\Phi(q_\Phi; \mathcal{C}_\Phi). \quad (765)$$

Exclusion conditions: non-identity (M1), non-contribution (M2), non-transfer (M3), and common-stage retention (M4).

$$(M1) \quad q_\Phi \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (766)$$

$$(M2) \quad T_{\text{ITOF}} \notin \text{Contributors}(\text{Rec}_\Phi), \quad (767)$$

$$(M3) \quad (J3) \not\Rightarrow q_\Phi \equiv T_{\text{ITOF}}, \quad (768)$$

$$(M4) \quad A, B \in \mathcal{K}_\Phi \cap \mathcal{S}_{\text{phys}}(s) \implies \text{CosmicCoPresence}_C(\{A, B\}; s) \wedge \text{PhysReal}_A^+(s) \wedge \text{PhysReal}_B^+(s). \quad (769)$$

In (J3), $\approx_{\sigma_P}$ denotes agreement within the declared uncertainty of P . In (J2), contributors are of the three classes fixed by CRP: internal structure of a bearer, influencing physical systems, and non-system physical factors.

Proposition 37.2 (Inclusion and exclusion of the phenomenon bridge). Let Φ be a relativistic phenomenon with an admissible phenomenon bridge,

$$\text{AdmissiblePhenomenonBridge}(\Phi) : \iff (J1) \wedge (J2) \wedge (J3). \quad (770)$$

Then every quantitative relativistic temporal result of Φ is retained as a relation among records of physical bearers under declared conditions, and (M1)–(M4) hold.

Proof. (J1)–(J3) are the admissibility conditions and are not inferred from one another; (J1) is satisfiable because every observable is a record produced by a physical bearer (Section 40), and (J2) requires that the declared contributors include every contributor that CRP assigns to the records. (M1) is Proposition 43.4 applied to q_Φ . (M2) holds because time is not a causal contributor (Eq. (355)). (M3) is the Generalized Non-Transfer Principle (Section 27). (M4) follows from Eq. (74) and UCC, since $\mathcal{K}_\Phi \subseteq \mathcal{U}_{\text{phys}}$.

The bridge is an application-level empirical bridge. It retains every relativistic prediction; under identical physical-to-observable specifications it creates no prediction separation (Section 39). That every quantitative result is retained follows from prediction non-separation: under identical physical-

to-observable specifications, ITOF and a relativistic temporal ontology yield the same predictions. The phenomena listed are those read explicitly through the bridge. Its function is to fix, for each phenomenon, what the measured quantity is a property of.

37.2 Lorentz transformations as a symmetry of record assignment

ITOF does not derive the Lorentz transformations from $(\mathcal{S}_C^{\text{tot}}, \prec_C)$, which carries no metric, rate, or dynamics. They follow from physical properties of the bearers by which coordinates are assigned. An inertial laboratory L is a composite qualified system of rods and clocks; it assigns to a record-bearing event the values (t, x) , with x from rod comparison and t from clock records synchronized by two-way light signals. For two laboratories L and L' in uniform relative motion with velocity v along x , assume:

- (H) *Homogeneity*: the map between their assignments is linear after choice of a common origin.
- (I) *Isotropy*: no spatial direction is distinguished.
- (P) *Relativity principle*: the dynamical laws governing the bearers have the same form in every inertial laboratory, and the maps form a group.
- (O) *Bearer-order preservation*: the order of the records of any one bearer is the same in every laboratory's assignment.

Premises (H), (I), and (P) fix the map up to one universal constant K [27], as derived below:

$$x' = \gamma_K(v)(x - vt), \quad t' = \gamma_K(v)(t - Kvx), \quad \gamma_K(v) = (1 - Kv^2)^{-1/2}. \quad (771)$$

Derivation. By (H) the map is linear. The origin of L' is a bearer at rest in L' and has $x = vt$ in L 's assignment, so $x' = \gamma(v)(x - vt)$ for some coefficient $\gamma(v) > 0$. By (P) the inverse map has the same form with velocity $-v$, and by (I) the coefficient does not depend on the direction of motion, $\gamma(-v) = \gamma(v)$; hence $x = \gamma(v)(x' + vt')$. Eliminating x' between the two relations gives

$$t' = \gamma(v)(t - K(v)vx), \quad K(v) := \frac{\gamma(v)^2 - 1}{\gamma(v)^2 v^2}, \quad (772)$$

that is, $\gamma(v) = (1 - K(v)v^2)^{-1/2}$. Write the map as $M(v) = \gamma(v) \begin{pmatrix} 1 & -v \\ -K(v)v & 1 \end{pmatrix}$ acting on (x, t) . By the group property in (P), the composite $M(v_2)M(v_1)$ is again of this form, so its two diagonal entries are equal:

$$1 + K(v_1)v_1v_2 = 1 + K(v_2)v_1v_2. \quad (773)$$

Since v_1 and v_2 are arbitrary, $K(v_1) = K(v_2)$: K is one universal constant, which gives Eq. (771). For $K > 0$ the maps are defined for $|v| < K^{-1/2}$, and $K^{-1/2}$ is an invariant speed. $\square$

If $K < 0$, the maps are rotations of the (t, x) plane, and composition within the group yields a map that reverses the order of a single bearer's records, contrary to (O); hence $K \geq 0$. $K = 0$ gives the Galilean map. The measured isotropy and invariance of the two-way speed of light under rotation and translation of the apparatus [6, 7], together with the measured frequency relations of moving ions [8], fix $K = 1/c^2$:

$$x' = \gamma(x - vt), \quad t' = \gamma\left(t - \frac{vx}{c^2}\right), \quad \gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}. \quad (774)$$

Two consequences follow. A clock bearer at rest in L' , with $x = vt$, has records $t' = t/\gamma$ in L 's assignment: the moving-clock relation is a relation between the records of two physical laboratories. Equality of t'

differs from equality of t : relativity of simultaneity is a difference in which record-bearing events receive equal coordinate values (Section 31.1).

Premises (H), (I), (P), (O) and the light-speed data concern bearers and records only; none refers to $\prec_C$, CMA, or UCC. Hence

$$T_{\text{TOF}}, \text{CMA}, \text{UCC} \not\Rightarrow \text{Eq. (774)}, \quad \text{Eq. (774)} \not\Rightarrow \neg \text{CMA}. \quad (775)$$

The first holds because the derivation uses physical premises that the temporal core does not supply. The second holds because the transformations constrain coordinate values assigned from records, whereas CMA constrains realization successions; an interpretation that retains Lorentz-covariant dynamics together with a frame-independent common succession is empirically equivalent to special relativity [27]. Premise (O) is the record-level counterpart of the non-reversal of $\prec_C$: orthochronous Lorentz maps never reverse the order of a single bearer's records.

37.3 Special-relativistic phenomena

Table 1: Special-relativistic phenomena under the phenomenon bridge.

Phenomenon	Records and representative tests	Model quantity	ITOF reading
Invariance and isotropy of the speed of light	Interferometer and rotating optical-cavity frequency records [6, 7]	c in Lorentz-covariant dynamics	A property of electromagnetic propagation and of the cavity and rod bearers; retained in full. It fixes $K = 1/c^2$ in Eq. (771). It is not a property of T_{TOF} .
Moving-clock frequency relation	Transition frequencies of fast ions in a storage ring [8]	γ, τ	Frequencies of moving ion bearers relative to laboratory records; the relation of Eq. (774). The ion has no private time.
Lifetime of moving unstable particles	Decay records of muons in a storage ring [9]	$\gamma\tau_0$	Decay is a physical process of the muon; its decay distribution under its motion state relative to the apparatus agrees with $\gamma\tau_0$. See Section 37.4.
Transported clocks	Clock records after transport by aircraft or in relative motion [10, 34]	$\tau[\gamma, g]$	Different accumulated clock records along different histories between common stages (Section 34.2).
Relativity of simultaneity	Coordinate values assigned by synchronization	x^0	Frame-dependent equality of coordinate values, not of stages (Section 31.1).

Phenomenon	Records and representative tests	Model quantity	ITOF reading
Length contraction	No isolated direct measurement; enters through Lorentz-covariant dynamics of the constituents of rods	L_0/γ	A relation among rod records of bearers in relative motion, explained by the covariant dynamics of their constituents [27]; not a property of space or time.

37.4 Unstable particles

Muons circulating in a storage ring at $\gamma \approx 29.3$ decay with a laboratory-recorded mean lifetime $\gamma\tau_0$, and the decay rate depends on speed but not on the very large centripetal acceleration [9]. In ITOF, the decay of a muon is a physical change of the muon bearer; the laboratory's decay-time records are records of detector and clock bearers. The relation between them is fixed by the Lorentz-covariant dynamics of the decay process under the muon's motion relative to the apparatus. The result is retained in full. It does not state that the muon had less time: the muon and the laboratory are co-present at every common stage of their shared existence, and each changes at each such stage (Eq. (769)). What differs is the amount of the muon's internal change between two common stages, as recorded by the laboratory.

37.5 Differential ageing

Two systems that separate and reunite, including two clocks or two living organisms, may display different accumulated change. In ITOF, each system has its own physical history and accumulated change, and both histories run through the same common stages:

$$I_A \cap I_B \supseteq [s_1, s_2]_{\prec_C} \wedge \text{Accumulated}_A(s_1, s_2) \neq \text{Accumulated}_B(s_1, s_2) \Rightarrow \text{FewerStages}(A) \vee \text{PrivateTime}(A). \quad (776)$$

Here $[s_1, s_2]_{\prec_C}$ is the set of stages from separation to reunion. Biological ageing is accumulated physical change of the organism; a smaller accumulation along one history is a smaller amount of change between the same common stages, not a smaller share of time. The relativistic model computes that amount through $\tau[\gamma, g]$; ITOF retains the computation and denies only that τ is time.

37.6 General-relativistic phenomena

Table 2: General-relativistic phenomena under the phenomenon bridge.

Phenomenon	Records and representative tests	Model quantity	ITOF reading
Gravitational frequency shift	Gamma-ray resonance over a tower [11]; space-borne maser [12]; eccentric satellite clocks [13]; optical clocks over 33 cm and across a millimetre-scale sample [34, 43]	$g_{00}, \Delta\Phi/c^2$	Transition frequencies of bearers under different gravitational relations, compared through a signal path (Section 34.4); not a difference in the amount of time.
Satellite navigation	Integrated clock, orbit, and signal records [31]	$\tau, g_{\mu\nu}$	Operational success of an integrated physical model (Section 34.5); success does not transfer temporal identity.
Deflection of light	Astrometric and radio-interferometric positions [25]	null geodesics of $g_{\mu\nu}$	Deviation of a signal path under a gravitational relation (Section 40.9).
Signal delay near a mass	Round-trip radio-link records to a spacecraft [14]	Shapiro delay	Longer round-trip record of a signal propagating near a mass; a propagation condition (Eq. (825)), not a delay of time.
Perihelion advance	Planetary ranging and astrometry [25]	orbit in $g_{\mu\nu}$	Orbital dynamics of a bearer in a gravitational relation; no temporal content.
Geodetic precession and frame dragging	Gyroscope spin-axis records in Earth orbit [15]	g_{0i} , connection	Precession of gyroscope bearers; the rotation of the Earth is a contributor to the frame-dragging part. Neither is a property of time.
Gravitational waves	Interferometer strain records [16]	$h_{\mu\nu}$	A propagating gravitational disturbance acting on test masses and on the light paths that read them; not a ripple of time.
Cosmological stretching of light curves	Supernova light-curve widths at redshift z [17]	$(1+z)$, scale factor	The received record sequence is stretched by propagation in the cosmological model; the change of the source is not thereby slowed (Section 40.5).

Phenomenon	Records and representative tests	Model quantity	ITOF reading
Horizons	No record from within a horizon reaches an exterior receiver	coordinate divergence of t	See Section 37.7.
Closed timelike curves	None observed	solutions such as [18, 19]	Excluded as a return to an earlier stage (Section 37.8).

37.7 Horizons and coordinate divergence

In the exterior Schwarzschild chart, the coordinate t of a system falling toward the horizon diverges, and signals it emits reach a distant receiver with unbounded delay and redshift. In the same model, the proper-time functional along the falling worldline to the horizon is finite. ITOF reads the divergence as a property of the chart and of signal access to the distant receiver:

$$\lim t_{\text{Schw}} = \infty \not\Rightarrow \text{ChangeStops}(A), \quad (777)$$

consistent with Eq. (808). The falling system continues to change under UCC. The statement “time stops at the horizon” is therefore not an ITOF statement and is not a statement of the relativistic model’s own proper-time account either.

37.8 Return to an earlier stage

A return to the past would require a physical system to realize a change, within its own history, at a stage earlier than a stage at which it has already realized change. CMA identifies each system’s own earlier–later order with the cosmic order, and Strict Cosmic Ordering makes that order asymmetric. Hence

$$\boxed{\text{CMA} \wedge \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \neg \exists A \in \mathcal{U}_{\text{phys}} \exists x, y \in \mathcal{W}_A : x \triangleleft_A y \wedge y \prec_C x.} \quad (778)$$

Proof. By CMA, $\triangleleft_A = \prec_C|_{\mathcal{W}_A}$, so $x \triangleleft_A y$ gives $x \prec_C y$; together with $y \prec_C x$ this contradicts the asymmetry of the strict total order (Eq. (24)). $\square$

No physical system of the universe returns to an earlier stage. Four cases follow.

1. *Closed timelike curves.* Some solutions of the Einstein field equations contain them [18]. A closed timelike curve in a solution is a geometric object of the representation; by itself it establishes no return in the ITOF order. What ITOF excludes is any physical realization in which a system realizes a later change at a stage it had already passed, the excluded pair of Eq. (778). Hence no physical realization of a closed timelike curve can return a system to an earlier stage, and a curve that does not do so is not a journey into the past. Therefore

$$\neg \exists A \in \mathcal{U}_{\text{phys}} : \text{RealizedOnClosedTimelikeCurve}(A) \wedge \text{ReturnToEarlierStage}(A). \quad (779)$$

Here $\text{ReturnToEarlierStage}(A)$ is the pair excluded by Eq. (778).

2. *Wormhole and warp-drive constructions.* Traversable-wormhole solutions proposed as time machines [19] and warp-drive metrics [20] require energy conditions to be violated by the assumed

matter. Their mathematical consistency does not establish physical realization (Definition 43.6). Whatever physics may establish about such configurations as spatial connections or transport, their use to bring a system to an earlier stage is excluded by Eq. (778).

3. *Consistency paradoxes.* Paradoxes of the grandfather type presuppose a return to an earlier stage. Since the presupposition is excluded, ITOF requires no consistency condition on histories to avoid them.
4. *Travel into the future.* A system that has accumulated less change between two common stages than another (Eq. (776)) has not traveled into the future of the other: both pass through the same stages, and neither reaches a stage before the other. A process that reproduces an earlier state is a new later change, not a return (Eq. (896)).

Within general relativity the physical realizability of closed timelike curves is itself open, with a conjecture that physical processes prevent their formation [21]. Eq. (778) is a definite ITOF commitment: an established physically realized return to an earlier stage would contradict CMA or Strict Cosmic Ordering.

38. Relativistic Type Register

38.1 Temporal identity conflict

ITOF fixes T_{ITOF} by Eq. (11). The relativistic temporal quantity under examination is

$$q_R \in \mathcal{Q}_{\text{rel}}. \quad (780)$$

ITOF therefore assigns the direct type relation:

$$q_R \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (781)$$

38.2 Common-stage conflict

An ontology of mutually private cosmic-stage successions conflicts with CMA; its failure condition is Eq. (904). This countercondition concerns a private stage or private ordering and is distinct from UCC failure, which requires a realized qualified system with complete physical non-change at an admitted member.

38.3 Private-time conflict

ITOF already fixes that many physical histories do not imply many times in Eq. (241). Any interpretation asserting that distinct physical-system path functionals are literally distinct temporal extensions conflicts with this type architecture.

Thus:

$$\text{PathDependentMetricQuantity}(A) \not\Rightarrow \text{PrivateTemporalExtension}(A). \quad (782)$$

38.4 Metric-time conflict

ITOF does not define a temporal metric:

$$T_{\text{ITOF}} \not\equiv_{\text{type}} \text{MetricSpaceTimeQuantity}. \quad (783)$$

Therefore an ontology identifying time itself with metric interval conflicts with the governing ITOF definition.

38.5 Causal-time conflict

ITOF fixes the causal type boundary:

$$\neg \text{TimeCausesPhysicalChange} . \quad (784)$$

Physical differences attributed in another model to variation of a quantity named “time” are therefore classified in ITOF through the physical systems, fields, conditions, interactions, paths, and record-production processes involved.

This does not predetermine the quantitative response.

It fixes the permissible causal type.

38.6 Geometrized-time non-identity

The consolidated result of Proposition 43.4 (Section 43) extends this register by giving, for each member of the family $\{x^0, T, t_{\text{cos}}, g_{\mu\nu}, ds^2, \tau[\gamma, g], R^\rho{}_{\sigma\mu\nu}\}$, the specific ground for $q \not\equiv_{\text{type}} T_{\text{ITOF}}$: failure of the invariance domain required of $\prec_C$ (Argument 43.1), the intra-/inter-stage type distinction (Argument 43.2), or a type difference stated for the quantity itself. The dimension-admission criterion of Definition 43.6 and Proposition 43.7 likewise governs the register entries for x^0 and for higher-dimensional geometric coordinates.

38.7 Empirical status of the conflict register

The conflict register identifies logical and ontological disagreement.

The conflict register alone entails neither empirical refutation of relativity nor empirical confirmation of ITOF:

$$\begin{aligned} \text{RelativisticConflictRegister} \not\Rightarrow \text{EmpiricalRefutationOfRelativity} \\ \vee \text{EmpiricalConfirmationOfITOF} . \end{aligned} \quad (785)$$

Those stronger conclusions require the observable comparison architecture of Section 36.

39. ITOF–Relativity Boundary

39.1 Foundational conclusion

The type-level conclusion is Eq. (561), supported quantity by quantity by Proposition 43.4. The governing temporal definition remains Eq. (11). Its stage semantics requires every member to be a common stage of the physical systems of the universe, which entails a nonempty population at every stage; CSPP records that consequence, and under UCC every member of that population changes (Eq. (104)).

CMA excludes system-private stages and orderings and yields objective co-presence of all physical systems of the universe realized at each stage. UCC independently requires actual physical change in every one of them at every stage: physical change does not cease in any physical system of the universe throughout its realized identity range. CMA and UCC are logically independent (Proposition 5.4).

CRP supplies nonempty physically admissible causal realization for those actual changes.

None of these commitments is replaced by a coordinate, metric, proper-time, foliation, synchronization, or clock construction.

39.2 Type-level and empirical separation

V39/F19 therefore separates three levels that must not be conflated:

$$\begin{aligned} \text{FoundationalTemporalIdentity} &\not\equiv_{\text{def}} \text{RelativisticRepresentation}, \\ \text{RelativisticRepresentation} &\not\equiv_{\text{def}} \text{PhysicalRecord}, \\ \text{PhysicalRecordAgreement} &\not\equiv_{\text{def}} \text{TemporalIdentity}. \end{aligned} \tag{786}$$

The foundational disagreement remains direct.

The empirical comparison remains open to physical investigation.

No identity or merger between the competing temporal identifications is asserted.

39.3 What V39/F19 does claim

V39/F19 claims:

$$\begin{aligned} &\text{one universal cosmic extension,} \\ &\text{one invariant universal earlier--later ordering,} \\ &\text{one common cosmic change-stage realization,} \\ &\text{system-specific physical change,} \\ &\text{system-specific physical causation,} \\ &\text{and type-distinct physical and operational measurements.} \end{aligned} \tag{787}$$

It further claims that successful quantitative comparison with external physical theories must proceed through independently specified physical and observational bridges.

39.4 What V39/F19 does not claim

The foundational temporal definition alone does not derive Lorentz transformations, Einstein field equations, clock shifts, gravitational redshift, signal-propagation laws, orbital dynamics, or other domain-specific quantitative predictions:

$$\text{TemporalDefinition}_{\text{ITOF}} \not\Rightarrow \text{RelativisticDomainSpecificDynamicsOrPredictions}. \tag{788}$$

Such predictions require physical application models.

Nor does V39/F19 claim that conceptual disagreement with relativistic temporal ontology constitutes experimental falsification of relativity.

39.5 Required future quantitative route

The scientifically admissible route is:

$$\begin{aligned}
 \text{ITOFFoundationalCommitment} &\longrightarrow \text{IndependentPhysicalApplicationModel} \\
 &\longrightarrow \text{FrozenQuantitativePrediction} \\
 &\longrightarrow \text{MeasurementAndRecordBridge} \\
 &\longrightarrow \text{ObservableComparison} \\
 &\longrightarrow \text{ModelDiscrimination} \\
 &\longrightarrow \text{FoundationalAttributionWhereIdentifiable}.
 \end{aligned} \tag{789}$$

The route permits no ontological conclusion beyond the dependency actually established by the physical and observational derivation.

40. Signals and Remote Physical Access

Signals and remote records are treated as physical source–propagation–receiver chains within the common cosmic ordering. The earlier relativistic causal-domain section used only the subset of these distinctions required to separate common-stage realization from model-specific causal accessibility.

40.1 Signals are physical processes

A signal relation contains physically realized systems, fields, interactions, or other physically admissible carriers and factors.

For a declared source–receiver chain Γ , the physical sequence may be represented schematically as:

$$\begin{aligned}
 \text{SourceChange} \rightsquigarrow_{\text{phys}} \text{Emission} \rightsquigarrow_{\text{phys}} \text{Propagation} \\
 \rightsquigarrow_{\text{phys}} \text{ReceiverInteraction} \rightsquigarrow_{\text{phys}} \text{RecordFormation}.
 \end{aligned} \tag{790}$$

Every physical-system identity participating in the chain remains governed by the same common cosmic ordering.

Where a participating entity A is independently qualified as a physical system and:

$$A \in \mathcal{S}_{\text{phys}}(s), \tag{791}$$

UCC gives:

$$\text{PhysReal}_A^+(s). \tag{792}$$

The physical signal chain therefore belongs to the system-specific physical realization architecture.

It is not a temporal transport chain.

40.2 Record-lag decomposition

A declared operational record lag may be represented as:

$$L_{\Gamma}^{\text{rec}} = L_{\Gamma}^{\text{emit}} + L_{\Gamma}^{\text{prop}} + L_{\Gamma}^{\text{path}} + L_{\Gamma}^{\text{interaction}} + L_{\Gamma}^{\text{detect}} + L_{\Gamma}^{\text{process}}. \quad (793)$$

Every term in this expression is an operationally or physically defined quantity under the declared signal model.

A positive lag:

$$L_{\Gamma}^{\text{rec}} > 0 \quad (794)$$

does not imply:

$$L_{\Gamma}^{\text{rec}} > 0 \not\Rightarrow \text{MultipleTemporalReferentsExist}. \quad (795)$$

Nor:

$$L_{\Gamma}^{\text{rec}} > 0 \not\Rightarrow \text{CosmicChangeStageDelayed}. \quad (796)$$

The delay belongs to the physical and operational chain.

40.3 Signals do not transport time

For a physical signal:

$$S : A \rightarrow B, \quad (797)$$

V39/F19 retains:

$$\text{SignalPropagation}(S) \not\Rightarrow \text{TimeTransported}(A \rightarrow B). \quad (798)$$

Likewise:

$$\text{SignalArrivalAt}(B; s) \not\Rightarrow \text{TimeArrivesAt}(B; s). \quad (799)$$

A signal may transport:

$$\begin{aligned} &\text{energy, momentum, information-bearing physical variation,} \\ &\text{or another physically warranted quantity,} \end{aligned} \quad (800)$$

depending on the applicable physical theory.

It does not transport the universal cosmic extension.

40.4 Remote source and receiver

Let:

$$A_S \quad (801)$$

be a remote source system and:

$$A_D \quad (802)$$

a detector or receiving system.

A record r_D received by A_D may be physically attributable to an earlier source manifestation:

$$\text{ManifestationAt}(A_S, \chi_S; s_S). \quad (803)$$

The record remains:

$$r_D \not\equiv_{\text{type}} \chi_S, \quad (804)$$

and:

$$r_D \not\equiv_{\text{type}} s_S. \quad (805)$$

A valid physical source–record bridge may warrant:

$$\text{Warrant}_{P,M} [\exists s_S \in I_{A_S} \text{ManifestationAt}(A_S, \chi_S; s_S)]. \quad (806)$$

It does not thereby identify that exact member of $\mathcal{S}_C^{\text{tot}}$.

40.5 Remote access delay does not delay remote physical change

Suppose the detector receives at common cosmic change stage s_D a record associated with source manifestation at some:

$$s_S \prec_C s_D. \quad (807)$$

The record-arrival stage is not the source stage.

Nor does delayed access imply delayed physical participation by the remote system:

$$\text{RemoteAccessDelayed}(A_S, A_D) \not\Rightarrow \text{RemotePhysicalChangeDelayed}(A_S). \quad (808)$$

If both identities are realized at a later current common cosmic change stage a :

$$A_S, A_D \in \mathcal{S}_{\text{phys}}(a), \quad (809)$$

then CMA supplies their objective common-stage co-presence at a , while UCC requires their respective actual physical changes:

$$\text{UCC} \wedge A_S, A_D \in \mathcal{S}_{\text{phys}}(a) \implies \text{PhysReal}_{A_S}^+(a) \wedge \text{PhysReal}_{A_D}^+(a). \quad (810)$$

UCC states the corresponding uninterrupted system-specific continuity throughout each realized identity range.

The arrival of an older record at A_D does not place the presently realized source identity in a private past time.

40.6 Successive remote records

Let two source manifestations:

$$\chi_1, \quad \chi_2 \quad (811)$$

belong to the same source identity A_S .

Suppose a warranted physical reconstruction establishes:

$$\exists s_1, s_2 \in I_{A_S}, \quad s_1 \prec_C s_2, \quad (812)$$

with:

$$\text{ManifestationAt}(A_S, \chi_1; s_1) \wedge \text{ManifestationAt}(A_S, \chi_2; s_2). \quad (813)$$

Let the reconstructed record separation satisfy:

$$\Delta_{\text{arr}} = \Delta_{\text{src}} + \Delta_{\text{prop}}. \quad (814)$$

Here:

$$\Delta_{\text{src}} \quad (815)$$

is an operational representation of source-development separation under the declared reconstruction model, while:

$$\Delta_{\text{prop}} \quad (816)$$

contains differential path, propagation, lensing, medium, source-motion, detector, and reconstruction contributions where physically applicable.

