Invariant Temporal Ordering Framework V37/F17: Universal Cosmic Extension, Integrated Universal Common-Stage Change Realization, and Quantitative Bridge Architecture

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Abstract

V37/F17 addresses the foundational question of whether time should be identified with quantities that measure, parameterize, or represent physical change, including clock outputs, coordinate components, metric intervals, and proper-time functionals. It addresses that question by retaining the V36/F16 governing temporal definition

$$T_{\mathrm{ITOF}} := \mathcal{E}_{\mathrm{C}} := \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right), \tag{1}$$

where time denotes the one universal cosmic extension of common cosmic change stages constituted by their invariant universal earlier–later ordering and succession. Strict Cosmic Ordering fixes irreversibility; NoInterruption and NoTerminalStage separately govern uninterrupted and continuing succession without adding a metric, density, adjacency, topology, differentiability, or equal stage spacing.

The realization core keeps CSPP, CMA, and UCC logically distinct. CSPP requires a nonempty qualified physical-system population at each admitted stage. CMA fixes literal one-common-stage co-realization of the complete then-realized qualified population within the single universal stage domain. UCC independently requires each qualified numerical physical-system identity to realize its own bearer-specific physical change throughout its identity range. In particular, CMA $\not\equiv_{\mathrm{def}}$ UCC and CMA $\nvdash$ UCC. Their conjunction with the separate succession commitments is collected, without adding a primitive, in the defined Integrated Universal Common-Stage Change Realization condition $\mathrm{UCSCR}_{\mathrm{C}}$. Complete physical non-change is written compactly as $\mathsf{NC}_A^{\mathrm{phys}}(s)$ and is the direct qualitative contrary of $\mathrm{PhysReal}_A^{+}(s)$; neither UCC nor its negation introduces a universal scalar rate or magnitude of change.

The physical architecture is stage-relative and typed. For each admitted stage,

$$\mathfrak{R}_{\mathrm{C}}(s) := \left(\mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s)\right), \tag{2}$$

with completeness meaning complete qualified-population coverage rather than one universal state,

change quantity, causal mechanism, or exhaustive physical description. The framework further treats hierarchical composition, identity-bounded histories, formation and ending, population transformation, cross-system comparison, mathematical-form-neutral dynamics, operational metrics, physical access, and exact-stage epistemic restraint while preserving $T_{\text{ITOF}} \not\equiv_{\text{type}} \mathfrak{R}_{\text{C}}(s)$.

V37/F17 also makes the route from ontology to measurement explicit. The internal Stage-to-Change representation is not an empirical bridge; observable claims require independently warranted physical inputs, dynamics, prediction maps, measurement and acquisition rules, uncertainty structure, frozen protocols, and identifiable attribution. An early clock-response orientation is given in the foundational-bridge section, while the later quantitative program derives the weak-field mass-defect response $\Delta\omega/\omega_0 = \Delta\phi/c^2$, adopts an independently established trapped-ion Hamiltonian branch, separately reconstructs the published 2025 six-mode $^{27}Al^+$ secular-motion correction from published modal inputs, and retains a controlled quantum-motional forward domain. These results recover physical benchmarks but do not by themselves supply an ITOF-specific residual. Under the same complete physical-to-observable specification, the ITOF and relativistic branches need not separate; a novel foundation-sensitive prediction requires independently warranted new physical content and predeclared bridge-robust prediction separation.

The confrontation with relativity is therefore stated at two different levels. Lorentz transformations, frame-dependent simultaneity, metric geometry, and proper-time functionals remain well-defined model structures, but none is identified with the ITOF temporal referent. CMA is not Einstein synchronization, a preferred inertial frame, or a temporal ether. The foundational conflict is explicit only where a relativistic ontology denies any frame-independent universal common-stage co-realization. That ontological conflict is not itself an empirical discriminant: direct experimental attribution requires the independent bridge and prediction-separation conditions specified in V37/F17. The framework thus distinguishes temporal identity, physical realization, model success, and empirical discrimination without converting any one of them into another.

Keywords: ITOF; time; universal cosmic extension; invariant cosmic ordering; invariant cosmic succession; common cosmic change stages; common cosmic change-stage realization; Cosmic Change-Stage Population Postulate; Cosmic Moment Axiom; Universal Change Continuity; complete-population change coverage; system-specific physical change; integrated universal common-stage change realization; hierarchical physical systems; system-specific physical directionality; order-representation non-metricity; relational physical-realization augmentation; foundational stage-to-change bridge; typed physical application chain; mathematical-form-neutral physical dynamics; operational metric construction; mass-defect clock response; trapped-ion Hamiltonian; quantum motional clock response; quantitative bridge architecture; predictive separation; physical-system identity; physical history; Exact-Change-Stage Restraint; Non-Transfer Principle; relativistic temporal identification.

Authorship and Intellectual Provenance

The Invariant Temporal Ordering Framework was conceived, initiated, and developed by Youssry Ghandour through sustained independent research. V37/F17 is the historical-critical successor to V36/F16. It is not a cumulative restatement of all earlier formulations and does not inherit an earlier definition, axiom, postulate, dependency, equation, or explanatory wording merely because that item belongs to the historical ITOF sequence.

Historical priority and governing authority are distinguished. Earlier versions remain documentary evidence of the development of the framework. The governing status of a statement within V37/F17 is fixed by its explicit formal or explanatory role in V37/F17. V36/F16 is the immediate predecessor; earlier versions remain historical records rather than sources of independent governing authority.

The V14–V36 record is non-cumulative: it contains reformulations, discarded dependencies, changes of statement status, and later replacements of earlier wording. Its net historical direction nevertheless moves from measured physical realization and reassignment of time-attributed effects toward increasingly explicit universal system-specific change, common-stage realization, and a mature separation of temporal identity, physical causation, physical-system identity, observation, clocks, operational quantities, and relativistic representations. V25 introduced the Cosmic Moment Axiom within a substantially strengthened common-cosmic-stage architecture. The later foundation-series sequence clarified identity-bounded histories, formation and ending, conditional successor production, causal realization, quantitative clock-response modeling, the Non-Transfer Principle, and direct confrontation with relativistic temporal identification. V35/F15 consolidated a broad universal cosmic-succession architecture. V36/F16 then made the one universal cosmic extension of common cosmic change stages the governing denotational head while preserving the ordered pair $(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$, separating CMA from UCC, and making complete-population change coverage and the conservative Stage-to-Change Bridge explicit.

V37/F17 retains that temporal core. Its principal foundational development is a broader theory of how the complete qualified physical-system population is physically realized within the one common cosmic extension. The extension is not made into a container of physical states, causes, records, or dynamical laws. Rather, those physical structures are typed separately and indexed by the common cosmic change stages at which they are realized.

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 V37/F17 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.

Contents

1. Foundational Position, Historical Authority, and Statement Status

1.1 Foundational scope of V37/F17

V37/F17 retains the V36/F16 temporal referent while extending the theory of physical realization within that referent. The added architecture concerns system-specific states, changes, causal realization, hierarchical composition, physical histories, records, comparison maps, and model quantities; none is added to the definition of time. Accordingly, the governing distinction is between the temporal identity

$$T_{\mathrm{ITOF}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \tag{3}$$

and the typed physical-realization architecture indexed by members of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

1.2 Historical authority condition

Historical occurrence does not confer governing status:

$$\mathrm{HistoricalOccurrence}(Q) \not\Rightarrow \mathrm{GoverningStatus}_{37}(Q). \tag{4}$$

V36/F16 is the immediate governing predecessor [1]; the wider V14–V36 sequence is documented in the consolidated project and archive record [2]. Earlier formulations retain historical value, whereas the status of a V37/F17 statement is determined by the definitions, axioms, postulates, principles, and dependencies stated in V37/F17 itself.

1.3 Net historical direction

The following grouping is descriptive of the archive and does not make historical sequence a premise of the theory or an inheritance rule for V37/F17.

The V14–V20 sequence concentrated strongly on measurable physical realization, physical reassignment, residual structure, clock-related physical effects, and the emerging principle that operational success does not by itself establish a temporal ontology.

The V21–V24 sequence broadened the framework toward universal physical change-realization, system-specific realization, physical histories, universal temporal meaning, and progressively stronger separation between physical change and the temporal ordering under which change is realized.

The V25–V29 sequence developed the common cosmic stage, the Cosmic Moment Axiom, universal change continuity, identity-bounded histories, formation, ending, transformation, successor attribution, and a more explicit universal cosmic domain.

The V30–V34 sequence reconstructed the formal dependencies, strengthened identity criteria, causal realization, observation and exact-stage restraint, quantitative clock-response architecture, cumulative physical effects, and identity-ending semantics.

V35/F15 consolidated those lines into one broad architecture of universal cosmic succession and system-specific physical change.

V36/F16 then made the one universal cosmic extension of common cosmic change stages the denotational head of the theory, while explicitly separating:

$$\begin{gathered}\text{formal carrier membership,}\\ \text{literal full-theory common-change-stage realization,}\\ \text{CMA common-stage unity,}\\ \text{UCC memberwise physical-change actuality,}\\ \text{complete-population change coverage,}\\ \text{and the conservative foundational Stage-to-Change representation.}\end{gathered} \tag{5}$$

V37/F17 develops from that separation rather than reversing it.

1.4 Statement-status discipline

The following statuses are kept distinct throughout V37/F17:

$$\begin{gathered}\text{Definition},\quad \text{Axiom},\quad \text{Postulate},\quad \text{Principle},\\ \text{DefinedConstruction},\quad \text{Proposition},\quad \text{Corollary},\\ \text{PhysicalApplicationModel},\quad \text{ObservationModel},\quad \text{MethodologicalConstraint}\,.\end{gathered} \tag{6}$$

A defined construction does not become an independent axiom merely because it collects several governing commitments. A mathematical representation does not become the physical entity represented. A physical application model does not become the definition of time. An empirical protocol does not become a physical law.

Accordingly,

$$\begin{gathered}\text{Definition} \not\Rightarrow \text{PhysicalCause},\\ \text{Representation} \not\Rightarrow \text{RepresentedPhysicalIdentity},\\ \text{OperationalSuccess} \not\Rightarrow \text{TemporalIdentity}\,.\end{gathered} \tag{7}$$

1.5 Notation compression and semantic readability

V37/F17 uses compact symbols where repetition would otherwise obscure the mathematical structure, but it does not compress notation at the cost of type or statement-status ambiguity. Named foundational commitments therefore retain stable mnemonic symbols such as CMA, UCC, and CSPP, while a frequently recurring descriptive predicate may receive a local compact symbol after its meaning has been fixed. In particular, the phrase *Complete Physical Non-Change* is represented by $\mathsf{NC}_A^{\text{phys}}(s)$ after its definition in Eq. (64).

The governing notation policy is therefore selective rather than cosmetic:

$$\text{NotationCompression} \not\Rightarrow [\text{TypeDistinctionLost} \vee \text{DependencyStatusLost}]\,. \tag{8}$$

Long descriptive names are retained where they carry semantic or methodological content that would otherwise have to be reintroduced by explanatory prose. This keeps the equations readable without turning the formal language into an opaque alphabet of abbreviations.

V37/F17 also fixes one consequence-notation convention. The symbol $\nvdash$ is reserved for an explicit formal non-derivability or model-theoretic independence claim whose status is supported by the declared premise architecture, a countermodel, or the formal independence analysis. The symbol $\not\Rightarrow$ is used for ordinary non-sufficiency, non-transfer, observational insufficiency, or conceptual non-implication where no proof-theoretic consequence relation is being asserted. Definitional and type nonidentity continue to use $\not\equiv_{\text{def}}$ and $\not\equiv_{\text{type}}$, respectively. These symbols are not interchangeable merely for visual uniformity.

1.6 Framework architecture is not the temporal referent

V37/F17 may be represented at framework level by a tuple containing temporal, physical, identity, causal, observational, and operational modules. Such a tuple is a representation of the theory and is not a replacement definition of time.

Schematically,

$$\mathfrak{F}_{37} = \left\langle T_{\text{ITOF}}, \mathcal{U}_{\text{phys}}, \{\mathfrak{R}_{\text{C}}(s)\}_{s\in\mathcal{S}_{\text{C}}^{\text{tot}}}, \{\mathcal{H}_A\}_{A\in\mathcal{U}_{\text{phys}}}, \mathfrak{K}, \mathfrak{M}_{\text{phys}}, \mathfrak{M}_{\text{op}}, \mathfrak{O} \right\rangle. \tag{9}$$

The governing type restraint is

$$T_{\text{ITOF}} \not\equiv_{\text{def}} \mathfrak{F}_{37}. \tag{10}$$

Only the temporal component retains the governing definition

$$T_{\text{ITOF}} = \mathcal{E}_{\text{C}} = \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right). \tag{11}$$

The remaining components describe physical realization, representation, access, or application within the common cosmic extension.

2. Foundational Meaning of Time

2.1 Governing definition

Definition 2.1 (Time in ITOF V37/F17)**.** Time denotes the one universal cosmic extension of common cosmic change stages, constituted by their invariant universal earlier–later ordering and succession:

$$\boxed{T_{\text{ITOF}} := \mathcal{E}_{\text{C}} := \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right).} \tag{12}$$

Here $\mathcal{S}_{\text{C}}^{\text{tot}} \neq \varnothing$ is the formal universal common cosmic-stage carrier and $\prec_{\text{C}}$ is the one governing universal earlier–later relation.

The expression $\mathcal{E}_{\text{C}}$ names the same temporal referent as T_{ITOF}. It does not add a third member to the ordered pair:

$$T_{\text{ITOF}} = \mathcal{E}_{\text{C}} = \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right), \qquad \mathcal{E}_{\text{C}} \neq \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}, \text{AdditionalTemporalComponent}\right). \tag{13}$$

2.2 Meaning of universal cosmic extension

The expression *universal cosmic extension* does not denote spatial extension, metric duration, a material medium, a physical field, a causal carrier, or a container through which systems move.

It denotes the one common temporal extension constituted by the invariant earlier–later ordering and succession of the common cosmic change stages.

Thus:

$$\begin{aligned}
&\mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{SpatialLength}, && \mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{MetricDuration}, \\
&\mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{CoordinateInterval}, && \mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{ProperTimeFunctional}, \\
&\mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{PhysicalField}, && \mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{PhysicalMedium}, \\
&\mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{MovingCarrier}, && \mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{CausalAgent}, \\
&\mathcal{E}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{ClockOutput}\,.
\end{aligned} \tag{14}$$

The phrase *extension of common cosmic change stages* does not mean that the stages are objects located inside an independently existing temporal container. The extension is constituted by their one ordered succession.

2.3 Common cosmic change-stage carrier and full-theory role

Bare carrier membership

$$s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \tag{15}$$

is a formal type- and dependency-level condition.

It does not analytically entail:

$$s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \not\Rightarrow \forall A \in \mathcal{S}_{\mathrm{phys}}(s), \quad \mathrm{PhysReal}_A^{+}(s). \tag{16}$$

The physical role-name *common cosmic change stage* is nevertheless literal in every admissible full V37/F17 realization. A stage does not contain systems or contain change. It denotes the one common cosmic realization position at which the complete then-realized qualified population is co-realized and at which, under UCC, each realized bearer undergoes its own physical change. The full role is secured through the governing population, common-stage, and memberwise-change architecture:

$$\mathrm{CSPP} \wedge \mathrm{CMA} \wedge \mathrm{UCC} \Longrightarrow \mathrm{FullTheoryCommonCosmicChangeStageRole}\,. \tag{17}$$

This prevents circularity. The word *change* in the ontological role-name does not function as a hidden set-membership definition that would make UCC logically redundant.

A typed logical witness may therefore retain $s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ while violating UCC for dependency analysis. Such a witness is not an admissible physically changeless common cosmic change stage in the full V37/F17 theory.

2.4 Invariant universal earlier–later ordering

Axiom 2.2 (Strict Cosmic Ordering)**.** The governing earlier–later relation is a strict total order on $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$:

$$\boxed{\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right).} \tag{18}$$

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

$$r \neq s \Longrightarrow \left[(r \prec_{\mathrm{C}} s \ \vee \ s \prec_{\mathrm{C}} r) \wedge \neg\,(r \prec_{\mathrm{C}} s \ \wedge \ s \prec_{\mathrm{C}} r)\right]. \tag{19}$$

Strictness gives:

$$\neg(s \prec_{\mathrm{C}} s), \tag{20}$$

and transitivity gives:

$$r \prec_{\mathrm{C}} s \wedge s \prec_{\mathrm{C}} t \Longrightarrow r \prec_{\mathrm{C}} t. \tag{21}$$

Hence:

$$r \prec_{\mathrm{C}} s \Longrightarrow \neg\left(s \prec_{\mathrm{C}} r\right). \tag{22}$$

Physical recurrence cannot reverse this relation.

2.5 Order representations and non-metricity

The invariant earlier–later relation can be represented by labels without identifying those labels with the common cosmic change stages or with time. Let $(L, <_L)$ be a declared ordered representation domain and let

$$\iota : \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \longrightarrow L \tag{23}$$

be an injective order representation satisfying

$$\mathrm{OrderRepresentation}(\iota) \Longleftrightarrow \forall r, s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad r \prec_{\mathrm{C}} s \Longleftrightarrow \iota(r) <_L \iota(s). \tag{24}$$

No such numerical or coordinate representation is required by the definition of time. Where one is introduced, the labels remain representational:

$$\forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \iota(s) \not\equiv_{\mathrm{type}} s, \qquad \iota(s) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{25}$$

For a numerical representation, let

$$\iota : \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \longrightarrow J \subseteq \mathbb{R} \tag{26}$$

be an injective order representation, and let

$$f : J \longrightarrow J' \subseteq \mathbb{R} \tag{27}$$

be a strictly increasing injection. Define

$$\iota' := f \circ \iota. \tag{28}$$

Then the earlier–later representation is preserved:

$$\mathrm{OrderRepresentation}(\iota) \wedge \mathrm{StrictlyIncreasing}(f) \Longrightarrow \mathrm{OrderRepresentation}(f \circ \iota). \tag{29}$$

The target range need not coincide with the original numerical range; only order preservation is required.