If:

$$|\Delta_{\text{prop}}| \leq \epsilon_{\text{prop}}, \quad (817)$$

then:

$$|\Delta_{\text{arr}} - \Delta_{\text{src}}| \leq \epsilon_{\text{prop}}. \quad (818)$$

This may warrant relative source development without identifying the exact stage pair:

$$\begin{aligned} & \text{Warrant}_{P,M} [\exists s_1, s_2 \in I_{A_S} (s_1 \prec_C s_2)] \\ & \Rightarrow \text{ExactCosmicChangeStagePairIdentified}_{P,M}(A_S, \chi_1, \chi_2). \end{aligned} \quad (819)$$

40.7 Large propagation delay and common-stage unity

A very large propagation delay does not enlarge or divide the common cosmic change stage:

$$L_{\text{T}}^{\text{prop}} \gg 0 \not\Rightarrow \text{CommonCosmicChangeStageSplit}. \quad (820)$$

Nor does:

$$L_{\text{T}}^{\text{prop}} \gg 0 \not\Rightarrow \text{RemoteSystemHasDifferentTime}. \quad (821)$$

Propagation delay concerns access to information-bearing physical records.

40.8 Light and radiation

A radiation pulse, photon-qualified entity, excitation, beam, field object, or other radiation-model object belongs to $\mathcal{U}_{\text{phys}}$ only if it independently satisfies the applicable physical-system identity criterion.

Thus:

$$\text{RadiationModelObject}(R) \Rightarrow \text{PhysicalSystem}(R). \quad (822)$$

Where $R \in \mathcal{U}_{\text{phys}}$ and $R \in \mathcal{S}_{\text{phys}}(s)$, UCC gives:

$$\text{UCC} \wedge R \in \mathcal{S}_{\text{phys}}(s) \implies \text{PhysReal}_R^+(s). \quad (823)$$

Propagation, scattering, attenuation, interference, refraction, lensing, spectral change, path deviation, polarization change, and detector interaction remain physical phenomena.

Therefore:

$$\text{OpticalPathDeviation}(R) \not\Rightarrow \text{TimeBent}, \quad (824)$$

and:

$$\text{RadiationArrivalDelay}(R) \not\Rightarrow \text{TimeDelayed}. \quad (825)$$

40.9 Observed deflection of light

An observed deflection of light is a difference between the propagation direction, or the reconstructed propagation path, of a physical signal R at a receiver and a reference direction or path, stated relative to declared physical reference systems $\mathcal{S}_{\text{ref}}$ and a declared reconstruction procedure P :

$$\text{ObservedDeflection}(R; \mathcal{S}_{\text{ref}}, P) := \angle(\hat{\mathbf{k}}_R^{\text{rec}}, \hat{\mathbf{k}}_R^{\text{ref}}) \Big|_{\mathcal{S}_{\text{ref}}, P}. \quad (826)$$

It is a property of the signal's physical propagation path or of its reconstruction. It is not a deformation of the light itself, as if the radiation were an elastic body that bends:

$$\text{ObservedDeflection}(R; \mathcal{S}_{\text{ref}}, P) \not\Rightarrow \text{IntrinsicDeformation}(R). \quad (827)$$

Nor is it evidence that time, or a temporal fabric, has bent (Eq. (824)). Within ITOF the expression “bending of time” is a type error rather than a false empirical claim: $T_{\text{ITOF}} = (\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}})$ carries no direction, curvature, or spatial structure (Eq. (11)), so no property of a propagation path is a property of T_{ITOF} . Time neither bends with light nor travels inside it; light is a physical signal with a path and propagation conditions.

A deflection is attributed only to declared physical contributors. The contributor families relevant to a signal path are

$$\begin{aligned} \text{DeflectionAttribution}(R) \implies \emptyset \neq \mathcal{C}_R \subseteq \{ &\text{Medium, Gravitational,} \\ &\text{MotionRotation, ScatteringReflectionRefraction,} \\ &\text{TransmissionReconstruction} \}, \end{aligned} \quad (828)$$

namely: a material medium and its refractive conditions (air, water, glass, plasma); the mass distribution or gravitational relation represented in the declared physical model; motion or rotation of the source, the receiver, the deflecting body, the medium, or the reference system; scattering, reflection, or refraction at physical boundaries; and the transmission conditions of the path between source and receiver together with the reconstruction model. Rotation is a contributor in some cases — where the deflecting body, the medium, or the reference system rotates — and is not the explanation of every deflection:

$$\text{ObservedDeflection}(R; \mathcal{S}_{\text{ref}}, P) \not\Rightarrow \mathcal{C}_R = \{\text{MotionRotation}\}. \quad (829)$$

Gravitational deflection is retained as a quantitative result of the applicable relativistic model [5, 26],

confirmed by astrometric and radio-interferometric observation [25]. ITOF attributes it to the physical gravitational relation between the signal and the deflecting mass distribution as represented in that model. The model represents the path as a null geodesic of a curved metric; by the Non-Transfer Principle and Proposition 43.4, curvature of the model geometry is not curvature of time, and the predictive success of the representation does not transfer temporal identity to it. ITOF does not dispute any measured deflection value; it specifies what the measured quantity is a property of.

40.10 Remote Records in Physical Realization

For a source stage s_S , the source system belongs to:

$$\mathfrak{R}_C(s_S). \quad (830)$$

At the later detector-record stage s_D , the detector and record-producing systems belong to:

$$\mathfrak{R}_C(s_D). \quad (831)$$

The physical source–record chain therefore connects physical realizations across the invariant order.

It does not identify the two stage-relative profiles:

$$s_S \prec_C s_D \not\Rightarrow \mathfrak{R}_C(s_S) = \mathfrak{R}_C(s_D). \quad (832)$$

Nor does it require a universal deterministic map from the earlier complete profile to the later complete profile.

The physical propagation model supplies only the dependencies warranted for the particular source–signal–receiver system.

41. Quantum Records and System Identity

41.1 Mathematical-form-neutral treatment

V39/F19 does not adopt one interpretation of quantum mechanics as part of the definition of time.

Quantum mathematical structures enter through the mathematical-form-neutral physical-model architecture defined in Section 18.

The formal time definition remains that of Eq. (11).

41.2 Quantum model objects are not automatically physical systems

A state vector:

$$|\psi\rangle, \quad (833)$$

density operator:

$$\rho, \quad (834)$$

operator:

$$\hat{O}, \quad (835)$$

path amplitude, probability distribution, entanglement relation, or superposition notation is not automatically a numerical physical-system identity.

Thus:

$$\text{ModelState}(|\psi\rangle) \not\Rightarrow \text{PhysicalSystem}(|\psi\rangle), \quad (836)$$

and:

$$\text{DensityOperator}(\rho) \not\Rightarrow \text{PhysicalSystem}(\rho). \quad (837)$$

Likewise:

$$\text{QuantumOperator}(\hat{O}) \not\Rightarrow \text{PhysicalSystem}(\hat{O}). \quad (838)$$

Their model status must be distinguished from the physical-system identities they may represent.

41.3 Quantum model objects are not time

The generalized Non-Transfer Principle gives:

$$|\psi\rangle \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad \rho \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad \hat{O} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (839)$$

A parameter appearing in a quantum evolution equation remains governed by the model-parameter Non-Transfer rule.

For example, where:

$$i\hbar \frac{\partial}{\partial \lambda} |\psi(\lambda)\rangle = \hat{H} |\psi(\lambda)\rangle, \quad (840)$$

the formal role of λ is fixed by the declared quantum model.

Its occurrence as an evolution parameter does not alter the governing type assignment:

$$\lambda \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (841)$$

41.4 Joint quantum states and system number

For joint state q_{AB} :

$$\text{JointQuantumState}(q_{AB}) \not\Rightarrow \text{PhysicalSystemNumber}(q_{AB}). \quad (842)$$

A physically warranted classification may involve:

$$\begin{aligned} &\text{two or more independently qualified systems,} \\ &\text{one composite system,} \\ &\text{a composite together with independently qualified subsystems,} \\ &\text{or another physically justified identity architecture.} \end{aligned} \quad (843)$$

The hierarchical composition relation:

$$A \triangleleft_{\kappa, s} B \quad (844)$$

may be used only where the physical identity and composition criteria justify it.

Quantum-state notation alone does not decide that relation.

41.5 Entanglement and Temporal Type

An entanglement relation does not by itself establish a private time or a second cosmic ordering:

$$\text{Entangled}_M(A, B) \not\Rightarrow \text{PrivateTime}(A, B), \quad (845)$$

$$\text{Entangled}_M(A, B) \not\Rightarrow \text{SecondCosmicOrdering}. \quad (846)$$

Where:

$$A, B \in \mathcal{S}_{\text{phys}}(s), \quad (847)$$

Entanglement classification neither supplies nor removes the common stage: CMA makes the represented qualified population co-present at the shared member, while UCC requires the respective system-specific physical changes and their continuation without admitted stasis throughout each realized identity range.

41.6 Quantum measurement

Let a quantum measurement arrangement contain physical source or sample, apparatus, interaction, detector, environment, record-bearing, observer, and laboratory or reference systems. Where those entities satisfy the governing physical-system criteria, each has its own identity-bounded history in the one cosmic succession and is subject to UCC at every stage at which it remains realized. Their stage-relative realizations belong to:

$$\mathfrak{R}_C(s). \quad (848)$$

No measurement-system component is assigned a changeless standpoint outside the physical process merely because it functions as an observer, detector, reference, or laboratory standard.

A detector outcome:

$$r_Q \quad (849)$$

is a physical record.

Thus:

$$r_Q \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (850)$$

A probability:

$$P(o|\psi, M) \quad (851)$$

is a model quantity:

$$P(o|\psi, M) \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (852)$$

41.7 Physical transformation versus representational update

If terminology such as “collapse” denotes an actual physical transformation of a qualified physical system, then:

$$\text{PhysicalCollapse}_M(A; s) \implies \text{PhysReal}_A^+(s) \quad (853)$$

where the applicable physical interpretation and system attribution are independently warranted.

If the same terminology instead denotes a change in state assignment, conditional description, information, or statistical representation, then the change belongs to the representational level.

Therefore:

$$\text{CollapseNotationChanged} \not\Rightarrow \text{PhysicalSystemIdentityChanged}. \quad (854)$$

And:

$$\text{CollapseNotationChanged} \not\Rightarrow \text{CosmicOrderingChanged}. \quad (855)$$

41.8 Delayed-choice and quantum-eraser records

Delayed-choice and quantum-eraser experiments provide concrete record-level contexts in which later measurement settings or later correlation classifications must be distinguished from retroactive physical alteration [47, 48, 49]. A delayed measurement setting or later correlation classification does not retroactively reverse the universal cosmic ordering.

Thus:

$$\text{LaterCorrelationClassification}(r) \not\Rightarrow \text{EarlierPhysicalRealizationAltered}. \quad (856)$$

Likewise:

$$\text{DelayedChoiceRecord}(r) \not\Rightarrow \exists \prec'_C \neq \prec_C. \quad (857)$$

A later record may alter the scientifically warranted description assigned to an earlier process.

It does not make a later common cosmic change stage earlier.

41.9 Quantum correlations and causal attribution

Observed quantum correlations are physical-record relations whose theoretical interpretation depends on the declared quantum model.

Their existence does not automatically identify:

$$\text{QuantumCorrelation}(A, B) \not\Rightarrow \text{SpecificPhysicalCausalMechanism}(A, B). \quad (858)$$

Nor does:

$$\text{QuantumCorrelation}(A, B) \not\Rightarrow \text{InstantaneousCausalSignal}(A, B). \quad (859)$$

CMA does not supply such a mechanism either.

The physical causal interpretation must remain independently warranted.

42. Higher-Dimensional Representations

42.1 Mathematical dimension and physical realization

Let:

$$\mathcal{M}_n \quad (860)$$

be an n -dimensional mathematical manifold, embedding space, state space, configuration space, phase space, or coordinate representation.

Its mathematical consistency may satisfy:

$$\text{MathematicallyConsistent}(\mathcal{M}_n). \quad (861)$$

It does not follow that:

$$\text{MathematicallyConsistent}(\mathcal{M}_n) \not\Rightarrow \text{AllDimensionsPhysicallyReal}(\mathcal{M}_n). \quad (862)$$

The physical interpretation of dimensions is an additional model question.

42.2 Coordinate dimensions do not become time

For coordinate component:

$$x^j, \quad (863)$$

V39/F19 retains:

$$x^j \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (864)$$

An additional coordinate dimension therefore does not establish:

$$\text{AdditionalCoordinateDimensionInModel} \not\Rightarrow \text{AdditionalCosmicTimeExists}. \quad (865)$$

Nor does a model containing several time-like coordinates establish several ITOF temporal extensions merely from its mathematical signature:

$$\text{MultipleTimelikeCoordinatesInModel} \not\Rightarrow \text{MultipleITOFTemporalExtensions}. \quad (866)$$

42.3 State-space dimension is not cosmic-stage multiplicity

A high-dimensional state space:

$$\Omega_A \quad (867)$$

may be required to represent the physical state of system A .

Its dimension does not determine the cardinality or order type of:

$$\mathcal{S}_C^{\text{tot}}. \quad (868)$$

Thus:

$$\dim(\Omega_A) = n \not\Rightarrow |\mathcal{S}_C^{\text{tot}}| = n. \quad (869)$$

The same distinction applies to:

$$\Xi_A, \quad \mathcal{Y}_P, \quad \mathcal{Z}_{AB,P}, \quad (870)$$

and other application-level spaces.

42.4 Coordinate transformations

For:

$$x' = \Phi(x), \quad (871)$$

the transformation changes the mathematical representation, not the universal cosmic ordered pair. Thus:

$$x' = \Phi(x) \not\Rightarrow \text{ITOFTimeTransformed}. \quad (872)$$

42.5 Fixed coordinate does not establish physical stasis

For:

$$s_1, s_2 \in I_A \quad (873)$$

with:

$$s_1 \prec_C s_2, \quad (874)$$

selected coordinate equality:

$$x_P(A; s_1) = x_P(A; s_2) \quad (875)$$

does not establish:

$$x_P(A; s_1) = x_P(A; s_2) \not\Rightarrow X_A(s_1) = X_A(s_2). \quad (876)$$

Under UCC, the selected coordinate equality leaves the governing actual-change consequence unchanged:

$$x_P(A; s_1) = x_P(A; s_2) \wedge s_2 \in I_A \wedge \text{UCC} \implies \text{PhysReal}_A^+(s_2). \quad (877)$$

A system can remain at the same selected spatial coordinate while undergoing physical change.

42.6 General representation rule

For any mathematical representation:

$$\mathcal{R}_M(A), \quad (878)$$

V39/F19 adopts:

$$\text{Represents}_M(\mathcal{R}_M(A), A) \not\Rightarrow \mathcal{R}_M(A) \equiv_{\text{type}} A. \quad (879)$$

Likewise:

$$\text{RepresentsTimeRelatedRecords}_M(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \quad (880)$$

This rule unifies the treatment of:

$$\begin{aligned} &\text{coordinates, state vectors, metrics, proper-time functionals,} \\ &\text{higher-dimensional spaces, clock readings, statistical estimators,} \\ &\text{and model-evolution parameters.} \end{aligned} \quad (881)$$

43. Geometrized-Time Asymmetry and Relativistic Commitment Distinctions

43.1 Purpose and method

For each relativistic temporal quantity, this section states which governing ITOF commitment the quantity fails to satisfy. Because $\prec_C$ is itself defined as a strict total, representation-invariant order (Eq. (11)), the arguments below identify commitment distinctions rather than premises independent of that definition; they are not offered as a derivation of non-identity from relativity alone. Where an argument compares an event ordering on a relativistic manifold with the stage ordering $\prec_C$, the comparison presupposes an independently declared cross-representation bridge of the kind required in Section 6 and is not itself a supplied instance of such a bridge. Two such distinctions, each stated as premises and a conclusion,

together with type considerations, establish in one proposition the non-identity with T_{ITOF} of each relativistic geometric temporal quantity, including global time functions and cosmological time. A third distinction concerns the eternalist interpretation only and is not used in that proposition.

Argument 43.1 (Total order versus boost-relative order). **Premise 1.** By the governing definition of $\prec_C$ and the invariance of the earlier–later ordering, $\prec_C$ is a strict, asymmetric total order on $\mathcal{S}_C^{\text{tot}}$ that is invariant under every admissible representation: no representation, coordinate assignment, or description converts $s \prec_C s'$ into $s' \prec_C s$, and no representation assigns distinct stages an order-independent status.

Premise 2. In a relativistic model with Lorentzian signature, a designated coordinate $x^0 = ct$ transforms under a boost as

$$x'^0 = \gamma(x^0 - \frac{v}{c}x^1), \quad \gamma = (1 - v^2/c^2)^{-1/2}, \quad (882)$$

so that the value of x'^0 for a fixed event depends on the spatial coordinate x^1 and on the boost parameter v . The temporal coordinate is thereby a component of a vector transformed by the Lorentz group together with the spatial components.

Premise 3. The order that relativistic physics does preserve is narrower than the order $\prec_C$ requires. The orthochronous subgroup preserves the sign of x^0 -separation only for pairs of events that are timelike or lightlike separated. For spacelike-separated events, the sign of Δx^0 is not preserved: there exist boosts under which $\Delta x^0 > 0$ becomes $\Delta x^0 < 0$, and the standard relativity-of-simultaneity result asserts exactly this. Hence the x^0 -ordering is a frame-dependent partial preservation, defined on a causally connected subset of event pairs.

Conclusion. ITOF requires a single relation invariant for every pair of distinct stages (Premise 1). Relativistic physics preserves an order-theoretic fact only for causally connected event pairs, and that fact is boost-reversible for spacelike-separated pairs (Premises 2 and 3): what relativity secures is a frame-independent partial causal order on events, not a frame-independent total order. This is a difference in the strength of commitment, not a discovery that relativity contradicts $\prec_C$ on some shared domain where both are defined: $\prec_C$ is a stage relation for which no relativistic quantity is, by itself, a supplied representation. Consequently x^0 , or any event-ordering fact recoverable from a relativistic model, is not type-identical with $\prec_C$: identifying the two would import ITOF's stronger total-order commitment into a domain where standard relativistic ontology commits only to the weaker partial causal order. This conclusion grants, and does not depend on denying, that the orthochronous Lorentz subgroup preserves time orientation for causally connected pairs.

Argument 43.2 (Intra-stage and inter-stage relations). **Premise 1.** By CMA, the qualified systems realized at a stage s are co-present at that one stage (Eq. (74)). Spatial relations among physical systems — separation, configuration, relative position — hold among systems realized together; each is borne by a stage population $\mathcal{S}_{\text{phys}}(s)$, not by a pair of distinct stages.

Premise 2. $\prec_C$ relates distinct stages; it holds between no two systems as members of one stage population.

Premise 3. In a Lorentzian representation, x^0 and x^i are components of one coordinate tuple on the event manifold, interconverted by Lorentz transformations (Eq. (882)); the representation assigns them one homogeneous type.

Conclusion. ITOF distinguishes in type the relation that orders stages from the relations that hold within a stage; the Lorentzian representation does not. x^0 is therefore not a representation of $\prec_C$ that preserves this distinction, and $x^0 \not\equiv_{\text{type}} T_{\text{ITOF}}$. The conclusion depends on CMA and is a commitment distinction, not a result derived from relativity alone. It does not concern the metrology of length and time standards, which are operationally linked through the defined speed of light, and it does not deny the predictive content of

the representation.

Argument 43.3 (Constitution-criterion conflict). This argument states a conflict between two constitution criteria for a totality of stage-like elements. It does not classify ITOF as presentist, growing-block, or any other tensed metaphysical position, and, per Section 6, it does not depend on whether NTCS_C holds.

Premise 1. By the stage-admissibility condition, membership of $s \in \mathcal{S}_C^{\text{tot}}$ is fixed by the criterion that s is a common stage of the physical systems of the universe, at which, by UCC, every one of them changes (Eq. (104)). This membership criterion is stated without reference to, and holds independently of, whether $\mathcal{S}_C^{\text{tot}}$ is order-isomorphic to a bounded or an unbounded total order: it fixes what makes a candidate element a member, not how many members the succession has.

Premise 2. The geometric formalism of relativistic spacetime, as a mathematical structure (a manifold M with a Lorentzian metric g), does not by itself assert a constitution criterion for the points of M . The eternalist interpretation adds to the formalism a distinct membership criterion: a point of M is a member of the completed manifold in virtue of its location in the fixed geometric structure, independently of any realization-based criterion applied to it.

Conclusion. The formalism and the eternalist interpretation are distinguished. Membership in $\mathcal{S}_C^{\text{tot}}$ is fixed by a realization criterion (Premise 1); membership in the eternalist manifold is fixed by a structural-location criterion (Premise 2). These are different constitution criteria regardless of the order type of either totality, so an identification of $\mathcal{S}_C^{\text{tot}}$ with the eternalist manifold would conflate two distinct membership criteria rather than merely restate one of them in different notation. The conflict is with the eternalist interpretation, not with the formalism itself, and it is not a claim that later cosmic stages fail to exist prior to some privileged present, a claim this framework does not make. A relativistic model interpreted without a completed-manifold commitment is not addressed by this argument, and no claim is made that the operational or predictive content of the formalism is false. An eternalist reading may also adopt a realization criterion for the points of M , in which case the distinction lapses; for this reason the argument is not used in Proposition 43.4.

Proposition 43.4 (Consolidated geometrized-time non-identity). For every relativistic geometric temporal quantity $q \in \{x^0, T, t_{\text{cos}}, g_{\mu\nu}, ds^2, \tau[\gamma, g], R^p_{\sigma\mu\nu}, 1+z, h_{\mu\nu}\}$, where T is a global time function and t_{cos} the cosmological time of a homogeneous model,

$$q \not\equiv_{\text{type}} T_{\text{ITOF}}, \quad (883)$$

by Arguments 43.1 and 43.2 and by the type considerations given for each quantity.

Proof. The derivation is given quantity by quantity, because the quantities fail different tests.

Coordinate time x^0 . It fails the invariance-domain test of Argument 43.1 and the intra-/inter-stage type distinction of Argument 43.2.

Global time function T and cosmological time t_{cos} . A globally hyperbolic spacetime admits smooth global time functions [30], and a homogeneous cosmological model distinguishes the proper time of comoving observers. Each induces a total preorder on events that is not reversed by boosts, so Argument 43.1 does not apply to it. Each fails as T_{ITOF} for other reasons. It is real-valued and metric, whereas $\prec_C$ carries no magnitude (Eq. (24)). It exists only in models satisfying stated global conditions, whereas T_{ITOF} is not conditional on a spacetime model. A global time function is not unique, since increasing reparametrizations and inequivalent foliations also qualify, and cosmological time is distinguished only within a homogeneous model, whereas $\prec_C$ is one designated order. The level sets of such a function are natural candidates for a representation bridge from events to stages; adopting one is additional application

structure (Section 6), not an identity.

Metric $g_{\mu\nu}$ and curvature $R^p_{\sigma\mu\nu}$. These are tensor fields on M . They are not orderings of any set of stages, so they have no domain of order-invariance to compare with $\prec_C$.

Interval ds^2 . It is boost-invariant, so Argument 43.1 does not apply to it as stated. It fails as a candidate for T_{ITOF} for a different reason: it is a signed quadratic quantity that takes a positive, zero, or negative value, and it does not supply an earlier–later relation between distinct stages at all.

Proper-time functional $\tau[\gamma, g]$. It is defined only along timelike worldlines γ , takes path-dependent values for the same pair of events, and is realized operationally as a clock record of one system; it supplies neither one order for all stage pairs nor an order of stages at all.

Redshift $1 + z$ and strain $h_{\mu\nu}$. The first is a ratio of received to emitted signal frequencies, the second a dimensionless perturbation of model geometry recorded by detectors. Both are real-valued record or model quantities; T_{ITOF} is an ordered pair, not a number or a field, so both are type-distinct from it.

Remark 43.5. Arguments 43.1–43.3 state structural, type, and interpretive distinctions. They do not derive the Lorentz transformations or any relativistic quantitative prediction, and they do not license inferring quantitative disagreement with a successful relativistic model from the foundational disagreement alone.

43.2 Dimensional reading of time and higher-dimensional spacetime

The claim that time is a geometric dimension has three separable parts, and the arguments above bear on them differently.

Definition 43.6 (Physical-dimension admission). A dimension of a mathematical representation $\mathcal{M}_n$ is admitted as physically realized only where an independently warranted physical criterion of realization for that dimension is supplied: a verification procedure or physical interaction signature that identifies the dimension in physical systems and does not consist in the representation’s own mathematical consistency. Accordingly, $\text{MathematicallyConsistent}(\mathcal{M}_n) \not\Rightarrow \text{AllDimensionsPhysicallyReal}(\mathcal{M}_n)$.

Proposition 43.7 (Status of time as a geometric dimension). Let x^0 be the temporal coordinate of a relativistic representation $\mathcal{M}_4$.

- (a) x^0 is admitted as a coordinate of the representation, and relativistic models that use it are not thereby denied operational or predictive content.
- (b) $x^0 \not\equiv_{\text{type}} T_{\text{ITOF}}$ (Proposition 43.4). The claim that ITOF time is a dimension of the geometric manifold is therefore not adopted.
- (c) x^0 represents an ordering across stages, whereas a spatial coordinate represents a relation within a stage (Argument 43.2). Treating them as homogeneous dimensions under one realization criterion in the sense of Definition 43.6 is therefore not warranted by the mathematical structure of $\mathcal{M}_4$ alone.

Proof. (a) is a statement of what is granted. (b) is Proposition 43.4. (c) follows from Argument 43.2: the two coordinates represent relations of different ITOF type, so no single realization criterion in the sense of Definition 43.6 covers both.

Remark 43.8 (Boundary of the claim). Proposition 43.7 does not assert that additional spatial dimensions of Kaluza–Klein or string-theoretic representations do or do not exist. Their status is governed by Definition 43.6 and by independent physical evidence, not by ITOF. What ITOF fixes is that any such dimension, and any additional timelike coordinate, leaves T_{ITOF} and the single stage domain $\mathcal{S}_C^{\text{tot}}$ unchanged (equations (865), (866) and (869)).

43.3 Temporal deformation predicates and their physical bearers

$T_{\text{ITOF}} = (\mathcal{S}_C^{\text{tot}}, \prec_C)$ is a set with a strict total order. It carries no metric, connection, curvature, direction in a space, dimension, or signature. Predicates defined only on such structures are therefore not false of time but inapplicable to it:

$$\begin{aligned} & \text{IllTyped}(P; T_{\text{ITOF}}) \quad \text{for} \\ & P \in \{\text{Curved, Warped, Dilated, Contracted, Stretched, Compactified, Bent}\}. \end{aligned} \quad (884)$$

Three further predicates are well typed but excluded by governing commitments: $\text{Reversed}(T_{\text{ITOF}})$ by Strict Cosmic Ordering, $\text{Multiplied}(T_{\text{ITOF}})$, that is, several times, by CMA, and TraversedBackward by Eq. (778).

Each deformation predicate used in relativistic language has a physical or representational bearer, and is reassigned to it:

$$\begin{aligned} \text{Curved, Warped} & \mapsto (g_{\mu\nu}, R^p_{\sigma\mu\nu}), (M_D, g_{AB}), \\ \text{Dilated} & \mapsto \Delta\tau[\gamma_1, \gamma_2; g], \Delta N_{C_1 C_2}, \\ \text{Contracted} & \mapsto L_0/\gamma, \\ \text{Stretched} & \mapsto (1+z), a, \\ \text{Compactified} & \mapsto \text{coordinate dimensions of } M_D, \\ \text{Bent} & \mapsto \text{ObservedDeflection}(R; \mathcal{S}_{\text{ref}}, P). \end{aligned} \quad (885)$$

The bearers are, in order: the model geometry representing the gravitational relation; worldline functionals and the clock records of physical bearers; rod records of bearers in relative motion; the received record sequence and the cosmological scale factor; representational coordinate dimensions; and signal paths (Section 40.9). For every bearer b in Eq. (885), no bearer predicate alters the stages of the universe or their order:

$$P(b) \not\Rightarrow \text{Altered}(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (886)$$

This consolidates Eq. (598) and the type boundary of Proposition 43.4.

43.4 Spacetime as representation and the gravitational relation

A spacetime $(M, g_{\mu\nu})$ is a mathematical representation of physical relations among bearers and fields. The gravitational relation that the metric represents is physically real: it belongs to the gravitational family of physical factors (Section 8), it contributes to change, and its propagating disturbances are recorded by detectors (Table 2). What ITOF does not admit is a physical entity composed of space and time, a “fabric” of which time is a component:

$$\begin{aligned} & \text{Represents}((M, g), \text{GravitationalRelation}) \wedge \text{PhysicalFactor}(\text{GravitationalRelation}) \\ & \not\Rightarrow T_{\text{ITOF}} \in \text{Components}(\text{PhysicalEntity}). \end{aligned} \quad (887)$$

The geometric representation of gravitation is retained in full as application physics; only the reading of time as one of its components is excluded.

43.5 Non-admission of temporal geometry

Proposition 43.9 (Non-admission of temporal geometry). No geometric structure is admitted in ITOF as a physical property of time:

$$\boxed{\begin{aligned} \forall G \in \{\text{metric, curvature, dimension, signature, warping}\} : \\ \neg \text{PhysicalPropertyOf}(G, T_{\text{ITOF}}). \end{aligned}} \quad (888)$$

Proof. Three independent grounds apply. (i) By type: each listed structure requires structure that T_{ITOF} does not carry (Eq. (884)). (ii) By admission: a geometric dimension is physically realized only under an independent realization criterion (Definition 43.6); for time as a dimension none is available that does not consist in the consistency of the representation, and its temporal coordinate represents an ordering across stages, not a relation within one (Proposition 43.7). (iii) By physical content: under the phenomenon bridge, every record that a temporal-geometric reading accounts for is accounted for as a relation among physical bearers, signals, and the gravitational relation (Proposition 37.2, Eq. (885)); the temporal-geometric reading has no physical correlate beyond those, and by the Generalized Non-Transfer Principle its predictive success does not confer one.

Ground (iii) states precisely in what sense a geometry of time does not correspond to physical reality: it has no physical correlate that is not already carried by physical systems, signals, and fields. The proposition does not deny the mathematical consistency of relativistic geometry, its predictive success, the reality of the gravitational relation, or the possibility that independent physical evidence establishes an additional spatial dimension. It denies that any of these makes geometry a property of time.

44. Reading the Relativistic Equations

The relativistic equations of this part are compact, and their force depends on reading each one in the same four steps: what it states; which relativistic temporal reading it answers; why it holds in ITOF; and what it leaves standing, including what would count against ITOF. This section applies those steps to the principal equations in order of their dependence.

1. Coordinate time is not time (Eqs. (562), (581)).

Statement. The coordinate x^0 of a chart is not T_{ITOF} . *Reading answered.* In ordinary relativistic language the time coordinate of an inertial frame is “the time” in that frame. *Why it holds.* x^0 is a value assigned to events by a chart; different charts assign different values to the same events, while T_{ITOF} is one designated order that no choice of chart changes. A quantity that changes with the chart cannot be the order that does not. *Retained.* Every use of x^0 in calculation. *Against ITOF.* Nothing about x^0 could count against ITOF, because the claim concerns type, not value.

2. Proper time is not time (Eqs. (602), (565), (607)).

Statement. The proper-time functional $\tau[\gamma, g]$ along a worldline is not T_{ITOF} , and two worldlines with different values of τ between the same events do not have two times. *Reading answered.* Relativity is commonly read as saying that each system carries its own time, measured by its proper time. *Why it holds.* τ is a number computed along one path; two paths between the same two events give two numbers. These numbers measure the amount of a clock’s internal change along each path, not two orders of stages: both clocks pass through the same common stages (Eq. (769)). *Retained.* The values of τ and their agreement

with clock records. *Against ITOF.* A physical system with a private ordering of stages would count against CMA; a difference in τ is not one.

3. Relativity of simultaneity (Eqs. (616), (620)).

Statement. Equality of coordinate time in one frame differs from that in another, and neither is co-presence at a common stage. *Reading answered.* Since observers disagree about which distant events are simultaneous, there is no fact of the matter about a universal “now.” *Why it holds.* Coordinate simultaneity is fixed by a synchronization convention between clocks; it is a relation among records. Co-presence is fixed by CMA through realization successions (Eq. (71)). The disagreement of conventions is a disagreement about records, and it does not reach realization. *Retained.* Every simultaneity convention and its use. *Against ITOF.* None of the disagreements of conventions; only a warranted private ordering of realization.

4. The direct conflict (Eqs. (625), (626)).

Statement. An interpretation that denies a frame-independent common stage contradicts CMA. *Reading answered.* The view that relativity itself establishes the absence of a common stage. *Why it holds.* Such an interpretation assigns each system an ordering of its realizations relative to a frame or worldline, that is, a private ordering, which is the contrary of CMA (Eq. (904)). *Retained.* Relativistic dynamics, which do not contain that interpretation. *Against ITOF.* The conflict is ontological; it becomes empirical only when a bridge from events to stages predicts a record that the competitor does not (Eq. (958)).

5. The phenomenon bridge (Eqs. (762)–(769)).

Statement. Every relativistic phenomenon is read through its bearers, conditions, model, model quantity, prediction map, and records; (J1)–(J3) include all data and all contributors and retain every quantitative result; (M1)–(M4) exclude time as model quantity and as contributor. *Reading answered.* That the success of relativistic predictions confirms the temporal reading of their quantities. *Why it holds.* The data of every relativistic test are records of physical bearers, and the contributors are physical; the temporal reading adds no record and no contributor. *Retained.* Every prediction. *Against ITOF.* A record that could not be attributed to any bearer or physical contributor — none is known.

6. Lorentz transformations (Eqs. (771)–(775)).

Statement. The transformations follow from homogeneity, isotropy, the relativity principle, and order preservation of each bearer’s records, with $K = 1/c^2$ fixed by experiment; the temporal core neither yields them nor is refuted by them. *Reading answered.* That the transformations are a property of time and space themselves. *Why it holds.* Every premise concerns rods, clocks, and records; none mentions $\prec_C$, CMA, or UCC. The moving clock relation $t' = t/\gamma$ is a relation between the records of two laboratories. *Retained.* The transformations in full. *Against ITOF.* A demonstration that the premises cannot be satisfied without a frame-relative order of realization.

7. Differential ageing (Eq. (776)).

Statement. Two systems that separate and reunite may accumulate different amounts of change, without either having fewer stages or a private time. *Reading answered.* The twin who travels “experiences less time.” *Why it holds.* Both twins pass through the same stages between separation and reunion; what differs is the amount of their own change, as ageing is the accumulated change of an organism. *Retained.* The computed difference, through τ . *Against ITOF.* Nothing in the size of the difference; only a private ordering.

8. Horizons (Eq. (777)).

Statement. The divergence of a coordinate does not stop the change of a falling system. *Reading answered.* “Time stops at the horizon.” *Why it holds.* The divergence belongs to one chart and to the delay of signals reaching a distant receiver; in the same model the falling system’s proper time remains finite, and under UCC it continues to change. *Retained.* The geometry of the solution. *Against ITOF.* None from the divergence; it is not a record of the falling system.

9. No return to an earlier stage (Eqs. (778), (779)).

Statement. No physical system realizes a change at a stage earlier than one it has already passed. *Reading answered.* Closed timelike curves, wormhole or warp-drive time machines, and journeys into the past. *Why it holds.* By CMA a system’s own earlier–later order is the cosmic order; by Strict Cosmic Ordering that order is asymmetric; a return would require both orders at once. *Retained.* The solutions as mathematics. *Against ITOF.* A physically established return to an earlier stage would contradict ITOF directly. This is a definite commitment that physics could test.

10. Deformation predicates (Eqs. (884)–(886)).

Statement. Curved, warped, dilated, contracted, stretched, compactified, or bent are not predicates of time; each belongs to a definite bearer. *Reading answered.* “Time is curved,” “time dilates,” “space-time is warped.” *Why it holds.* T_{ITOF} is an ordered set without metric, connection, or dimension, so these predicates do not apply to it; the measurements behind them are of model geometry, clocks, rods, signals, and received light. *Retained.* Every measured curvature effect, dilation relation, and stretching. *Against ITOF.* None, because the claim is about type.

11. Spacetime and temporal geometry (Eqs. (887), (888)).

Statement. Spacetime is a representation of the gravitational relation, and no metric, curvature, dimension, signature, or warping is a physical property of time. *Reading answered.* That time is the fourth dimension of a physical entity. *Why it holds.* By type; by the dimension-admission criterion, because no realization criterion for time as a dimension exists apart from the consistency of the representation; and by physical content, because every record that the geometric reading explains is explained by bearers, signals, and the gravitational relation. *Retained.* The gravitational relation as a physical factor and its geometric representation as a tool. *Against ITOF.* An independent physical criterion showing a dimension of time realized beyond the representation.

12. Non-identity of the whole family (Proposition 43.4).

Statement. None of x^0 , a global time function, cosmological time, the metric, the interval, proper time, or curvature is time. *Reading answered.* That some relativistic quantity, if not coordinate time, must be the real time, for example cosmological time. *Why it holds.* Cosmological time and global time functions are boost-invariant, but they are metric, conditional on a model, and not unique; T_{ITOF} is none of these. *Retained.* Their use as representation bridges from events to stages. *Against ITOF.* None from the identification question; bridges remain empirical hypotheses.

13. The Rietdijk–Putnam argument (Eq. (629)).

Statement. Equal coordinate time does not imply realization at a common stage. *Reading answered.* That relativity forces a block universe because what is real for an observer is fixed by its simultaneity hypersurface. *Why it holds.* The argument’s first premise identifies co-presence with frame simultaneity;

ITOF denies that premise, and nothing in the argument addresses the order of realization. *Retained.* The relativity of simultaneity. *Against ITOF.* The cost is stated: no record selects the common stage.

14. Light deflection (Eqs. (826)–(829)).

Statement. Deflection is a property of a signal path or of its reconstruction, attributed to declared contributors, of which rotation is one. *Reading answered.* “Light bends because space-time is curved,” and “gravity bends time.” *Why it holds.* The measured quantity is an angle between directions relative to reference systems; it is a property of a path. *Retained.* The measured deflection and its gravitational prediction. *Against ITOF.* None from the angle itself.

Summary.

In each case the relativistic quantity, its value, and its prediction are retained, and only one step is refused: the step from the quantity to time. The refusal rests on type, on the governing axioms, or on the absence of any record that the temporal reading adds. Where ITOF makes a claim that physics could contradict — a private ordering, a return to an earlier stage, a physically realized dimension of time — the claim is stated as such.

45. Foundational Scope and Limits of ITOF V39/F19

45.1 Framework layers remain typed

V39/F19 distinguishes the temporal foundation from physical realization, identity, causation, observation, operational metrics, application physics, and empirical bridge structures. Schematically,

$$\begin{aligned} \mathfrak{L}_{39} = \{ & \text{Temporal, PhysicalRealization, IdentityLifecycle, Causation} \} \\ & \cup \{ \text{Observation, OperationalMetrics, ApplicationPhysics, EmpiricalBridges} \}. \end{aligned} \quad (889)$$

Membership in one framework does not make these layers definitionally identical or logically interchangeable. The layer distinction is a type distinction, not a claim of dependency isolation: the change of all physical systems of the universe supplies the content of every stage, while independently warranted physics supplies the dynamics of that change.

45.2 Minimal temporal core

The minimal temporal core is the time definition (Eq. (11)) subject to temporal admissibility (Eq. (22)). The ordered pair contains no physical-state profile, causal-source set, measurement rule, clock output, metric, or application dynamics. Temporal admissibility does not fix the extent of the complete succession:

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \not\Rightarrow \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \quad (890)$$

and the converse is also insufficient because non-termination alone does not supply common-stage admission or strict ordering.

45.3 Three non-interchangeable foundational roles

The three roles of Eq. (5) are not interchangeable. The temporal role fixes stage realization and the designated earlier–later order. CMA excludes system-private stages and orderings and yields objective co-

presence of the complete then-realized qualified population at each stage. UCC supplies system-specific physical-change continuity throughout realized identity ranges. Consequently,

$$T_{\text{ITOF}} \not\equiv_{\text{def}} \text{CMA}, \quad T_{\text{ITOF}} \not\equiv_{\text{def}} \text{UCC}, \quad \text{CMA} \not\equiv_{\text{def}} \text{UCC}. \quad (891)$$

No statement supplies a dynamical law merely by belonging to the foundation.

45.4 Foundational consequence of stage admissibility

Stage admission excludes a stage without physical systems; the postulate of change, UCC, makes every stage a stage of change of all physical systems of the universe realized there (Eq. (104)); CMA excludes a system-private stage (Eq. (73)). The partition of stages on which these exclusions rest is stated in Section 6.2.

45.5 Limits of the foundation

Time, stage realization, CMA, UCC, and the non-termination hypothesis do not by themselves specify a Hamiltonian, field equation, constitutive law, transition probability, universal change magnitude, clock response, signal law, or observable residual. Such quantities require independently warranted physical and measurement structures. Likewise, absence of an observed difference is not proof that physical change has ceased. Because the target, apparatus, record-bearing systems, observer, and laboratory/reference systems are themselves within the changing physical domain when qualified, an observed manifestation is produced and accessed through an internal physical chain; it does not by itself identify the exact cosmic stage or its absolute order position.

46. Core Commitments and Logical Status

The governing commitments are:

- (1) **Temporal referent and stage meaning.** $T_{\text{ITOF}} = (\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}})$. A written stage symbol designates an admitted member of the formal cosmic-stage domain; that member of the formal cosmic-stage domain is the formal expression of the physical change of all physical systems of the universe realized there and its place within the one universal earlier–later cosmic succession. Neither notation nor the member of the formal cosmic-stage domain is an independently existing physical object; its type boundary is that of the Cosmic Stage Definition (Section 2.3).
- (2) **Designated objective orientation, strict ordering, and non-reversal of the governing cosmic succession.** $\prec_{\text{C}}$ denotes the governing earlier–later relation. Strict Cosmic Ordering requires that designated relation to be a strict total order. A later realization remains later even if its declared physical state equals or recurs to an earlier state; state recurrence is not stage recurrence.
- (3) **Scientific openness of complete cosmic extent.** V39/F19 does not assert whether the complete future succession terminates or is unlimited. Non-termination (Eq. (17)) is a revisable cosmological hypothesis, used only as an explicit premise, and not a constituent of temporal admissibility.
- (4) **One common succession and Cosmic Moment Axiom.** One universal formal domain of cosmic stages is adopted. The identity ranges $I_A \subseteq \mathcal{S}_{\text{C}}^{\text{tot}}$ and stage populations record identity-stage incidence; they do not establish objective co-presence. CMA states that every system’s realization succession is a segment of the one common succession, which excludes system-private stages and orderings and yields objective co-presence of the complete then-realized population at each stage. UCC independently requires every qualified system in that population to realize its own actual

change there. No synchronization construction or private-stage identification is introduced.

- (5) **Universal Change Continuity.** UCC requires $\text{PhysReal}_A^+(s)$ for every qualified A and every $s \in I_A$. Its continuity means absence of complete physical-system stasis throughout the realized identity range; it is non-metric and does not itself select the system's dynamical law. UCC and CMA are logically independent (Proposition 5.4).
- (6) **Cosmic physical totality, systems, factors, and granularity.** The physical universe denotes $\mathcal{U}_C^{\text{phys}}$, the physical totality of system identities and physically realized physical factors; it is neither a physical container nor a single physical-system identity. Physical-system status is objective, while application-level individuation is fixed relative to a physically warranted class and organizational level. Simple systems need not be composite. Composite qualification requires physically warranted interconnection and coherence; ending or failure of a constituent does not by itself end the composite identity.
- (7) **Identity and lifecycle.** Identity-Realization Convexity, AFB, PIECP, conditional successor attribution, and optional UEIE retain distinct scopes. AFB constrains the least member of an identity range within the common cosmic-stage domain; it neither introduces a private stage nor marks the onset of physical change. AFB and UEIE are not derived from the governing temporal/CMA realization core; UEIE applies only when universal eventual identity ending is explicitly adopted. A terminal identity stage is the end of that identity range, not automatically a terminal cosmic stage. Identity ending does not itself require a successor. Where an ending transformation physically produces a genuinely new identity, the direct-successor relation fixes the required production, formation, and numerical-distinction conditions; absorption by a pre-existing persisting identity can instead end the absorbed system without creating a successor.
- (8) **Physical causation.** CRP separately requires actual physical causal contributors for actual physical change. Time, ordering, stage unity, and UCC are not causal-source classes.
- (9) **Observation and empirical discipline.** The sample or target, apparatus, detector, record-bearing system, observer, and laboratory are physical systems of the universe, and under UCC they continue changing throughout their realized identity ranges. The observation chain is therefore internal to the same cosmic succession and supplies no changeless external stage marker. Clock readings, proper-time functionals, coordinates, and metric intervals are physical or mathematical operational constructions, not the ITOF temporal referent. Prediction separation requires independently warranted physical provenance; ontological difference alone does not manufacture a residual.

47. Integrated Dependency Architecture

47.1 Temporal branch

The constructional dependency is

$$\langle \mathcal{S}_C^{\text{tot}}, \prec_C \rangle \overset{\text{definition}}{\rightsquigarrow} T_{\text{ITOF}}, \quad (892)$$

with temporal admissibility as defined in Eq. (22). The designated earlier-later semantics is fixed independently of the strict-order axiom. The explicit earlier-later pair supplies only temporal non-degeneracy; it does not imply unlimited continuation. Common-stage admission together with UCC makes every stage a stage of change of all physical systems realized there, without supplying a dynamical law. Cosmic non-termination is a separate revisable cosmological hypothesis.

47.2 Physical-system, population, CMA, and UCC branches

At the governing ontic level,

$$\langle \text{PhysicalSystem}, \text{ExistsAs} \rangle \xrightarrow{\text{dep}} \langle \mathcal{U}_{\text{phys}}, I_A, \mathcal{S}_{\text{phys}}(s) \rangle. \quad (893)$$

Temporal stage admissibility then yields CSPP as a population corollary. The definition of time fixes one formal cosmic-stage domain; CMA states that every system's realization succession is a segment of it, which yields objective co-presence. UCC states complete system-specific actual-change realization systemwise across identity ranges; by the stage-population definition the same UCC content can be re-indexed stagewise. That quantifier conversion concerns UCC only and does not derive CMA; it is shown in Appendix C.

47.3 Causal branch

The UCC condition states physical-change actuality but does not type or supply causal contributors. CRP is separate:

$$\text{UCC} \wedge \text{CRP} \implies \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \quad (894)$$

No temporal symbol, CMA relation, or UCC predicate is thereby promoted into a physical causal source.

47.4 Identity and lifecycle branch

Identity qualification precedes application-level persistence, formation, ending, and successor attribution. For a protocol P , admissible application requires the prospective conditions of Eq. (215); a specific attribution additionally requires Eq. (217). AFB fixes the least member of each identity range within the common cosmic-stage domain. Under UCC, actual physical change is realized at that member and at every other admitted member of the range. Ending together with UCC therefore implies actual physical-change realization at the ending boundary. Optional UEIE remains independent of UCC and is not part of the governing core; ending does not by itself entail a direct successor; successor attribution is conditional on genuine new-identity production, while optional UEIE independently determines whether every qualified identity ends.

47.5 Application and observation branch

A physical prediction depends on declared model inputs, laws, parameter provenance, and model-output bridges. Observation additionally depends on acquisition, calibration, comparison, and uncertainty structures. Therefore

$$\text{ApplicationModelFailure} \not\Rightarrow \text{ITOFFoundationRejected}. \quad (895)$$

A foundation-level conclusion requires an identifiable bridge from the targeted foundational statement to the failed observable. Under identical complete physical-to-observable specifications, ontological difference alone produces no prediction separation.

47.6 Direct derivations under the current architecture

Exact or equivalent state recurrence does not change the governing order:

$$r \prec_C s \wedge X_A(r) = X_A(s) \implies r \neq s \wedge \neg(s \prec_C r). \quad (896)$$

A physical trajectory may reverse a variable, recur, cycle, or reconstruct a previously realized state description; such a process is a new later dynamical change, not a return to the earlier stage. From common-stage admission and the postulate of change,

$$\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \text{CSPP}, \quad \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{UCC} \implies \forall s \in \mathcal{S}_C^{\text{tot}} \text{RealizedChangeStage}_C(s). \quad (897)$$

Order asymmetry (Eq. (26)), complete-population change coverage under $\mathfrak{T}_C \wedge \text{UCC}$ (Eq. (106)), and the conditional results under non-termination (no greatest stage and an infinite stage domain, Eqs. (1085)–(1086)) are stated with their premises where cited. These derivations supply no Hamiltonian, causal law, metric scale, or observable beyond their declared premises.

48. Core Counterconditions

48.1 Scope and countercondition discipline

The direct contraries of the core foundational commitments are distinguished from identity-level, causal, formation, ending, application-model, and empirical failure conditions, which retain their separately typed definitions.

Three levels must remain distinct:

$$\text{LogicalNegation}(P) \not\equiv_{\text{def}} \text{PhysicalFailureRealization}(P) \not\equiv_{\text{def}} \text{EmpiricalNonConfirmation}(P). \quad (898)$$

Failure to detect a predicted quantity is not by itself the logical negation of a foundational commitment:

$$\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{FailureToObserve}(F). \quad (899)$$

48.2 Temporal-extension countercondition

Failure of temporal admissibility is

$$\neg \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \quad (900)$$

and, by definition, occurs if the stage domain is empty, the designated relation fails to be a strict total order, at least one admitted stage fails to denote an actual physical-change realization, or the admitted domain contains no nontrivial earlier–later pair:

$$\begin{aligned} & \neg \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \iff [\mathcal{S}_C^{\text{tot}} = \emptyset] \vee \neg \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \quad \vee \exists s \in \mathcal{S}_C^{\text{tot}} \neg \text{CommonStage}_C(s) \\ & \quad \vee \neg \exists r \in \mathcal{S}_C^{\text{tot}} \exists t \in \mathcal{S}_C^{\text{tot}} (r \prec_C t). \end{aligned} \quad (901)$$

A relabeling or coordinate transformation does not constitute reversal of the governing order when it preserves Eq. (30).

48.3 Contrary to the non-termination hypothesis

Where the conditional cosmological premise is under consideration, Strict Cosmic Ordering makes its direct contrary the existence of a greatest admitted stage:

$$\begin{aligned} \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) &\implies \left[\neg \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \right. \\ &\left. \iff \exists g \in \mathcal{S}_C^{\text{tot}} \forall t \in \mathcal{S}_C^{\text{tot}} (t = g \vee t \prec_C g) \right]. \end{aligned} \quad (902)$$

This is not itself a failure of temporal admissibility. Nor is either side established merely by a finite observational gap, failure to receive a signal, lack of a record, or non-detection of a selected observable.

48.4 Countercondition to the derived CSPP population principle

$$\neg \text{CSPP} \iff \exists s \in \mathcal{S}_C^{\text{tot}} : \mathcal{S}_{\text{phys}}(s) = \emptyset. \quad (903)$$

Because stage admissibility requires every stage to be a common stage of the physical systems of the universe (Eq. (15)), $\neg \text{CSPP}$ is a failure of the governing stage semantics rather than an independent foundational countercondition.

48.5 Countercondition to CMA

The direct formal contrary to CMA is a qualified system with a private stage or a private ordering of stages:

$$\neg \text{CMA} \iff \exists A \in \mathcal{U}_{\text{phys}} : \neg \left[\mathcal{W}_A \subseteq \mathcal{S}_C^{\text{tot}} \wedge \triangleleft_A = \prec_C|_{\mathcal{W}_A} \right]. \quad (904)$$

This contrary is distinct from complete physical non-change of a realized system, which is the direct contrary to UCC.

48.6 Countercondition to UCC

$$\neg \text{UCC} \iff \exists A \in \mathcal{U}_{\text{phys}} \exists s \in I_A : \text{NC}_A^{\text{phys}}(s). \quad (905)$$

This means that a qualified identity remains realized at s while the UCC actual physical-change condition fails for that physical system. It does not imply that the cosmic succession terminates:

$$\neg \text{UCC} \not\Rightarrow \neg \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C). \quad (906)$$

Nor does non-detection of change establish $\text{NC}_A^{\text{phys}}(s)$.