A representational interval may be defined by

$$\Delta_\iota(r, s) := \iota(s) - \iota(r), \qquad r \prec_{\mathrm{C}} s. \tag{30}$$

Under the reparameterization,

$$\Delta_{\iota'}(r,s) = f(\iota(s)) - f(\iota(r))\,. \tag{31}$$

Order preservation alone does not entail equality of these numerical intervals:

$$\mathrm{OrderRepresentation}(\iota) \wedge \mathrm{StrictlyIncreasing}(f) \nvdash \Delta_{\iota'}(r,s) = \Delta_{\iota}(r,s). \tag{32}$$

For example, the strictly increasing map $f(x) = 2x$ preserves every order comparison while replacing each nonzero representational interval by $2\Delta_{\iota}(r,s)$. Thus interval magnitude is not fixed by the order relation alone. Consequently, the strict universal order by itself does not determine a canonical scalar interval magnitude:

$$\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{CanonicalMetricIntervalOn}(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}). \tag{33}$$

A metric, duration scale, clock scale, or numerical stage parameter therefore requires additional physical or mathematical structure. This proposition does not prohibit such structures; it fixes their status as additions to the bare order rather than constituents already determined by it.

2.6 Later physical similarity does not reverse order

Let K_A be a declared state-comparison criterion for system A. It may occur that:

$$r \prec_{\mathrm{C}} s \wedge K_A(X_A(r), X_A(s)) = \mathrm{Equivalent}\,. \tag{34}$$

Nevertheless:

$$r \prec_{\mathrm{C}} s \wedge K_A(X_A(r), X_A(s)) = \mathrm{Equivalent} \Longrightarrow \neg\,(s \prec_{\mathrm{C}} r)\,. \tag{35}$$

The later state may resemble or satisfy the same declared condition as an earlier state. The later common cosmic change stage remains later.

2.7 No motion of the temporal extension

Neither time nor the universal cosmic extension moves from stage to stage:

$$\neg\,\mathrm{Moves}\,(T_{\mathrm{ITOF}})\,, \qquad \neg\,\mathrm{Moves}\,(\mathcal{E}_{\mathrm{C}})\,. \tag{36}$$

Likewise, a common cosmic change stage is not a moving object transported through the extension:

$$\forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \neg\,\mathrm{StageMovesThroughTime}(s). \tag{37}$$

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

3. Invariant Uninterrupted Cosmic Succession

3.1 Non-interruption

Postulate 3.1 (Uninterrupted Cosmic Succession)**.** The actual common cosmic succession is uninterrupted in the governing non-metric sense:

$$\boxed{\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right).} \tag{38}$$

Its governing content is a primitive ontological constraint on the admitted actual succession. Within the admissible semantics of V37/F17, NoInterruption is satisfied exactly when the actual succession represented by $(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$ is not supplemented by an ontologically distinct temporal waiting state, suspension interval, or interruption layer outside $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ interposed between portions of that same succession. Its denial therefore commits to at least one such additional temporal interruption layer; it is not established merely by discreteness, failure of density, absence of adjacency, or failure of topological or metric continuity.

NoInterruption is thus not derived from Strict Cosmic Ordering and is not a metric or topological axiom. V37/F17 presently supplies no independent direct empirical operationalization of this postulate; its status remains that of a separately declared non-metric ontological succession commitment. In particular:

$$\begin{gathered}
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{DenseOrder}, \\
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{Adjacency}, \\
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{TopologicalContinuity}, \\
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{Differentiability}, \\
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{EqualSpacing}, \\
\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \nvdash \mathrm{MetricDuration}.
\end{gathered} \tag{39}$$

3.2 No terminal common cosmic change stage

Postulate 3.2 (Non-Terminating Cosmic Succession)**.** Every admitted common cosmic change stage has a later admitted common cosmic change stage:

$$\boxed{\mathrm{NoTerminalStage}_{\mathrm{C}} \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \exists t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\,(s \prec_{\mathrm{C}} t).} \tag{40}$$

The actual cosmic succession therefore has no greatest admitted common cosmic change stage.

This postulate does not derive cosmic continuation from the persistence, formation, ending, or successor production of any particular physical system.

3.3 Integrated succession statement

Definition 3.3 (Integrated Cosmic Succession Condition)**.** For compact reference:

$$\boxed{\mathrm{IntegratedCosmicSuccession}_{\mathrm{C}} \iff \mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \wedge \mathrm{NoTerminalStage}_{\mathrm{C}}.} \tag{41}$$

This is a defined conjunction. It does not merge the two succession commitments or alter their individual contrary conditions.

Under NoInterruption and NoTerminalStage, the actual cosmic succession is uninterrupted and continuing in the explicitly non-metric sense stated above.

3.4 Cosmic origin remains independent

The definition of time and the cosmic-succession postulates do not entail a least member of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$. If a cosmic origin is adopted, it therefore remains a separate cosmological commitment.

Postulate 3.4 (Cosmic Origin — Cosmological Module)**.**

$$\boxed{\mathrm{CosmicOrigin} \iff \exists! s_{\mathrm{C}}^{0} \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \setminus \{s_{\mathrm{C}}^{0}\}, \quad s_{\mathrm{C}}^{0} \prec_{\mathrm{C}} s.} \tag{42}$$

Cosmic Origin is not included in the minimal definition of time and is not entailed by NoTerminalStage:

$$\mathrm{NoTerminalStage}_{\mathrm{C}} \nvdash \mathrm{CosmicOrigin}\,. \tag{43}$$

Cosmic Origin therefore remains logically distinct from the governing denotation of time and from non-termination of the cosmic succession.

3.5 Full cosmic-stage totality and reference-stage order prefix

Membership in $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ means membership in the complete objective cosmic-stage totality admitted by V37/F17. It does not mean that every member is already not-later-than an arbitrarily chosen reference stage. For any admitted reference stage $a \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, define only the derived order prefix

$$\mathcal{S}_{\mathrm{C}}^{\leq a} := \Big\{ v \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid v = a \ \vee \ v \prec_{\mathrm{C}} a \Big\}\,. \tag{44}$$

Membership in this prefix is a relation to the declared reference stage a; it is not a second mode of stage existence and does not partition $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ into private temporal domains. Under non-termination,

$$\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \wedge \mathrm{NoTerminalStage}_{\mathrm{C}} \Longrightarrow \forall a \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \exists v \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \left[a \prec_{\mathrm{C}} v \wedge v \notin \mathcal{S}_{\mathrm{C}}^{\leq a} \right]. \tag{45}$$

Thus full-totality membership and reference-stage prefix membership are distinct. Any stage-relative reading of this construction refers only to membership in the derived order prefix relative to the declared reference stage. No second primitive stage-status predicate is introduced. The construction adds no metric, duration, adjacency, stage-count scale, moving present, generated frontier, presentism axiom, or third temporal component, and it does not alter $T_{\mathrm{ITOF}} = (\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$.

4. Physical Totality and Common Cosmic Change-Stage Realization

4.1 Qualified physical-system totality

Let the qualified physical-system totality be:

$$\boxed{\mathcal{U}_{\text{phys}} := \left\{ A \mid \text{PhysicalSystem}(A) \wedge \exists s \in \mathcal{S}_{\text{C}}^{\text{tot}} \ \text{ExistsAs}(A, s) \right\}.} \tag{46}$$

In V37/F17, the term *physical universe*, where used, denotes the totality of qualified physical systems considered by the framework; it does not denote a separate container in which those systems are placed. At stage s, $\mathcal{S}_{\text{phys}}(s)$ denotes the complete then-realized qualified population, not the contents of a stage-object.

This closes the governing domain against nominal systems having no realized identity range.

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

$$\boxed{I_A := \left\{ s \in \mathcal{S}_{\text{C}}^{\text{tot}} \mid \text{ExistsAs}(A, s) \right\}.} \tag{47}$$

Then:

$$\forall A \in \mathcal{U}_{\text{phys}}, \quad I_A \neq \varnothing. \tag{48}$$

I_A is an identity-realization range within the one universal common cosmic-stage carrier. It is not a private time belonging to A.

4.2 Complete stage-relative qualified population

At common cosmic change stage s, define:

$$\boxed{\mathcal{S}_{\text{phys}}(s) := \{ A \in \mathcal{U}_{\text{phys}} \mid s \in I_A \}.} \tag{49}$$

This set denotes the complete qualified physical-system population whose numerical identities are realized at s under the governing physical-system criterion.

Its membership is not an observer-knowledge set:

$$\mathcal{S}_{\text{phys}}(s) \neq \text{SystemsKnownToObserverAt}(s). \tag{50}$$

Nor is membership defined by detectability:

$$A \in \mathcal{S}_{\text{phys}}(s) \nRightarrow \text{Detected}(A; s). \tag{51}$$

4.3 Cosmic Change-Stage Population Postulate

Postulate 4.1 (Cosmic Change-Stage Population Postulate — CSPP)**.** Every admitted common cosmic change stage has a nonempty qualified physical-system population:

$$\boxed{\text{CSPP} \iff \forall s \in \mathcal{S}_{\text{C}}^{\text{tot}}, \quad \mathcal{S}_{\text{phys}}(s) \neq \varnothing.} \tag{52}$$

CSPP supplies population non-emptiness only. Common-stage co-realization and memberwise physical-change actuality are not definitional components of CSPP; they are governed separately by CMA and UCC.

Before stating CMA, fix the semantic status of its governing notation. For a qualified-system set $P \subseteq \mathcal{U}_{\mathrm{phys}}$ and an admitted stage $s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, $\mathrm{CosmicCoPresence}_{\mathrm{C}}(P; s)$ expresses the fixed semantic–ontological content of literal objective co-realization of the members of P at one and the same stage s of the single universal cosmic-stage domain. For typed use its signature is:

$$\boxed{\mathrm{CosmicCoPresence}_{\mathrm{C}} \;\subseteq\; \mathcal{P}(\mathsf{U}_{\mathrm{phys}}) \times \mathsf{S}_{\mathrm{C}}.} \tag{53}$$

Within the admissible-model semantics of V37/F17, this relation symbol is meaning-fixed. It is primitive only in the limited syntactic sense that its literal common-stage content is not definitionally reduced to population membership or to another already defined predicate. That syntactic status does not make $\mathrm{CosmicCoPresence}_{\mathrm{C}}$ an independently toggleable ontic degree of freedom or a freely reassignable interpretation while the declared meanings of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, stage identity, ExistsAs, and common-stage realization are held fixed. The notation is not defined by population membership or identity realization alone, and it does not mean that system-private stage domains are first formed and then synchronized, identified, or mapped onto s. In particular:

$$\mathrm{CosmicCoPresence}_{\mathrm{C}}(P; s) \not\equiv_{\mathrm{def}} [P = \{A \in \mathcal{U}_{\mathrm{phys}} \mid \mathrm{ExistsAs}(A, s)\}]\,. \tag{54}$$

The population construction answers *which qualified identities are realized at s*. CMA separately asserts that the complete then-realized population is literally co-realized at that same one objective common cosmic stage. A construction that keeps the declared meanings of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, s, ExistsAs, and $\mathcal{S}_{\mathrm{phys}}(s)$ fixed while replacing this common-stage content by mutually private system-stage domains changes the common-stage ontology rather than merely toggling an independent predicate within it.

4.4 Cosmic Moment Axiom

Axiom 4.2 (Cosmic Moment Axiom — CMA)**.** At every common cosmic change stage s, the complete qualified physical-system population whose numerical identities are then realized is literally co-realized at that same one objective stage of the single universal cosmic-stage domain, as expressed by $\mathrm{CosmicCoPresence}_{\mathrm{C}}$. By its fixed semantic–ontological meaning, this is not a synchronization or identification of system-private cosmic stage domains. Formally:

$$\boxed{\mathrm{CMA} \Longleftrightarrow \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right).} \tag{55}$$

CMA is the constitutive semantic–ontological meaning-fixing axiom of one-common-change-stage realization for the complete then-realized qualified population. Its common-stage meaning is fixed within the admissible V37/F17 semantics, while the applicability of that ontology to physical reality remains externally contestable through independently warranted physical and observational bridges. CMA is therefore not a freely toggleable empirical parameter under fixed common-stage semantics, and its constitutive status does not make it immune to an externally discriminating challenge. The word *complete* is exhaustive rather than observational or sample-relative: by Eq. (49), $\mathcal{S}_{\mathrm{phys}}(s)$ contains all and only qualified physical systems whose numerical identities are realized at s, whether or not they are detected, mutually interacting, or mutually signal-accessible. Its common-stage claim is read together with the already fixed history-domain conditions $I_A \subseteq \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ and $\mathrm{OrderOfHistory}(A) = \prec_{\mathrm{C}} |_{I_A}$. Hence CMA does not introduce a second ITOF cosmic-stage domain or private ITOF temporal referent for any system and does not permit the common population to be partitioned into mutually private system-stage sequences. Spatial separation, signal delay, or lack of mutual detectability does not divide the asserted common-stage co-realization; those are physical-access conditions rather than partitions of the common cosmic stage.

It asserts unity of the common cosmic change stage. It does not assert equality of physical states, changes, magnitudes, rates, causes, locations, clock readings, signal conditions, or observational outcomes.

Accordingly:

$$\mathrm{CMA} \nvdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A, B \in \mathcal{S}_{\mathrm{phys}}(s), \quad X_A(s) = X_B(s). \tag{56}$$

Likewise:

$$\mathrm{CMA} \nvdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A, B \in \mathcal{S}_{\mathrm{phys}}(s), \quad \Delta_A^{\mathrm{phys}}(s) = \Delta_B^{\mathrm{phys}}(s). \tag{57}$$

The second expression is to be read only where the respective change-content terms are well typed. CMA alone does not provide that typing.

CMA is also not definitionally reducible to population existence or memberwise change. CSPP and UCC do not define the literal one-common-stage co-realization relation fixed by CMA. CMA is separately adopted as the constitutive semantic–ontological axiom that supplies that relation in the full theory. Its foundational role is therefore not to cause physical change but to fix the single universal co-realization relation that would otherwise remain unasserted. No reverse model-theoretic non-entailment from UCC, or from CSPP together with UCC, to CMA is asserted merely from this definitional separation under the fixed common-stage semantics of V37/F17.

The formal contrary to CMA represents rejection of the one-common-stage ontological commitment. It is not, by definition alone, a directly observable local event. An empirical challenge to CMA therefore requires an independently specified physical and observational bridge from the common-stage commitment to a discriminating observable; clock disagreement, signal delay, spatial separation, or coordinate disagreement do not by themselves instantiate that contrary.

4.5 Common-stage unity does not imply universal interaction

For $A, B \in \mathcal{S}_{\mathrm{phys}}(s)$, CMA asserts their membership in the complete population literally co-realized at the same one objective common cosmic stage. That ontological unity does not supply a physical interaction or signal relation. Formally:

$$\mathrm{CMA} \nvdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A, B \in \mathcal{S}_{\mathrm{phys}}(s), \quad \mathrm{PhysicalInteraction}(A, B; s). \tag{58}$$

Likewise:

$$\mathrm{CMA} \nvdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A, B \in \mathcal{S}_{\mathrm{phys}}(s), \quad \mathrm{SignalAccessible}(A, B; s). \tag{59}$$

Common-stage unity is therefore not an all-to-all causal coupling postulate, signal-transmission rule, or synchronization procedure. Spatial separation, causal coupling, signal propagation, and record arrival remain physical relations with their own independently specified conditions.

5. Universal System-Specific Physical Change

5.1 Actual-change subset

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

$$I_A^{\Delta} := \left\{ s \in I_A \mid \mathrm{PhysReal}_A^{+}(s) \right\}. \tag{60}$$

The definition is restricted to actual-change pairs.

Let Ξ_A be the system-specific physical-change-content type appropriate to the physical description of A. Define:

$$\Delta_A^{\mathrm{phys}} : I_A^{\Delta} \longrightarrow \Xi_A. \tag{61}$$

This avoids assigning physical-change content to a pair at which actual physical change has been denied in a logical countermodel.

5.2 Universal Change Continuity

Postulate 5.1 (Universal Change Continuity — UCC)**.** For every qualified physical system and every common cosmic change stage within its realized identity range, that system realizes its own system-specific physical change:

$$\boxed{\mathrm{UCC} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \mathrm{PhysReal}_A^{+}(s).} \tag{62}$$

Accordingly, a qualified numerical identity does not occupy a member of its realized identity range without actual physical change. Criterion-relative stability, operational waiting, or non-detection does not constitute an exemption from UCC while that identity remains realized.

It follows:

$$\mathrm{UCC} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}}, \quad I_A^{\Delta} = I_A. \tag{63}$$

The word *continuity* in UCC means uninterrupted physical-change actuality throughout the realized identity range. It does not introduce a mathematical continuity structure, infinitesimal stage spacing, differentiability, or a continuous scalar change variable.

5.3 Qualitative actuality and exclusion of complete physical non-change

For $A \in \mathcal{U}_{\mathrm{phys}}$ and $s \in I_A$, define the direct qualitative contrary to actual physical-change realization by

$$\mathsf{NC}_A^{\mathrm{phys}}(s) \iff \neg\, \mathrm{PhysReal}_A^{+}(s). \tag{64}$$

This is a defined predicate, not an additional postulate. Under this definition, UCC has the exact equivalent form

$$\mathrm{UCC} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \neg \mathsf{NC}_A^{\mathrm{phys}}(s). \tag{65}$$

Thus UCC excludes complete physical non-change at every realized identity-stage pair. As a universal foundational postulate, its direct empirical burden is stronger than finite non-detection or a null result in selected variables: a direct contrary requires positive physical warrant for complete physical non-change of a qualified system at a realized stage. Ordinary benchmark recovery therefore does not establish UCC. The superscript "+" in $\mathrm{PhysReal}_A^+(s)$ marks actual physical-change realization; it does not denote positivity of a universal numerical magnitude.

Accordingly,

$$\mathrm{UCC} \nvdash \mathrm{UniversalScalarMagnitudeOfPhysicalChange}\,. \tag{66}$$

Terms such as *small*, *large*, *faster*, or *slower* therefore have no foundational meaning until a declared system-specific measurement or comparison construction supplies a numerical codomain and a criterion. Where an application introduces a scalar-valued specialization of that declared operational or comparison architecture,

$$\mu_{A;P,M} : \Xi_A \longrightarrow \mathbb{R}, \tag{67}$$

its numerical output characterizes the change only relative to the declared system, protocol, model, map, and criterion. This is an application-level special case of the general comparison architecture, not a second foundational scalarization layer. Neither UCC nor $\prec_\mathrm{C}$ supplies a universal map of this form.

A zero or unresolved result for selected variables is therefore not equivalent to complete physical non-change. For a declared protocol and model, and for $r, s \in I_A$ with $r \prec_\mathrm{C} s$, let $\mathrm{NoResolvedDifference}_{P,M}(A; r, s)$ denote failure of the selected observables to resolve a difference between the corresponding declared records or represented physical conditions. Then

$$\mathrm{NoResolvedDifference}_{P,M}(A; r, s) \not\Rightarrow \mathsf{NC}_A^{\mathrm{phys}}(s). \tag{68}$$

No adjacency, immediate predecessor, or exact-stage identification is introduced by this comparison. The distinction is compatible with criterion-relative stability and with non-detection while system-specific physical change remains actual.