48.7 Application Failure Is Not a Core Contrary

Failure of a declared application model warrants rejection or restriction of that model on the tested domain. It does not automatically negate temporal admissibility, CSPP, CMA, UCC, or CRP:

$$\text{ApplicationModelRejectedOrRestricted}(M, D) \not\Rightarrow \text{ITOFFoundationRejected}. \quad (907)$$

A foundation-level conclusion requires an independently warranted and identifiable dependency chain from the targeted foundational premise to the failed observable.

49. Mass-Defect and Clock-Response Program

49.1 Status and physical provenance

The mathematical-form-neutral dynamics and bridge architecture admits physical models whose governing laws have independent physical provenance. A quantitative atomic-clock response branch instantiates that architecture based on the internal-energy mass defect and weak gravitational coupling. The branch is denoted

$$\Omega_{\text{MD}} \quad (908)$$

and has the status

$$\text{Status}(\Omega_{\text{MD}}) = \text{ApplicationLevelPhysicalModelBranch}. \quad (909)$$

The branch is a physical model instantiation, not itself a measurement bridge. Its independently specified inputs enter the model-input layer, its Hamiltonian or response law belongs to the dynamics layer, its calculated fractional shifts belong to the prediction domain, and comparison with experimental records occurs only through the declared measurement and empirical-assessment layers. It is not derived from the temporal definition, CMA, or UCC. Its physical input is independently sourced from mass-energy equivalence, atomic transition physics, and the equality of inertial and gravitational mass in the weak-field model used below. Mass-defect formulations of atomic-clock shifts have been developed independently in the atomic-clock literature [35, 36].

Accordingly,

$$\Omega_{\text{MD}} \not\equiv_{\text{type}} T_{\text{ITOF}}. \quad (910)$$

The program predicts physical clock-transition quantities; comparison with record differences belongs to the declared measurement and empirical-assessment layers. It does not redefine the entity denoted by time.

For application-level derivability statements below, let $\Gamma_{39}^{\text{fund}}$ denote the conjunction of the governing V39/F19 foundational commitments actually invoked by the declared application. This premise shorthand is distinct from the framework-level tuple $\mathfrak{F}_{39}$ defined in Eq. (7) and from all application-specific physical assumptions. If a narrower premise set is used, its scope must be declared explicitly rather than inferred from the symbol.

49.2 Two-level clock physical system and mass-defect relation

Consider a clock physical system with internal states $|g\rangle$ and $|e\rangle$, unperturbed energies $E_g^{(0)}$ and $E_e^{(0)}$, and unperturbed angular transition frequency

$$\hbar\omega_0 = E_e^{(0)} - E_g^{(0)}. \quad (911)$$

Let the corresponding rest masses be M_g and M_e . Mass-energy equivalence gives

$$M_e - M_g = \frac{\hbar\omega_0}{c^2}. \quad (912)$$

The difference is a physical mass defect associated with the different internal energies of the same clock physical system. It is not a difference of times or cosmic stages.

49.3 Weak gravitational physical-response law

Let $\phi(\mathbf{r})$ be a weak classical gravitational potential over the declared experimental domain, with $|\phi|/c^2 \ll 1$, defined relative to a declared fixed reference-potential convention for the adopted weak-field model. Only potential differences enter the operational clock-comparison predictions; no undeclared absolute potential zero is assigned physical significance here. Under equality of inertial and gravitational mass, the physical energy assigned to internal state $j \in \{g, e\}$ is

$$E_j(\phi) = M_j c^2 + M_j \phi = M_j c^2 \left(1 + \frac{\phi}{c^2} \right). \quad (913)$$

Using Eq. (912), the transition frequency becomes

$$\omega(\phi) = \frac{E_e(\phi) - E_g(\phi)}{\hbar} = \omega_0 \left(1 + \frac{\phi}{c^2} \right). \quad (914)$$

For two locations $\mathbf{r}_1$ and $\mathbf{r}_2$, define the model fractional response relative to the unperturbed transition frequency by

$$y_{12}^{\text{MD}} := \frac{\omega(\phi_1) - \omega(\phi_2)}{\omega_0} = \frac{\phi_1 - \phi_2}{c^2}. \quad (915)$$

This is a physical transition-frequency relation. No proper-time functional, metric interval, clock-defined time, or stage-count magnitude occurs in its derivation. The benchmark observable is conventionally reported relative to a local clock frequency rather than ω_0 ; within the retained weak-field order, replacing the denominator by that local reference changes only terms beyond c^{-2} and therefore does not alter the benchmark predictions below.

For a sufficiently small vertical separation Δh , assume that the declared local potential profile is twice differentiable on the interval between h and $h + \Delta h$. Define the signed local potential gradient

$$g_h(h) := \frac{\partial \phi}{\partial h}(h), \quad (916)$$

which has dimensions of acceleration. Taylor's theorem gives, for some ξ between h and $h + \Delta h$,

$$\phi(h + \Delta h) - \phi(h) = g_h(h) \Delta h + \frac{1}{2} \frac{\partial^2 \phi}{\partial h^2}(\xi) (\Delta h)^2. \quad (917)$$

The sign of g_h is fixed by the declared vertical coordinate. Where the quadratic remainder is negligible on the stated domain, the retained leading local prediction is

$$y_h^{\text{MD}} = \frac{g_h \Delta h}{c^2}, \quad \kappa_h^{\text{MD}} := \frac{y_h^{\text{MD}}}{\Delta h} = \frac{g_h}{c^2}. \quad (918)$$

The coefficient is not fitted to the clock outcome in the benchmark protocol; it is fixed by the independently supplied local potential gradient and the exact SI value of c .

49.4 Record model and independently controlled systematics

A measured clock comparison generally contains physical contributions beyond the weak gravitational response. For a declared protocol P , write

$$y_{12}^{\text{obs}} = y_{12}^{\text{MD}} + \sum_{k=1}^K s_{k,12} + \epsilon_{12}, \quad (919)$$

where $s_{k,12}$ denotes a separately characterized differential physical systematic contribution and ϵ_{12} denotes the residual stochastic record term under the declared acquisition model. Depending on the clock class, the systematic family may include Zeeman, Stark, black-body-radiation, density, lattice, motional, vibration (Section 22.9), link, and calibration contributions. The membership of that family and the associated correction and uncertainty models are protocol- and physical-system-specific.

A benchmark claim using a corrected published result requires

$$\begin{aligned} \text{BenchmarkAdmissible} \implies & \text{InputsExternallySpecified} \\ & \wedge \text{SystematicCorrectionsDeclared} \\ & \wedge \text{UncertaintyDeclared}. \end{aligned} \quad (920)$$

No unreported adjustment of g_h , Δh , or the coefficient in Eq. (918) is permitted after inspection of the target clock result.

49.5 Benchmark A: 0.33-m aluminium-ion clock comparison

Status: the clock result below is an externally reported measurement; the V39/F19 comparison value is calculated from independently supplied published inputs under the declared weak-field model.

Chou et al. reported a height change of

$$\Delta h_A = 0.33 \text{ m} \quad (921)$$

and a measured fractional frequency change

$$y_A^{\text{obs}} = (4.1 \pm 1.6) \times 10^{-17} \quad (922)$$

in a comparison of two $^{27}\text{Al}^+$ optical clocks [34].

Using only the published nominal local value $g_{h,A} = 9.80 \text{ ms}^{-2}$ for the upward height coordinate, the height change, and the exact value of c , Eq. (918) gives

$$y_A^{\text{MD}} = \frac{(9.80)(0.33)}{c^2} = 3.5983 \times 10^{-17}. \quad (923)$$

Using the published quoted uncertainty as the benchmark standard deviation, the nominal standardized residual is

$$z_A := \frac{y_A^{\text{obs}} - y_A^{\text{MD}}}{1.6 \times 10^{-17}} = 0.314. \quad (924)$$

This is a published-input consistency benchmark, not a reconstruction of the raw clock record or its full covariance.

49.6 Benchmark B: millimetre-scale strontium clock gradient

Status: the observed gradients below are externally reported measurements, while the comparison value is a model calculation from the independently reported local gravitational acceleration and exact c .

Bothwell et al. reported a local vertical gravitational acceleration

$$a_B = -9.796 \text{ ms}^{-2} \quad (925)$$

for the coordinate convention of their vertically oriented ^{87}Sr optical-lattice-clock sample and a predicted weak-field fractional frequency gradient of approximately $-1.09 \times 10^{-19} \text{ mm}^{-1}$ [43]. Equation (918) gives directly

$$\kappa_B^{\text{MD}} = \frac{a_B}{c^2} (10^{-3} \text{ m/mm}) = -1.08995 \times 10^{-19} \text{ mm}^{-1}. \quad (926)$$

The same work reports a corrected campaign gradient

$$\kappa_{B,1}^{\text{obs}} = -9.8(2.3) \times 10^{-20} \text{ mm}^{-1} \quad (927)$$

and a corrected synchronous two-region determination

$$\kappa_{B,2}^{\text{obs}} = -1.28(27) \times 10^{-19} \text{ mm}^{-1}. \quad (928)$$

The corresponding nominal standardized residuals are

$$z_{B,1} = \frac{\kappa_{B,1}^{\text{obs}} - \kappa_B^{\text{MD}}}{2.3 \times 10^{-20}} = 0.478. \quad (929)$$

$$z_{B,2} = \frac{\kappa_{B,2}^{\text{obs}} - \kappa_B^{\text{MD}}}{2.7 \times 10^{-20}} = -0.704. \quad (930)$$

The two reported determinations are not combined here as statistically independent measurements. Each is used only as a separate consistency check against the physical-response prediction with its response coefficient fixed by externally supplied physical inputs.

49.7 Cross-system benchmark meaning

The aluminium-ion and strontium benchmarks involve different atomic clock physical systems, different apparatuses, and different local gravitational fields. Under the mass-defect response law, physical-system independence concerns the response coefficient conditional on the same local physical potential gradient. For a physical-system class A realized at location $\mathbf{r}$,

$$\kappa_h^{(A)}(\mathbf{r}) = \frac{g_h(\mathbf{r})}{c^2} \quad (931)$$

for every physical-system class to which the stated physical assumptions apply. Thus the law does not require numerically identical gradients in laboratories with different g_h ; it requires the same fractional response per unit local potential difference. The published benchmark values above are consistent with that conditional physical-system independence relation at their quoted precision.

This result warrants only the bounded claim

$$\text{MassDefectClockResponseBenchmarkRecovered}(D_{\text{Al}^+}, D_{\text{Sr}}). \quad (932)$$

It does not establish UCC, CMA, the ITOF temporal definition, or any universal claim outside the tested physical domains.

49.8 Benchmark recovery is not relativistic discrimination

The leading weak-field relation in Eq. (915) coincides with the standard gravitational clock-shift relation through the retained order c^{-2} . Let the superscript (2) denote the prediction truncated consistently through that order. On the same physical inputs and benchmark domain,

$$\mathbf{y}_{\text{MD}}^{(2),P,D} = \mathbf{y}_R^{(2),P,D}. \quad (933)$$

No equality of uncalculated higher-order terms follows from this relation. Consequently,

$$\text{BenchmarkRecovered} \not\Rightarrow \text{FoundationalDiscrimination}(\text{ITOF}, \text{Relativity}). \quad (934)$$

The quantitative importance of $\mathfrak{Q}_{\text{MD}}$ is different: it supplies an independently sourced physical route from atomic internal-energy structure and external physical conditions to clock records without identifying the record difference with a difference in T_{ITOF} .

49.9 Hamiltonian physical-system extension for confined-ion motion

The weak-field scalar benchmark can be extended to confined-ion motion without altering the temporal definition. For this purpose V39/F19 adopts, as an independently sourced application model, the leading internal–external Hamiltonian structure derived for a charged composite clock physical system in external electromagnetic and weak gravitational fields [36]. In the notation used here, the relevant decomposition is

$$\hat{H} = \hat{H}_{\text{com}} + \hat{H}_{\text{int}} + \hat{H}_{\text{at-emf}} + \hat{H}_{\text{metric}} + \hat{H}_{\text{MD}}. \quad (935)$$

The diagonal mass-defect coupling between center-of-mass and internal degrees of freedom is

$$\hat{H}_{\text{MD}} = \left(M\phi(\hat{\mathbf{R}}) - \frac{\hat{\mathbf{P}}^2}{2M} \right) \otimes \frac{\hat{H}_{\text{int}}^{(0)}}{Mc^2}. \quad (936)$$

Here M is the physical-system rest mass used in the external Hamiltonian, $\hat{\mathbf{R}}$ is its center-of-mass position, $\hat{\mathbf{P}}$ is the mechanically coupled center-of-mass momentum, and $\hat{H}_{\text{int}}^{(0)}$ is the unperturbed internal Hamiltonian. In the stationary nondegenerate internal-state regime treated by the cited derivation, the metric term has no diagonal energy contribution at the retained order; the leading diagonal internal–external clock coupling is then carried by Eq. (936).

Define the external kinematic–gravitational coupling operator

$$\hat{K}_{\text{ext}} := \phi(\hat{\mathbf{R}}) - \frac{\hat{\mathbf{P}}^2}{2M^2}. \quad (937)$$

For a two-level transition satisfying Eq. (911), first-order diagonal perturbation theory in c^{-2} gives the instantaneous fractional transition response

$$y_H(t) = \frac{1}{c^2} \text{Tr}_{\text{ext}} \left[\rho_{\text{ext}}(t) \hat{K}_{\text{ext}} \right]. \quad (938)$$

For interrogation interval $[0, T]$, the corresponding cycle-averaged branch is

$$\bar{y}_H(T) := \frac{1}{Tc^2} \int_0^T \text{Tr}_{\text{ext}} \left[\rho_{\text{ext}}(t) \hat{K}_{\text{ext}} \right] dt. \quad (939)$$

This expression contains the gravitational contribution through $\phi(\hat{\mathbf{R}})$ and the motional second-order contribution through $\hat{\mathbf{P}}^2$. It is an application-level perturbative physical response formula. If internal–external entanglement or additional relativistic terms are non-negligible in a selected experiment, the corresponding full Hamiltonian evolution must replace this reduced first-order expression.

49.10 Hamiltonian Content Does Not Create a Residual

The independently derived full trapped-ion Hamiltonian framework cited above provides the external–internal relativistic dynamics in electromagnetic and weak gravitational fields and is applied to Paul-trap effects including secular motion, micromotion, excess micromotion, and trap imperfections [36]. Within that broader framework, Eq. (936) is the retained leading diagonal internal–external mass-defect coupling under the stated approximation; the isolated displayed $\hat{H}_{\text{MD}}$ term must not be read as, by itself, encoding every trap, field, micromotion, or imperfection contribution of the full derivation. The cited framework recovers the established relativistic frequency-shift content in its domain and does not thereby supply an additional ITOF-specific residual. Earlier mass-defect analyses had considered additional trapped-clock contributions [35]; those proposals are not promoted here to governing V39/F19 predictions.

Accordingly, the V39/F19 temporal core together with the established physical Hamiltonian does not supply an independently nonzero additional residual:

$$\left[\Gamma_{39}^{\text{fund}} \wedge \text{BaseHamiltonianSpecified} \left(\hat{H}_{\text{base}} \right) \right] \not\Rightarrow \delta y_X \neq 0, \quad (940)$$

where $\hat{H}_{\text{base}}$ denotes the independently warranted standard Hamiltonian for the declared physical system and apparatus. This is a dependency boundary, not a claim that every possible physical extension must have zero residual.

49.11 Hamiltonian benchmark C: reconstructed secular-motion shift

This benchmark reconstructs a published systematic correction from published modal inputs; it is neither an independent measurement nor an advance ITOF prediction.

A direct modal benchmark is supplied by the 2025 NIST $^{27}\text{Al}^+$ quantum-logic clock [37]. Its supplemental evaluation reports six secular modes with mode-specific fractional frequency shift per motional quantum s_α , mean occupation $\bar{n}_\alpha$, and uncertainty $\sigma_{\bar{n},\alpha}$. For the reported modal model, define

$$y_{\text{sec}}^{\text{modal}} := \sum_{\alpha=1}^6 s_\alpha \left(\bar{n}_\alpha + \frac{1}{2} \right). \quad (941)$$

The factor $1/2$ retains the zero-point motional contribution. The published inputs are:

Mode	ν_α [MHz]	s_α [10^{-19}]	$\bar{n}_\alpha$	$\sigma_{\bar{n},\alpha}$	$s_\alpha(\bar{n}_\alpha + 1/2)$ [10^{-19}]
Axial COM	2.16	-0.95	8.22	0.48	-8.2840
Axial STR	3.75	-1.42	4.50	0.19	-7.1000
X COM	4.22	-1.77	5.68	0.49	-10.9386
X STR	3.48	-6.48	6.69	0.51	-46.5912
Y COM	5.37	-1.42	4.31	0.14	-6.8302
Y STR	4.75	-6.53	4.84	0.24	-34.8702

Therefore,

$$y_{\text{sec}}^{\text{modal}} = -114.6142 \times 10^{-19}. \quad (942)$$

Using only the reported occupation-number uncertainties and the published modal coefficients, the corresponding propagated uncertainty is

$$\sigma_{\text{sec}}^{(\bar{n})} = \left[\sum_{\alpha=1}^6 (s_\alpha \sigma_{\bar{n},\alpha})^2 \right]^{1/2} = 3.80135 \times 10^{-19}. \quad (943)$$

Rounding to the precision of the published clock evaluation gives

$$y_{\text{sec}}^{\text{modal}} = -(114.6 \pm 3.8) \times 10^{-19}, \quad (944)$$

which reproduces the reported secular-motion correction. This is a reconstruction of the published modal systematic model, not an independent experimental confirmation and not a foundational ITOF–relativity discrimination.

49.12 Independent nonstandard Hamiltonian residual family

A genuinely new residual requires an independently specified physical interaction beyond $\hat{H}_{\text{base}}$. Let

$$\hat{H}_{\text{test}} := \hat{H}_{\text{base}} + \lambda_X \hat{O}_X, \quad (945)$$

where $\hat{O}_X$ is a physically typed operator and λ_X has independent physical provenance. Their dimensions must be declared for each candidate so that $\lambda_X \hat{O}_X$ has units of energy. Thus the normalization of λ_X is not a free notational choice that can be changed after confronting data. In the perturbative diagonal regime, define

$$D_X(t) := \text{Tr}_{\text{ext}} \left[\rho_{\text{ext}}(t) (\langle e | \hat{O}_X | e \rangle - \langle g | \hat{O}_X | g \rangle) \right]. \quad (946)$$

After the internal-state matrix elements are taken, the bracketed difference in Eq. (946) is an operator on the external motional state space. The external trace therefore gives the state-dependent transition-energy contribution per unit λ_X . The induced cycle-averaged fractional residual is then

$$\delta_{yX}(T) = \frac{\lambda_X}{\hbar \omega_0 T} \int_0^T D_X(t) dt. \quad (947)$$

No advance prediction follows unless the operator, coupling, physical-system state, apparatus parameters, domain, and acquisition bridge are fixed independently of the evaluation outcome. In particular,

$$\Gamma_{39}^{\text{fund}} \not\Rightarrow \lambda_X \neq 0. \quad (948)$$

The ITOF temporal ontology therefore cannot be used as a substitute for the missing physical derivation of a new interaction.

Let y_{base} denote the prediction derived from $\hat{H}_{\text{base}}$ in the same declared protocol. For a rival prediction y_R , model-level resolved separation requires

$$|y_{\text{base}} + \delta y_X - y_R| > \eta_*, \quad (949)$$

with the combined uncertainty structure and admissible bridge class fixed before evaluation. A foundational conclusion additionally requires the attribution and bridge-robust conditions of Section 25 and Section 36.

49.13 Forward quantum-motional test domain

Status: the numerical effects discussed here are externally sourced forward physical-model predictions used as a test domain for the bridge architecture; they are not derived from the temporal ontology.

Recent trapped-ion theory provides a further application domain in which the external motional state is genuinely quantum rather than a classical trajectory surrogate [38]. For a harmonically trapped clock physical system, let

$$\epsilon_m := \frac{\hbar \omega_m}{Mc^2}, \quad (950)$$

where ω_m is the motional angular frequency. The cited Hamiltonian model predicts, for the motional ground state,

$$y_{\text{vSODS}} = -\frac{\epsilon_m}{4}, \quad (951)$$

and for a squeezed motional state with squeeze parameter r , to the stated leading order,

$$y_{\text{sqSODS}} \simeq -\frac{\epsilon_m}{4} \cosh(2r). \quad (952)$$

The same model predicts a motion–clock entanglement signature in the Ramsey visibility. In its leading small-parameter form,

$$\mathcal{V} \simeq 1 - \frac{(\epsilon_m \omega_0 T)^2}{16} \sinh^2(2r). \quad (953)$$

For the $^{27}\text{Al}^+$ parameter example analyzed in the cited work, a 20-MHz trap, one-second evolution, and $r = 2.26$ give a predicted visibility of approximately 0.93, while the magnitude of the squeezing-associated fractional frequency shift is approximately 3.8×10^{-17} . These are external physical-model predictions and constitute a forward experimental domain for the V39/F19 bridge architecture.

Observation of such quantum-motional effects would test the corresponding Hamiltonian model. It would not by itself identify the proper-time quantity used in that model with the entity denoted by time in ITOF:

$$\text{QuantumMotionalClockEffectObserved} \not\Rightarrow \tau \equiv_{\text{type}} T_{\text{ITOF}}. \quad (954)$$

49.14 Quantitative claim boundary

The program now contains a weak-field gravitational branch, a trapped-ion Hamiltonian physical-system branch, a modal reconstruction of a published secular-motion correction, and a forward quantum-motional application domain. None supplies a nonzero ITOF-specific interaction coefficient. The governing

quantitative status is therefore

$$\begin{aligned}
& \text{QuantitativePhysicalBridgeSpecified} \\
& \wedge \text{HamiltonianPhysicalSystemBranchSpecified} \\
& \wedge \text{BenchmarkRecoveryDemonstrated} \\
& \wedge \text{PublishedMotionalBenchmarkReconstructed} \\
& \wedge \neg \text{ITOFSpecificResidualDerived} \\
& \wedge \neg \text{FoundationSpecificPredictionSeparationDemonstrated}.
\end{aligned} \tag{955}$$

The distinction between quantitative physical adequacy and foundational discrimination is preserved.

50. Predictive Separation Boundary

50.1 Claim boundary

The quantitative program has established physical benchmark recovery and a Hamiltonian physical-system branch, but neither result supplies a nonzero ITOF-specific residual. The next question is therefore narrower: under what conditions can a physically testable prediction differ from a rival prediction while the V39/F19 temporal definition remains unchanged?

Candidate interactions remain subject to the stated physical and inferential constraints. A candidate does not become a governing V39/F19 postulate merely because it would produce a measurable difference.

50.2 Non-Separation Under Identical Physics

Using the governing-premise shorthand $\Gamma_{39}^{\text{fund}}$ fixed in Section 49, let two application branches I and R be defined on the same evaluation domain D . For each branch $J \in \{I, R\}$, define the complete physical-to-observable specification

$$\begin{aligned}
\mathfrak{S}_J^{P,D} := & \left(\text{PhysicalTarget}_J, \text{StatePreparation}_J, \text{PhysicalParameters}_J, \text{SystemBoundaries}_J, \right. \\
& \mathcal{B}_J^{\text{in}}, \text{Dyn}_J, \mathcal{B}_J^{\text{out}}, \text{AuxiliaryPhysicalPremises}_J, \\
& \left. \mathcal{B}_{J;P,D}^{\text{obs}}, \text{AcquisitionModel}_J, \text{Calibration}_J, \text{UncertaintyModel}_J \right).
\end{aligned} \tag{956}$$

The temporal ontological interpretation is not a component of $\mathfrak{S}_J^{P,D}$. Define

$$\text{SamePhysicalSpecification}_{P,D}(I, R) \iff \mathfrak{S}_I^{P,D} = \mathfrak{S}_R^{P,D}. \tag{957}$$

The predicate therefore holds only when every declared component relevant either to the predicted record or to its empirical evaluation is held fixed across the typed encoding–dynamics–prediction–measurement chain. $\mathbf{y}_J^{P,D}$ denotes the declared predicted observable object: a numerical/vector prediction in a deterministic branch, a probability law or other distributional record object in a stochastic branch, or the declared quantum measurement-statistics object in a quantum branch. Equality of these objects does not assert identity of separately realized stochastic samples or individual measurement outcomes.

Proposition 50.1 (Physical-Prediction Non-Separation). If the only difference between the two branches

is the temporal ontological interpretation while $\text{SamePhysicalSpecification}_{P,D}(I,R)$ holds, then no observable prediction separation follows from that ontological difference alone:

$$\text{SamePhysicalSpecification}_{P,D}(I,R) \implies \mathbf{y}_I^{P,D} = \mathbf{y}_R^{P,D}. \quad (958)$$

Consequently,

$$\Delta_{I:R}^{P,D} = 0, \quad \delta_{I:R}^{P,D} = 0, \quad (959)$$

where the second equality applies to the bridge-robust separation margin when the admissible bridge classes contain no physically distinct prediction branch.

Proof. By Eq. (957), the two branches have identical physical target, state preparation, physical parameters, system boundaries, model-input bridge, model dynamics, model-output bridge, auxiliary physical premises, measurement bridge, acquisition model, calibration, and uncertainty model on (P,D) . The identical dynamical and prediction chain evaluated on identical physical inputs therefore gives the same pre-observable prediction in both branches. Applying the identical measurement and acquisition specification gives the same declared predicted observable object—including the same probability law or quantum outcome-statistics object when the bridge is non-deterministic—so $\mathbf{y}_I^{P,D} = \mathbf{y}_R^{P,D}$. This equality is not an assertion that two independent stochastic realizations must return the same sample. Hence $\Delta_{I:R}^{P,D} = 0$. If the admissible bridge classes contain no physically distinct prediction branch, every admissible bridge pair yields zero prediction distance, so the infimum defining $\delta_{I:R}^{P,D}$ is also zero.

This is a dependency proposition. It does not add a dynamical law or assert empirical equivalence between ITOF and every relativistic physical theory.