5.4 CMA and UCC retain distinct governing roles

CMA and UCC answer different questions.

CMA:

$$\mathrm{WhichCommonCosmicChangeStageIsShared?} \tag{69}$$

UCC:

$$\mathrm{DoesEachRealizedQualifiedSystemPhysicallyChangeThere?} \tag{70}$$

Their governing distinction is:

$$\mathrm{CMA} \not\equiv_{\mathrm{def}} \mathrm{UCC}, \qquad \mathrm{CMA} \nvdash \mathrm{UCC}\,. \tag{71}$$

No reverse non-entailment is asserted here merely for symmetry.

5.5 System specificity

For distinct $A, B \in \mathcal{U}_{\mathrm{phys}}$:

$$A \neq B \not\Rightarrow \Xi_A = \Xi_B. \tag{72}$$

Even where an application supplies a common comparison space, mapped equality does not identify the physical changes themselves:

$$\phi_A\left(\Delta_A^{\mathrm{phys}}(s)\right) = \phi_B\left(\Delta_B^{\mathrm{phys}}(s)\right) \not\Rightarrow \Delta_A^{\mathrm{phys}}(s) \equiv_{\mathrm{type}} \Delta_B^{\mathrm{phys}}(s). \tag{73}$$

The realized change belongs to its bearer.

5.6 Universal change does not create universal change content

UCC universalizes actual change over qualified realized systems. It does not universalize the content of those changes.

Hence:

$$\mathrm{UCC} \nvdash \exists \Xi_{\mathrm{univ}}\ \forall A \in \mathcal{U}_{\mathrm{phys}}, \quad \Xi_A = \Xi_{\mathrm{univ}}. \tag{74}$$

Nor does it imply:

$$\mathrm{UCC} \nvdash \mathrm{OneUniversalChangeSubstance}. \tag{75}$$

5.7 Criterion-relative stability

Let K_A be a declared stability criterion.

It is possible that:

$$\mathrm{Stable}_{K_A}(A; s) \wedge \mathrm{PhysReal}_A^{+}(s). \tag{76}$$

There is no contradiction. Stability is criterion-relative; UCC concerns actual physical change of the qualified system.

Thus:

$$\mathrm{Stable}_{K_A}(A; s) \not\Rightarrow \mathsf{NC}_A^{\mathrm{phys}}(s). \tag{77}$$

Likewise, non-detection does not establish complete physical stasis:

$$\neg\, \mathrm{DetectedChange}_{P,M}(A; s) \not\Rightarrow \mathsf{NC}_A^{\mathrm{phys}}(s). \tag{78}$$

6. Integrated Universal Common-Stage Change Realization and Foundational Bridge Architecture

6.1 Change-realizing physical-system population

Define:

$$\mathcal{B}_\Delta(s) := \left\{ A \in \mathcal{S}_{\mathrm{phys}}(s) \mid \mathrm{PhysReal}_A^{+}(s) \right\}. \tag{79}$$

By definition:

$$\mathcal{B}_\Delta(s) \subseteq \mathcal{S}_{\mathrm{phys}}(s). \tag{80}$$

Proposition 6.1 (Complete-population change-coverage equivalence)**.** Under the governing definitions of I_A, $\mathcal{S}_{\mathrm{phys}}(s)$, and $\mathcal{B}_\Delta(s)$,

$$\boxed{\mathrm{UCC} \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathcal{B}_\Delta(s) = \mathcal{S}_{\mathrm{phys}}(s).} \tag{81}$$

Proof. Assume UCC. Let $s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ and $A \in \mathcal{S}_{\mathrm{phys}}(s)$. By the definition of $\mathcal{S}_{\mathrm{phys}}(s)$, $s \in I_A$.

UCC therefore gives $\mathrm{PhysReal}^{+}_{A}(s)$, so $A \in \mathcal{B}_{\Delta}(s)$. Together with the definitional inclusion $\mathcal{B}_{\Delta}(s) \subseteq \mathcal{S}_{\mathrm{phys}}(s)$, equality follows.

Conversely, assume $\mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s)$ for every $s \in \mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}$. Let $A \in \mathcal{U}_{\mathrm{phys}}$ and $s \in I_A$. Then $A \in \mathcal{S}_{\mathrm{phys}}(s)$, hence $A \in \mathcal{B}_{\Delta}(s)$, and therefore $\mathrm{PhysReal}^{+}_{A}(s)$. Thus UCC holds.

Proposition 6.2 (Universal non-null physical change realization)**.** Under CSPP and UCC, every admitted common cosmic change stage has a nonempty qualified population and the complete population realizes actual bearer-specific physical change:

$$\mathrm{CSPP} \wedge \mathrm{UCC} \Longrightarrow \forall s \in \mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \quad \mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing. \tag{82}$$

Define the stage-relative global null condition by

$$\mathrm{GlobalChangeNull}_{\mathrm{C}}(s) \Longleftrightarrow \mathcal{B}_{\Delta}(s) = \varnothing. \tag{83}$$

Then Eq. (82) gives

$$\mathrm{CSPP} \wedge \mathrm{UCC} \Longrightarrow \forall s \in \mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \quad \neg\, \mathrm{GlobalChangeNull}_{\mathrm{C}}(s). \tag{84}$$

The universality in this result is universality of physical-change actuality and population coverage. It is not equality of change content, magnitude, rate, or mechanism across systems, and it does not define a sum, norm, or scalar amount of "total cosmic change." A stage can therefore be globally non-null in physical change while its members realize changes of different types and while selected measured differences are individually zero, unresolved, small, or large under declared application criteria.

The succession commitments, complete-population change coverage, and CMA common-stage unity are collected in one defined condition without introducing an additional hierarchy of foundational realization conditions.

Definition 6.3 (Integrated Universal Common-Stage Change Realization — UCSCR)**.**

$$\boxed{\begin{aligned}\mathrm{UCSCR}_{\mathrm{C}} \Longleftrightarrow\ & \mathrm{IntegratedCosmicSuccession}_{\mathrm{C}} \wedge \forall s \in \mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \Big[\mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right) \\ & \wedge \mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing\Big].\end{aligned}} \tag{85}$$

Proposition 6.4 (Integrated UCSCR governing-equivalence)**.** Under the governing definitions of Integrated Cosmic Succession, CMA, CSPP, UCC, and complete-population change coverage,

$$\boxed{\mathrm{UCSCR}_{\mathrm{C}} \Longleftrightarrow \mathrm{IntegratedCosmicSuccession}_{\mathrm{C}} \wedge \mathrm{CMA} \wedge \mathrm{CSPP} \wedge \mathrm{UCC}\,.} \tag{86}$$

This definition introduces no new primitive commitment. The adjective *Integrated* is governing in the descriptive name: the condition collects succession commitments together with common-stage population and physical-change commitments without retyping succession as physical realization. The symbol $\mathrm{UCSCR}_{\mathrm{C}}$ is retained for notational continuity and does not erase that separation. The condition is the compact integration of four already distinct roles: succession is uninterrupted and non-terminal; the admitted population is nonempty; the complete then-realized qualified population is co-realized at literally the same one objective common cosmic change stage; and every member of that population realizes its own bearer-specific physical change there. UCSCR is evaluated within the already governing Strict Cosmic Ordering background; it neither replaces nor independently entails Strict Cosmic Ordering.

The condition does not merge CMA with UCC. CMA supplies common-stage unity; CSPP supplies population nonemptiness; UCC supplies memberwise physical-change actuality; and $\mathrm{IntegratedCosmicSuccession}_{\mathrm{C}}$ supplies the non-metric succession commitments. Falsity of any defining conjunct makes $\mathrm{UCSCR}_{\mathrm{C}}$ false. By contrast, omission of a commitment from a reduced premise set merely leaves its corresponding content unasserted unless that content is independently derived.

The word *universal* concerns complete qualified-population coverage and the single common stage domain. It does not assert equal states, equal change contents, equal magnitudes, equal rates, common mechanisms, common causes, or all-to-all interaction. The common stage is not a receptacle for systems or change. It denotes the shared cosmic realization position at which the systems and their own physical changes are realized.

Accordingly, throughout $\mathrm{UCSCR}_{\mathrm{C}}$, no realized qualified system is assigned an independent private stage in place of the common stage at which it is realized; no admitted stage is empty; and no admitted stage is globally change-null. This does not introduce adjacency, immediate successors, equal change increments, or a discrete step dynamics. A physical change may also remain below observational resolution; when a manifestation becomes resolved, the observation warrants realization at some common cosmic change stage without identifying that exact stage or its exact order position.

The distinction from physical dynamics is categorical: $\mathrm{UCSCR}_{\mathrm{C}}$ states universal common-stage change realization, whereas application-level physical dynamics specify how declared physical variables, states, fields, probabilities, or other model quantities are related or evolve. The formal non-equivalence is stated once in Section 18. Time, the common stage, CMA, UCC, and $\mathrm{UCSCR}_{\mathrm{C}}$ remain non-causal with respect to system-specific physical change.

This yields the full-theory common-stage realization statement without making common-stage unity a causal, metric, synchronization, or physical-dynamics law.

6.2 Early empirical-bridge orientation: atomic-clock response

The bridge architecture can be made concrete without promoting an application model into the temporal foundation. Consider the weak-field atomic-clock branch developed quantitatively in the later application sections. For externally specified physical inputs and a frozen protocol P, the application-level chain has the schematic form

$$(\omega_0, \phi_1, \phi_2, P) \overset{M_{\mathrm{MD}}}{\longmapsto} y_{12}^{\mathrm{MD}} = \frac{\phi_1 - \phi_2}{c^2} \overset{\mathcal{B}_P^{\mathrm{obs}}}{\rightsquigarrow} \widehat{y}_{12}. \tag{87}$$

The first arrow is a physical model-to-prediction map. The second is the declared measurement and record bridge, written in the generalized form-neutral relation notation used throughout V37/F17; in a deterministic clock-comparison protocol it may reduce to an ordinary map. Neither step is supplied by CMA, UCC, Integrated UCSCR, or the definition of time. The chain is empirically testable because the predicted clock-response quantity can be compared with a record under specified uncertainties and controls.

This example also fixes the present limit of the foundational claim. At the retained weak-field order, the later quantitative analysis shows that the same physical inputs recover the same leading gravitational clock-shift observable as the standard relativistic branch. Benchmark recovery therefore does not by itself yield foundation-sensitive prediction separation. A direct test of a foundational difference requires an independently warranted physical extension that changes at least one prediction-relevant component and produces a predeclared observable separation that survives admissible bridge freedom. Thus V37/F17 supplies an empirical route and an explicit falsification burden without inventing a theory-specific residual merely to make the ontology look testable.

6.3 Conditional discriminating thought-experiment template

A useful discriminating thought experiment must expose the missing physical burden rather than assume the desired result. Consider a predeclared domain $D^\star$ and protocol $P^\star$ for which the validated baseline physical model predicts an observable $y_{\text{base}}^{P^\star,D^\star}$. Suppose, only conditionally, that a future independently warranted ITOF-sensitive physical extension supplies a specific interaction

$$\widehat{H}_I = \widehat{H}_{\text{base}} + \lambda_X \widehat{O}_X, \qquad \widehat{H}_R = \widehat{H}_{\text{base}}, \tag{88}$$

with the operator, coupling provenance, preparation, acquisition model, and uncertainty budget fixed before outcome inspection. If that independently derived interaction produces the predeclared response coefficient $K_X^{P^\star,D^\star}$, the candidate observable separation has the schematic form

$$\Delta y_{I:R}^{P^\star,D^\star} = \lambda_X K_X^{P^\star,D^\star}. \tag{89}$$

A genuinely discriminating experiment would then require this separation to survive the admissible measurement bridges and declared covariance at a preassigned threshold.

These equations are a test template, not an ITOF prediction. V37/F17 presently does not derive $\lambda_X \neq 0$, does not select a unique $\widehat{O}_X$, and does not claim that the relativistic branch must exclude every independently warranted physical interaction of the same form. If the extra term lacks independent physical provenance, or if both branches admit the same complete physical-to-observable specification, the thought experiment collapses back to the non-separation result developed later. The scientific role of the template is therefore to identify what a future discriminating experiment must add without manufacturing prediction separation from ontology alone.

6.4 Common-stage system-change profile

Define:

Definition 6.5 (Common-stage system-change profile)**.**

$$\mathfrak{D}_{\mathrm{C}}(s) := \Big(A \mapsto \Delta_A^{\text{phys}}(s)\Big)_{A \in \mathcal{B}_\Delta(s)} \in \prod_{A \in \mathcal{B}_\Delta(s)} \Xi_A. \tag{90}$$

Under UCC:

$$\operatorname{dom} \mathfrak{D}_{\mathrm{C}}(s) = \mathcal{S}_{\text{phys}}(s). \tag{91}$$

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

6.5 Foundational Stage-to-Change Bridge

The V36/F16 Stage-to-Change definition is retained with the same minimal dependency content.

Definition 6.6 (Foundational Stage-to-Change Bridge)**.**

$$\boxed{\mathrm{StageChangeBridge}_{\mathrm{C}}(s) \iff \mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right) \wedge \left[\mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s)\right].} \tag{92}$$

The bridge contains:

(i) CMA-governed literal common-stage realization;

(ii) UCC-equivalent complete-population physical-change coverage.

It creates neither component.

Proposition 6.7 (Joint CMA–UCC equivalence)**.** Under the governing definitions:

$$(\mathrm{CMA} \wedge \mathrm{UCC}) \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathrm{StageChangeBridge}_{\mathrm{C}}(s). \tag{93}$$

With CSPP:

$$\{\mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}\} \vdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \left[\mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing \wedge \mathrm{StageChangeBridge}_{\mathrm{C}}(s)\right]. \tag{94}$$

6.6 Logical status of the foundational bridge

The Stage-to-Change Bridge is a conservative defined representation.

Therefore:

$$\mathrm{Status}(\mathrm{StageChangeBridge}_{\mathrm{C}}) = \mathrm{DefinedFoundationalRepresentation}. \tag{95}$$

It is not an additional axiom or postulate and has no causal, synchronization, observation, measurement, or prediction-law status.

In particular:

$$\mathrm{CommonCosmicChangeStage}(s) \nRightarrow \mathrm{StageCausesChange}(s). \tag{96}$$

Physical change remains realized by physical systems and receives its causal account from physical contributors.

6.7 Bridge-type separation and typed dynamics composition

V37/F17 separates the internal foundational Stage-to-Change representation from all application-level encoding, dynamics, prediction, and measurement constructions. The Stage-to-Change Bridge is the proposition

$$\mathrm{StageChangeBridge}_{\mathrm{C}}(s). \tag{97}$$

and is not itself a physical map.

For a declared application model M, let $\mathcal{I}_M^{\mathrm{phys}}$ be the declared physical-input domain and $\mathcal{I}_M^{\mathrm{model}}$ the corresponding typed model-input domain. The physical encoding bridge is

$$\mathcal{B}_M^{\mathrm{in}} : \mathcal{I}_M^{\mathrm{phys}} \longrightarrow \mathcal{I}_M^{\mathrm{model}}. \tag{98}$$

It assigns independently warranted physical conditions, parameters, boundaries, or preparations to the variables and inputs used by the application model. It does not itself determine their subsequent modeled evolution.

Let $\mathcal{Z}_M$ denote the declared model-realization or solution domain. The model dynamics are represented schematically by

$$\mathrm{Dyn}_M : \mathcal{I}_M^{\mathrm{model}} \rightsquigarrow \mathcal{Z}_M. \tag{99}$$

The symbol $\rightsquigarrow$ is mathematical-form-neutral: depending on the application, Dyn_M may be a deterministic map, evolution relation, stochastic kernel, quantum channel, constrained solution rule, field solution operator, or another independently specified physical-model rule.

The physical prediction bridge maps a model realization to declared predicted physical quantities or conditions:

$$\mathcal{B}_M^{\mathrm{out}} : \mathcal{Z}_M \longrightarrow \mathcal{Q}_M. \tag{100}$$

The codomain $\mathcal{Q}_M$ is a prediction domain; its members are not measurement records merely by being model outputs.

The measurement or observation bridge is represented schematically by

$$\mathcal{B}_{P,M}^{\mathrm{obs}} : \mathcal{Q}_M \rightsquigarrow \mathcal{R}_{P,M}. \tag{101}$$

where $\mathcal{R}_{P,M}$ is the declared record or observable-output domain under protocol P. The symbol $\rightsquigarrow$ does not impose a hidden deterministic reading: depending on the declared application, $\mathcal{B}_{P,M}^{\mathrm{obs}}$ may be a deterministic map, a stochastic kernel, a quantum-measurement map into a distributional record object, a record-generation relation, or another explicitly typed acquisition or reconstruction rule.

The governing non-conflation rule is therefore

$$\begin{aligned} &\mathrm{StageChangeBridge}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathcal{B}_M^{\mathrm{in}}, \qquad &&\mathrm{StageChangeBridge}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathrm{Dyn}_M, \\ &\mathrm{StageChangeBridge}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathcal{B}_M^{\mathrm{out}}, \qquad &&\mathrm{StageChangeBridge}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathcal{B}_{P,M}^{\mathrm{obs}}. \end{aligned} \tag{102}$$

The application chain is typed as

$$\mathcal{I}_M^{\mathrm{phys}} \xrightarrow{\mathcal{B}_M^{\mathrm{in}}} \mathcal{I}_M^{\mathrm{model}} \overset{\mathrm{Dyn}_M}{\rightsquigarrow} \mathcal{Z}_M \xrightarrow{\mathcal{B}_M^{\mathrm{out}}} \mathcal{Q}_M \overset{\mathcal{B}_{P,M}^{\mathrm{obs}}}{\rightsquigarrow} \mathcal{R}_{P,M}. \tag{103}$$

This displayed chain states type order, not universal determinism. The model-input and model-output bridges are written as maps at this level of abstraction. Both the dynamical rule and the measurement bridge may be non-functional, as indicated by $\rightsquigarrow$; when either is a relation, stochastic kernel, quantum channel or measurement rule, constrained solution rule, distribution-valued map, or another declared mathematical object, composition is interpreted according to the stated types rather than as ordinary function composition by default.

The Stage-to-Change proposition is not an input to this physical chain and does not make the common cosmic stage a physical cause of the record. A foundation-sensitive claim requires a separate logical derivation showing which foundational commitments, physical encoding premises, dynamical premises, prediction premises, acquisition premises, and auxiliaries support the claimed observable statement.

6.8 Foundational-to-observable derivational chain

Let F be a declared foundational commitment or conjunction of foundational commitments. Let B_{phys} denote the conjunction of independently warranted premises that fix the physical encoding, model dynamics, and model-to-prediction transformation for the declared application. Let B_{meas} denote independently warranted measurement, acquisition, calibration, and source–record premises, and let $\mathcal{P}_{\text{aux}}$ contain any additional declared auxiliary premises. For application M, the physical premise class may be resolved schematically as

$$B^{M}_{\text{phys}} := \text{Prem}[\mathcal{B}^{\text{in}}_{M}] \wedge \text{Prem}[\text{Dyn}_{M}] \wedge \text{Prem}[\mathcal{B}^{\text{out}}_{M}]. \tag{104}$$

Here $\text{Prem}[\cdot]$ denotes the conjunction of independently declared premises needed to specify the indicated component. This resolves the premise classes without identifying the encoding, dynamics, and prediction objects with one another.

A foundational observable claim requires:

$$F \wedge B_{\text{phys}} \wedge B_{\text{meas}} \wedge \mathcal{P}_{\text{aux}} \vdash O. \tag{105}$$

At the minimal derivational level, record the premise core of a foundation-to-observable bridge by:

$$\boxed{\text{DerivCore}\,[\text{FoundationalEmpiricalBridge}(F \rightsquigarrow O)] := (B_{\text{phys}}, B_{\text{meas}}, \mathcal{P}_{\text{aux}})\,.} \tag{106}$$

This equation does not define the later full empirical bridge tuple; it isolates only the premises that enter the derivation of O. The full tuple in Eq. (481) additionally carries covariance and attribution structure required for empirical assessment. Neither object is an ontological constituent of time.

The central restraint is that the Stage-to-Change Bridge alone contains no measurement or prediction map. Any nontrivial application-level observable claim attributed to it must instead be derived through explicit bridge premises:

$$\text{StageChangeBridge}_{\text{C}}(s) \wedge B_{\text{phys}} \wedge B_{\text{meas}} \wedge \mathcal{P}_{\text{aux}} \vdash O. \tag{107}$$

Likewise:

$$\text{StageChangeBridge}_{\text{C}} \not\equiv_{\text{type}} \text{FoundationalEmpiricalBridge}\,. \tag{108}$$

6.9 Failure attribution

Suppose:

$$F \wedge B_{\text{phys}} \wedge B_{\text{meas}} \wedge \mathcal{P}_{\text{aux}} \vdash O. \tag{109}$$

Then:

$$\neg O \not\Rightarrow \neg F. \tag{110}$$

A foundational attribution requires independent grounds that failure cannot be absorbed by failure or misspecification of the physical encoding–dynamics–prediction specification, the measurement or acquisition specification, auxiliary premises, parameter provenance, or the uncertainty model.

Accordingly:

$$\text{FoundationalAttribution}(F;\neg O) \Longrightarrow \begin{bmatrix} \text{BridgeIndependentlySpecified} \\ \wedge\ \text{AuxiliariesIndependentlySpecified} \\ \wedge\ \text{AcquisitionSupportValid} \\ \wedge\ \text{UncertaintyStructureValid} \\ \wedge\ \text{PredictionSeparationIdentifiable} \\ \wedge\ \text{AlternativeAttributionControlled} \end{bmatrix}. \tag{111}$$

This condition is necessary, not sufficient.

6.10 Bridge architecture and theory identity

An application may introduce new physical and measurement bridges without redefining time:

$$\text{NewPhysicalBridge} \wedge \text{NewMeasurementBridge} \not\Rightarrow \text{NewDefinitionOfTime}\,. \tag{112}$$

Conversely, an application that silently replaces the temporal referent with a model parameter, clock output, metric interval, or proper-time functional is not an identity-preserving ITOF application.

The bridge architecture therefore has a dual function:

(i) it permits independently developed physical theories and measurement models to connect ITOF commitments to testable quantities;
(ii) it prevents those physical or operational quantities from acquiring temporal identity merely because they occur in a successful bridge.

This separation also applies to physical dynamics, operational metrics, clocks, observation, empirical discrimination, and direct confrontation with relativistic temporal identifications.

7. System-Specific Physical State and Common-Stage State Realization

7.1 System-specific physical state spaces

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

$$\Omega_A \tag{113}$$

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

Define:

$$X_A : I_A \longrightarrow \Omega_A. \tag{114}$$

For every $s \in I_A$,

$$X_A(s) \tag{115}$$

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

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

$$s \not\equiv_{\text{type}} X_A(s). \tag{116}$$

Likewise, under UCC,

$$s \not\equiv_{\text{type}} \Delta_A^{\text{phys}}(s). \tag{117}$$

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:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \wedge A \neq B \not\Rightarrow \Omega_A = \Omega_B. \tag{118}$$

Accordingly, V37/F17 introduces no universal physical-state space Ω_{univ} satisfying

$$\text{CommonStageRealization} \not\Rightarrow \exists \Omega_{\text{univ}} \, \forall A \in \mathcal{U}_{\text{phys}}, \quad \Omega_A = \Omega_{\text{univ}}. \tag{119}$$

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 $s \in \mathcal{S}_{\text{C}}^{\text{tot}}$, 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:

$$\mathfrak{X}_{\text{C}}(s) := (A \mapsto X_A(s))_{A \in \mathcal{S}_{\text{phys}}(s)} \in \prod_{A \in \mathcal{S}_{\text{phys}}(s)} \Omega_A. \tag{120}$$

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:

$$\mathfrak{X}_{\text{C}}(s) \not\equiv_{\text{def}} \text{OneUniversalPhysicalState}(s). \tag{121}$$

Nor does the existence of the profile imply:

$$\text{Defined}(\mathfrak{X}_{\text{C}}(s)) \not\Rightarrow \forall A, B \in \mathcal{S}_{\text{phys}}(s), \quad X_A(s) = X_B(s). \tag{122}$$

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

7.4 Common stage does not become a universe-wide system 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 $\mathfrak{X}_{\text{C}}(s)$ 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 $\mathfrak{X}_{\text{C}}(s)$.

8. System-Specific Physical Causation

8.1 Causation remains physical and bearer-specific

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.

For every actual-change pair:

$$A \in \mathcal{U}_{\text{phys}}, \qquad s \in I_A^{\Delta}, \tag{123}$$

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

The following are not causal-source classes:

$$\begin{Bmatrix} T_{\text{ITOF}}, \mathcal{E}_{\text{C}}, s, \prec_{\text{C}}, \text{CSPP}, \text{CMA}, \text{UCC}, \\ \text{IntegratedCosmicSuccession}_{\text{C}}, \text{UCSCR}_{\text{C}}, \text{StageChangeBridge}_{\text{C}}, \text{CRP} \end{Bmatrix} \tag{124}$$
$$\cap\, \text{PhysicalCausalSourceClass} = \varnothing.$$

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.

8.2 Three physical causal-source classes

For system A at s, retain the V36/F16 causal-source taxonomy.

Let:

$$\mathcal{C}_A^{\text{int}}(s) \tag{125}$$

denote operative internal physical contributors arising from the constitution, organization, properties, relations, retained physical conditions, and internal processes of A.

Let:

$$\mathcal{C}_A^{\text{ext-sys}}(s) \tag{126}$$

denote independently realized physical systems external to the declared boundary of A whose physically realized interactions, couplings, transfers, contacts, emissions, constraints, or other established physical influences contribute to the change realized by A.

Let:

$$\mathcal{C}_A^{\text{ext-fac}}(s) \tag{127}$$

denote operative external physical factors that contribute to the realized change but are not independently classified as physical-system identities under the applicable identity criterion.

The causal profile is:

$$\mathfrak{C}_A(s) := \left(\mathcal{C}_A^{\text{int}}(s), \mathcal{C}_A^{\text{ext-sys}}(s), \mathcal{C}_A^{\text{ext-fac}}(s)\right). \tag{128}$$

For one declared system boundary and one causal attribution:

$$\text{PairwiseDisjoint}\left(\mathcal{C}_A^{\text{int}}(s), \mathcal{C}_A^{\text{ext-sys}}(s), \mathcal{C}_A^{\text{ext-fac}}(s)\right). \tag{129}$$

The complete actual causal-source set is:

$$\mathcal{C}_A^{\text{act}}(s) := \mathcal{C}_A^{\text{int}}(s) \cup \mathcal{C}_A^{\text{ext-sys}}(s) \cup \mathcal{C}_A^{\text{ext-fac}}(s). \tag{130}$$

No fourth unrestricted causal class is created to absorb incomplete knowledge.

8.3 Actual physical contribution

Let:

$$\text{PhysicallyContributes}\left(c; \Delta_A^{\text{phys}}(s)\right) \tag{131}$$

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:

$$c \in \mathcal{C}_A^{\text{act}}(s) \iff \text{PhysicallyContributes}\left(c; \Delta_A^{\text{phys}}(s)\right). \tag{132}$$

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.

8.4 Quantum and stochastic physical models

The three causal-source classes are classified by the contributor's physical role relative to the declared boundary of A, not by whether the application model is classical, deterministic, stochastic, or quantum. A quantum description may represent physically instantiated internal degrees of freedom, interactions, or couplings associated with A; independently realized external systems that physically interact or couple with A; and warranted external physical factors that are not separately classified as system identities under the governing criterion. The mathematical state, operator, channel, probability law, or Hamiltonian used to represent such physical content is not itself promoted to a physical causal source merely by appearing in the model.

Entanglement, correlation, or nonfactorization alone does not establish PhysicallyContributes. Causal membership requires an independently warranted physical contribution 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.

If a declared interpretation of a quantum process positively denies that any actual physical contributor exists in all three admissible classes for a change that nevertheless satisfies $\text{PhysReal}_A^{+}(s)$, then that application stands in direct tension with CRP. V37/F17 does not resolve such a tension by inventing a fourth unrestricted causal class or by reclassifying probability, entanglement, the common stage, or time itself as a cause.

8.5 Causal Realization Principle

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

$$\boxed{\mathrm{CRP} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \mathrm{PhysReal}_A^{+}(s) \Longrightarrow \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing.} \tag{133}$$

CRP and UCC have different functions:

$$\mathrm{UCC} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \mathrm{PhysReal}_A^{+}(s), \tag{134}$$

$$\mathrm{CRP} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \mathrm{PhysReal}_A^{+}(s) \Longrightarrow \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing. \tag{135}$$

Thus:

$$\{\mathrm{UCC}, \mathrm{CRP}\} \vdash \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \mathrm{PhysReal}_A^{+}(s) \wedge \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing. \tag{136}$$

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

8.6 Failure to identify a cause is not absence of physical causation

Epistemic incompleteness is not a fourth causal category.

Thus:

$$\mathrm{CauseNotIdentified}_{P,M}(A; s) \not\Rightarrow \mathcal{C}_A^{\mathrm{act}}(s) = \varnothing. \tag{137}$$

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.

8.7 Common-stage causal-realization profile

For each admitted stage s, define:

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

$$\mathfrak{G}_{\mathrm{C}}(s) := \Big(A \mapsto \mathcal{C}_A^{\mathrm{act}}(s)\Big)_{A \in \mathcal{S}_{\mathrm{phys}}(s)}. \tag{138}$$

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

In a governing V37/F17 realization satisfying UCC and CRP:

$$\{\mathrm{UCC}, \mathrm{CRP}\} \vdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \forall A \in \mathcal{S}_{\mathrm{phys}}(s), \quad \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing. \tag{139}$$

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

$$\mathrm{Defined}(\mathfrak{G}_{\mathrm{C}}(s)) \not\Rightarrow \exists c\ \forall A \in \mathcal{S}_{\mathrm{phys}}(s), \quad c \in \mathcal{C}_A^{\mathrm{act}}(s). \tag{140}$$

Nor does it imply one common causal mechanism:

$$\mathrm{Defined}(\mathfrak{G}_{\mathrm{C}}(s)) \not\Rightarrow \mathrm{OneUniversalCausalMechanism}(s). \tag{141}$$

9. Complete-Population Common-Stage Physical-Realization Architecture

9.1 Motivation and scope

V36/F16 made complete-population physical-change coverage explicit.

V37/F17 extends that result without redefining time.

CMA already fixes literal one-common-stage co-realization for the complete then-realized qualified population within the single universal stage domain, and UCC already fixes memberwise system-specific physical-change actuality. The additional V37/F17 requirement is therefore representational: complete population coverage must be expressible without erasing bearer-specific state, change, or causal typing. This role is served by the dependent population-indexed physical-realization architecture.

9.2 Aligned domains in the governing theory

The state profile has domain:

$$\mathrm{dom}\,\mathfrak{X}_{\mathrm{C}}(s) = \mathcal{S}_{\mathrm{phys}}(s). \tag{142}$$

The change profile has domain:

$$\mathrm{dom}\,\mathfrak{D}_{\mathrm{C}}(s) = \mathcal{B}_{\Delta}(s)\,. \tag{143}$$

Under UCC:

$$\mathrm{dom}\,\mathfrak{D}_{\mathrm{C}}(s) = \mathcal{S}_{\mathrm{phys}}(s). \tag{144}$$

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

Therefore:

$$\{\mathrm{UCC}, \mathrm{CRP}\} \vdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \begin{aligned} \mathrm{dom}\,\mathfrak{X}_{\mathrm{C}}(s) &= \mathcal{S}_{\mathrm{phys}}(s), \\ \mathrm{dom}\,\mathfrak{D}_{\mathrm{C}}(s) &= \mathcal{S}_{\mathrm{phys}}(s), \\ \mathrm{dom}\,\mathfrak{G}_{\mathrm{C}}(s) &= \mathcal{S}_{\mathrm{phys}}(s). \end{aligned} \tag{145}$$

With CSPP:

$$\{\mathrm{CSPP}, \mathrm{UCC}, \mathrm{CRP}\} \vdash \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing. \tag{146}$$

CMA separately supplies literal common-stage unity for that population.

9.3 Definition of the complete physical-realization profile

Definition 9.1 (Complete-Population Common-Stage Physical-Realization Profile)**.** In a governing V37/F17 realization, define:

$$\boxed{\mathfrak{R}_{\mathrm{C}}(s) := (\mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s))\,.} \tag{147}$$

The profile is indexed by the complete qualified population $\mathcal{S}_{\text{phys}}(s)$ under the governing physical-system qualification and numerical-identity conditions. Its completeness is exactly completeness of representation over that population. It 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 atomic-clock carriers $C, D \in \mathcal{S}_{\text{phys}}(s)$ in a governing realization satisfying UCC and CRP. Their stage-relative entries may be written as

$$X_C(s) \in \mathcal{X}_C, \qquad \Delta_C^{\text{phys}}(s) \in \Xi_C, \qquad \mathcal{C}_C^{\text{act}}(s) \neq \varnothing, \tag{148}$$

$$X_D(s) \in \mathcal{X}_D, \qquad \Delta_D^{\text{phys}}(s) \in \Xi_D, \qquad \mathcal{C}_D^{\text{act}}(s) \neq \varnothing. \tag{149}$$

CMA supplies literal common-stage co-realization of the complete then-realized qualified population containing C and D:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right). \tag{150}$$

Nothing in this common-stage statement 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 carriers 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_{ITOF}. 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) $\mathfrak{X}_{\text{C}}(s)$ represents the system-specific physical states realized by that population;
(iii) $\mathfrak{D}_{\text{C}}(s)$ represents the system-specific physical-change contents realized by that population under UCC;
(iv) $\mathfrak{G}_{\text{C}}(s)$ 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:

$$\pi_{\text{pop}}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) = \mathcal{S}_{\text{phys}}(s), \tag{151}$$

$$\pi_{\text{state}}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) = \mathfrak{X}_{\mathrm{C}}(s)\,, \tag{152}$$

$$\pi_{\text{change}}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) = \mathfrak{D}_{\mathrm{C}}(s)\,, \tag{153}$$

$$\pi_{\text{cause}}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) = \mathfrak{G}_{\mathrm{C}}(s)\,. \tag{154}$$

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

$$\text{ComponentsFixed}\left(\mathcal{S}_{\text{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s)\right) \Longrightarrow \text{ProfileUniquelyFixed}\left(\mathfrak{R}_{\mathrm{C}}(s)\right). \tag{155}$$

This is the formal sense in which the central V37/F17 profile is an integrating construction rather than a new 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

$$\mathcal{R}_M(s) \tag{156}$$

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

$$\mathfrak{R}_{\mathrm{C}}^{[M]}(s) := \left(\mathfrak{R}_{\mathrm{C}}(s)\,, \mathcal{R}_M(s)\right). \tag{157}$$

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:

$$\mathfrak{R}_{\mathrm{C}}^{[M]}(s) \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad \mathfrak{R}_{\mathrm{C}}^{[M]}(s) \not\equiv_{\text{type}} \text{TemporalComponent}\,. \tag{158}$$

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 V37/F17 definition of time.

9.7 Population completeness, physical multiplicity, and representational scope

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

$$\text{ProfileDomain}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) = \mathcal{S}_{\text{phys}}(s). \tag{159}$$

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

$$\text{CompletePopulationCoverage}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) \not\Rightarrow \text{ExhaustivePhysicalDescriptionAt}(s). \tag{160}$$

In particular:

$$\begin{aligned} &\text{CompletePopulationCoverage}(\mathfrak{R}_{\mathrm{C}}(s)) \not\Rightarrow \text{OneUniversalState}, \\ &\text{CompletePopulationCoverage}(\mathfrak{R}_{\mathrm{C}}(s)) \not\Rightarrow \text{OneUniversalChangeContent}, \\ &\text{CompletePopulationCoverage}(\mathfrak{R}_{\mathrm{C}}(s)) \not\Rightarrow \text{OneUniversalCausalSet}\,. \end{aligned} \tag{161}$$

The same non-entailment applies to a universal change magnitude, change rate, or physical mechanism. The relational augmentation of Eq. (157) 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:

$$\mathfrak{R}_{\mathrm{C}}(s) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{162}$$

Nor is:

$$\mathfrak{R}_{\mathrm{C}}(s) \not\equiv_{\mathrm{type}} s. \tag{163}$$

Nor does V37/F17 redefine time by adjoining the realization-profile family:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{def}} \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}, \{\mathfrak{R}_{\mathrm{C}}(s)\}_{s\in\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}}\right). \tag{164}$$

The governing time definition remains Eq. (12); the realization-profile family is not appended to that ordered pair.

The physical-realization profiles belong to the physical architecture realized within the common cosmic extension.