By contraposition of Eq. (958), an observable prediction separation requires a difference in the complete physically operative specification:

$$\mathbf{y}_I^{P,D} \neq \mathbf{y}_R^{P,D} \implies \mathfrak{S}_I^{P,D} \neq \mathfrak{S}_R^{P,D}. \quad (960)$$

For a claimed novel physical prediction, the differing component must also be prediction-relevant and independently warranted. This condition is necessary, not sufficient. The V39/F19 temporal definition, CMA, and UCC do not by themselves specify such an additional physically operative difference.

50.3 Minimal stage-referenced preferred-frame candidate

A direct attempt to connect objective common-stage realization to a measurable clock response is to introduce, at application level, a physically specified preferred-stage rest frame. V39/F19 does not identify such a frame with the cosmic microwave background or with any coordinate system. For screening only, let $\mathbf{V}_n$ denote the laboratory velocity relative to a separately specified candidate stage-referenced frame and let $\hat{\mathbf{p}}$ be the physical-system momentum relative to the laboratory apparatus.

For a nonrelativistic physical system in this application-level screening model, define

$$\hat{\mathbf{v}}_n := \mathbf{V}_n + \frac{\hat{\mathbf{p}}}{M}. \quad (961)$$

For a spin-independent, parity-even response constructed only from this relative physical-system velocity

and the scalar internal clock energy, the leading nonconstant rotational scalar is parameterized by

$$\hat{H}_{\text{SR}}^{(2)} := \xi_2 \hat{H}_{\text{int}}^{(0)} \frac{\hat{\mathbf{v}}_n^2}{c^2}. \quad (962)$$

Here ξ_2 is a dimensionless physical coupling. It is not fixed by the time definition:

$$\Gamma_{39}^{\text{fund}} \not\Rightarrow (\xi_2 \neq 0). \quad (963)$$

Expanding Eq. (962) gives

$$\hat{H}_{\text{SR}}^{(2)} = \xi_2 \hat{H}_{\text{int}}^{(0)} \left[\frac{V_n^2}{c^2} + \frac{2\mathbf{V}_n \cdot \hat{\mathbf{p}}}{Mc^2} + \frac{\hat{\mathbf{p}}^2}{M^2 c^2} \right]. \quad (964)$$

This decomposition separates a preferred-frame kinematic term, a motion–frame cross term, and a quantum or classical motional-energy term.

50.4 Phenomenological non-uniqueness of the quadratic candidate

A clock-frequency response proportional to V_n^2/c^2 belongs to the same phenomenological class as preferred-frame and Lorentz-symmetry-violation clock tests. Robertson–Mansouri–Sexl clock comparisons already constrain a quadratic time-dilation-violation coefficient at the level $|\alpha| \lesssim 1.1 \times 10^{-8}$ in the normalization used in that test framework [40]. Optical-clock comparisons also constrain orientation-dependent electron-sector Lorentz-violation coefficients at levels reaching approximately 10^{-21} for the reported combinations [41], and more general matter–gravity clock comparisons constrain additional SME coefficient combinations [42].

Therefore Eq. (962) is not a unique ITOF signature. Let $\alpha_{\text{vio}}^{\text{RMS}}$ denote the quadratic time-dilation-violation coefficient in the convention used for the clock-network bound of Ref. [40]. Under the conditional normalization

$$\xi_2 \equiv \alpha_{\text{vio}}^{\text{RMS}}, \quad (965)$$

the existing clock-network constraint gives the screening bound

$$|\xi_2| \lesssim 1.1 \times 10^{-8}. \quad (966)$$

This is a conditional phenomenological mapping, not an identification of ITOF with the RMS framework and not a claim that ITOF selects the preferred frame used in that analysis. The cited RMS result directly constrains the corresponding leading observable quadratic preferred-frame response under this declared normalization. Extending the same ξ_2 to the motion–frame cross term and the motional $\hat{\mathbf{p}}^2$ term is a model assumption of the screened candidate Hamiltonian, not a separately measured operator-level bound. The quantum-motional estimates below are therefore conditional projections of that candidate under the stated shared-coefficient normalization.

50.5 Conditional quantum-motional scale

For one harmonic motional mode of angular frequency ω_m , the ground state satisfies

$$\left\langle \frac{\hat{\mathbf{p}}^2}{M^2} \right\rangle_0 = \frac{\hbar \omega_m}{2M}. \quad (967)$$

The corresponding magnitude of the quadratic stage-referenced quantum-motional fractional response is bounded by

$$|\delta y_{\text{SR},0}^{(2)}| \leq |\xi_2| \frac{\hbar \omega_m}{2Mc^2}. \quad (968)$$

For a squeezed state with squeeze parameter r , the phase-averaged momentum variance introduces the factor $\cosh(2r)$, giving

$$|\delta y_{\text{SR},\text{sq}}^{(2)}| \leq |\xi_2| \frac{\hbar \omega_m}{2Mc^2} \cosh(2r). \quad (969)$$

Using $^{27}\text{Al}^+$, $\omega_m = 2\pi \times 20\text{MHz}$, $r = 2.26$, and the conditional bound in Eq. (966), the numerical screening values are

$$|\delta y_{\text{SR},0}^{(2)}| \lesssim 1.81 \times 10^{-26}, \quad (970)$$

and

$$|\delta y_{\text{SR},\text{sq}}^{(2)}| \lesssim 8.31 \times 10^{-25}. \quad (971)$$

Thus squeezing does not make this already constrained quadratic candidate a competitive source of a new clock-frequency residual at present optical-clock precision. The conclusion concerns the explicitly screened candidate, not every possible physical extension.

50.6 Higher-order preferred-stage scalar candidates

A formally possible next term is

$$\hat{H}_{\text{SR}}^{(4)} := \xi_4 \hat{H}_{\text{int}}^{(0)} \left(\frac{\hat{\mathbf{v}}_n^2}{c^2} \right)^2. \quad (972)$$

Such a term is not adopted as a prediction. The absence of the lower-order coefficient ξ_2 while $\xi_4 \neq 0$ requires an independent symmetry, selection rule, or microscopic mechanism. V39/F19 supplies none. Moreover, higher-order preferred-frame matter couplings belong generically to broader Lorentz-violation effective-field-theory searches, where operators of multiple mass dimensions and background tensors are already classified [39], rather than constituting a signature unique to ITOF. The quartic term is therefore retained only as a classification example and is not promoted to the predictive branch.

50.7 Coherence Alone Is Not a Valid Shortcut

A proposed residual depending directly on a state functional such as $\rho_{\text{off-diagonal}}$, a variance, or an expectation value inside the Hamiltonian would in general introduce state-dependent nonlinear dynamics unless it is derived from a state-independent operator and an independently specified physical interaction. Accordingly,

$$\text{DesiredQuantumOnlyResidual} \not\Rightarrow \text{AdmissibleLinearHamiltonianInteraction}. \quad (973)$$

If a term is instead written as an ordinary linear operator, for example through quadratic motional operators associated with an apparatus phase reference, its physical coefficient and phase reference require independent provenance. Such a term is then a generic physical interaction and does not become ITOF-specific by being evaluated on a squeezed state.

50.8 Complete-population coupling is not implied by stage-change

A different proposal would couple a local system directly to a functional of the complete common-stage population or of $\mathfrak{R}_C(s)$. A schematic expression would be

$$\hat{H}_A^{\text{pop}}(s) = g_A F(\mathfrak{R}_C(s)) \hat{O}_A. \quad (974)$$

CMA does not entail this interaction. Adopting it would add a new physical coupling law connecting one system to information about the complete population, whereas V39/F19 explicitly separates common-stage co-realization from physical interaction, signal accessibility, and causal determination. Such a law would therefore require a separately specified physical mediator or nonlocal dynamics and its own no-signalling, conservation, and causal analysis. It is not a minimal predictive consequence of the present framework.

50.9 Differential Structure for Foliation Couplings

A metric application could introduce a smooth stage-association scalar and a unit timelike normal, then construct expansion, shear, acceleration, or extrinsic-curvature tensors. V39/F19 itself does not require a differentiable stage parameter, a metric on $\mathcal{S}_C^{\text{tot}}$, adjacency, or topology. Consequently, terms depending on derivatives of a foliation field are not derivable from the bare temporal ordered pair. In particular:

$$\text{TemporalDefinition}_{\text{ITOF}} \not\Rightarrow \text{FoliationDerivativeStructuresSpecified}. \quad (975)$$

The unprovided structures include $\nabla_\mu n_\nu$, $K_{\mu\nu}$, θ_n , and $\sigma_{\mu\nu}$. They remain possible structures of an independently supplied spacetime model, but using them as a new physical interaction would constitute a substantially larger extension than the minimal clock-response program examined here.

50.10 Result of the minimal predictive search

The candidate screening produces the following bounded result:

$$\begin{aligned} & \text{PhysicalPredictionNonSeparationEstablished} \\ & \wedge \text{QuadraticPreferredStageCandidateClassified} \\ & \wedge \text{QuadraticQuantumEnhancementInsufficientUnderExistingBound} \\ & \wedge \text{HigherOrderCandidateNotIndependentlyMotivated} \\ & \wedge \text{StateFunctionalShortcutRejected} \\ & \wedge \text{PopulationWideCausalCouplingNotDerivedFromCMA} \\ & \wedge \text{DifferentiableFoliationCouplingNotDerivedFromBareOrder} \\ & \wedge \neg \text{UniqueITOFSpecificHamiltonianOperatorDerived}. \end{aligned} \quad (976)$$

This is a formal dependency-boundary result. It identifies where a genuinely new prediction must enter: through an independently warranted physical postulate or microscopic mechanism that changes the physical application model while remaining consistent with the established benchmark limits. No such mechanism is manufactured from temporal ontology alone.

51. Physical Research Program

Quantum fluctuation and entanglement program.

Future work may apply ITOF's existing type discipline to quantum fluctuation models and entangled physical systems by fixing the physical-system boundary, identifying which attributions of system-specific change are warranted by the applicable quantum dynamics, and separating physical correlations from detector records and reconstruction. This program does not modify the quantum state, Hamiltonian, Born rule, or entanglement correlations by definition. Any ITOF-specific observable difference would require an independently specified physical interaction or bridge that changes a prediction relative to an otherwise identical physical model.

51.1 Foundational completion is not completion of physical theory

V39/F19 develops a foundational temporal and physical-realization architecture and now includes the domain-specific quantitative mass-defect clock-response branch of Section 49.

That benchmark branch does not amount to a complete dynamics of all physical phenomena.

The distinction is:

$$\text{FoundationalArchitectureSpecified} \not\Rightarrow \text{CompletePhysicalTheoryOfNatureSpecified}. \quad (977)$$

In particular, the governing temporal definition (Eq. (11)) does not determine one universal law of system-specific physical change.

Likewise, the complete-population common-stage physical-realization profile

$$\mathfrak{R}_C(s) = (\mathcal{S}_{\text{phys}}(s), \mathfrak{X}_C(s), \mathfrak{D}_C(s), \mathfrak{G}_C(s)) \quad (978)$$

does not supply one universal equation transforming one such profile into another.

51.2 Open Problem 1: Domain-Specific Dynamics

For a declared class of physical systems $\mathcal{A}$ not already covered by the mass-defect clock-response benchmark, or for physical effects beyond that branch's declared validity domain, a major application problem is to derive or independently warrant a physical model

$$M_{\mathcal{A}} \quad (979)$$

with a sufficiently explicit typed application chain connecting system-specific physical inputs to model realizations, predictions, and records.

The required route is:

$$\begin{aligned}
&\text{DeclaredPhysicalSystems} \longrightarrow \text{TypedPhysicalInputs} \\
&\quad \longrightarrow \text{ModelEncoding} \\
&\quad \longrightarrow \text{PhysicalDynamics} \\
&\quad \longrightarrow \text{AdvancePrediction} \\
&\quad \longrightarrow \text{MeasurementAndAcquisition} \\
&\quad \longrightarrow \text{PhysicalRecord}.
\end{aligned} \tag{980}$$

The response law must be established independently of the ITOF temporal definition.
No equation is accepted merely because it produces a desired interpretation of time.

51.3 Open Problem II: Realization across System Levels

The hierarchy relation

$$A \triangleleft_{\kappa,s} B \tag{981}$$

makes cross-level questions explicit without answering them universally.
Future physical work may investigate:

$$\begin{aligned}
&\text{how subsystem change contributes to composite change,} \\
&\quad \text{how composite constraints affect constituent change,} \\
&\quad \text{how causal contributions are redistributed under changing boundaries,} \\
&\quad \text{and how new numerical identities emerge from physical reorganization.}
\end{aligned} \tag{982}$$

Any quantitative cross-level rule requires its own physical derivation.
Composition alone is insufficient.

51.4 Third open problem: population transformation

The stage-pair population descriptor

$$\mathfrak{P}_C^{\text{pop}}(r,s) \tag{983}$$

provides a general identity-level classification of persistence, formation, ending, and intermediate-only realization.

Future work may connect these sets to specific physical models of:

$$\begin{aligned}
&\text{formation, decay, fusion, fission, reorganization,} \\
&\quad \text{biological formation and ending, astrophysical transformation,} \\
&\quad \text{chemical transformation, and other identity-changing physical processes.}
\end{aligned} \tag{984}$$

No universal law of population conservation, one-to-one successorship, or successor nonemptiness is

presupposed. An actual ending may produce zero, one, or several direct successors according to the physically warranted transformation and identity criteria.

51.5 Open Problem IV: Domain-Specific Directionality

The criterion-indexed descriptor $\mathfrak{A}_{A,\alpha}$ permits physical “arrows” to be studied without identifying them with time. Domain-specific applications must determine which state variables and comparison relations are physically warranted, whether alignment holds over a stated domain, and whether plateaus, recurrence, or criterion-relative reversals occur. No universal thermodynamic, developmental, decay-statistical, memory, record, or computational arrow is inferred from UCC alone.

51.6 Fifth open problem: operational metrics

V39/F19 defines the general operational architecture

$$m_P = \mathcal{M}_P^{\text{op}}(r_1, \dots, r_n; \mathbf{K}_P). \quad (985)$$

A major future task is to classify physically important metric constructions according to:

$$\begin{aligned} &\text{record source, calibration, comparison rule, model dependence,} \\ &\text{physical sensitivity, systematic effects, uncertainty, and predictive role.} \end{aligned} \quad (986)$$

The purpose is not to eliminate metric science.

It is to identify precisely what each metric measures or represents without transferring that quantity into the definition of time. The order-representation result in Eq. (39) further requires that any claimed metric interval specify the additional physical or mathematical structure that fixes its scale beyond bare earlier–later order.

51.7 Sixth open problem: physical-system-specific residual physics

The quantitative program in Section 49 now includes both weak-field gravity and an independently sourced trapped-ion Hamiltonian branch. It also reconstructs the published 2025 six-mode secular-motion correction. These results show that clock-system motion and confinement can be treated quantitatively without redefining time, but the established Hamiltonian does not itself generate an ITOF-specific residual.

Any stronger physical-system-specific program must therefore identify a physical interaction beyond the declared base Hamiltonian and specify

$$\begin{aligned} \mathfrak{M}_C^X = \Big(&\text{ClockSystemBoundary}, \hat{H}_{\text{base}}, \lambda_X \hat{O}_X, \text{StatePreparation}, \\ &\text{ParameterProvenance}, \text{AcquisitionModel}, \\ &\text{UncertaintyStructure}, \text{PredictionCriterion} \Big). \end{aligned} \quad (987)$$

The additional operator and coupling must be physically derived or independently warranted. A nonzero value may not be inferred from the ITOF temporal definition, CMA, UCC, or disagreement with a rival temporal ontology.

The quantum-motional branch of Eqs. (951)–(953) provides a near-term experimental domain for testing

internal–external quantum clock dynamics while preserving this attribution boundary. The minimal candidate screening in Section 50 additionally shows that the simplest quadratic preferred-stage clock coupling is neither unique to ITOF nor rescued by squeezed-state enhancement under the existing clock-network bound. A stronger residual therefore requires a physically new mechanism rather than a relabeling of an already constrained preferred-frame coefficient.

51.8 Seventh open problem: prediction separation

A foundation-sensitive empirical program requires a domain D^* in which independently specified ITOF and relativistic application branches remain separated after the admissible bridge freedom has been propagated. In the notation of Section 36, the target condition is:

$$\delta_{I:R}^{P,D^*} > \eta_*, \quad (988)$$

with the bridge classes, covariance construction, and threshold fixed independently of the evaluation outcome. Such a separation creates empirical discriminatory potential that cannot be removed merely by choosing another already-admissible bridge realization.

Without it:

$$\text{FoundationalDisagreement} \not\Rightarrow \text{ObservableDiscrimination}. \quad (989)$$

This remains one of the principal unresolved physical tasks of the framework.

51.9 Eighth open problem: attribution to foundational commitments

Even where an ITOF-admissible application model and a relativistic model make distinct predictions, further work is required to determine whether the difference originates in:

$$\begin{aligned} &\text{a foundational temporal commitment,} \\ &\text{a physical response law,} \\ &\text{a parameter choice,} \\ &\text{an approximation,} \\ &\text{a measurement bridge,} \\ &\text{or another auxiliary physical assumption.} \end{aligned} \quad (990)$$

Therefore:

$$\text{ObservableModelSeparation} \not\Rightarrow \text{FoundationalAttributionIdentified}. \quad (991)$$

The attribution problem is a distinct stage of theory testing.

51.10 Open Problem 9: Empirical Access to Global Stages

V39/F19 contains two distinct empirical burdens. CMA is challenged only by an independently warranted private stage or private ordering. UCC can be challenged by positive physical warrant that any physical

system of the universe is completely physically non-changing at a member of its identity range:

$$\exists A \in \mathcal{S}_{\text{phys}}(s) \text{ NC}_A^{\text{phys}}(s). \quad (992)$$

Because CMA and UCC are independent commitments, such a warranted counterinstance refutes UCC only; it does not by itself refute CMA. CMA is challenged only by a warranted private stage or private ordering (Eq. (904)); whether such a finding is empirically accessible is a separate question. Coordinate disagreement, clock-rate differences, signal delay, frame-dependent synchronization, or finite observational silence do not by themselves challenge either burden.

51.11 Open Problem X: Class-Specific Identity

Empirical tests of CMA, AFB, UEIE, persistence, ending, and population transformation require domain-specific physical-system and numerical-identity criteria. Future work must construct physically warranted class-specific profiles

$$\mathcal{Q}_{\mathcal{K}}^{\text{id}} = (\kappa_{\text{sys}}, \kappa_{\text{boundary}}, \kappa_{\text{id}}, \kappa_{\text{persist}}, \kappa_{\text{form}}, \kappa_{\text{end}})_{\mathcal{K}} \quad (993)$$

that distinguish continued numerical identity, functional alteration, component replacement, formation of a new identity, ending of an old identity, and successor production. For a given protocol these criteria must satisfy the prospective admissibility discipline of Eq. (215); V39/F19 does not supply one universal empirical identity criterion for all physical-system classes.

51.12 Eleventh open problem: complete cosmological extent

Equation (17) defines a possible non-terminating cosmological extension condition, but V39/F19 does not assert that the actual universe satisfies it. The scientific problem is first to determine what physically warranted evidence or cosmological theory could bear on whether realized physical change has a greatest future stage at all. Only if a specific non-termination hypothesis is adopted does the further question arise of whether a complete physical bridge can connect that hypothesis to discriminating observables or predictions.

A genuine empirical discriminator requires a complete physical-to-observable specification $\mathfrak{P}$ such that

$$P_{\text{TOF}}(\mathcal{O} \mid \mathfrak{P}) \neq P_{\text{alt}}(\mathcal{O} \mid \mathfrak{P}). \quad (994)$$

If the complete physical specification is identical and yields the same observable distribution, the ontological difference alone does not generate a test:

$$P_{\text{TOF}}(\mathcal{O} \mid \mathfrak{P}) = P_{\text{alt}}(\mathcal{O} \mid \mathfrak{P}) \implies \neg \text{PredictionSeparation}_{\mathfrak{P}}. \quad (995)$$

No temporal definition, stage symbol, CMA, or UCC supplies the required physical coupling or observable map by itself. Likewise,

$$\text{NonDetectionOfChange} \not\Rightarrow \text{CessationOfPhysicalChange}. \quad (996)$$

A finite observational gap, insensitive observable, threshold limitation, or unmeasured degree of freedom cannot be promoted into proof that the cosmic succession has stopped.

51.13 Research-program restraint

The open program is governed by:

$$\text{OpenProblem} \not\Rightarrow \text{CurrentITOFFailure} . \quad (997)$$

But also:

$$\text{OpenProblem} \not\Rightarrow \text{AlreadySolvedByFoundationalDefinition} . \quad (998)$$

Unresolved physical questions remain unresolved.

They must not be filled by semantic assertion.

52. Conclusion: Invariant Cosmic Extension, Co-Presence, and Change Continuity

V39/F19 defines time as the invariant universal cosmic extension: the objective, fixed, and non-reversed succession of the common stages of physical change of all physical systems in the universe (Eq. (11)). The members of $\mathcal{S}_C^{\text{tot}}$ are formal stage expressions of realized physical change within that one objective earlier–later succession. A stage symbol formally expresses a realized physical change in its ordered relation to other realized changes; its type boundary is stated in the Cosmic Stage Definition (Section 2.3). Every stage is a common stage of the physical systems of the universe, and under the postulate of change every one of them changes there (Eq. (104)). This gives every stage physical content without making the temporal ordered pair a dynamical law and without asserting that change causes time.

The relation $\prec_C$ is designated as the objective earlier–later relation before Strict Cosmic Ordering imposes its strict-total-order properties. Non-reversal means that a later realization remains later even if its state is equal or equivalent to an earlier state (Eq. (896)).

CMA states the unity of the stages of change for all physical systems of the universe: every one of them realizes its changes on the one common succession, with no private stage or private ordering (Eq. (73)); hence the complete population realized at each stage is objectively co-present there. Co-presence is not a synchronization signal, private-time identification map, coordinate equality, hidden interaction, or causal mechanism. UCC, the postulate of change, requires every physical system of the universe, without exception, to realize its own change at every member of its identity range (Eq. (83)); its continuity is non-metric. CMA and UCC are logically independent; their conjunction is the full content of the cosmic moment. No stage of the universe is empty, static, or private.

A terminal identity stage ends that identity's range; it does not erase the change already realized, and it does not terminate UCC for other persistent or newly formed qualified identities. Simple and composite systems are both admissible. Composite identity requires physically warranted interconnection and coherence at the declared organizational level, and constituent failure is not by itself composite identity ending.

The complete extent of cosmic change remains open. Non-termination (Eq. (17)) is a revisable cosmological hypothesis, not part of temporal admissibility. If adopted together with temporal admissibility, it yields an infinite stage domain; with additional lifecycle premises it may yield further conditional infinite-cardinality results. The symbol ∞ in such results is conditional mathematical notation, not a constituent of the temporal definition and not a claim that present cosmological evidence has

established an unlimited future.

The physical universe denotes $\mathcal{U}_C^{\text{phys}}$, not an independent container surrounding physical entities and not a single numerical system identity. Its physical content consists of the totality of physical-system identities together with objectively realized physical factors. Consequently $\mathcal{U}_C^{\text{phys}} \notin \mathcal{U}_{\text{phys}}$, and adoption of optional UEIE does not convert the cosmic physical totality into one universally ending system. Physical-system realization and ontic systemhood are objective. A scientifically warranted class/granularity scheme $\mathcal{Q}$ governs application-level identification, tracking, and attribution for particular systems without creating $\mathcal{U}_{\text{phys}}$ or the cosmic stages. This prevents arbitrary decomposition while allowing a subsystem and a coherent composite to be distinguished under physically warranted criteria at different organizational levels.

Physical change has three classes of causal contributors: internal structure and properties of the system, influencing physical systems, and non-system physical factors. A contributing physical system remains a system. “Response” denotes an application-level characterization of the magnitude, amount or extent, type, direction, or result of the realized physical change attributable to an influence; it is not a separate causal layer. The realized effect is system-specific and is conditioned by the system’s state, physically relevant coupling or susceptibility, and internal structural, dynamical, or organizational coherence. A supportive or adverse effect is criterion-relative rather than an intrinsic sign carried by the contributor or by physical change itself. CRP remains independent because physical-change actuality does not specify its causal contributors.

AFB, Identity-Realization Convexity, PIECP, optional UEIE, and conditional successor attribution remain identity and lifecycle commitments. AFB constrains the least member of each realized identity range within the common cosmic-stage domain; it does not introduce a private stage or a beginning of physical change. Successor status requires genuine new-identity production; no universal postulate requires such production at every actual ending, and absorption into a persisting system ends the absorbed identity without creating a successor.

The quantitative program preserves the Non-Transfer Principle. Clock systems, observers, apparatus, record-bearing systems, and laboratory systems are physical systems of the universe and therefore remain within UCC rather than outside the changing physical domain. Their readings and records arise through physical processes. Clock readings, proper-time functionals, coordinate quantities, and metric intervals do not become the ITOF temporal referent through successful application. Conversely, time, CMA, UCC, and the non-termination hypothesis do not manufacture Hamiltonians, couplings, measurement maps, or observable residuals. Under identical complete physical-to-observable specifications, ontological difference alone does not create prediction separation.

The governing V39/F19 core is therefore

$$\begin{aligned}
T_{\text{ITOF}} &= (\mathcal{S}_C^{\text{tot}}, \prec_C) \quad \text{subject to} \quad \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C), \\
\text{CSPP} &\iff \forall s \in \mathcal{S}_C^{\text{tot}} : \mathcal{S}_{\text{phys}}(s) \neq \emptyset \quad (\text{derived from } \mathfrak{T}_C), \\
\text{CMA} &\iff \forall A \in \mathcal{U}_{\text{phys}} : \mathcal{W}_A \subseteq \mathcal{S}_C^{\text{tot}} \wedge \triangleleft_A = \prec_C|_{\mathcal{W}_A}, \\
\text{UCC} &\iff \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A : \text{PhysReal}_A^+(s).
\end{aligned} \tag{999}$$

Every stage has physical content because it is a common stage of the physical systems of the universe at which every one of them changes (Eq. (104)); scientific attribution of a particular realization remains subject to independent physical warrant. Strict ordering and the nontrivial earlier–later pair provide order structure and non-degeneracy. Independently sourced physics supplies dynamics, causal attribution, and empirical bridges.