9.9 Ontological population completeness is not epistemic completeness

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

Thus:

$$\text{CompletePopulationCoverage}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) \not\Rightarrow \text{CompleteObservation}\left(\mathfrak{R}_{\mathrm{C}}(s)\right). \tag{165}$$

And:

$$\text{CompletePopulationCoverage}\left(\mathfrak{R}_{\mathrm{C}}(s)\right) \not\Rightarrow \text{CompleteScientificKnowledge}\left(\mathfrak{R}_{\mathrm{C}}(s)\right). \tag{166}$$

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

9.10 Full-profile consequences under UCSCR 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 UCSCR and CRP, the governing stage-relative conditions are:

$$\begin{aligned} \mathrm{UCSCR_C} \wedge \mathrm{CRP} \Longrightarrow \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \\ \mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing \wedge \mathrm{StageChangeBridge_C}(s), \\ \forall A \in \mathcal{S}_{\mathrm{phys}}(s), \quad \mathcal{C}_{A}^{\mathrm{act}}(s) \neq \varnothing. \end{aligned} \tag{167}$$

This is a derived consequence of already declared commitments, not a new layer or independent foundational predicate. The Physical Realization Profile records the typed physical content at a stage; the Stage-to-Change Bridge retains the narrower CMA–UCC representation; UCSCR supplies the integrated global realization condition; and CRP supplies physical causal realization.

10. Hierarchical Physical-System Composition

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 at the same common 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 $\mathcal{S}_{\mathrm{phys}}(s)$, 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

A physical reality may support several scientifically legitimate system boundaries at different levels of organization.

A physical system may contain:

$$\begin{gathered} \text{constituents,} \quad \text{subsystems,} \quad \text{components,} \quad \text{organized substructures,} \\ \text{or other independently identifiable physical-system identities.} \end{gathered} \tag{168}$$

V37/F17 does not infer numerical physical-system identity merely from linguistic description, spatial inclusion, material overlap, or analytical convenience.

Composition therefore requires a declared physical composition criterion κ.

10.2 Stage-relative constituent relation

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

$$A \triangleleft_{\kappa,s} B \tag{169}$$

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:

$$A \lhd_{\kappa,s} B \Longrightarrow A, B \in \mathcal{S}_{\text{phys}}(s) \wedge A \neq B. \tag{170}$$

The relation concerns simultaneously realized physical identities.

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

$$A \lhd_{\kappa,s} B \not\Rightarrow A \equiv_{\text{type}} X_B(s). \tag{171}$$

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

10.3 Composition profile

Define:

$$\boxed{\mathfrak{K}_{\text{C}}(s) := \{(A, B, \kappa) \mid A \lhd_{\kappa,s} B\}.} \tag{172}$$

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:

$$\text{Defined}(\mathfrak{K}_{\text{C}}(s)) \not\Rightarrow \text{OneUniqueHierarchy}(s), \tag{173}$$

$$\text{Defined}(\mathfrak{K}_{\text{C}}(s)) \not\Rightarrow \text{OneUniversalTreeOfSystems}(s). \tag{174}$$

Likewise, V37/F17 does not universally postulate transitivity of $\lhd_{\kappa,s}$. From composition membership alone, without an additional closure condition on the declared criterion κ, the transitive conclusion is not a V37/F17 consequence:

$$A \lhd_{\kappa,s} B \wedge B \lhd_{\kappa,s} C \nvdash_{\text{V37}} A \lhd_{\kappa,s} C. \tag{175}$$

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

$$\text{TransitiveCompositionCriterion}(\kappa; \mathcal{A}) \tag{176}$$

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 Not every physical constituent is automatically a qualified system

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

Therefore:

$$\text{PhysicalConstituentOf}(x, B; s) \not\Rightarrow x \in \mathcal{U}_{\text{phys}}. \tag{177}$$

The relation

$$A \lhd_{\kappa,s} B \tag{178}$$

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 applies independently at each qualified level

If:

$$A \lhd_{\kappa,s} B, \tag{179}$$

then:

$$A, B \in \mathcal{S}_{\text{phys}}(s). \tag{180}$$

Under UCC:

$$A \lhd_{\kappa,s} B \wedge \text{UCC} \Longrightarrow \text{PhysReal}^{+}_{A}(s) \wedge \text{PhysReal}^{+}_{B}(s). \tag{181}$$

These are two bearer-specific physical-change realizations.

The result does not imply:

$$A \lhd_{\kappa,s} B \wedge \text{UCC} \nvdash \Delta^{\text{phys}}_{A}(s) = \Delta^{\text{phys}}_{B}(s). \tag{182}$$

Nor does it imply:

$$A \lhd_{\kappa,s} B \not\Rightarrow \Xi_A = \Xi_B. \tag{183}$$

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:

$$A \lhd_{\kappa,s} B \not\Rightarrow \text{PhysicallyDetermines}_{\kappa} \left(\Delta^{\text{phys}}_{A}(s); \Delta^{\text{phys}}_{B}(s)\right). \tag{184}$$

Likewise:

$$A \lhd_{\kappa,s} B \not\Rightarrow \text{PhysicallyDetermines}_{\kappa} \left(\Delta^{\text{phys}}_{B}(s); \Delta^{\text{phys}}_{A}(s)\right). \tag{185}$$

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 of constituent change

Even where qualified constituents

$$A_1, \ldots, A_n$$

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

$$\left[\bigwedge_{i=1}^{n} A_i \triangleleft_{\kappa_i,s} B\right] \not\Rightarrow \Delta_B^{\text{phys}}(s) = \sum_{i=1}^{n} \Delta_{A_i}^{\text{phys}}(s). \tag{186}$$

Such an expression may be mathematically ill typed because:

$$\Xi_{A_i} \neq \Xi_{A_j} \tag{187}$$

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 external-system contribution merely because A also possesses an independently qualified physical-system identity.

Thus the causal classification depends jointly on:

$$\langle \text{NumericalIdentity}, \text{DeclaredSystemBoundary}, \text{PhysicalCausalRole} \rangle . \tag{188}$$

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:

$$A \triangleleft_{\kappa,s} B, \tag{189}$$

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:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow \text{PrivateTime}(A) \vee \text{PrivateTime}(B). \tag{190}$$

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

11. Numerical Physical-System Identity and Formation

11.1 Governing identity notion

Unless an application explicitly declares another domain-specific identity notion, V37/F17 uses numerical physical-system identity.

The relevant question is:

$$\text{IsThisTheSamePhysicalSystem?} \tag{191}$$

rather than:

$$\text{DoesThisSystemHaveTheSameState?} \tag{192}$$

Accordingly:

$$\text{SameNumericalIdentity}_A(r, s) \not\Rightarrow X_A(r) = X_A(s). \tag{193}$$

Identity persistence is compatible with physical change.

11.2 Material continuity is not sufficient for numerical identity

A later system may:

$$\begin{gathered}\text{contain earlier constituents,} \quad \text{contain transferred matter,} \quad \text{occupy a similar region,} \\ \text{perform a similar function,} \quad \text{or resemble an earlier system}\end{gathered} \tag{194}$$

without being numerically identical to that earlier system.

Hence:

$$\text{MaterialOverlap}(A, B) \not\Rightarrow A = B. \tag{195}$$

And:

$$\text{FunctionalEquivalence}(A, B) \not\Rightarrow A = B. \tag{196}$$

The applicable physical identity criterion governs the attribution.

11.3 Identity-Realization Convexity

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

$$\boxed{r \in I_A \wedge t \in I_A \wedge r \prec_{\text{C}} s \wedge s \prec_{\text{C}} t \Longrightarrow s \in I_A.} \tag{197}$$

The principle prevents an internal gap in one numerical physical-system identity.

Equivalently:

$$r, t \in I_A \wedge r \prec_{\text{C}} s \prec_{\text{C}} t \Longrightarrow \neg(s \notin I_A). \tag{198}$$

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.

11.4 Actual Formation Boundary

Postulate 11.2 (Actual Formation Boundary — AFB)**.** Every qualified physical-system identity has one unique least member of its realized identity range:

$$\boxed{\text{AFB} \Longleftrightarrow \forall A \in \mathcal{U}_{\text{phys}}\ \exists! f \in I_A \left[\nexists r \in I_A \left(r \prec_{\text{C}} f\right)\right].} \tag{199}$$

Let the unique least member be:

$$f_A. \tag{200}$$

Define:

$$f : \mathcal{U}_{\text{phys}} \longrightarrow \mathcal{S}_{\text{C}}^{\text{tot}}, \qquad f(A) = f_A. \tag{201}$$

Formation is the physical realization of a new numerical physical-system identity.

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

$$r \prec_{\text{C}} f_A \Longrightarrow \neg\,\text{ExistsAs}(A, r). \tag{202}$$

No earlier state of A exists before f_A, because the numerical identity A is not yet realized.

Earlier physical contributors from which A forms may possess their own histories. Those histories are not earlier states of A.

11.5 Formation change

Formation change denotes the identity-constituting physical realization of the newly formed system at f_A. It is not defined as a finite difference between two states of a numerically pre-existing A, and it does not require an earlier state of that same numerical identity.

Define:

$$\boxed{\text{FormationChange}_A(s) \Longleftrightarrow s = f_A \wedge \text{PhysReal}_A^+(s).} \tag{203}$$

AFB and UCC give:

$$\{\text{AFB}, \text{UCC}\} \vdash \forall A \in \mathcal{U}_{\text{phys}}, \quad \text{FormationChange}_A(f_A). \tag{204}$$

The causal contributors to formation change remain physical contributors in the sense of CRP; T_{ITOF}, f_A, $\prec_{\text{C}}$, CMA, and UCC are not additional causal-source classes.

Under CRP:

$$\{\text{AFB}, \text{UCC}, \text{CRP}\} \vdash \forall A \in \mathcal{U}_{\text{phys}}, \quad \mathcal{C}_A^{\text{act}}(f_A) \neq \varnothing. \tag{205}$$

11.6 Formation does not imply cosmic origin

AFB concerns each physical-system identity separately.

Therefore:

$$\text{AFB} \nvdash \text{CosmicOrigin}\,. \tag{206}$$

Only the optional Cosmic Origin postulate determines whether $\mathcal{S}_{\text{C}}^{\text{tot}}$ possesses a least common cosmic change stage.

12. Identity-Bounded Physical History

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:

$$I_A \subseteq \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}. \tag{207}$$

The restriction:

$$\prec_{\mathrm{C}}|_{I_A} \tag{208}$$

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:

$$\mathrm{OrderOfHistory}(A) = \prec_{\mathrm{C}}|_{I_A}. \tag{209}$$

No independent private ordering is introduced for A.

12.2 Formal physical-history representation

In a governing V37/F17 realization, UCC gives:

$$I_A^{\Delta} = I_A. \tag{210}$$

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

Define:

$$\boxed{\mathcal{H}_A := \left(I_A, \prec_{\mathrm{C}}|_{I_A}, X_A, \Delta_A^{\mathrm{phys}}\right).} \tag{211}$$

$\mathcal{H}_A$ 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:

$$\mathcal{H}_A \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{212}$$

And:

$$\mathcal{H}_A \not\equiv_{\mathrm{type}} A. \tag{213}$$

12.3 Many physical histories within one cosmic extension

V37/F17 assigns an identity-indexed physical history to each qualified numerical physical-system identity. It does not replace those histories with one collective physical history, and it does not assign a private temporal succession to any of them. Each history is restricted from the same universal ordering through its own identity range.

For distinct qualified systems:

$$A \neq B \nRightarrow \mathcal{H}_A = \mathcal{H}_B. \tag{214}$$

Their identity domains may overlap:

$$I_A \cap I_B \neq \varnothing. \tag{215}$$

At every shared member:

$$s \in I_A \cap I_B \tag{216}$$

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

Thus:

$$\text{ManyPhysicalHistories} \not\Rightarrow \text{ManyTimes}\,. \tag{217}$$

12.4 Hierarchical histories

If:

$$A \triangleleft_{\kappa,s} B, \tag{218}$$

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:

$$A \triangleleft_{\kappa,s} B \not\Rightarrow I_A \subseteq I_B. \tag{219}$$

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:

$$r \prec_{\mathrm{C}} s, \tag{220}$$

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

$$K_A\left(X_A(r), X_A(s)\right) = \text{Equivalent}\,. \tag{221}$$

The later physical realization remains later:

$$r \prec_{\mathrm{C}} s \Longrightarrow \neg(s \prec_{\mathrm{C}} r). \tag{222}$$

State recurrence does not constitute historical reversal.

13. Historical Physical Accumulation and Present Embodied Resultant

13.1 Strictly earlier identity history

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

$$I_A^{<s} := \{r \in I_A \mid r \prec_{\mathrm{C}} s\}\,. \tag{223}$$

Under UCC:

$$I_A^{<s} \neq \varnothing \Longrightarrow \forall r \in I_A^{<s}, \quad \mathrm{PhysReal}_A^{+}(r). \tag{224}$$

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 $A \in \mathcal{U}_{\mathrm{phys}}$ and $s \in I_A$ with $I_A^{<s} \neq \varnothing$, the expression

$$\mathrm{HistoricalPhysicalAccumulation}_A^{<s} \tag{225}$$

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:

$$\mathrm{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\mathrm{def}} \sum_{r \in I_A^{<s}} \Delta_A^{\mathrm{phys}}(r). \tag{226}$$

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

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

$$\mathrm{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\mathrm{def}} \mathcal{H}_A^{<s}. \tag{227}$$

13.3 The physical past is not a stored present object

Historical physical accumulation is not a present physical object:

$$\neg\,\mathrm{PresentPhysicalObjectAt}\left(\mathrm{HistoricalPhysicalAccumulation}_A^{<s}; s\right). \tag{228}$$

Nor is it an additional causal-source class:

$$\mathrm{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\mathrm{type}} \mathrm{PhysicalCausalContributor}\,. \tag{229}$$

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:

$$\begin{gathered} \text{persist}, \quad \text{transform}, \quad \text{combine}, \quad \text{diminish}, \\ \text{intensify}, \quad \text{be compensated}, \quad \text{or cease to remain embodied}. \end{gathered} \tag{230}$$

Therefore:

$$\mathrm{EarlierChangeOccurred}(A; r) \wedge r \prec_{\mathrm{C}} s \not\Rightarrow \mathrm{EarlierEffectStillEmbodied}(A; r; s). \tag{231}$$

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

$$X_A(s). \tag{232}$$

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:

$$\text{EmbodiedEarlierEffects}_A\left(X_A(s); s\right) \tag{233}$$

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)**.**

$$\text{CumulativePhysicalResultThrough}_A(s) \iff \text{EmbodiedEarlierEffects}_A\left(X_A(s); s\right). \tag{234}$$

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

Thus:

$$\text{HistoricalPhysicalAccumulation}_A^{<s} \not\equiv_{\text{def}} \text{CumulativePhysicalResultThrough}_A(s). \tag{235}$$

And:

$$\text{PairwiseDefDistinct}\Big(\mathcal{H}_A^{<s}, \text{HistoricalPhysicalAccumulation}_A^{<s}, \text{CumulativePhysicalResultThrough}_A(s)\Big). \tag{236}$$

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:

$$I_A^{<s} \neq \varnothing \wedge \text{UCC} \nvdash \text{CumulativePhysicalResultThrough}_A(s). \tag{237}$$

Likewise:

$$\text{UCC} \nvdash \text{MonotonicCumulativeGrowth}(A). \tag{238}$$

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

14. Physical-System Identity Ending

14.1 Identity-ending transformation

Let:

$$\text{IdentityEndingTransformation}(A; e) \tag{239}$$

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 $e \in \mathcal{S}_{\text{C}}^{\text{tot}}$:

$$\boxed{\text{End}_A(e) \iff e \in I_A \wedge \text{IdentityEndingTransformation}(A; e) \wedge \forall t \in \mathcal{S}_{\text{C}}^{\text{tot}} \, (e \prec_{\text{C}} t \Longrightarrow t \notin I_A) \, .} \tag{240}$$

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

It is not a final stage of the cosmic extension.

Thus:

$$\text{End}_A(e) \wedge \text{NoTerminalStage}_{\text{C}} \Longrightarrow \exists t \in \mathcal{S}_{\text{C}}^{\text{tot}}, \quad e \prec_{\text{C}} t. \tag{241}$$

14.3 UCC remains active at the ending boundary

From:

$$\text{End}_A(e) \Longrightarrow e \in I_A, \tag{242}$$

UCC gives:

$$\text{End}_A(e) \wedge \text{UCC} \Longrightarrow \text{PhysReal}_A^+(e). \tag{243}$$

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

Define:

$$\Delta_A^{\text{end}}(e) := \Delta_A^{\text{phys}}(e), \qquad \text{when } \text{End}_A(e) \wedge \text{UCC} \, . \tag{244}$$

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

It does not introduce a separate type of change:

$$\Delta_A^{\text{end}}(e) \not\equiv_{\text{type}} \text{IndependentTerminalProcess} \, . \tag{245}$$

14.4 Uniqueness of ending

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

$$\begin{aligned}\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \vdash \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall e_1, e_2 \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}},\\ \mathrm{End}_A(e_1) \wedge \mathrm{End}_A(e_2) \Longrightarrow e_1 = e_2.\end{aligned} \tag{246}$$

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:

$$\mathrm{FunctionalFailure}_{\Gamma}(A; s) \not\Rightarrow \mathrm{End}_A(s). \tag{247}$$

Conversely:

$$\mathrm{End}_A(e) \not\Rightarrow \mathrm{FunctionalFailure}_{\Gamma}(A; e). \tag{248}$$

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:

$$I_A^{<e} \neq \varnothing \tag{249}$$

and:

$$\mathrm{End}_A(e) \wedge \mathrm{UCC}, \tag{250}$$

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

$$\left[\forall r \in I_A^{<e}, \quad \mathrm{PhysReal}_A^{+}(r)\right] \wedge \mathrm{PhysReal}_A^{+}(e). \tag{251}$$

This is uninterrupted physical-change actuality relative to the identity range.

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

14.7 Ending configuration

For an actual ending define:

$$\mathfrak{K}_A^{\mathrm{end}}(e) := \left(X_A(e), \Delta_A^{\mathrm{end}}(e), \mathfrak{C}_A(e)\right). \tag{252}$$

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:

$$\mathrm{Defined}\Big(\mathfrak{K}_A^{\mathrm{end}}(e)\Big) \not\Rightarrow \mathrm{SequentialThreeStepEnding}\,. \tag{253}$$

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 part of the identity's historical physical accumulation. Where effects of those earlier changes remain physically embodied at the ending stage, they are present through $X_A(e)$ and, where causally operative, through the already governed current causal-source classes. Historical physical accumulation itself is not a separate co-present object or an additional causal source at the ending stage.

14.8 Physical Identity-Ending Causation Principle

Principle 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:

$$\boxed{\begin{aligned} &\mathrm{PIECP} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall e \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \\ &\qquad \mathrm{End}_A(e) \implies \exists c \in \mathcal{C}_A^{\mathrm{act}}(e) : \\ &\qquad\qquad \mathrm{PhysicallyContributes}\left(c; \mathrm{IdentityEndingTransformation}(A; e)\right). \end{aligned}} \tag{254}$$

PIECP has 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:

$$\mathrm{CRP} \wedge \mathrm{End}_A(e) \nvdash \mathrm{PIECP}\,. \tag{255}$$

PIECP introduces no fourth 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:

$$\mathrm{CumulativePhysicalResultThrough}_A(e) \not\Rightarrow \mathrm{IdentityEndingTransformation}(A; e). \tag{256}$$

And:

$$I_A^{<e} \neq \varnothing \nvdash \mathrm{End}_A(e). \tag{257}$$

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

15. Universal Lifecycle Commitment and Conditional Successor Attribution

15.1 Completed numerical identity

Define:

$$\mathrm{HistoryComplete}(A) \iff \exists e \in I_A \;\; \mathrm{End}_A(e). \tag{258}$$

Let:

$$\mathcal{U}_{\mathrm{phys}}^{\mathrm{end}} := \{A \in \mathcal{U}_{\mathrm{phys}} \mid \mathrm{HistoryComplete}(A)\}\,. \tag{259}$$

For ended identities:

$$e : \mathcal{U}_{\mathrm{phys}}^{\mathrm{end}} \longrightarrow \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \qquad e(A) = e_A. \tag{260}$$

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

15.2 Universal Eventual Identity Ending

Postulate 15.1 (Universal Eventual Identity Ending — UEIE)**.**

$$\boxed{\mathrm{UEIE} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\; \exists e_A \in I_A\, [\mathrm{End}_A(e_A) \wedge \exists r_A \in I_A\, (r_A \prec_{\mathrm{C}} e_A)]\,.} \tag{261}$$

UEIE has a separate lifecycle status. Its universal quantifier ranges only over the qualified physical-system domain $\mathcal{U}_{\mathrm{phys}}$ fixed by the governing system and numerical-identity criteria. It therefore carries an independent physical lifecycle burden: arbitrary mathematical subsystems, merely convenient decompositions, or entities not admitted to $\mathcal{U}_{\mathrm{phys}}$ 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; V37/F17 does not supply one universal empirical identity criterion for all physical-system classes.

It is not derived from:

$$\{T_{\mathrm{ITOF}}, \mathrm{StrictTotalOrder}, \mathrm{NoTerminalStage}_{\mathrm{C}}, \mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}, \mathrm{CRP}, \mathrm{AFB}\}\,. \tag{262}$$

In particular:

$$\mathrm{UCC} \nvdash \mathrm{UEIE}\,. \tag{263}$$

UEIE requires a nonempty strict pre-ending identity history:

$$\mathrm{UEIE} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}}, \quad I_A^{<e_A} \neq \varnothing. \tag{264}$$

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 Direct successor relation

Some identity-ending transformations physically produce one or more genuinely new numerical physical-system identities.

Define:

$$\boxed{\mathrm{SuccAt}(A,B;e) \iff \mathrm{End}_A(e) \wedge A \neq B \wedge f_B = e \wedge \mathrm{PhysicalProductionLink}(A,B;e).} \tag{265}$$

The relation requires:

(i) actual ending of A;

(ii) numerical distinction between predecessor and successor;

(iii) formation of B at the same common cosmic change stage e;

(iv) an independently warranted physical-production relation linking the ending transformation of A to formation of B.

A pre-existing system does not become a direct successor merely by receiving matter or energy, absorbing constituents, interacting with the ending system, or remaining after that ending. Direct-successor status requires the stated new-identity and physical-production conditions.

15.4 No universal successor closure

Identity ending does not entail successor production. Therefore:

$$\boxed{\mathrm{End}_A(e) \nvdash \exists B \in \mathcal{U}_{\mathrm{phys}}\ \mathrm{SuccAt}(A,B;e).} \tag{266}$$

The ending of one identity may physically result in:

$$\begin{gathered}\text{one new successor,}\quad \text{multiple new identities,}\quad \text{absorption into pre-existing systems,}\\ \text{redistribution of constituents,}\quad \text{or another physically warranted outcome}\end{gathered} \tag{267}$$

without requiring a universal successor relation.

15.5 Successor history remains numerically distinct

Where:

$$\mathrm{SuccAt}(A,B;e), \tag{268}$$

the successor has:

$$f_B = e, \tag{269}$$

its own identity range:

$$I_B = \left\{ s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid \mathrm{ExistsAs}(B,s) \right\}, \tag{270}$$

and, under UCC, its own physical history:

$$\mathcal{H}_B = \left(I_B, \prec_{\mathrm{C}}|_{I_B}, X_B, \Delta_B^{\mathrm{phys}} \right). \tag{271}$$

The relation does not transfer the predecessor identity:

$$\mathrm{SuccAt}(A, B; e) \Longrightarrow A \neq B. \tag{272}$$

Nor does it transfer one physical history into another:

$$\mathrm{SuccAt}(A, B; e) \nvDash \mathcal{H}_B = \mathcal{H}_A. \tag{273}$$

The predecessor and successor remain two numerical physical-system identities within the same universal cosmic extension.

15.6 Cosmic continuation remains independent of successors

For any ending:

$$\mathrm{End}_A(e) \wedge \mathrm{NoTerminalStage}_{\mathrm{C}} \Longrightarrow \exists t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \left(e \prec_{\mathrm{C}} t\right). \tag{274}$$

No successor premise occurs in this derivation.

Therefore:

$$\mathrm{CosmicContinuation} \nRightarrow \mathrm{UniversalSuccessorClosure}\,. \tag{275}$$

The common cosmic succession does not depend on the lifecycle of any particular physical-system identity.

16. Population Transformation Across the Universal Cosmic Order

16.1 Population-level extension

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

$$\mathcal{S}_{\mathrm{phys}}(s). \tag{276}$$

It also provides identity-realization ranges:

$$I_A. \tag{277}$$

V37/F17 now uses those existing objects to represent how the qualified population may differ between arbitrary ordered common cosmic change stages without introducing:

$$\left\{ \begin{array}{c} \mathrm{AdjacentStages}, \mathrm{MovingPopulation}, \mathrm{PopulationCarrier}, \\ \mathrm{UniversalSuccessorChain}, \mathrm{PopulationConservationLaw} \end{array} \right\}. \tag{278}$$

Let:

$$r, s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \qquad r \prec_{\mathrm{C}} s. \tag{279}$$

No assumption is made that r and s are adjacent.

16.2 Endpoint-persistent population

Define:

$$\mathcal{P}_{r,s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \in I_A \wedge s \in I_A\}. \tag{280}$$

Every member belongs to both endpoint populations:

$$\mathcal{P}_{r,s} = \mathcal{S}_{\text{phys}}(r) \cap \mathcal{S}_{\text{phys}}(s). \tag{281}$$

Under Identity-Realization Convexity:

$$A \in \mathcal{P}_{r,s} \wedge r \prec_{\mathrm{C}} u \prec_{\mathrm{C}} s \Longrightarrow u \in I_A. \tag{282}$$

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:

$$\mathcal{N}_{r\to s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \notin I_A \wedge s \in I_A\}. \tag{283}$$

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:

$$A \in \mathcal{N}_{r\to s} \Longrightarrow r \prec_{\mathrm{C}} f_A \ \vee \ f_A = s. \tag{284}$$

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

$$A \in \mathcal{N}_{r\to s} \Longrightarrow \neg\,(s \prec_{\mathrm{C}} f_A). \tag{285}$$

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:

$$\mathcal{L}_{r\to s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \in I_A \wedge s \notin I_A\}. \tag{286}$$

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

Under UEIE and Identity-Realization Convexity, if $A \in \mathcal{L}_{r\to s}$, its ending member must occur before s.

Thus:

$$\{\text{UEIE}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{L}_{r\to s} \Longrightarrow e_A \prec_{\mathrm{C}} s. \tag{287}$$

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

$$r = e_A \quad \text{or} \quad r \prec_C e_A. \tag{288}$$

No metric lifetime is inferred.

16.5 Endpoint population decomposition

The later endpoint population decomposes exactly as:

$$\mathcal{S}_{\text{phys}}(s) = \mathcal{P}_{r,s} \,\dot{\cup}\, \mathcal{N}_{r\to s}. \tag{289}$$

The earlier endpoint population decomposes exactly as:

$$\mathcal{S}_{\text{phys}}(r) = \mathcal{P}_{r,s} \,\dot{\cup}\, \mathcal{L}_{r\to s}. \tag{290}$$

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

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

In particular:

$$|\mathcal{S}_{\text{phys}}(r)| - |\mathcal{L}_{r\to s}| + |\mathcal{N}_{r\to s}| = |\mathcal{S}_{\text{phys}}(s)| \tag{291}$$

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:

$$\mathcal{T}_{r,s} := \{A \in \mathcal{U}_{\text{phys}} \mid r \notin I_A \wedge s \notin I_A \wedge \exists u \in I_A \, (r \prec_C u \prec_C s)\}. \tag{292}$$

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:

$$\mathcal{T}_{r,s} \cap (\mathcal{S}_{\text{phys}}(r) \cup \mathcal{S}_{\text{phys}}(s)) = \varnothing. \tag{293}$$

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:

$$\{\text{AFB}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{T}_{r,s} \Longrightarrow r \prec_{\text{C}} f_A \prec_{\text{C}} s. \tag{294}$$

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:

$$\{\text{AFB}, \text{UEIE}, \text{IdentityRealizationConvexity}\} \wedge A \in \mathcal{T}_{r,s} \Longrightarrow r \prec_{\text{C}} f_A \prec_{\text{C}} e_A \prec_{\text{C}} s. \tag{295}$$

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:

$$\mathfrak{P}^{\text{pop}}_{\text{C}}(r, s) := (\mathcal{S}_{\text{phys}}(r), \mathcal{P}_{r,s}, \mathcal{N}_{r\to s}, \mathcal{L}_{r\to s}, \mathcal{T}_{r,s}, \mathcal{S}_{\text{phys}}(s)), \qquad r \prec_{\text{C}} s. \tag{296}$$

This is a defined representation:

$$\text{Status}(\mathfrak{P}^{\text{pop}}_{\text{C}}(r, s)) = \text{DefinedPopulationMembershipProfile}. \tag{297}$$

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:

$$\mathcal{S}_{\text{phys}}(r) \neq \mathcal{S}_{\text{phys}}(s). \tag{298}$$

Population difference does not generate stage-specific temporal extensions:

$$\mathcal{S}_{\text{phys}}(r) \neq \mathcal{S}_{\text{phys}}(s) \not\Rightarrow \text{DifferentTemporalExtensions}(r, s). \tag{299}$$

The one temporal referent remains Eq. (12).

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

16.10 Population transformation and complete physical realization

The endpoint profiles $\mathfrak{R}_{\text{C}}(r)$ and $\mathfrak{R}_{\text{C}}(s)$ 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:

$$r \prec_{\text{C}} s \not\Rightarrow \exists F_{\text{univ}} : \mathfrak{R}_{\text{C}}(s) = F_{\text{univ}}(\mathfrak{R}_{\text{C}}(r)). \tag{300}$$

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:

$$\Delta_A^{\text{phys}}(s) \in \Xi_A, \qquad \Delta_B^{\text{phys}}(s) \in \Xi_B, \tag{301}$$

without requiring

$$\Xi_A = \Xi_B. \tag{302}$$

Consequently, a mathematical comparison between the physical-change contents of distinct systems is not automatically well typed.

For a declared comparison protocol P, let

$$\mathcal{Y}_{AB,P} \tag{303}$$

be a comparison space whose physical interpretation, units or normalization, domain of validity, and uncertainty structure are explicitly declared.

Introduce independently supplied maps

$$\phi^P_{A\to AB} : \Xi_A \longrightarrow \mathcal{Y}_{AB,P}, \tag{304}$$

$$\phi^P_{B\to AB} : \Xi_B \longrightarrow \mathcal{Y}_{AB,P}. \tag{305}$$

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:

$$\text{MappedChange}_{A|AB,P}(s) := \phi^P_{A\to AB}\left(\Delta_A^{\text{phys}}(s)\right) \tag{306}$$

and similarly

$$\text{MappedChange}_{B|AB,P}(s) := \phi^P_{B\to AB}\left(\Delta_B^{\text{phys}}(s)\right). \tag{307}$$

Even if:

$$\text{MappedChange}_{A|AB,P}(s) = \text{MappedChange}_{B|AB,P}(s), \tag{308}$$

it does not follow that:

$$\text{MappedChange}_{A|AB,P}(s) = \text{MappedChange}_{B|AB,P}(s) \nRightarrow \Delta_A^{\text{phys}}(s) \equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \tag{309}$$

Mapped equality is equality under the declared comparison representation.

It is not bearer identity.

17.3 General comparison operator

Let:

$$\Psi_{AB,P} : \mathcal{Y}_{AB,P} \times \mathcal{Y}_{AB,P} \longrightarrow \mathcal{Z}_{AB,P} \tag{310}$$

be a declared comparison operator.

Define:

$$\begin{aligned}\mathrm{Cmp}_{AB,P}(s) := \Psi_{AB,P}\Big(&\phi^P_{A\to AB}(\Delta^{\mathrm{phys}}_A(s)),\\ &\phi^P_{B\to AB}(\Delta^{\mathrm{phys}}_B(s))\Big).\end{aligned} \tag{311}$$

The output belongs to the comparison codomain:

$$\mathrm{Cmp}_{AB,P}(s) \in \mathcal{Z}_{AB,P}. \tag{312}$$

It is not:

$$\mathrm{Cmp}_{AB,P}(s) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{313}$$

Nor is it:

$$\mathrm{Cmp}_{AB,P}(s) \not\equiv_{\mathrm{type}} s. \tag{314}$$

17.4 Admissibility of a physical comparison

A comparison is scientifically admissible only where its construction is independently specified.

Define:

$$\begin{aligned}\mathrm{AdmissibleComparison}(A, B; P) \Longrightarrow\ &\mathrm{PhysicalTargetDeclared}(A, B; P)\\ &\wedge \mathrm{ComparisonMapsDeclared}(A, B; P)\\ &\wedge \mathrm{ComparisonCodomainDeclared}(P)\\ &\wedge \mathrm{UnitsOrNormalizationDeclared}(P)\\ &\wedge \mathrm{ParameterProvenanceDeclared}(P)\\ &\wedge \mathrm{UncertaintyStructureDeclared}(P)\\ &\wedge \mathrm{DomainOfValidityDeclared}(P).\end{aligned} \tag{315}$$

The condition is methodological.

It does not state that every pair of systems must admit a physically meaningful comparison.

Thus:

$$A, B \in \mathcal{S}_{\mathrm{phys}}(s) \nvdash \exists P\ \mathrm{AdmissibleComparison}(A, B; P). \tag{316}$$

Shared membership in $\mathcal{S}_{\mathrm{phys}}(s)$, and under CMA literal common-stage co-realization, do not by themselves provide quantitative comparability.

17.5 No universal scalar amount of change

V37/F17 does not infer:

$$\exists \mu_{\Delta} : \bigcup_{A \in \mathcal{U}_{\mathrm{phys}}} \Xi_A \longrightarrow \mathbb{R} \tag{317}$$

as a foundational requirement.

Accordingly:

$$\mathrm{UCC} \nvdash \mathrm{UniversalScalarAmountOfChange}\,. \tag{318}$$

The complete-population physical-realization architecture likewise supplies no universal cross-system ranking of change.

Statements such as

$$\text{“}A \text{ changed more than } B\text{”} \tag{319}$$

require a declared comparison construction.

They do not follow from the cosmic ordering itself.

17.6 Cross-level comparison under hierarchical composition

If:

$$A \lhd_{\kappa,s} B, \tag{320}$$

a comparison between constituent and composite change remains subject to the same mapping discipline.

Thus:

$$A \lhd_{\kappa,s} B \nRightarrow \mathrm{Cmp}_{AB,P}(s) \text{ is defined.} \tag{321}$$

A physical composition model may independently supply the necessary maps.

Composition itself does not.

18. Mathematical-Form-Neutral Physical Dynamics

18.1 Foundational neutrality toward the form of physical dynamics

The temporal definition:

$$T_{\mathrm{ITOF}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \tag{322}$$

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, the integrated realization condition defined in Eq. (85) remains type-distinct from every application-level physical-dynamics descriptor:

$$\mathrm{UCSCR}_{\mathrm{C}} \not\equiv_{\mathrm{type}} \mathfrak{Dyn}_{M;\mathcal{A}}. \tag{323}$$

The left-hand side fixes common-stage, complete-population change realization; the right-hand side specifies a declared physical model. Neither is 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

$$\mathfrak{Dyn}_{M;\mathcal{A}} := (\mathcal{Z}_M, \Theta_M, \mathcal{L}_M, D_M, \mathrm{Sol}_M)\,. \tag{324}$$

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

$$\mathrm{Sol}_M(D_M, \Theta_M) := \{z \in \mathcal{Z}_M(D_M) \mid \mathrm{LawSatisfied}_M(z; \mathcal{L}_M, \Theta_M, D_M)\}\,. \tag{325}$$

Here $\mathrm{LawSatisfied}_M$ 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:

$$\begin{aligned}
\mathrm{AdmissiblePhysicalModel}(M;\mathcal{A}) \Longrightarrow\ & \mathrm{PhysicalTargetDeclared}(M;\mathcal{A}) \\
& \wedge \mathrm{ModelRealizationSpaceTyped}(M) \\
& \wedge \mathrm{PhysicalSystemBoundariesDeclared}(M) \\
& \wedge \mathrm{IdentityCriterionDeclaredWhereApplicable}(M) \\
& \wedge \mathrm{ParameterProvenanceDeclared}(M) \\
& \wedge \mathrm{DynamicsFormDeclared}(M) \\
& \wedge \mathrm{SolutionRuleDeclared}(M) \\
& \wedge \mathrm{ModelInputBridgeDeclared}(M) \\
& \wedge \mathrm{ModelOutputBridgeDeclared}(M) \\
& \wedge \mathrm{DomainOfValidityDeclared}(M) \\
& \wedge \mathrm{ApproximationStatusDeclared}(M) \\
& \wedge \mathrm{ObservationBridgeDeclaredWhereNeeded}(M).
\end{aligned} \tag{326}$$

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:

$$\lambda_M \tag{327}$$

be such a parameter.