A. Statement-Status and Dependency Register

Table 3: Logical status and direct role of principal V39/F19 statements and constructions.

Item	Status	Direct dependency or role
$\mathcal{S}_C^{\text{tot}}$	Primitive formal cosmic-stage domain	Formal cosmic-stage domain whose admitted members are formal stage expressions of realized physical change in the one universal cosmic succession. A written stage symbol designates a member of the formal cosmic-stage domain; neither the symbol nor the member is a further physical or ontic stage object behind the realized change it expresses.
One-global-stage domain architecture	Foundational formal architecture	One formal cosmic-stage domain; every I_A is its restriction. Exclusion of private per-system successions, followed by mapping or synchronization, is the content of CMA, not of the domain definition, strict ordering, synchronization, clock agreement, or coordinate choice.
$\prec_C$	Primitive ordering relation with governing semantic designation	The one objective earlier–later relation on $\mathcal{S}_C^{\text{tot}}$. Its earlier–later orientation is designated by ITOF semantics; Strict Cosmic Ordering constrains that designated relation rather than selecting it over its inverse.
Strict Cosmic Ordering	Foundational axiom	Requires $\prec_C$ to be a strict total order on $\mathcal{S}_C^{\text{tot}}$; yields asymmetry and total comparability but does not itself supply the semantic orientation.
NonTerminating CosmicSuccession _C	Revisable cosmological hypothesis	Requires every admitted stage to have a later stage. It is non-metric and order-theoretic, but V39/F19 does not assume that the complete future satisfies it; all results using it are conditional.

Item	Status	Direct dependency or role
Temporal-extension admissibility	Defined temporal-admissibility condition	Requires a nonempty formal cosmic-stage domain, Strict Cosmic Ordering, every member a common stage of the physical systems of the universe, and a nontrivial earlier–later pair. The last requirement excludes a succession-free singleton but neither asserts nor denies a greatest future stage. Temporal admissibility neither entails CMA nor entails UCC.
Order-representation non-metricity	Derived mathematical result	Any supplied order representation remains non-unique under strictly increasing reparameterization; the ordering alone does not determine a canonical scalar interval magnitude.
T_{ITOF}	Governing definition	$T_{\text{ITOF}} := \mathcal{E}_C := (\mathcal{S}_C^{\text{tot}}, \prec_C)$. Time denotes the one universal earlier–later extension of objectively realized physical change. A written stage symbol designates a member of the formal cosmic-stage domain; that member expresses realized change in the order without becoming a temporal container, physical stage object, or causal agent. Unlimited future extent is not built into the definition.
Ordinal Succession	Postulate (Postulate 2.2)	$0 \prec_C 1 \prec_C 2 \prec_C 3 \prec_C 4 \prec_C \dots \infty$ (conditional): stage 0 is the first stage of change, with the genesis of the universe; the numerals express only the fixed succession of the stages and are not added; no stage between any two of them is empty of change or static; ∞ is not a stage and is conditional.
CosmicOrigin	Independent cosmological postulate, supported by observational evidence	$\mathcal{S}_C^{\text{tot}}$ has one unique least member, the stage at which change in the universe begins, with the formation and genesis of the universe. Its contrary is established evidence of systems realized earlier. Non-termination neither entails nor is entailed by it.
$\mathcal{U}_C^{\text{phys}}$	Defined cosmic physical totality	Physical universe understood as the typed totality of physical-system identities and physically realized physical factors. It is neither an independent physical container nor a numerical physical-system identity.

Item	Status	Direct dependency or role
$\mathfrak{F}_{\text{phys}}$	Defined physical-factor totality	Physically realized physical-factor reality that is type-distinct from a numerical physical-system identity; every admitted factor has stage support by Eq. (51), while actual influence on a particular system is not required for membership.
$\text{FactorRealizedAt}(F, s)$	Typed stage-relative factor-realization relation	Records physical realization of factor F at admitted stage s ; it does not by itself assert causal influence on a system.
$\mathfrak{F}_{\text{phys}}(s)$	Defined stage-relative physical-factor population	Physical factors realized at admitted stage s ; membership alone does not assert influence on a system.
$\mathcal{U}_{\text{C}}^{\text{phys}}(s)$	Defined stage-relative cosmic physical totality	Typed stage-relative totality $\mathcal{S}_{\text{phys}}(s) \sqcup_{\text{ont}} \mathfrak{F}_{\text{phys}}(s)$; neither a container nor a retyping of factors as systems.
$\mathfrak{F}_{\text{phys}}^{\text{inf}}$	Defined influencing physical-factor domain	Members of $\mathfrak{F}_{\text{phys}}$ that actually influence at least one realized system–stage pair; scientific attribution of a particular influence requires applicable physical warrant.
$\mathcal{U}_{\text{phys}}$	Defined physical-system totality	Objectively realized numerical physical-system identities possessing at least one realized identity member in $\mathcal{S}_{\text{C}}^{\text{tot}}$. Class/granularity schemes govern application-level identification and attribution rather than ontic systemhood.
I_A	Defined identity-realization range	Subset of the one cosmic-stage domain at which numerical identity A is realized; it is an identity-bounded restriction, not a private time.
$\mathcal{S}_{\text{phys}}(s)$	Defined population	Complete qualified physical-system population realized at s , obtained from memberwise identity-stage incidence.
$\text{CosmicCoPresence}_{\text{C}}(P; s)$	Defined ontological relation (Eq. (71))	Each member of P realizes s as a member of the one common succession, with no private stage or ordering. Stronger than population membership; not synchronization, signal access, interaction, or coordinate equality.

Item	Status	Direct dependency or role
CSPP	Derived population principle	Records the consequence $\mathcal{S}_{\text{phys}}(s) \neq \emptyset$ for every admitted $s \in \mathcal{S}_{\text{C}}^{\text{tot}}$, because each admitted stage is a formal expression of objectively realized physical change and therefore has a nonempty qualified change-realizing population. It is not an additional independent postulate.
CMA	Independent governing foundational axiom	Every qualified system's realization succession is a segment of the one common succession: no private stage or ordering. Yields objective co-presence of the complete then-realized population at every admitted stage. It does not assert complete all-system change; that burden belongs to UCC.
UCC	Independent foundational physical postulate	Physical change continues without interruption in every physical system of the universe, without exception, throughout its realized identity range. Equivalently, for every admitted member $s \in \mathcal{S}_{\text{C}}^{\text{tot}}$, every qualified system whose identity range contains s realizes actual physical change. UCC is not the non-termination hypothesis and supplies no universal scalar rate or magnitude.
CommonChange $\text{StageRole}_{\text{C}}(s)$	Defined full-theory stage role	Stage-relative role requiring a common stage of the physical systems of the universe, co-presence of its population under CMA, and change of every one of them under UCC.
Complete physical non-change	Defined qualitative contrary predicate	Equivalent to $\neg \text{PhysReal}_A^+(s)$ for $s \in I_A$. Application of this contrary requires positive physical warrant under the applicable theory/model and declared system boundary and granularity that no physically constitutive change admissible to the claim is realized at that pair. Selected-observable equality or finite non-detection is insufficient. A warranted instance is the direct change countercondition to UCC; it is not by itself a countercondition to CMA.
I_A^Δ	Defined actual-change subset	Members of I_A at which actual physical change is realized; equals I_A under UCC.

Item	Status	Direct dependency or role
Δ_A^{phys}	Typed physical-change map	$\Delta_A^{\text{phys}} : I_A^\Delta \rightarrow \Xi_A$; preserves system-specific change content and countermodel typing.
$\mathcal{B}_\Delta(s)$	Defined population subset	Change-realizing members of $\mathcal{S}_{\text{phys}}(s)$; equality with the entire population at every s is equivalent to UCC.
$\text{GCN}_C(s)$	Defined stage-relative null predicate	Holds exactly when $\mathcal{B}_\Delta(s) = \emptyset$. Governing stage admissibility already excludes it at every admitted stage; UCC strengthens the result to change realization by every then-realized qualified physical system. It does not denote a universal numerical zero.
$\mathfrak{D}_C(s)$	Defined construction	Dependent system-indexed physical-change-content profile.
$\text{SCB}_C(s)$	Defined foundational representation	Defined local conjunction of co-presence at the stage and UCC complete-population physical-change realization; at every stage, equivalent to $\text{CMA} \wedge \text{UCC}$ under domain admissibility. The representation is not an axiom, cause, synchronization rule, or observation bridge.
$X_A : I_A \rightarrow \Omega_A$	Defined physical-state map	System-specific physical state realized at each member of I_A .
$\mathfrak{X}_C(s)$	Defined construction	Dependent complete-population profile of system-specific physical states.
CRP	Independent foundational physical postulate	Requires nonempty actual physical causal realization for every actual system-specific physical change.
$\mathfrak{G}_C(s)$	Defined construction	Complete-population mapping from each realized system to its actual causal set.
$\mathfrak{R}_C(s)$	Defined construction	Integrates population, state profile, change profile, and causal-realization profile without becoming a temporal object.
$\mathfrak{R}_C^{[M]}(s)$	Application-level defined augmentation	Adds independently warranted model-relative physical relations to the complete-population realization profile without changing temporal identity or claiming exhaustive physical description.

Item	Status	Direct dependency or role
CMA–UCC–CRP stage-relative realization consequence	Derived consequence	Under temporal admissibility together with CMA, UCC, and CRP, every admitted stage is nonempty, satisfies the local Stage-to-Change condition, and has nonempty actual causal realization for every qualified member; no additional realization predicate is introduced.
$A \triangleleft_{\kappa, s} B$	Defined current-version physical relation	Stage-relative constituent/subsystem relation under declared physical composition criterion κ ; does not itself provide cross-level dynamics.
$\mathfrak{K}_C(s)$	Defined construction	Collection of warranted stage-relative constituent relations among qualified physical-system identities.
Cross-Level Non-Transfer	V39 physical/type principle	Composition alone does not transfer state, physical-change content, causal determination, or numerical identity across system levels.
Identity-Realization Convexity	Independent foundational identity postulate	Prevents an internal gap in one numerical identity range.
AFB	Independent identity postulate	Requires one unique least member for every qualified identity range within the single common cosmic-stage domain; does not introduce a private stage or a change-onset claim.
$\mathfrak{Q}_{\mathcal{H}}^{\text{id}}$	V39/F19 class-indexed application-admissibility formalization	Six-component current profile governing system class, boundary, numerical identity, persistence, formation, and ending criteria where relevant; not a universal identity criterion and not a temporal component.
$\mathcal{H}_A$	Formal history representation	$(I_A, \prec_C \upharpoonright_{I_A}, X_A, \Delta_A^{\text{phys}})$; not a private time.
Historical Physical Accumulation	Historical designation	Earlier actually realized system-specific physical change; not an arithmetic sum or causal-source class.
Present Cumulative Physical Resultant	Defined present-resultant predicate	States that retained or transformed earlier effects remain physically embodied in the present developed condition.

Item	Status	Direct dependency or role
$\text{End}_A(e)$	Defined identity-ending predicate	Physical identity-ending transformation at the final member of numerical identity A .
PIECP	Independent ending-specific causal postulate	Requires at least one actual causal contributor to contribute specifically to the identity-ending transformation.
UEIE	Optional universal lifecycle postulate	Requires eventual identity ending together with nonempty strict pre-ending identity history. Its quantifier ranges over the governing ontic physical-system totality $\mathcal{U}_{\text{phys}}$. Empirical attribution of ending within any declared class still requires an independently warranted class-specific numerical-identity criterion; no universal empirical identity criterion is supplied.
$\text{SuccAt}(A, B; e)$	Defined direct-successor relation	New numerical identity B is physically produced through the ending transformation of A at e .
$\mathfrak{S}^+(A, e)$	Defined successor family	Direct successors physically produced through the ending of A at e ; the set may be empty when the ending produces no new qualified identity.
$\mathcal{P}_{r,s}$	Defined current-version set	Systems whose numerical identities are realized at both ordered endpoints.
$\mathcal{N}_{r \rightarrow s}$	Defined current-version set	Systems absent at r and realized at s .
$\mathcal{L}_{r \rightarrow s}$	Defined current-version set	Systems realized at r and absent at s .
$\mathcal{T}_{r,s}$	Defined current-version set	Identities realized strictly between r and s while absent from both selected endpoints.
Cross-system comparison maps	Application-level defined constructions	Map system-specific physical quantities into a declared common comparison space without identifying the underlying physical quantities.

Item	Status	Direct dependency or role
Mathematical-form-neutral dynamics	Application architecture	Uses a typed internal dynamics descriptor and separates physical encoding, dynamics, model-to-prediction mapping, and measurement. It permits independently warranted deterministic, stochastic, quantum, field, geometrical, or other model classes without defining one universal dynamics.
$\mathfrak{A}_{A,\alpha}$	Current application-level construction	Criterion-indexed physical directionality for a declared system and physical model; may align with the cosmic order without becoming that order or a second time.
$\mathcal{M}_P^{\text{op}}$	Current application-level construction	Maps physical records and calibration conditions to an operational metric quantity; output remains type-distinct from time.
Exact-Change-Stage Restraint	Epistemic principle	Observation may warrant manifestation at some actual common cosmic change stage without automatically identifying the exact stage or global order position. The source, apparatus, record-bearing systems, observer, and laboratory/reference systems remain within the changing physical domain; UCC contributes this physical non-stasis but does not alone prove non-invertibility of an observation map.
Foundational empirical bridge	V39 methodological bridge architecture	Records the independently specified physical, observational, auxiliary, uncertainty, and attribution conditions connecting a foundational commitment to an observable and to any subsequent foundation-sensitive inference.
Foundational Empirical Attribution Principle	Methodological inferential principle	Restricts foundational inference to cases with independent bridges, frozen protocol, identifiable prediction separation, valid uncertainty, and controlled alternative attribution.
Ω_{MD}	Application-level quantitative physical-model branch	Independently sourced mass-defect and trapped-ion clock-response program used for benchmark recovery and forward physical modeling; not a temporal component and not by itself a foundation-specific prediction.

Item	Status	Direct dependency or role
Same physical specification	Defined application-comparison predicate	Holds exactly when the complete physically operative target-to-observable specifications $\mathfrak{S}_I^{P,D}$ and $\mathfrak{S}_R^{P,D}$ are equal; temporal ontological interpretation is not a component of that tuple.
Physical-Prediction Non-Separation under Identical Physical-to-Observable Specification	Derived dependency/ identifiability proposition	From equality of the complete physical-to-observable specifications, identical prediction rules and observable maps yield identical predicted observables. The result is a dependency boundary, not a new dynamical law.
NTP	Foundational type principle	Mathematical consistency, physical applicability, and predictive or operational success do not by themselves transfer temporal identity.
$\mathcal{Q}_{\text{rel}}$	External model family	Relativistic coordinate, metric, proper-time, simultaneity, foliation, cosmological, and related quantities tested for temporal nonidentity.
$\mathfrak{B}_{I:R}^{P,D}$	Current empirical- comparison architecture	Connects independently specified ITOF and relativistic application branches to one observable comparison domain without temporal-identity merger.
$\delta_{I:R}^{P,D}$	Current methodological comparison quantity	Infimum prediction separation across independently admissible ITOF and relativistic bridge classes; used to test whether separation survives residual bridge freedom.
Mutual independence of CMA and UCC (Prop. 5.4)	Derived result, by explicit countermodel	Each countermodel satisfies every other governing postulate; neither axiom is recoverable from the other.
No change-void admissible stage (Cor. 5.5)	Derived result, from UCC with stage admission	Stagewise content of UCC; nonempty population is supplied by stage admission.

Item	Status	Direct dependency or role
Arguments 43.1–43.3 and Prop. 43.4	Commitment distinction; derived result	Distinguish $\prec_C$ from relativistic geometric temporal quantities, including global time functions and cosmological time, by invariance domain, intra-/inter-stage type, or quantity type; the constitution-criterion argument concerns the eternalist interpretation only.
Dimension-admission criterion (Def. 43.6, Prop. 43.7)	Foundational type criterion / derived result	Blocks inference from mathematical consistency of a coordinate or higher dimension to its physical reality; applied to x^0 and to higher-dimensional geometric representations.

B. Governing Symbol and Type Register

Table 4: Core V39/F19 notation and governing meanings.

Symbol	Type	Meaning
T_{ITOF}	Temporal referent	Time in ITOF V39/F19.
$\mathcal{E}_C$	Temporal referent	The same one universal non-metric cosmic extension denoted by T_{ITOF} .
$\mathcal{S}_C^{\text{tot}}$	Formal cosmic-stage domain	Formal domain of the common stages of the physical systems of the universe in the one universal cosmic succession. Under UCC every member is a stage of change of all physical systems realized there; membership does not analytically entail CMA or UCC.
$\prec_C$	Strict order	Designated governing objective earlier–later relation; strict-order properties are imposed separately.
l	Order-representation map	Optional injective representation of the cosmic order in a declared ordered label domain; its labels and numerical intervals are not time.
NonTerminatingCosmicSuccessionC	Conditional cosmological condition	If adopted for a cosmological model, every admitted cosmic stage has a later stage; formally this is absence of a greatest member. V39/F19 does not assume that the complete future satisfies this condition.

Symbol	Type	Meaning
s_C^0	Boundary symbol	Unique least cosmic stage, fixed by Cosmic Origin.
$\mathcal{U}_C^{\text{phys}}$	Cosmic physical totality	Physical universe as the typed ontological totality of physical-system identities and physically realized physical factors; not a physical container and not one numerical physical-system identity.
$\mathfrak{F}_{\text{phys}}$	Physical-factor totality	Physically realized physical-factor reality, type-distinct from numerical physical-system identity; every admitted factor has stage support in $\mathcal{S}_C^{\text{tot}}$, while actual influence on a particular system is represented separately.
FactorRealizedAt(F, s)	Stage-relative factor realization	Records physical realization of non-system factor F at s , separately from any warranted causal-influence relation.
$\mathfrak{F}_{\text{phys}}(s)$	Stage-relative physical-factor population	Physical factors realized at admitted stage s , irrespective of whether they influence a particular system.
$\mathcal{U}_C^{\text{phys}}(s)$	Stage-relative cosmic physical totality	Typed union of the physical-system population and physical-factor population realized at s ; not a container or a physical-system identity.
$\mathfrak{F}_{\text{phys}}^{\text{inf}}$	Influencing physical-factor domain	Those members of the physical-factor totality that actually influence at least one realized system–stage pair; attribution of a particular influence requires applicable physical warrant.
$\mathcal{U}_{\text{phys}}$	Physical-system totality	Governing totality of objectively realized physical-system identities having at least one realized member in $\mathcal{S}_C^{\text{tot}}$. Application schemes Ω select warranted subdomains for identification, tracking, or testing but do not create this totality.
I_A	Identity range	Members of $\mathcal{S}_C^{\text{tot}}$ at which numerical identity A is physically realized.
I_A^Δ	Actual-change subset	Members of I_A at which actual system-specific physical change is realized.
$\mathcal{S}_{\text{phys}}(s)$	Population	Complete qualified physical-system population realized at s .

Symbol	Type	Meaning
$\mathfrak{T}_C$	Foundational-definition symbol	Temporal admissibility, TemporalExtensionAdmissible _C : the defining predicate of Eq. (22), fixing a nonempty, strictly ordered, non-degenerate domain of common stages of the physical systems of the universe. Abbreviated for legibility in long equations; not itself CMA, UCC, or CSPP.
CSPP	Derived-principle symbol	Cosmic Change-Stage Population Principle; a consequence of the revised common-stage admission, retained as a useful named population result.
CMA	Axiom symbol	Cosmic Moment Axiom (Eq. (73)).
UCC	Foundational postulate symbol	Universal Change Continuity; the independent system-specific physical-change postulate requiring actual physical change throughout every realized identity range.
CommonChange StageRole _C (s)	Defined stage-role predicate	Full-theory role-name for a common stage of the universe whose population is co-present under CMA and fully covered by UCC.
PhysReal _A ⁺ (s)	Physical relation	Actual system-specific physical change realized by A at s. Attribution requires independent physical warrant under the applicable theory/model and a declared system boundary and granularity; stage membership or detection alone does not supply that warrant.
Ξ_A	Change-content type	System-specific codomain for physical-change content.
$\Delta_A^{\text{phys}}(s)$	Physical-change content	System-specific physical content of change for an actual-change pair.
$\mathcal{B}_\Delta(s)$	Population subset	Change-realizing members of the stage-relative population.
$\mathfrak{D}_C(s)$	Dependent profile	System-indexed family of physical-change contents.
SCB _C (s)	Defined foundational bridge	Defined local conjunction of co-presence at the stage and UCC complete-population actual-change coverage.
Ω_A	Physical state space	Declared state space appropriate to system A.
$X_A(s)$	Physical state	State of system A realized at s.

Symbol	Type	Meaning
$\mathfrak{X}_C(s)$	V39 state profile	Complete-population dependent family of system-specific physical states.
$\mathfrak{C}_A(s)$	Causal profile	Internal physical contributors and external physical-influence sources. The external set contains influencing physical systems and influencing physical factors; each source retains its physical type.
$\mathcal{E}_A^{\text{ext}}(s)$	Defined external-influence set	External physical-influence sources applicable to physical system A at s , formed by the union of influencing physical systems and influencing physical factors.
System-specific external response	Application-level characterization	Characterizes, where physically warranted, the magnitude, amount or extent, type, direction, or result of physical change actually realized under a declared external-influence attribution. It is prose-level application terminology, not an intermediate causal layer, universal response variable, causal-source class, or temporal law.
Criterion-relative external impact	Application-level classification	Supportive/beneficial, adverse/harmful, mixed, or neutral impact is assigned only relative to a declared physical or functional criterion; unresolved is an epistemic status rather than an additional physical impact type.
$\mathcal{C}_A^{\text{act}}(s)$	Actual causal set	Union of the actual physical causal contributors for the change of A at s .
$\mathfrak{G}_C(s)$	V39 causal profile	Population-indexed family of actual causal sets.
$\mathfrak{R}_C(s)$	V39 realization profile	Population, physical-state, physical-change, and causal-realization architecture at common cosmic change stage s .
$\mathfrak{R}_C^{[M]}(s)$	Relational augmentation	Model-relative enrichment of the complete-population realization profile by additional independently warranted physical relations.
$A \triangleleft_{\kappa,s} B$	Composition relation	Qualified physical-system identity A is physically realized as a proper constituent or subsystem of B under criterion κ at s .
$\mathfrak{R}_C(s)$	Composition profile	Collection of warranted stage-relative constituent relations.

Symbol	Type	Meaning
f_A	Formation boundary	Unique least member of I_A under AFB within the common cosmic-stage domain; not a private stage or a marker for the beginning of physical change.
e_A	Ending boundary	Identity-ending member where an ending exists.
$\mathcal{H}_A$	History representation	Identity domain, restricted common order, state map, and physical-change-content map.
$\mathcal{P}_{r,s}$	Population set	Identities realized at both r and s .
$\mathcal{N}_{r \rightarrow s}$	Population set	Identities absent at r and realized at s .
$\mathcal{L}_{r \rightarrow s}$	Population set	Identities realized at r and absent at s .
$\mathcal{T}_{r,s}$	Population set	Identities realized only at one or more members strictly between selected endpoints r and s .
$\text{Cmp}_{AB,P}(s)$	Comparison output	Mapped comparison of declared system-specific physical-change quantities.
$\mathfrak{A}_{A,\alpha}$	Physical-directionality descriptor	Criterion-indexed triple $(\mathcal{Y}_{A,\alpha}, Y_{A,\alpha}, \preccurlyeq_{A,\alpha})$ used to represent a physically warranted directional regularity over I_A .
$\text{ArrowAligned}_{A,\alpha}(J)$	Directionality predicate	The selected physical descriptor is nondecreasing according to its declared criterion relation over $J \subseteq I_A$; not a second temporal ordering.
λ_M	Model parameter	Declared evolution or representation parameter of application model M ; not automatically time.
$\mathcal{M}_P^{\text{op}}$	Operational map	Maps records and calibration structures to an operational metric quantity.
r	Physical record	Physically produced record in an acquisition chain.
J_r^{phys}	Physical support set	Common cosmic change stages whose physical realizations contribute to production of record r .
$\mathfrak{P}^*$	Test protocol	Predeclared quantitative test architecture.
$\mathfrak{B}_F^{P,D}$	Empirical bridge tuple	Physical, observational, auxiliary, uncertainty, and attribution conditions connecting foundational commitment F to empirical evaluation.
NTP	Type principle	Generalized Non-Transfer Principle.

Symbol	Type	Meaning
$\mathcal{Q}_{\text{rel}}$	External quantity family	Declared relativistic quantities and representations examined for temporal nonidentity.
$\mathfrak{B}_{I:R}^{P,D}$	Comparison bridge	ITOF–relativistic observable comparison architecture.
$\delta_{I:R}^{P,D}$	Robust separation margin	Infimum common-observable prediction separation over independently admissible bridge classes for the two comparison branches.

C. Formal Models and Dependencies

C.1 Logical status of formal model constructions

Formal model constructions test satisfiability, definitional conservativity, and declared logical dependencies; they are not empirical cosmological models or microscopic dynamics. For commitments Γ and proposition P ,

$$\text{Model}[\Gamma \wedge \neg P] \implies \Gamma \not\models P. \quad (1000)$$

Conversely,

$$\text{FormalModelExists}(M) \not\Rightarrow \text{PhysicallyRealized}(M). \quad (1001)$$

C.2 Typed realization-core signature

Use the primitive typed language

$$\begin{aligned} \Sigma_{39}^{\text{primitive}} &:= \langle P, S_C, U_{\text{phys}}; \prec_C, \triangleleft, \text{ExistsAs}, \text{PhysReal}^+ \rangle, & S_C &\subseteq P, \\ \prec_C &\subseteq S_C \times S_C, & \triangleleft &\subseteq U_{\text{phys}} \times P \times P, \\ \text{ExistsAs} &\subseteq U_{\text{phys}} \times P, & \text{PhysReal}^+ &\subseteq U_{\text{phys}} \times P. \end{aligned} \quad (1002)$$

Here $\mathcal{W}_A = \{x \in P \mid \text{ExistsAs}(A, x)\}$ and $\triangleleft_A$ is the section of $\triangleleft$ at A . The objects $I_A, I_A^\Delta, \mathcal{S}_{\text{phys}}(s), \mathcal{B}_\Delta(s)$, $\text{CommonStage}_C(s)$, $\text{RealizedChangeStage}_C(s)$, and $\text{CosmicCoPresence}_C(P; s)$ are defined constructions. Identity-stage incidence determines which qualified identities are represented at s ; co-presence additionally requires that each realization succession be a segment of $(\mathcal{S}_C^{\text{tot}}, \prec_C)$, which CMA asserts for every system. UCC independently requires complete physical-change actuality in every qualified physical system throughout its realized identity range.