Then:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}. \tag{328}$$

Even where:

$$\lambda_M \mapsto X_A^M(\lambda_M) \tag{329}$$

accurately predicts physical records, the parameter remains a model parameter.

Thus:

$$\begin{aligned}&\text{ModelEvolutionParameter}(\lambda_M; M)\\&\quad\wedge \text{OperationalSuccess}_{P,M,D}(\lambda_M)\\&\quad\not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}.\end{aligned} \tag{330}$$

18.5 The model parameter is not a common cosmic change-stage index

No global numerical map $\iota : \mathcal{S}_{\text{C}}^{\text{tot}} \to \mathbb{R}$ is required by the temporal definition. An application may introduce an index only with an independently declared representational role. Therefore:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \not\Rightarrow \text{ExactCommonCosmicChangeStageIndex}(\lambda_M). \tag{331}$$

A model may parameterize a reconstructed or predicted physical history without enumerating the members of $\mathcal{S}_{\text{C}}^{\text{tot}}$.

18.6 Physical laws operate on physical content, not on time as a cause

The mathematical-form-neutral requirement is that a declared realization $z \in \mathcal{Z}_M$ satisfy the independently specified governing rule:

$$\text{LawSatisfied}_M(z; \mathcal{L}_M, \Theta_M, D_M). \tag{332}$$

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:

$$\text{AppearsAsEvolutionParameter}(\lambda_M) \not\Rightarrow \text{PhysicalCause}(\lambda_M). \tag{333}$$

Likewise, the temporal referent is not a member of the physical causal-source domain:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \mathrm{PhysicalCausalContributor}\,. \tag{334}$$

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:

$$\Psi^{\mathrm{hist}}_{M,A} : \mathrm{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}^M_A. \tag{335}$$

where $\mathcal{H}^M_A$ 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:

$$\left[\Psi^{\mathrm{hist}}_{M,A} : \mathrm{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}^M_A\right] \not\Rightarrow \mathcal{H}^M_A = \mathcal{H}_A. \tag{336}$$

Equality would require an independent argument for complete representational adequacy over every component relevant to the claim. Likewise,

$$\left[\Psi^{\mathrm{hist}}_{M,A} : \mathrm{Sol}_M(D_M, \Theta_M) \longrightarrow \mathcal{H}^M_A\right] \not\Rightarrow \lambda_M \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{337}$$

18.8 Different valid models need not share one evolution parameter

Two physical models may successfully represent different aspects of the same physical system or different systems:

$$M_1, \qquad M_2. \tag{338}$$

Their parameters may satisfy:

$$\lambda_{M_1} \neq \lambda_{M_2}. \tag{339}$$

Distinct model parameters do not imply distinct temporal referents:

$$\lambda_{M_1} \neq \lambda_{M_2} \not\Rightarrow \mathrm{DistinctTemporalReferents}(M_1, M_2). \tag{340}$$

It indicates different representational constructions.

18.9 Formal reversibility does not reverse cosmic ordering

A physical model may admit:

$$\lambda_M \mapsto -\lambda_M. \tag{341}$$

This mathematical transformation does not reverse:

$$\prec_{\mathrm{C}}\,. \tag{342}$$

Therefore:

$$\mathrm{ModelInvariantUnder}(\lambda_M \mapsto -\lambda_M) \not\Rightarrow \mathrm{CosmicOrderingReversed}\,. \tag{343}$$

Mathematical reversibility, physical recurrence, and universal cosmic irreversibility 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

$$Y_{A,\alpha} : I_A \longrightarrow \mathcal{Y}_{A,\alpha} \tag{344}$$

be a declared physical or model-supported descriptor, and let

$$\preccurlyeq_{A,\alpha} \subseteq \mathcal{Y}_{A,\alpha} \times \mathcal{Y}_{A,\alpha} \tag{345}$$

be the comparison relation warranted for that criterion. No totality, metric, linearity, or universal cross-system meaning is assumed for $\preccurlyeq_{A,\alpha}$.

Define the criterion-indexed directionality descriptor:

$$\mathfrak{A}_{A,\alpha} := (\mathcal{Y}_{A,\alpha}, Y_{A,\alpha}, \preccurlyeq_{A,\alpha}) . \tag{346}$$

For $J \subseteq I_A$, define alignment with the universal cosmic ordering on that domain by:

$$\mathrm{ArrowAligned}_{A,\alpha}(J) \iff \forall r, s \in J, \quad r \prec_{\mathrm{C}} s \Longrightarrow Y_{A,\alpha}(r) \preccurlyeq_{A,\alpha} Y_{A,\alpha}(s). \tag{347}$$

Where the strict part of the criterion relation is needed, define:

$$u \prec^{\mathrm{phys}}_{A,\alpha} v \iff u \preccurlyeq_{A,\alpha} v \wedge \neg (v \preccurlyeq_{A,\alpha} u) . \tag{348}$$

A criterion-relative reversal over an ordered pair may then be represented by:

$$\mathrm{CriterionReversal}_{A,\alpha}(r, s) \iff r \prec_{\mathrm{C}} s \wedge Y_{A,\alpha}(s) \prec^{\mathrm{phys}}_{A,\alpha} Y_{A,\alpha}(r). \tag{349}$$

Such a reversal concerns the selected physical criterion. It does not reverse the cosmic order:

$$\mathrm{CriterionReversal}_{A,\alpha}(r, s) \nRightarrow s \prec_{\mathrm{C}} r. \tag{350}$$

A conventional physical "arrow" is therefore admissible only as a criterion-indexed physical regularity:

$$\mathrm{PhysicalArrow}_{A,\alpha}(J) \iff \mathrm{ArrowAligned}_{A,\alpha}(J). \tag{351}$$

The designation is not a second meaning of time. The physical comparison relation and the universal cosmic order have different types:

$$\preccurlyeq_{A,\alpha} \not\equiv_{\mathrm{type}} \prec_{\mathrm{C}} . \tag{352}$$

Even perfect alignment over a declared domain does not transfer temporal identity:

$$\mathrm{PhysicalArrow}_{A,\alpha}(J) \nRightarrow \preccurlyeq_{A,\alpha} \equiv_{\mathrm{type}} \prec_{\mathrm{C}} . \tag{353}$$

UCC requires actual bearer-specific physical change; it does not require one criterion to be monotonic for every system:

$$\mathrm{UCC} \nvdash \exists\alpha\ \forall A \in \mathcal{U}_{\mathrm{phys}}, \quad \mathrm{PhysicalArrow}_{A,\alpha}(I_A). \tag{354}$$

Nor does a physical arrow require a metric on the identity range:

$$\mathrm{PhysicalArrow}_{A,\alpha}(J) \not\Rightarrow \mathrm{MetricOn}(J). \tag{355}$$

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 Metric Construction

19.1 Operational metric layer

V37/F17 moves beyond the statement that a clock output is not time.

It asks how numerical quantities conventionally used to represent:

$$\begin{gathered}\text{duration,} \quad \text{elapsed units,} \quad \text{frequency ratios,} \quad \text{rates,} \\ \text{synchronization differences,} \quad \text{path-dependent intervals,} \quad \text{and related metric outputs}\end{gathered} \tag{356}$$

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 $(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$.

19.2 Non-metricity is a typed boundary, not a hidden missing metric

V37/F17 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,

$$\mathrm{TemporalDefinition}_{\mathrm{ITOF}} \nvdash \mathrm{DynamicsDescriptorSpecified}(M; \mathcal{A}). \tag{357}$$

and successful application dynamics do not convert their evolution parameter or metric output into time.

In this section, *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 $\mathcal{M}_P^{\mathrm{op}}$ 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:

$$\mathfrak{R}_P \tag{358}$$

be a declared physical record domain associated with protocol P.

Let:

$$\mathcal{K}_P \tag{359}$$

contain the calibration, reference, normalization, unit, alignment, and comparison information required by the declared operational construction.

Define:

$$\boxed{\mathcal{M}_P^{\mathrm{op}} : \mathfrak{R}_P^n \times \mathcal{K}_P \longrightarrow \mathcal{Y}_P.} \tag{360}$$

For records:

$$r_1, \ldots, r_n \in \mathfrak{R}_P \tag{361}$$

and declared calibration bundle $\kappa_P \in \mathcal{K}_P$, define:

$$m_P := \mathcal{M}_P^{\mathrm{op}}\left(r_1, \ldots, r_n; \kappa_P\right). \tag{362}$$

The output:

$$m_P \in \mathcal{Y}_P \tag{363}$$

is an operational quantity.

It is not time:

$$m_P \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{364}$$

19.4 Operational metric output is not an order magnitude

The ordered pair

$$\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \tag{365}$$

contains no foundationally defined numerical distance function. This is the application-level consequence of the order-representation non-metricity result in Eq. (33). A map of the form $d_C : \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \times \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \to \mathbb{R}$ 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:

$$\mathrm{OperationalMetricOutput}(m_P) \nRightarrow \mathrm{CosmicStageSeparationMagnitudeDefined}(m_P). \tag{366}$$

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:

$$\mu_M = \mathcal{G}_M \left(\mathcal{V}_M, \Theta_M \right) \tag{367}$$

be such a model-derived metric quantity.

Then:

$$\mu_M \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{368}$$

Where:

$$m_P \approx K_{P,M}(\mu_M) \tag{369}$$

successfully connects model quantity and operational output, the agreement warrants the declared quantitative association.

It does not establish:

$$m_P \approx K_{P,M}(\mu_M) \not\Rightarrow \mu_M \equiv_{\text{type}} T_{\text{ITOF}}. \tag{370}$$

19.6 Operational interval

For two ordered records r_1, r_2, let:

$$N_P : \mathfrak{R}_P \longrightarrow \mathbb{R}_P \tag{371}$$

be a declared numerical reading map.

Define:

$$\Delta N_P := N_P(r_2) - N_P(r_1). \tag{372}$$

The quantity may conventionally be described as elapsed time or duration.

Within ITOF it remains:

$$\Delta N_P \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{373}$$

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. V37/F17 supplies no stage-count function, adjacency rule, or independently warranted stage-identification-and-counting procedure from the bare strict order $(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$. 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:

$$\Delta_P Q_A := \widehat{Q}_{A;P,M}(r_{A,2}) - \widehat{Q}_{A;P,M}(r_{A,1}). \tag{374}$$

Where:

$$\Delta N_P \neq 0, \tag{375}$$

define:

$$\overline{v}^{\,P}_{Q_A|N} := \frac{\Delta_P Q_A}{\Delta N_P}. \tag{376}$$

This is a relation between a measured physical difference and a declared operational numerical interval.

It is not:

$$\overline{v}^{P}_{Q_A|N} \not\equiv_{\text{type}} \text{RateOfTime}\,. \tag{377}$$

19.8 Operational synchronization

Let two physical standard systems produce mapped outputs:

$$n_1, \qquad n_2. \tag{378}$$

Define:

$$d^P_{12} := \Gamma_{1,P}(n_1) - \Gamma_{2,P}(n_2). \tag{379}$$

For declared synchronization tolerance $\varepsilon_{\text{sync}}$:

$$\text{Synchronized}_{P,\varepsilon_{\text{sync}}}(1,2) \iff \left|d^P_{12}\right| \le \varepsilon_{\text{sync}}. \tag{380}$$

This is an operational relation.

It neither creates nor defines CMA:

$$\text{Synchronized}_{P,\varepsilon_{\text{sync}}}(1,2) \not\Rightarrow \text{CMA}\,. \tag{381}$$

Nor does failure of synchronization negate CMA:

$$\neg\,\text{Synchronized}_{P,\varepsilon_{\text{sync}}}(1,2) \not\Rightarrow \neg\,\text{CMA}\,. \tag{382}$$

Clock-output agreement and common cosmic-stage unity remain different claims.

20. Physical Access, 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:

$$\text{PairwiseTypeDistinct}\Big(\text{PhysReal}^+_A(s), \text{ManifestationAt}(A,\chi;s), \text{Detected}_{P,M,\varepsilon}(A,\chi;r)\Big)\,. \tag{383}$$

Hence:

$$\text{PhysReal}^+_A(s) \not\Rightarrow \text{Detected}_{P,M,\varepsilon}(A,\chi;r). \tag{384}$$

And:

$$\neg\,\text{Detected}_{P,M,\varepsilon}(A,\chi;r) \not\Rightarrow \mathsf{NC}^{\text{phys}}_A(s). \tag{385}$$

20.2 Access relations are physically distinct from common-stage realization

For $A, B \in \mathcal{S}_{\text{phys}}(s)$, CMA supplies literal one-common-stage co-realization through the population-level statement $\text{CosmicCoPresence}_{\text{C}}(\mathcal{S}_{\text{phys}}(s); s)$. The physical relations of interaction, signal accessibility, and observational accessibility remain separately typed:

$$\text{PhysicalInteraction}(A, B; s), \tag{386}$$

$$\text{SignalAccessible}(A, B; s), \tag{387}$$

and:

$$\text{ObservationallyAccessible}_{P,M}(B; A, s). \tag{388}$$

The first two non-entailments are fixed in Eqs. (58) and (59). Observational accessibility is likewise not supplied by CMA:

$$\text{CMA} \nvdash \forall s \in \mathcal{S}_{\text{C}}^{\text{tot}}\ \forall A, B \in \mathcal{S}_{\text{phys}}(s), \quad \text{ObservationallyAccessible}_{P,M}(B; A, s). \tag{389}$$

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:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \wedge \text{SignalNotYetReceived}(A, B; s) \nRightarrow B \notin \mathcal{S}_{\text{phys}}(s). \tag{390}$$

Under UCC:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \wedge \text{SignalNotYetReceived}(A, B; s) \nRightarrow \neg\, \text{PhysReal}_B^+(s). \tag{391}$$

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:

$$\mathcal{L}_P \tag{392}$$

denote the declared family of target, apparatus, detector, record-bearing, observer, reference, calibration, communication, processing, and environmental systems entering protocol P.

For every:

$$X \in \mathcal{L}_P \cap \mathcal{S}_{\text{phys}}(s), \tag{393}$$

UCC gives:

$$\text{PhysReal}_X^+(s). \tag{394}$$

Thus no observer or apparatus occupies a changeless standpoint outside the common cosmic extension.

20.5 Source-to-record physical chain

A physical observation may be schematically represented by:

$$\begin{aligned}\text{SourceManifestation} &\rightsquigarrow_{\text{phys}} \text{AccessiblePhysicalEffect} \\ &\rightsquigarrow_{\text{phys}} \text{DetectorInteraction} \\ &\rightsquigarrow_{\text{phys}} \text{RecordFormation}\,.\end{aligned} \tag{395}$$

Subsequent interpretation is:

$$\text{RecordFormation} \longrightarrow \text{Reading} \longrightarrow \text{RestrictedScientificConclusion}\,. \tag{396}$$

The first chain is physical.

The second includes representational and inferential operations.

No arrow means identity.

20.6 Record type

For physical record r:

$$r \not\equiv_{\text{type}} \text{SourceManifestation}\,. \tag{397}$$

Also:

$$r \not\equiv_{\text{type}} s. \tag{398}$$

And:

$$r \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{399}$$

A record may physically encode information about a source.

Information carriage does not erase the type distinction between:

$$\text{source}, \quad \text{record}, \quad \text{stage}, \quad \text{time}. \tag{400}$$

20.7 Physical acquisition support

For record $r \in \mathfrak{R}_P$, define:

$$J_r^{\text{phys}} := \left\{ s \in \mathcal{S}_{\text{C}}^{\text{tot}} \mid \exists X \in \mathcal{L}_P \ \text{PhysicalContributionToRecord}(X, s; r) \right\}. \tag{401}$$

A physically produced record satisfies:

$$\text{PhysicallyProducedRecord}(r) \Longrightarrow J_r^{\text{phys}} \neq \varnothing. \tag{402}$$

The support need not be a singleton:

$$\left| J_r^{\text{phys}} \right| > 1 \tag{403}$$

is admissible.

Therefore:

$$\text{ReadableAt}(r; s_d) \not\Rightarrow J_r^{\text{phys}} = \{s_d\}. \tag{404}$$

20.8 Observation as a physically restricted projection

Let:

$$\mathfrak{A}_{\mathrm{C}}^{P,M} \subseteq \left\{ \mathfrak{R}_{\mathrm{C}}(s) \mid s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \right\} \tag{405}$$

denote only the physically accessible part of the common-stage physical-realization architecture relevant to protocol P and model M.

Define schematically:

$$\mathcal{O}_{P,M} : \mathfrak{A}_{\mathrm{C}}^{P,M} \times \Theta_{P,M} \longrightarrow \mathfrak{R}_{P}. \tag{406}$$

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 $\mathrm{ObservationMapSpecified}_{P,M}$ denote that the declared map is well defined for the stated protocol and model. Then:

$$\mathrm{ObservationMapSpecified}_{P,M} \not\Rightarrow \mathrm{Injective}\left(\mathcal{O}_{P,M}\right), \tag{407}$$

$$\mathrm{ObservationMapSpecified}_{P,M} \not\Rightarrow \mathrm{SurjectiveOntoCompletePhysicalReality}\left(\mathcal{O}_{P,M}\right). \tag{408}$$

Thus:

$$\mathrm{ObservationMapSpecified}_{P,M} \not\Rightarrow \mathrm{RecordToExactCosmicChangeStageInverse}. \tag{409}$$

This construction formalizes the distinction between ontological population completeness and physically restricted observational access.

21. Exact-Change-Stage Restraint

21.1 Objective stage and epistemic identification

Every actual common cosmic change stage is objective within the governing theory.

Yet:

$$s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \not\Rightarrow \mathrm{ExactCosmicChangeStageObservationallyIdentified}(s). \tag{410}$$

The distinction is epistemic.

It does not make the cosmic ordering observer-dependent.

21.2 Positive observational warrant

Define:

$$\begin{aligned} \mathrm{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi; r) \Longleftrightarrow\ & \mathrm{Detected}_{P,M,\varepsilon}(A, \chi; r) \\ & \wedge \mathrm{ValidSystemAttribution}_{P,M}(r; A) \\ & \wedge \mathrm{PhysicalSourceRecordLink}_{P,M}(A, \chi; r) \\ & \wedge \mathrm{AcceptedDifference}_{P,M,\varepsilon}(r). \end{aligned} \tag{411}$$

Then:

$$\begin{aligned} &\text{PositiveManifestationWitness}_{A;P,M,\varepsilon}(\chi; r) \\ &\quad \Longrightarrow \text{Warrant}_{P,M}\left[\exists s \in I_A \left(\text{ManifestationAt}(A,\chi;s) \wedge \text{PhysReal}^{+}_{A}(s)\right)\right]. \end{aligned} \tag{412}$$

The existential witness is physically actual.