C.3 Domain admissibility

$$\text{DomainAdmissible}_{39} \iff \forall A \in \mathcal{U}_{\text{phys}} \exists s \in \mathcal{S}_C^{\text{tot}} \text{ExistsAs}(A, s). \quad (1003)$$

This enforces the definition of $\mathcal{U}_{\text{phys}}$ and is not an additional physical postulate.

C.4 Governing realization-core model

A governing V39/F19 realization-core model satisfies

$$\mathfrak{M} \models \mathfrak{G}_{39}^{\text{core}} \iff \text{DomainAdmissible}_{39} \wedge \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \wedge \text{CMA} \wedge \text{UCC}. \quad (1004)$$

CSPP follows from temporal stage admissibility and is therefore not an independent core conjunct. UCC is an independent physical postulate and is therefore included explicitly alongside CMA in the governing realization core. The typed realization-core signature intentionally omits the separate physical-factor module; any fuller model that instantiates members of $\mathfrak{F}_{\text{phys}}$ must also satisfy the stage-support requirement in Eq. (51). This does not add physical factors to CMA or UCC quantification. Non-terminating cosmic succession is absent from the governing core: it may be added as a conditional cosmological premise in a stronger model. CRP, identity, lifecycle, observation, composition, and application modules retain their separate statuses.

Proposition C.1 (Governing-core expansion). Under Eq. (22),

$$\begin{aligned} \mathfrak{M} \models \mathfrak{G}_{39}^{\text{core}} \iff & \text{DomainAdmissible}_{39} \wedge [\mathcal{S}_C^{\text{tot}} \neq \emptyset] \wedge \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ & \wedge \forall s \in \mathcal{S}_C^{\text{tot}} \text{ CommonStage}_C(s) \\ & \wedge \exists r \in \mathcal{S}_C^{\text{tot}} \exists t \in \mathcal{S}_C^{\text{tot}} (r \prec_C t) \wedge \text{CMA} \wedge \text{UCC}. \end{aligned} \quad (1005)$$

C.5 Historical status of realization-core elements

The V39/F19 realization core is governed by the present definitions and commitments. Earlier versions are relevant only as developmental history. Where a predecessor formulation expresses the same stated content, V39/F19 may describe that content as retained; where the earlier formulation is insufficient, the present version corrects, strengthens, or reclassifies it. No undefined cross-version equivalence predicate is used as a substitute for this item-specific assessment.

C.6 A joint-satisfiability witness

Let

$$\mathcal{S}_C^{\text{tot}} = \mathbb{N}_0, \quad m \prec_C n \iff m < n. \quad (1006)$$

Then $\mathcal{S}_C^{\text{tot}} \neq \emptyset$ and Strict Cosmic Ordering holds. This particular witness also satisfies the stronger optional condition

$$\forall n \in \mathbb{N}_0 \exists m \in \mathbb{N}_0 (n < m), \quad (1007)$$

so $\text{NTCS}_C(\mathbb{N}_0, <)$ holds in the witness even though non-termination is not required by the governing core, and Cosmic Origin holds with $s_C^0 = 0$.

Let

$$\mathcal{U}_{\text{phys}} = \{A_0, A_1, A_2, \dots\}, \quad I_{A_k} = \{k, k+1\}. \quad (1008)$$

Every range is convex with $f_{A_k} = k$ and $e_{A_k} = k+1$. Assign the relevant ending transformation so that

$\text{End}_{A_k}(k+1)$ holds. At stage n ,

$$\mathcal{S}_{\text{phys}}(n) = \begin{cases} \{A_0\}, & n = 0, \\ \{A_{n-1}, A_n\}, & n \geq 1, \end{cases} \quad \mathcal{S}_{\text{phys}}(n) \neq \emptyset, \quad (1009)$$

so CSPP holds. Set the realization successions to

$$\mathcal{W}_{A_k} = I_{A_k}, \quad \triangleleft_{A_k} = <|_{I_{A_k}}, \quad (1010)$$

so CMA holds and, by Eq. (74), $\text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(n); n)$ holds at every n . Assign complete system-specific actual change by

$$\forall k \forall n \in I_{A_k}, \quad \text{PhysReal}_{A_k}^+(n). \quad (1011)$$

This assignment satisfies CMA and UCC as separate conditions; both are jointly satisfiable with the temporal and population core, and

$$\forall n \in \mathbb{N}_0, \quad \mathcal{B}_\Delta(n) = \mathcal{S}_{\text{phys}}(n) \neq \emptyset. \quad (1012)$$

This witness is a consistency construction, not a proposed physical cosmology.

For the causal and lifecycle extensions used below, choose for every realized pair (A_k, n) one explicitly internal physical contributor $c_{k,n}$:

$$\mathcal{C}_{A_k}^{\text{int}}(n) = \{c_{k,n}\}, \quad \mathcal{C}_{A_k}^{\text{infl-sys}}(n) = \emptyset, \quad \mathcal{C}_{A_k}^{\text{infl-factor}}(n) = \emptyset, \quad (1013)$$

so that

$$\mathcal{C}_{A_k}^{\text{act}}(n) = \{c_{k,n}\}. \quad (1014)$$

This supplies a fully typed witness for the causal-source union; it is only one consistency assignment and does not privilege internal causation in physical applications. Assign

$$\text{PhysicallyContributes}(c_{k,n}; \Delta_{A_k}^{\text{phys}}(n)). \quad (1015)$$

CRP is therefore satisfied. At the ending member assign

$$\text{PhysicallyContributes}(c_{k,k+1}; \text{IdentityEndingTransformation}(A_k; k+1)), \quad (1016)$$

so PIECP holds. The ranges $I_{A_k} = \{k, k+1\}$ are convex, have least member k , and contain the strict pre-ending member k before $e_{A_k} = k+1$; thus Identity-Realization Convexity, AFB, and the optional UEIE extension are simultaneously satisfiable in the same witness.

C.7 Stagewise and Systemwise Forms of UCC

The conversion between the stagewise and systemwise forms of UCC uses the common stage domain and the stage-population definition

$$A \in \mathcal{S}_{\text{phys}}(s) \iff [A \in \mathcal{U}_{\text{phys}} \wedge s \in I_A]. \quad (1017)$$

UCC's stagewise clause is

$$\forall s \in \mathcal{S}_C^{\text{tot}} \forall A \in \mathcal{S}_{\text{phys}}(s) : \text{PhysReal}_A^+(s), \quad (1018)$$

and re-indexing the same identity–stage pairs gives

$$\forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A : \text{PhysReal}_A^+(s), \quad (1019)$$

which is the systemwise form of UCC. This re-indexing establishes only the equivalence of two formulations of UCC; it does not yield CMA (Proposition 5.4).

C.8 State and change profiles in the consistency witness

For each A_k , let:

$$\Omega_{A_k} = \mathbb{N}_0 \quad (1020)$$

and define:

$$X_{A_k}(n) = n + k. \quad (1021)$$

Let:

$$\Xi_{A_k} = \mathbb{N}_0 \times \{k\} \quad (1022)$$

This codomain keeps the change content explicitly system-typed in the consistency model.

Define the corresponding change-content map by

$$\Delta_{A_k}^{\text{phys}}(n) = (n, k). \quad (1023)$$

Then Eq. (1012) supplies the complete change-realizing population at every n .

The state profile:

$$\mathfrak{X}_C(n) = (A_k \mapsto n + k)_{A_k \in \mathcal{S}_{\text{phys}}(n)} \quad (1024)$$

is well defined.

The change profile:

$$\mathfrak{D}_C(n) = (A_k \mapsto (n, k))_{A_k \in \mathcal{S}_{\text{phys}}(n)} \quad (1025)$$

is well defined.

The causal-realization profile:

$$\mathfrak{G}_C(n) = (A_k \mapsto \{c_{k,n}\})_{A_k \in \mathcal{S}_{\text{phys}}(n)} \quad (1026)$$

is well defined.

Hence:

$$\mathfrak{R}_C(n) = (\mathcal{S}_{\text{phys}}(n), \mathfrak{X}_C(n), \mathfrak{D}_C(n), \mathfrak{G}_C(n)) \quad (1027)$$

exists at every n .

Therefore the witness satisfies, at every n , the nonempty population, local stage-change, and nonempty causal-realization conditions of Eq. (186). No additional temporal object or realization predicate is introduced.

C.9 Optional successor links in the joint witness

The consistency witness does not require successor production. One admissible extension may nevertheless assign, for selected k ,

$$\text{PhysicalProductionLink}(A_k, A_{k+1}; k+1) \quad (1028)$$

and therefore

$$\text{SuccAt}(A_k, A_{k+1}; k+1). \quad (1029)$$

Because $f_{A_{k+1}} = k+1$, such a $B = A_{k+1}$ is a genuinely new direct successor in that selected extension. The same base witness remains admissible without any such assignment, demonstrating that successor production is not a universal lifecycle requirement.

The principal witness therefore tests simultaneous satisfiability of

$$\begin{aligned} &\text{StrictTotalOrder}(\mathbb{N}_0, <), \quad \text{NTCS}_C(\mathbb{N}_0, <), \quad \text{CSPP}, \\ &\text{CMA}, \quad \text{UCC}, \quad \text{CRP}, \quad \text{IdentityRealizationConvexity}, \\ &\text{AFB}, \quad \text{UEIE}, \quad \text{PIECP}, \end{aligned} \quad (1030)$$

together with the complete V39/F19 physical-realization profile construction.

The construction is only a satisfiability witness. Its countable population, two-member identity ranges, state assignments, and any optional successor links are not proposed as a physical cosmology.

C.10 The V39 realization profile is a conservative construction

Suppose all component functions:

$$\mathcal{S}_{\text{phys}}(s), \quad \mathfrak{X}_C(s), \quad \mathfrak{D}_C(s), \quad \mathfrak{G}_C(s) \quad (1031)$$

are already fixed.

Then:

$$\mathfrak{R}_C(s) \quad (1032)$$

is uniquely fixed by definition.

Therefore:

$$\text{ComponentInterpretationsFixed} \implies \text{RealizationProfileUniquelyDetermined}. \quad (1033)$$

The profile introduces no additional independent truth assignment.

In particular, the profile is not a temporal primitive:

$$\mathfrak{R}_C(s) \not\equiv_{\text{type}} \text{TemporalPrimitive}. \quad (1034)$$

C.11 Profile Coverage and State Plurality

Consider two qualified systems A and B realized at the same stage s .

Let:

$$\Omega_A = \mathbb{R}, \quad \Omega_B = \mathbb{R}^3. \quad (1035)$$

Assign:

$$X_A(s) = 1, \quad X_B(s) = (0, 1, 2). \quad (1036)$$

The complete state profile:

$$\mathfrak{X}_C(s) = (A \mapsto 1, B \mapsto (0, 1, 2)) \quad (1037)$$

is well defined.

Yet:

$$\Omega_A \neq \Omega_B. \quad (1038)$$

Therefore:

$$\text{CompleteStateProfileCoverage} \not\models \text{OneUniversalPhysicalStateSpace}. \quad (1039)$$

C.12 Change Coverage and System-Specific Codomains

Let:

$$\Xi_A = \mathbb{R}, \quad \Xi_B = \mathbb{R}^2. \quad (1040)$$

Assign actual change to both systems.

Then:

$$\mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) = \{A, B\} \quad (1041)$$

may hold while:

$$\Xi_A \neq \Xi_B. \quad (1042)$$

Thus:

$$\mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) \not\models \exists \Xi_{\text{univ}} \forall X \in \mathcal{S}_{\text{phys}}(s), \quad \Xi_X = \Xi_{\text{univ}}. \quad (1043)$$

C.13 Composition does not imply cross-level change identity

Let:

$$A \triangleleft_{\kappa, s} B. \quad (1044)$$

Assign:

$$\Xi_A = \mathbb{R}, \quad \Xi_B = \mathbb{R}^3. \quad (1045)$$

Under UCC both systems change.

Nevertheless:

$$\Delta_A^{\text{phys}}(s) \not\equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \quad (1046)$$

Hence:

$$A \triangleleft_{\kappa, s} B \not\models \Delta_A^{\text{phys}}(s) \equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \quad (1047)$$

C.14 Composition does not imply cross-level causal determination

Consider two typed structures $\mathfrak{M}_1$ and $\mathfrak{M}_2$ with the same:

$$A, \quad B, \quad s, \quad A \triangleleft_{\kappa, s} B, \quad X_A(s), \quad X_B(s), \quad \Delta_A^{\text{phys}}(s). \quad (1048)$$

Let the structures differ only in the admissible causal realization assigned to B :

$$\mathcal{C}_{B,1}^{\text{act}}(s) \neq \mathcal{C}_{B,2}^{\text{act}}(s). \quad (1049)$$

Both may satisfy CRP.

Therefore the composition relation alone does not determine the composite causal profile:

$$A \triangleleft_{\kappa, s} B \not\models \mathcal{C}_B^{\text{act}}(s) = F_\kappa(\mathcal{C}_A^{\text{act}}(s)). \quad (1050)$$

Any such F_κ requires additional physical premises.

C.15 Common-stage co-realization does not entail interaction

Let:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \quad (1051)$$

and retain CMA.

Assign:

$$\neg \text{PhysicalInteraction}(A, B; s). \quad (1052)$$

This does not violate CMA.

Hence:

$$\text{CMA} \not\models \text{UniversalPairwisePhysicalInteraction}. \quad (1053)$$

Likewise assign:

$$\neg \text{SignalAccessible}(A, B; s). \quad (1054)$$

Then:

$$\text{CMA} \not\models \text{UniversalInstantaneousSignalAccessibility}. \quad (1055)$$

C.16 Population transformation does not require adjacent stages

Take:

$$0 \prec_C 1 \prec_C 2. \quad (1056)$$

Compare the nonadjacent endpoints:

$$r = 0, \quad s = 2. \quad (1057)$$

The sets:

$$\mathcal{P}_{0,2}, \quad \mathcal{N}_{0 \rightarrow 2}, \quad \mathcal{L}_{0 \rightarrow 2}, \quad \mathcal{T}_{0,2} \quad (1058)$$

remain well defined.

Therefore:

$$\text{PopulationTransformationDescriptorDefined}(r, s) \not\models \text{Adjacent}(r, s). \quad (1059)$$

C.17 Population transformation does not imply population motion

The pairwise descriptor is constructed entirely from correctly typed identity-domain membership statements of the form

$$A \in \mathcal{U}_{\text{phys}}, \quad u \in \mathcal{S}_C^{\text{tot}}, \quad v \in I_A, \quad (1060)$$

with v instantiated by the selected endpoints or, where required by $\mathcal{T}_{r,s}$, by an intermediate common cosmic change stage.

No motion predicate occurs in its definition.

Thus:

$$\text{Defined}(\mathfrak{P}_C^{\text{pop}}(r, s)) \not\models \text{PopulationMovesFrom}(r, s). \quad (1061)$$

C.18 Successorship does not imply population conservation

The direct-successor definition constrains only those candidate relations that are actually asserted. It neither requires every ending to have a successor nor requires every later entrant to be a successor, and it imposes no one-to-one correspondence between departing and newly realized populations. Therefore

$$\text{Defined}(\text{SuccAt}) \not\models \text{PopulationConservationLaw}. \quad (1062)$$

An ending may produce several successors, one successor, or none, while independently formed systems may enter the later population without being successors of an identity that ended in the selected interval.

C.19 Operational Metrics Do Not Imply Temporal Identity

Consider two physically admissible calibration conventions:

$$m_P = \mathcal{M}_P^{\text{op}}(r_1, r_2; \mathbf{K}_P), \quad (1063)$$

$$m'_P = 2m_P. \quad (1064)$$

The two representations may encode the same ordered physical records under different unit scales.

The universal cosmic ordering is unchanged.

Thus:

$$m_P \neq m'_P \not\models \text{DifferentTemporalReferents}(P, P'). \quad (1065)$$

More importantly:

$$\text{OperationalMetricSuccessfullyConstructed} \not\models m_P \equiv_{\text{type}} T_{\text{ITOF}}. \quad (1066)$$

C.20 Model Success Does Not Confer Temporal Identity

Let one application model use parameter:

$$\lambda \quad (1067)$$

and an equivalent reparameterization use:

$$\lambda' = 2\lambda. \quad (1068)$$

Suppose both representations predict exactly the same physical observables after the corresponding

transformation of the model equations.

Then:

$$\text{Success}(\lambda) \wedge \text{Success}(\lambda'). \quad (1069)$$

Operational success alone cannot identify both distinct numerical parameters with the same temporal referent.

Therefore:

$$\text{SuccessfulEvolutionParameter} \not\vdash \text{TemporalIdentity}. \quad (1070)$$

C.21 Non-injective observation remains possible

Let:

$$s_0 \prec_C s_1 \prec_C s_2 \prec_C s_3 \quad (1071)$$

belong to I_A .

Define:

$$\mathcal{O}_{P,\varepsilon} : I_A \longrightarrow \{0, 1\} \quad (1072)$$

with:

$$\mathcal{O}_{P,\varepsilon}(s) = \begin{cases} 0, & \text{Response}_P(A; s) < \varepsilon, \\ 1, & \text{Response}_P(A; s) \geq \varepsilon. \end{cases} \quad (1073)$$

Suppose:

$$\mathcal{O}_{P,\varepsilon}(s_0) = \mathcal{O}_{P,\varepsilon}(s_1) = 0 \quad (1074)$$

and:

$$\mathcal{O}_{P,\varepsilon}(s_2) = \mathcal{O}_{P,\varepsilon}(s_3) = 1. \quad (1075)$$

Then the map is non-injective.

Therefore:

$$\mathcal{O}_{P,\varepsilon}(s) = 1 \not\Rightarrow \text{ExactCosmicChangeStageIdentified}(s). \quad (1076)$$

This remains one formal source of Exact-Change-Stage Restraint.

C.22 State reconstruction does not identify a unique stage

Suppose:

$$\widehat{X}_{A;P,M}(r) = X^*. \quad (1077)$$

If:

$$\exists s_1, s_2 \in I_A, \quad s_1 \neq s_2, \quad X_A(s_1) = X_A(s_2) = X^*, \quad (1078)$$

then:

$$\text{UniqueSelectedStateReconstruction} \not\Rightarrow \text{UniqueCosmicChangeStageIdentification}. \quad (1079)$$

State recurrence and exact cosmic-stage identity remain distinct.

C.23 Model failure is not foundational failure

Suppose:

$$M_1 \neq M_2 \quad (1080)$$

and:

$$\text{DiscriminationFavours}(M_1). \quad (1081)$$

Let both models contain application-level bridge assumptions not deductively fixed by their respective foundational commitments.

Then model discrimination establishes:

$$\text{ApplicationModelSupportOrRestriction} \quad (1082)$$

without logically isolating a foundational premise.

Therefore:

$$\text{ModelDiscrimination} \not\vdash \text{FoundationalAttribution}. \quad (1083)$$

The additional attribution burden of Section 25 is therefore non-redundant.

C.24 CMA and UCC in the V39 dependency architecture

CMA and UCC are logically independent (Proposition 5.4). The stagewise form of UCC follows from the population definition by the quantifier conversion of Eqs. (1018)–(1019).

C.25 Current principal modular non-entailments

The identity, lifecycle, causal, application, and representation modules remain separated unless an explicit dependency is stated. Every retained formal non-derivability claim requires a corresponding witness or admissible modular extension. Ordinary non-transfer claims use $\nRightarrow$ rather than $\nVdash$.

C.26 Current direct derivations

V39/F19 also preserves genuine derivations.

From strict total ordering:

$$r \prec_C s \implies \neg(s \prec_C r). \quad (1084)$$

From Non-Terminating Cosmic Succession:

$$\text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \nexists g \in \mathcal{S}_C^{\text{tot}} \text{ Greatest}_{\prec_C}(g). \quad (1085)$$

Because unlimited future extent is not part of temporal admissibility, infinity of the stage domain follows only conditionally when the additional cosmological non-termination hypothesis is adopted:

$$\begin{aligned} &\mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \\ &\wedge \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \implies \text{Infinite}(\mathcal{S}_C^{\text{tot}}). \end{aligned} \quad (1086)$$

From AFB and the UCC:

$$\text{AFB} \wedge \text{UCC} \implies \forall A \in \mathcal{U}_{\text{phys}}, \quad \text{FormationChange}_A(f_A). \quad (1087)$$

This derived statement concerns physical change of A at its identity-range boundary only. It does not order that change ahead of or behind the changes of other qualified systems sharing the same common cosmic stage.

From ending and UCC, the ending stage is a stage of actual change of the ending system (Eq. (266)).

From UCC and CRP:

$$\text{UCC} \wedge \text{CRP} \implies \forall A \in \mathcal{U}_{\text{phys}} \forall s \in I_A, \quad \mathcal{C}_A^{\text{act}}(s) \neq \emptyset. \quad (1088)$$

From CSPP, CMA, and UCC:

$$\forall s \in \mathcal{S}_C^{\text{tot}}, [\mathcal{S}_{\text{phys}}(s) \neq \emptyset \wedge \text{CosmicCoPresence}_C(\mathcal{S}_{\text{phys}}(s); s) \wedge \mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s)]. \quad (1089)$$

From temporal admissibility, CMA, UCC, and CRP, Eq. (186) supplies the corresponding nonempty stage-relative population, local stage-change condition, and nonempty causal realization for every member. This identifies the causal completion of the governing common-stage realization without adding a new independent universal postulate or realization predicate.

D. Governing Equation Reference

The following register identifies the principal equations that determine the architecture of V39/F19.

Table 5: Principal governing equations of V39/F19.

Role	Reference	Status
Definition of time	Eq. (11)	Governing ordered-pair denotation with explicit formal-symbolic stage meaning.
Governing earlier–later designation	Eq. (23)	Meaning-fixing semantic designation of $\prec_C$; not supplied by the strict-order axiom.
Strict Cosmic Ordering	Eq. (24)	Foundational axiom constraining the designated earlier–later relation as a strict total order.
Non-Terminating Cosmic Succession	Eq. (17)	Revisable cosmological non-termination hypothesis: every admitted cosmic stage has a later stage. It is non-metric and directly evaluable once adopted, but it is not assumed as a fact about the unknown complete future.
Temporal-extension admissibility	Eq. (22)	Defined condition: nonempty formal cosmic-stage domain + Strict Cosmic Ordering + every member a common stage of the physical systems of the universe + a nontrivial earlier–later pair. CSPP follows as a derived population consequence; CMA and UCC are logically independent (Proposition 5.4), and Non-Terminating Cosmic Succession is a revisable hypothesis.
Order-representation non-metricity	Eqs. (38)–(39)	Derived representation-level result; no canonical metric interval follows from order preservation.
Cosmic physical totality	Eqs. (49)–(60)	Defines the stage-supported physical-factor component, its stage-relative population, and the physical universe as the typed totality of physical-system identities and physically realized physical factors, excluding both container semantics and a silent retyping of the totality as one physical-system identity.

Role	Reference	Status
Physical-system totality	Eq. (57)	Definition of the governing ontic system-identity totality.
Common stage and stage of change	Eqs. (15), (16)	Definitions; every member of $\mathcal{S}_C^{\text{tot}}$ is a common stage, and under UCC a stage of change of all physical systems realized there (Eq. (104)).
Noticed(A, s), Measured $_{P,M,\varepsilon}(A, s)$	Eq. (85)	A manifestation of the change of A at s recognized by an observer system, and detected under a declared protocol, model, and resolution; type-distinct from the change itself and from each other.
Recognizes $_O(m; r)$	Eq. (85)	Primitive typed predicate: observer system O identifies the manifestation m in a record at r .
Components(T_{ITOF})	Eq. (9)	The constituents named in the definition of T_{ITOF} : the stage domain and its order.
Responsiveness profile RespProf $_A(s)$	Eq. (145)	Physically realized features of A conditioning the change contributed by an influence; part of the internal basis, not a fourth causal-source class.
Realization succession ($\mathcal{W}_A, \triangleleft_A$)	Eq. (62)	Primitive; the positions and order of the system's own realizations. CMA makes it a segment of $(\mathcal{S}_C^{\text{tot}}, \prec_C)$.
Identity-realization range	Eq. (63)	Definition; $\mathcal{W}_A \cap \mathcal{S}_C^{\text{tot}}$, equal to $\mathcal{W}_A$ under CMA; not a private time.
Stage-relative population	Eq. (64)	Definition from memberwise identity realization.
Stage-relative cosmic physical totality	Eqs. (50)–(65)	Defined stage-relative typing of realized non-system physical factors and their typed union with the realized physical-system population; these definitions do not alter CMA or UCC quantification over qualified systems.
CSPP	Eq. (68)	Derived population principle following from governing common-stage semantics.

Role	Reference	Status
CMA	Eq. (73)	Governing foundational axiom requiring objective common-stage co-presence of the complete then-realized qualified physical-system population at each admitted member; it is distinct from UCC and does not itself impose complete actual-change coverage.
UCC	Eq. (83)	Independent foundational physical postulate requiring system-specific actual physical change at every member of each realized identity range. It remains logically distinct from CMA and supplies no common-stage co-presence claim.
Actual-change subset	Eq. (81)	Definition.
Complete-population change coverage	Eq. (103)	Distinct conjunction with UCC.
System-change profile	Eq. (113)	Defined construction.
Local stage-change condition	Eq. (111)	Defined local representation of complete-population change coverage in the already common global-stage co-presence and complete-population actual-change coverage.
State profile	Eq. (130)	Defined construction.
CRP	Eq. (154)	Independent foundational physical postulate.
Causal-realization profile	Eq. (159)	Defined construction.
Complete physical-realization profile	Eq. (167)	Defined construction.
Relationally augmented realization profile	Eq. (176)	Application-level extension of the complete-population realization profile.
Hierarchical constituent relation	Eq. (189)	Current typed physical relation.
Class-indexed identity-qualification profile	Eqs. (214)–(215)	Current V39/F19 application-admissibility formalization of class-specific physical-system identity qualification; its governing status is entirely current-version status.
Physical history	Eq. (235)	Formal representation.

Role	Reference	Status
Identity ending	Eq. (263)	Definition.
PIECP	Eq. (277)	Independent ending-specific causal postulate.
UEIE	Eq. (284)	Optional independent lifecycle postulate; not a governing core requirement.
Direct successor	Eq. (291)	Defined physically produced new-identity relation.
Endpoint-persistent population	Eq. (302)	Current definition.
Later-endpoint entrant population	Eq. (305)	Current definition.
Earlier-endpoint departing population	Eq. (308)	Current definition.
Intermediate-only identities	Eq. (314)	Current definition.
System-specific physical directionality	Eqs. (367)–(373)	Current criterion-indexed physical construction; not a temporal-order identity.
Operational metric map	Eq. (381)	Application-level construction.
Exact-Change-Stage Restraint	Eqs. (432), (433), and (434)	Epistemic principle.
Generalized Non-Transfer Principle	Eq. (541)	Foundational type principle.
Relativistic temporal nonidentity	Eq. (561)	Direct external type position.
ITOF–relativistic comparison bridge	Eq. (710)	Application-level empirical-comparison architecture.
Bridge-robust separation margin	Eq. (739)	Methodological comparison quantity over independently admissible bridge classes.
Foundational discrimination burden	Eq. (755)	Methodological inferential condition.

E. Framework Identity and Extension Boundary

E.1 Identity-preserving temporal conditions

A physical extension or application presented as V39/F19-admissible must preserve the temporal identity fixed by Eq. (11).

It must preserve the designated earlier–later meaning, Strict Cosmic Ordering, and the realized-change

semantics of admitted stages. A model that additionally adopts Non-Terminating Cosmic Succession must preserve the exact conditional meaning of Eq. (17), but adopting that cosmological condition is not required for framework identity.

An application that replaces the temporal referent with another quantity is not an identity-preserving V39/F19 application.

E.2 Identity-preserving realization conditions

An identity-preserving V39/F19 realization preserves governing CMA, UCC, and the identity-range and stage-population definitions that keep common-stage co-presence distinct from system-specific physical-change actuality. CSPP remains the derived population consequence of temporal admissibility and is not promoted to an independent realization condition. Applications containing actual system endings must preserve the conditional direct-successor criterion rather than imposing universal successor production. If the non-termination hypothesis is adopted, it remains a separate cosmological premise rather than part of the realization core.

The local $SCB_C(s)$ remains only a defined conjunction of CMA common-stage co-presence and UCC complete-population actual-change coverage at an admitted stage. It creates no additional temporal layer, causal content, or dynamical mechanism.

E.3 Identity-preserving physical typing

An admissible extension must preserve the distinction between:

$$\begin{aligned} & \text{time,} \quad \text{cosmic physical totality,} \quad \text{common cosmic change stage,} \\ & \text{physical system,} \quad \text{physical state,} \quad \text{physical change,} \quad \text{physical factor,} \\ & \quad \text{causal contributor,} \quad \text{physical history,} \quad \text{record,} \\ & \text{operational metric,} \quad \text{coordinate,} \quad \text{model parameter,} \quad \text{model geometry.} \end{aligned} \tag{1090}$$

In particular, the extension must preserve the causal-source boundary of Eq. (355).

E.4 Identity-preserving physical-realization architecture

A V39/F19 application may refine the physical content represented inside:

$$\mathfrak{R}_C(s) \tag{1091}$$

and may add independently warranted model-relative relations through $\mathfrak{R}_C^{[M]}(s)$. Neither construction may be reinterpreted as time; the type boundary of Eq. (181) is identity-preserving.

Likewise, a specific application may introduce additional physical relations not included in the profile.

Their introduction does not require expansion of the temporal ordered pair.

E.5 What may vary

Subject to physical warrant, explicit typing, parameter provenance, and appropriate empirical evaluation, V39/F19 permits variation in:

$$\begin{aligned}
& \text{SystemClass, SystemBoundary, IdentityCriterion,} \\
& \text{CompositionCriterion, StateSpace, ChangeContentType,} \\
& \text{PhysicalDynamics, CausalModel, ComparisonMap,} \\
& \text{SignalModel, ObservationModel, ClockResponseModel,} \\
& \text{OperationalMetric, ExperimentalProtocol.}
\end{aligned} \tag{1092}$$

No single application model is permanently built into the definition of time.

E.6 What would constitute a foundational revision

The following substitutions would alter the governing identity of V39/F19 rather than constitute ordinary application-level extension:

$$\begin{aligned}
T_{\text{ITOF}} &\longrightarrow \text{ClockOutput,} \\
T_{\text{ITOF}} &\longrightarrow \text{CoordinateTime,} \\
T_{\text{ITOF}} &\longrightarrow \text{MetricInterval,} \\
T_{\text{ITOF}} &\longrightarrow \text{ProperTimeFunctional,} \\
T_{\text{ITOF}} &\longrightarrow \text{PhysicalRealizationProfile,} \\
\mathcal{U}_{\text{C}}^{\text{phys}} &\longrightarrow \text{PhysicalContainer,} \\
\mathcal{U}_{\text{C}}^{\text{phys}} &\longrightarrow \text{PhysicalSystemIdentity,} \\
\text{OneCommonCosmicStageTotality} &\longrightarrow \text{IndependentPerSystemTimes,} \\
\text{PhysicalCausation} &\longrightarrow \text{TimeAsCauseOfChange,} \\
\text{HistoricalPhysicalAccumulation} &\longrightarrow \text{FourthPhysicalCausalSource.}
\end{aligned} \tag{1093}$$

Removal or alteration of a governing axiom, constitutive condition, or derived definition that fixes the V39/F19 architecture—including Strict Cosmic Ordering, common-stage semantics, the non-container cosmic physical-totality distinction, governing CMA, or the UCC continuity condition—would constitute a foundational revision rather than an admissible application-level extension. Changing the definition of the optional Non-Terminating Cosmic Succession predicate would likewise revise its declared cosmological module, but a finite-extent application is not excluded merely for not assuming that optional condition.

E.7 Admissible extension condition

Let E be a proposed extension.

Define the structural admissibility burden:

$$\begin{aligned}
\text{AdmissibleExtension}_{39}(E) \implies & \text{TemporalCorePreserved}(E) \\
& \wedge \text{CommonStageArchitecturePreserved}(E) \\
& \wedge \text{CMAUCCDependencyPreserved}(E) \\
& \wedge \text{PhysicalTypingExplicit}(E) \\
& \wedge \text{IdentityCriteriaExplicitWhereUsed}(E) \\
& \wedge \text{CausalTypingPreserved}(E) \\
& \wedge \text{NonTransferPreserved}(E) \\
& \wedge \text{ProvenanceDeclared}(E).
\end{aligned} \tag{1094}$$

Where E produces an empirical prediction:

$$\text{PredictiveExtension}_{39}(E) \implies \text{AdmissibleExtension}_{39}(E) \wedge \text{PredeclaredEmpiricalProtocol}(E). \tag{1095}$$

Where foundational discrimination is claimed, the stronger attribution burden also applies.

F. Scientific Claim Boundary

F.1 Formal countercondition and empirical procedure

V39/F19 retains the governing distinction:

$$\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{DirectFiniteExperimentFor}(F). \tag{1096}$$

A formal contrary states what would contradict a commitment. An empirical procedure specifies how physical evidence may warrant that contrary. The existence of the first does not guarantee the second, and current experimental practice may be unable to identify the contrary without additional physical characterization. Conversely, the absence of a simple finite direct test does not remove the formal contrary of UCC or of any other universal commitment.

F.2 Universal commitments and finite evidence

For universal foundational statement F :

$$\text{FinitePositiveObservations} \not\Rightarrow \text{DeductiveProof}(F). \tag{1097}$$

Likewise:

$$\text{FiniteNullObservation} \not\Rightarrow \text{PhysicalCounterexample}(F). \tag{1098}$$

The inferential relation depends on what the observation actually establishes.

F.3 Application-level failure

For application model M , let:

$$\mathfrak{P}_M^* \tag{1099}$$

be its predeclared evaluation protocol.

Advance-prediction status requires:

$$\begin{aligned} \text{AdvancePrediction}(M) \implies & \text{ProtocolFrozen}(\mathfrak{P}_M^*) \\ & \wedge \text{IndependentParameterProvenance}(M) \\ & \wedge \text{NoEvaluationLeakage}(\mathfrak{P}_M^*, D_M). \end{aligned} \tag{1100}$$

If the prediction fails under the declared rule:

$$\text{ApplicationModelRejectedOrRestricted}(M, D_M) \tag{1101}$$

is the immediate conclusion.

F.4 Foundation-level failure

A failed observable reaches foundational commitment F only where the derivation of Eq. (506) holds and the failed result cannot be assigned to an independently unsettled bridge, auxiliary, measurement, parameter, approximation, or uncertainty component.

Thus:

$$\neg O_F + \text{AttributionIdentifiableTo}(F) \implies \text{FoundationalChallenge}(F). \tag{1102}$$

Without attribution identifiability, Eq. (508) applies.

F.5 Post-hoc revision status

The no-post-hoc rule of Eq. (521) remains applicable: a scientifically legitimate revised model does not alter the historical status of the original advance prediction and requires new independent evaluation.

F.6 Bounded support

Where a predeclared test favours application model M :

$$\text{DiscriminationFavours}(M, D) \implies \text{Warrant}[\text{PhysicalApplicationModelSupportedOn}(M, D)]. \tag{1103}$$

The conclusion remains bounded to the inferential level actually tested.

It does not automatically establish:

$$\text{DiscriminationFavours}(M, D) \not\Rightarrow \text{OperationalQuantityIsTime}. \quad (1104)$$

or every universal foundational commitment.

F.7 Final scientific inference rule

The governing scientific discipline is:

Scientific inference propagates only through explicitly declared
logical dependency, a typed physical application chain, observational support, (1105)
uncertainty structure, and warranted evidential scope.

G. V39/F19 Modular Architecture

G.1 Time-definition module

Define

$$\mathfrak{T}_{\text{ref}}^{39} = \{ \mathcal{S}_C^{\text{tot}}, \prec_C, T_{\text{ITOF}} \}. \quad (1106)$$

This module collects the symbols used in the formal definition of time. The stage members are formal expressions of realized physical change within the universal objective earlier–later cosmic succession. Physical systems are not components of the ordered pair, but actual physical-change realization is part of the semantic admission condition for a stage; no dynamical law or independent stage object is thereby inserted into T_{ITOF} .

G.2 Temporal Admissibility and Conditional Extent

Define

$$\begin{aligned} \mathfrak{T}_{\text{adm}}^{39} = \{ & \mathcal{S}_C^{\text{tot}} \neq \emptyset, \text{StrictTotalOrder}(\mathcal{S}_C^{\text{tot}}, \prec_C), \\ & \forall s \in \mathcal{S}_C^{\text{tot}} \text{ CommonStage}_C(s), \quad \exists r, t \in \mathcal{S}_C^{\text{tot}} (r \prec_C t), \\ & \mathfrak{T}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \}. \end{aligned} \quad (1107)$$

These entries are exactly the contents compressed by governing temporal admissibility. The separate cosmological extension condition is

$$\mathfrak{T}_{\text{extent}}^{39} = \{ \text{NTCS}_C(\mathcal{S}_C^{\text{tot}}, \prec_C) \}, \quad (1108)$$

and is optional because the complete future extent of physical change is not scientifically fixed by the framework. The stage-realization entry supplies semantic physical actuality, not a system state profile or dynamical law.

For organizational reference,

$$\mathfrak{T}_{\text{temporal}}^{39} = \mathfrak{T}_{\text{ref}}^{39} \cup \mathfrak{T}_{\text{adm}}^{39}, \quad \mathfrak{T}_{\text{extent}}^{39} \text{ remains a conditional cosmological module.} \quad (1109)$$

The union is organizational: ordered-pair identification and admissibility remain distinct statement roles even though both concern the temporal foundation. Conditional future extent is intentionally kept outside that union.

G.3 Common physical-realization module

Define:

$$\begin{aligned} \mathfrak{T}_{\text{real}}^{39} = \{ & \mathfrak{U}_{\text{C}}^{\text{phys}}, \quad \mathfrak{F}_{\text{phys}}, \quad \mathcal{U}_{\text{phys}}, \quad (\mathcal{W}_A, \triangleleft_A), \quad I_A, \\ & \mathcal{S}_{\text{phys}}(s), \quad \text{CSPP}, \quad \text{CMA}, \quad \text{UCC}, \quad \mathcal{B}_{\Delta}(s), \quad \text{SCB}_{\text{C}}(s), \\ & \mathfrak{X}_{\text{C}}(s), \quad \mathfrak{D}_{\text{C}}(s), \quad \mathfrak{G}_{\text{C}}(s), \quad \mathfrak{R}_{\text{C}}(s) \}. \end{aligned} \quad (1110)$$

$\mathfrak{U}_{\text{C}}^{\text{phys}}$ fixes the non-container meaning of the physical universe as the totality of physical systems and physically realized physical factors; it is not a temporal component and is not itself a system identity. CSPP, CMA, and UCC retain distinct statement roles: CSPP is the derived population principle supplied by common-stage admission; CMA is the axiom excluding system-private stages and orderings, from which common-stage co-presence follows; and UCC is the independent system-specific physical-change continuity postulate. Their conjunction, together with admitted stage semantics, supplies the defined full-theory common-cosmic-change-stage role without introducing a new primitive or causal law. $\text{SCB}_{\text{C}}(s)$ is a defined local representation, not a new primitive. The non-termination belongs to the separate cosmological-extent branch rather than the realization core. CRP belongs to the causal module even though its output contributes to the complete physical- realization profile.

G.4 Composition module

Define:

$$\mathfrak{T}_{\text{comp}}^{39} = \{ \triangleleft_{\kappa, s}, \mathfrak{R}_{\text{C}}(s), \text{CrossLevelNonTransfer} \}. \quad (1111)$$

G.5 Identity-history module

Define:

$$\begin{aligned} \mathfrak{T}_{\text{id}}^{39} = \{ & \text{IdentityRealizationConvexity}, \text{AFB}, \mathfrak{Q}_{\mathcal{H}}^{\text{id}}, X_A, \mathcal{H}_A, \\ & \text{HistoricalPhysicalAccumulation}_A^{<s}, \text{CumulativePhysicalResultThrough}_A(s) \}. \end{aligned} \quad (1112)$$

G.6 Lifecycle module

Define the governing lifecycle module by

$$\mathfrak{T}_{\text{life}}^{39} = \{ \text{End}_A(e), \Delta_A^{\text{end}}(e), \text{PIECP}, \text{SuccAt}(A, B; e), \mathfrak{G}^+(A, e) \}. \quad (1113)$$

UEIE has lifecycle type but is not included as a governing truth commitment in this module; it enters only when the optional postulate of Eq. (284) is explicitly adopted.

G.7 Population-transformation module

Define:

$$\mathfrak{T}_{\text{pop}}^{39} = \{ \mathcal{P}_{r,s}, \mathcal{N}_{r \rightarrow s}, \mathcal{L}_{r \rightarrow s}, \mathcal{I}_{r,s}, \mathfrak{P}_{\text{C}}^{\text{pop}}(r,s) \}. \quad (1114)$$

G.8 Representation and physical-model module

Define:

$$\begin{aligned} \mathfrak{T}_{\text{model}}^{39} = \{ & \text{AdmissiblePhysicalModel}, \mathcal{B}_M^{\text{in}}, \text{Dyn}_M, \mathcal{B}_M^{\text{out}}, \\ & \text{ModelEvolutionParameter}, \text{CrossSystemComparison}, \mathfrak{A}_{A,\alpha}, \text{ArrowAligned}_{A,\alpha}, \mathcal{M}^{\text{op}}, \\ & \Omega_{\text{MD}}, \text{PredictiveSeparationScreen} \}. \end{aligned} \quad (1115)$$

G.9 Observation module

Define:

$$\mathfrak{T}_{\text{obs}}^{39} = \{ \mathcal{L}_P, \text{ManifestationAt}, \mathcal{O}, \mathcal{B}_{P,M}^{\text{obs}}, J_r^{\text{phys}}, \text{ExactChangeStageRestrict} \}. \quad (1116)$$

G.10 Empirical bridge module

Define:

$$\mathfrak{T}_{\text{emp}}^{39} = \{ \mathfrak{P}^*, \text{FoundationalEmpiricalBridge}, \text{FoundationalAttribution}, \text{PredictionSeparation} \}. \quad (1117)$$

G.11 External-theory and Non-Transfer module

Define:

$$\mathfrak{T}_{\text{ext}}^{39} = \{ \text{NTP}, \mathcal{Q}_{\text{rel}}, \mathfrak{B}_{I:R}^{P,D}, \delta_{I:R}^{P,D} \}. \quad (1118)$$

G.12 Governing modular architecture

The governing V39/F19 architecture, apart from the cosmological Cosmic Origin module, may be represented as an ordered family of typed modules:

$$\begin{aligned} \mathfrak{V}_{\text{V39}}^{\text{gov}} := \langle & \mathfrak{T}_{\text{temporal}}^{39}, \mathfrak{T}_{\text{real}}^{39}, \mathfrak{T}_{\text{comp}}^{39}, \mathfrak{T}_{\text{id}}^{39}, \mathfrak{T}_{\text{life}}^{39}, \\ & \mathfrak{T}_{\text{pop}}^{39}, \mathfrak{T}_{\text{model}}^{39}, \mathfrak{T}_{\text{obs}}^{39}, \mathfrak{T}_{\text{emp}}^{39}, \mathfrak{T}_{\text{ext}}^{39} \rangle. \end{aligned} \quad (1119)$$

The tuple records modular organization only. It does not collapse the distinct statement statuses of the objects contained in those modules and does not imply that the modules share one physical or ontological type.

With the Cosmic Origin postulate, which V39/F19 adopts as a separate cosmological module, the

architecture is:

$$\mathfrak{F}_{V39}^{(+Origin)} := \langle \mathfrak{F}_{V39}^{gov}, \text{CosmicOrigin} \rangle. \quad (1120)$$

The full framework tuple is not the definition of time:

$$\mathfrak{F}_{V39}^{gov} \not\equiv_{\text{def}} T_{\text{ITOF}}. \quad (1121)$$

H. Historical-Critical Status of V39/F19

H.1 Immediate predecessor and reference basis

The immediate predecessor and the archive record are identified in Section 1.2; the archive permits older definitions, dependencies, and formulations to be distinguished from the present governing theory. The reference basis comprises:

$$\begin{aligned} &\text{ImmediateV38Predecessor,} \\ &\text{ConsolidatedHistoricalITOFRecord,} \\ &\text{ExternalScientificLiterature.} \end{aligned} \quad (1122)$$

The first identifies the immediate historical predecessor; it supplies provenance, not current governing authority.

The second preserves historical traceability.

The third supplies external scientific and mathematical context where relevant.

No earlier ITOF version overrides a governing V39/F19 statement merely by historical priority.

Likewise, external scientific literature is not cited as authority for the definition of time.

It is used where external physical models, measurements, mathematical constructions, experimental records, or competing interpretations are discussed.

H.2 Positions retained from V38/F18

The following positions are retained from V38/F18 [1]; where the basis of a position changed, the change is stated.

- **Successor closure.** A necessary-successor commitment is absent from V28/F8 and V29/F9, which explicitly treat an ending outcome as not necessarily a successor; the commitment appears in explicit “necessarily produces a successor” form from V30/F10 through V34/F14. That commitment was replaced by conditional successor attribution in V35/F15. The conditional position, under which an identity ending does not by itself entail a direct successor and absorption without a newly formed successor identity is admissible (Section 15.5), is retained unchanged in V39/F19. Universal closure is not reinstated, and this retained position is, in substance, closer to the original V28/F8–V29/F9 non-necessity than to the intervening V30/F10–V34/F14 commitment.
- **Stage population.** A stage-population condition first appears in V26/F6, as the nonempty-population conjunct of the Cosmic Moment Axiom; V27/F7 restated it as a separate population condition. It was stated as an independent axiom, the Cosmic Change-Stage Population Postulate

(CSPP), from V34/F14 through V37/F17, and was replaced in V38/F18 by a derived consequence of stage admissibility (Section 4.2). V39/F19 retains this derived status with a changed basis: V38/F18 admitted a stage by actual change in at least one qualified system, whereas V39/F19 admits every stage as a common stage of the physical systems of the universe (Eq. (15)), from which CSPP follows directly, and derives the change of all systems realized at each stage from UCC (Eq. (104)). CSPP is not reinstated as an independent postulate.

- **Cosmic non-termination.** V28/F8 and V29/F9 explicitly decline to postulate a greatest cosmic stage and treat a possible cosmic ending as an open question, without asserting non-termination. Non-termination was first derived in V33/F13, from the population content of CMA together with the cumulative eventual-ending postulate (CPCES) and Necessary Successor Closure, and again in V34/F14, from CSPP, UEIE, the Actual Formation Boundary, and Necessary Successor Closure; it was restated as a direct foundational succession commitment in V35/F15 through V37/F17; and it was made an optional, non-derived cosmological condition in V38/F18. Non-termination remains conditional in V39/F19 (Section 3), with the evidential justification given in Section 3.4. This conditional status recovers the open treatment of V28/F8 and V29/F9.

The developmental history of the definition of time, UCC, the Non-Transfer Principle, and the quantitative test architecture is documented in the project archive [3].

H.3 Positions newly established in V39/F19

The following are new in V39/F19:

- **Realization-succession form of CMA** (Eqs. (62)–(74)). Each system’s own realization succession is a primitive, and CMA states that it is a segment of the one common succession. Objective co-presence is defined from this condition rather than left as an uninterpreted relation, and CMA acquires a direct contrary: a private stage or private ordering.
- **Mutual independence of CMA and UCC** (Proposition 5.4). V38/F18 gave a countermodel to the entailment of CMA by UCC using an uninterpreted co-presence relation; both directions are now proved by countermodels that satisfy every other governing postulate.
- **Common-stage admission and the theorem of stages of change** (Eqs. (15), (16), (104)): stage admission no longer refers to change in some system; every stage is a common stage of the physical systems of the universe, and, under the postulate of change, a stage of change of every one of them.
- **Exclusion of empty, change-null, static, and private stages** (Eq. (104), Corollary 5.5, Eq. (108)): a stage without systems is excluded by stage admission, change-null and static stages by UCC, and private stages by CMA.
- **Uninterrupted change** (Eq. (86)): UCC together with Identity-Realization Convexity excludes both a member of an identity range without change and a gap in the range.
- **Evidential justification of conditional non-termination** (Section 3.4).
- **Relativistic commitment distinctions and a consolidated non-identity proposition** (Section 43), covering global time functions and cosmological time.
- **Observed deflection of light** (Section 40.9): a path or reconstruction property of a physical signal, attributed to declared physical contributors, with rotation as one contributor among several; “bending of time” is a type error.
- **Relativistic phenomenon bridge** (Definition 37.1, Proposition 37.2) with inclusion conditions (J1)–(J3) and exclusion conditions (M1)–(M4), applied phenomenon by phenomenon to special and general relativity (Section 37); a record-level derivation of the Lorentz transformations that

uses no temporal premise; a reply to the Rietdijk–Putnam argument; the exclusion of any return to an earlier stage, along closed timelike curves or through wormhole or warp-drive time machines (Eq. (778)); the reassignment of temporal deformation predicates to their physical bearers; the reading of spacetime as representation of the gravitational relation; the non-admission of temporal geometry (Proposition 43.9); and the reading of horizons and differential ageing. Experimental anchors used in V23/F3 (Pound–Rebka, Vessot, Hafele–Keating, the CERN muon ring), the twin-clock case of V33/F13, and the satellite-navigation analysis of V19 onward are carried into this section in V39/F19 terms.

- **The meaning of invariance** (Section 2): the extension is a non-metric succession and invariance means that it is non-reversed, with no stage empty of change or static, stated by the Ordinal Succession postulate $0 \prec_C 1 \prec_C 2 \prec_C 3 \prec_C 4 \prec_C \cdots \infty$ (conditional), whose numerals express only the fixed succession of the stages and are not added. The account draws on V14 (the ordinal picture), V23/F3 (preservation by representations as a consequence of invariance, not a constituent), V24/F4 (fixity of the succession while what it orders changes), V25/F5–V26/F6 (no interchange of stages; distinction from Lorentz invariance), and V31/F11–V32/F12 (no stopping and no static condition), which is restored while the stronger requirement, that every system change, remains with UCC.
- **Cosmic Origin adopted** (Section 3.2): the first stage, optional since V35/F15, is adopted as a postulate on observational evidence, while non-termination remains a revisable hypothesis; the first stage is distinguished from a model singularity and from the age assigned in cosmological time.
- **Reading the relativistic equations** (Section 44): each principal relativistic equation is read for what it states, the temporal reading it answers, why it holds, what it retains, and what would count against ITOF.
- **Pathways, influence profile, responsiveness, and response classes** (Sections 8.7–8.11). These sections restore, in corrected form, material developed in early versions: system resistance as cohesion, coherence, and integrity relative to an influence (V16); the characteristics of an influence — intensity, mode, exposure, coupling — (V17); the same influence being supportive for one system, adverse for another, and bounded for a third (V18); and engagement, thresholds, stability as maintained change, resistance and adaptation, and living and non-living response organization (V22). Two corrections are made: the realized response is no longer a state produced by a separate operator but the change itself, with the responsiveness profile counted in the internal basis; and thresholds are criterion-relative rather than values of a universal scalar measure of engagement.
- **Clock vibration-condition protocol** (Section 22.9, Definition 22.1). Clock sensitivity to vibration and other environmental conditions was stated qualitatively in V20 (failure under vibration belongs to the clock’s physical structure) and listed among bearer-condition variables in V31/F11 and among controlled perturbations in V35/F15; it is now a declared protocol with a record model, an independent motion record, interleaved control, and a no-post-hoc rule.
- **A dimension-admission criterion** (Definition 43.6, Proposition 43.7).
- **A currently-complete physical isolation criterion** (Definition 5.2, Proposition 5.3), with the bounded, cumulative form of evidence against UCC and the ground-state case.

Earlier ITOF versions remain documentary and developmental evidence. Their definitions, axioms, postulates, principles, and claims are authoritative for V39/F19 only insofar as they are explicitly retained in Section H.2 or restated without qualification elsewhere in this document.

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