The record does not thereby identify which member of I_A it is.

21.3 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.

Formally:

$$\boxed{\text{ValidObservedManifestation}_{A;P,M,\varepsilon}(\chi;\mathbf{r}) \Longrightarrow \text{Warrant}_{P,M}\left[\exists s \in I_A\ \text{ManifestationAt}(A,\chi;s)\right],} \tag{413}$$

while:

$$\text{ValidObservedManifestation}_{A;P,M,\varepsilon}(\chi;\mathbf{r}) \not\Rightarrow \text{ExactCosmicChangeStageIdentified}_{P,M}(A,\chi), \tag{414}$$

and:

$$\text{ValidObservedManifestation}_{A;P,M,\varepsilon}(\chi;\mathbf{r}) \not\Rightarrow \text{ExactCosmicOrderPositionIdentified}_{P,M}(A,\chi). \tag{415}$$

21.4 Exact-stage restraint is not derived from UCC alone

UCC supplies physical-change actuality.

It does not by itself establish observational non-identifiability.

Therefore:

$$\text{UCC} \not\Rightarrow \text{ExactChangeStageNonidentifiabilityAsLogicalTheorem}. \tag{416}$$

The restraint additionally depends on:

$$\begin{gathered} \text{source–record separation}, \quad \text{finite physical access}, \quad \text{changing acquisition systems}, \\ \text{record support}, \quad \text{model dependence}, \quad \text{and stage–record type distinction}. \end{gathered} \tag{417}$$

21.5 First notice is not first change

Under UCC:

$$\text{FirstResolvedManifestation}_{P,M,\varepsilon}(A;r) \not\Rightarrow \text{FirstPhysicalChangeOf}(A). \tag{418}$$

A detection threshold concerns the acquisition system and 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 $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ nor its exact position in the universal ordering is thereby identified.

21.6 Record order and source-development order

Let:

$$r_1 \prec_P r_2 \tag{419}$$

be an order relation in a declared record domain.

Then:

$$r_1 \prec_P r_2 \not\Rightarrow \mathrm{SourceDevelopmentEarlier}(A, \chi_1, \chi_2). \tag{420}$$

A physical source-order bridge is required.

Let:

$$\mathrm{OrderBridge}_{A;P,M}(r_1, r_2; \chi_1, \chi_2) \tag{421}$$

denote such a warranted relation.

Then a record comparison may support:

$$\begin{aligned} \mathrm{Warrant}_{P,M} \Big[\exists s_1, s_2 \in I_A : s_1 \prec_{\mathrm{C}} s_2 \\ \wedge \mathrm{ManifestationAt}(A, \chi_1; s_1) \\ \wedge \mathrm{ManifestationAt}(A, \chi_2; s_2) \Big]. \end{aligned} \tag{422}$$

This still does not identify the exact pair:

$$\mathrm{Warrant}_{P,M}[\exists s_1, s_2\,(\cdots)] \not\Rightarrow \mathrm{ExactCosmicChangeStagePairIdentified}_{P,M}(A, \chi_1, \chi_2). \tag{423}$$

22. Clocks as Physical Systems and Operational 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 [11, 12, 22, 23, 24].

Thus:

$$\mathrm{Clock}(C) \Longrightarrow \mathrm{PhysicalSystem}(C). \tag{424}$$

The clock possesses:

$$I_C = \left\{ s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \mid \mathrm{ExistsAs}(C, s) \right\}, \tag{425}$$

and under UCC:

$$C \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow \mathrm{PhysReal}_C^+(s). \tag{426}$$

Under CRP:

$$\mathrm{PhysReal}_C^+(s) \Longrightarrow \mathcal{C}_C^{\mathrm{act}}(s) \neq \varnothing. \tag{427}$$

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:

$$\mathrm{ClockProcess}, \qquad \mathrm{ClockRecord}, \qquad \mathrm{ClockReading}\,. \tag{428}$$

Each remains type-distinct from time:

$$\mathrm{ClockProcess} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{429}$$

$$\mathrm{ClockRecord} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{430}$$

and:

$$\mathrm{ClockReading} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{431}$$

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:

$$\mathcal{R}_{C,P} : (\mathcal{H}_C|_J, \Theta_{C,P}) \longmapsto r_C. \tag{432}$$

This map is a physical/operational construction.

It does not assign a rate to time.

22.4 Numerical clock reading

Define:

$$N_{C,P} : \mathfrak{R}_{C,P} \longrightarrow \mathbb{R}_P. \tag{433}$$

For:

$$r_C \in \mathfrak{R}_{C,P}, \tag{434}$$

let:

$$n_C = N_{C,P}(r_C). \tag{435}$$

Then:

$$n_C \not\equiv_{\mathrm{type}} r_C, \tag{436}$$

and:

$$n_C \not\equiv_{\mathrm{type}} s, \qquad n_C \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{437}$$

22.5 Clock interval as a special operational metric

For two records:

$$r_{C,1} \lhd_P r_{C,2}, \tag{438}$$

define:

$$\Delta N_{C,P} := N_{C,P}(r_{C,2}) - N_{C,P}(r_{C,1}). \tag{439}$$

Then:

$$\Delta N_{C,P} \not\equiv_{\text{type}} \text{MagnitudeOf}\left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right). \tag{440}$$

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:

$$d_{12}^{\text{obs}} := \Gamma_{1,12}\left(N_{C_1,P_1}(r_1)\right) - \Gamma_{2,12}\left(N_{C_2,P_2}(r_2)\right). \tag{441}$$

A resolved:

$$d_{12}^{\text{obs}} \neq 0 \tag{442}$$

warrants a physical/operational difference under the declared comparison conditions.

It does not establish:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{DifferentCosmicExtensions}(C_1, C_2). \tag{443}$$

Nor:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{CosmicOrderingDeformed}\,. \tag{444}$$

Nor:

$$d_{12}^{\text{obs}} \neq 0 \not\Rightarrow \text{DifferentRatesOfTime}(C_1, C_2). \tag{445}$$

22.7 Clock synchronization and CMA

Clock synchronization remains operational:

$$\text{Synchronized}_{P,\varepsilon}(C_1, C_2). \tag{446}$$

CMA remains ontological:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right). \tag{447}$$

Their distinction is:

$$\text{Synchronized}_{P,\varepsilon} \not\equiv_{\text{type}} \text{CosmicCoPresence}_{\text{C}}\,. \tag{448}$$

Common-stage unity is not constructed by clock agreement.

22.8 Clock failure

Functional clock failure need not terminate numerical identity:

$$\mathrm{ClockFailure}_P(C;s) \nRightarrow \mathrm{End}_C(s). \tag{449}$$

If:

$$s \in I_C, \tag{450}$$

then under UCC:

$$\mathrm{ClockFailure}_P(C;s) \wedge s \in I_C \Longrightarrow \mathrm{PhysReal}_C^+(s). \tag{451}$$

Likewise:

$$\mathrm{NoClockOutputAfter}_P(C;s) \nRightarrow \mathrm{CosmicSuccessionStopsAt}(s). \tag{452}$$

23. General Physical Response Chain

23.1 From clock-specific response modeling to a general typed application chain

V36/F16 developed clock-response modeling as an application-level construction. V37/F17 generalizes the same discipline to arbitrary admissible physical-system classes without promoting any application model into the temporal core.

The governing typed chain is Eq. (103). 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, UCC, or the Stage-to-Change Bridge alone.

23.2 Application-level status

The distinction is:

$$\mathrm{TemporalTypeClaim} \not\equiv_{\mathrm{def}} \mathrm{PhysicalResponseModel}\,. \tag{453}$$

And:

$$\mathrm{SuccessfulPhysicalPrediction} \nRightarrow \mathrm{ModelOutput} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{454}$$

23.3 Physical-condition bundle

For system A_i and accepted comparison index k, let:

$$\mathcal{B}_{i,k} := \left(\widehat{X}_{i,k}, \widehat{Z}_{i,k}, \widehat{R}_{i,k}, \widehat{\Pi}_{i,k}\right), \tag{455}$$

where:

(i) $\widehat{X}_{i,k}$ is the reconstructed system state relevant to the declared model;

(ii) $\widehat{Z}_{i,k}$ is the declared local or environmental physical-condition bundle;

(iii) $\widehat{R}_{i,k}$ contains relevant physical relations to other systems or reference structures;

(iv) $\widehat{\Pi}_{i,k}$ 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 $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

23.4 Physical response function

Let:

$$\widehat{q}_{i,k}^{M} = \mathcal{Q}_{i,M}\left(\mathcal{B}_{i,k};\theta_i\right) \tag{456}$$

be a predicted physical or operational response. Where atomic or optical carrier models are used, independently derived sensitivity calculations can supply application-level coefficient provenance when physically warranted [25].

The model parameters:

$$\theta_i = \left(\theta_{i,1},\ldots,\theta_{i,p_i}\right) \tag{457}$$

must possess declared provenance:

$$\mathrm{Prov}\left(\theta_{i,j}\right) = \mathcal{P}_{i,j}. \tag{458}$$

Admissible provenance may include:

$$\begin{gathered}\text{independent physical derivation,}\quad \text{independent measurement,}\\ \text{construction specification,}\quad \text{independent calibration,}\\ \text{external physical constraint,}\quad \text{or declared derivation-domain estimation.}\end{gathered} \tag{459}$$

23.5 Benchmark recovery is not independent prediction

If:

$$\mathrm{Prov}(\theta) = \mathrm{BenchmarkAssigned}, \tag{460}$$

then:

$$\mathrm{Prov}(\theta) = \mathrm{BenchmarkAssigned} \not\Rightarrow \mathrm{IndependentPrediction}(\theta). \tag{461}$$

Likewise:

$$\theta = \Theta\left(D_{\mathrm{eval}}\right) \not\Rightarrow \mathrm{IndependentPrediction}\left(D_{\mathrm{eval}}\right). \tag{462}$$

A model may successfully recover an existing benchmark.

Recovery and advance prediction remain distinct inferential statuses.

24. Predeclared Quantitative Test Architecture

24.1 Four inferential levels

V37/F17 retains the hierarchy:

$$\text{Recovery} \longrightarrow \text{AdvancePrediction} \longrightarrow \text{ModelDiscrimination} \longrightarrow \text{FoundationalAssessment}\,. \tag{463}$$

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:

$$\mathfrak{P}^{\star} := (\mathcal{S}, \mathcal{B}, \mathcal{Q}, \mathfrak{M}, \Theta, \mathcal{C}, \Sigma, \mathcal{E}, \mathcal{A}, \mathcal{F}, \mathcal{R})\,. \tag{464}$$

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:

$$\text{ProtocolFrozen}\,(\mathfrak{P}^{\star}) \Longrightarrow \text{NoEvaluationOutcomeDependence}\,(\mathfrak{P}^{\star})\,. \tag{465}$$

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:

$$\begin{aligned}&\mathrm{ProtocolFrozen}(\mathfrak{P}^\star)\wedge \mathrm{IdentitySensitiveApplication}(\mathfrak{P}^\star)\\&\implies \mathrm{OutcomeIndependentSystemClass}(\mathfrak{P}^\star)\\&\quad\wedge \mathrm{OutcomeIndependentSystemBoundary}(\mathfrak{P}^\star)\\&\quad\wedge \mathrm{OutcomeIndependentIdentityCriterion}(\mathfrak{P}^\star).\end{aligned} \tag{466}$$

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:

$$\mathrm{PostEvaluationIdentityOrBoundaryRevision} \not\Rightarrow \mathrm{OriginalProtocolPredictionSucceeded}\,. \tag{467}$$

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:

$$D_{\mathrm{der}} \tag{468}$$

be the derivation domain and:

$$D_{\mathrm{eval}} \tag{469}$$

the evaluation domain.

Require:

$$D_{\mathrm{der}} \cap D_{\mathrm{eval}} = \varnothing. \tag{470}$$

But:

$$D_{\mathrm{der}} \cap D_{\mathrm{eval}} = \varnothing \not\Rightarrow \mathrm{NoEvaluationLeakage}\,. \tag{471}$$

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:

$$\widehat{\mathbf{y}}^{\,M_1}, \qquad \widehat{\mathbf{y}}^{\,M_2} \tag{472}$$

be their predeclared evaluation predictions.

Define:

$$\Delta\widehat{\mathbf{y}}_{12} := \widehat{\mathbf{y}}^{\,M_1} - \widehat{\mathbf{y}}^{\,M_2}. \tag{473}$$

A meaningful discrimination claim requires that the predicted separation be resolved relative to the declared combined uncertainty structure. Using the short predicate $\mathrm{ResolvedSep}_{\Sigma_{12}}$ for that declared criterion:

$$\boxed{\text{PredictionSeparation}(M_1, M_2; P, D) \Longrightarrow \text{ResolvedSep}_{\Sigma_{12}}(\Delta\widehat{\mathbf{y}}_{12})\,.} \tag{474}$$

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:

$$\mathsf{J}_D = \left[\frac{\partial \widehat{y}_k^M}{\partial \theta_j}\right]_{k\in D} \tag{475}$$

be the local sensitivity matrix.

For positive-definite covariance:

$$\mathsf{W}_D^{\mathsf{T}}\mathsf{W}_D = \Sigma_D^{-1}, \tag{476}$$

define:

$$\mathsf{X}_D = \mathsf{W}_D\mathsf{J}_D. \tag{477}$$

A local identifiability criterion may require:

$$\text{Identifiable}_D(M) \Longleftrightarrow \text{rank}(\mathsf{X}_D) = p_M \wedge \kappa_2(\mathsf{X}_D) \le \kappa_{\max}, \tag{478}$$

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. Foundational Empirical Bridge and Attribution

25.1 Internal foundational bridge and empirical bridge are different

The Stage-to-Change Bridge remains:

$$\text{StageChangeBridge}_{\mathrm{C}}(s). \tag{479}$$

It records the joint foundational content of CMA and UCC at s.

A foundational empirical bridge instead records the additional physical and observational premises required to derive a measurable consequence.

Therefore:

$$\text{StageChangeBridge}_{\mathrm{C}} \not\equiv_{\text{type}} \text{FoundationalEmpiricalBridge}\,. \tag{480}$$

The distinction is central to V37/F17.

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:

$$\mathfrak{B}_F^{P,D} := \left(B_F^{\text{phys}}, B_F^{\text{obs}}, \mathcal{P}_F^{\text{aux}}, \Sigma_F, \mathcal{A}_F\right). \tag{481}$$

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 introduced in Eq. (106); 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:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F. \tag{482}$$

The derivation itself must not be reconstructed after observing the outcome if advance predictive status is claimed.

Thus:

$$\text{AdvanceFoundationalPrediction} \Longrightarrow \text{OutcomeIndependentSpecification}\left(\mathfrak{B}_F^{P,D}, O_F\right). \tag{483}$$

25.4 Failure of an observable does not automatically refute the foundation

If:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F \tag{484}$$

and:

$$\neg O_F, \tag{485}$$

then:

$$\neg O_F \not\Rightarrow \neg F. \tag{486}$$

The failure may instead lie in:

$$B_F^{\text{phys}}, \quad B_F^{\text{obs}}, \quad \mathcal{P}_F^{\text{aux}}, \quad \Sigma_F, \quad \text{or their declared domain.} \tag{487}$$

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:

$$\begin{aligned}\text{FoundationalAttribution}(F; O, P, D) \implies\ & \text{FoundationToObservableDerivationDeclared} \\ & \wedge \text{OutcomeIndependentBridges} \\ & \wedge \text{ProtocolFrozen}(P) \\ & \wedge \text{NoEvaluationLeakage}(P, D) \\ & \wedge \text{ValidPhysicalSystemBoundaries} \\ & \wedge \text{ValidIdentityCriteriaWhereApplicable} \\ & \wedge \text{ValidAcquisitionSupport} \\ & \wedge \text{ValidCovariance} \\ & \wedge \text{PredictionSeparationIdentifiable} \\ & \wedge \text{AlternativeAttributionControlled}\,.\end{aligned} \tag{488}$$

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-preference boundary

The existence of formal counterconditions to CMA, UCC, 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, V37/F17 does not claim that experiment has already established empirical preference for ITOF over that rival ontology:

$$\neg\, \text{FoundationSpecificSeparation}_{P,D} \implies \neg\, \text{ExperimentalPreferenceEstablished}_{P,D}(I, R). \tag{489}$$

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.

25.7 Foundational discrimination between two alternatives

For foundational alternatives:

$$F, \qquad F^\star, \tag{490}$$

a warranted discrimination claim requires independently specified observable consequences:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F, \tag{491}$$

$$F^\star \wedge B_{F^\star}^{\text{phys}} \wedge B_{F^\star}^{\text{obs}} \wedge \mathcal{P}_{F^\star}^{\text{aux}} \vdash O_{F^\star}. \tag{492}$$

A necessary condition is:

$$\begin{aligned}
&\text{Warrant}_{P,D}\left[\text{FoundationalDiscrimination}(F, F^\star)\right] \\
&\implies \text{OutcomeIndependentSpecification}\left(\mathfrak{B}_F^{P,D}, \mathfrak{B}_{F^\star}^{P,D}\right) \\
&\qquad \wedge \text{ProtocolFrozen}(P) \\
&\qquad \wedge \text{NoEvaluationLeakage}(P, D) \\
&\qquad \wedge \text{PredictionSeparationBeyondCombinedUncertainty}\left(O_F, O_{F^\star}; P, D\right) \\
&\qquad \wedge \text{FoundationalAttributionIdentifiable}\left(F, F^\star; P, D\right).
\end{aligned} \tag{493}$$

Shared calibrations or systematic inputs are not prohibited where their dependence is explicitly represented in provenance and covariance.

25.8 Application-model discrimination is weaker than foundational discrimination

If two application models differ:

$$M_1 \neq M_2, \tag{494}$$

and observation favours one:

$$\text{DiscriminationFavours}(M_1), \tag{495}$$

the warranted conclusion is initially:

$$\text{Warrant}\left[\text{ApplicationModelSupportedOn}(M_1; D)\right]. \tag{496}$$

It does not automatically follow that:

$$\text{DiscriminationFavours}(M_1) \not\Rightarrow \text{FoundationalTheoryEstablished}. \tag{497}$$

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:

$$M_2 \tag{498}$$

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:

$$\text{PostEvaluationRevision}(M_1 \to M_2) \not\Rightarrow \text{OriginalAdvancePredictionSucceeded}\,. \tag{499}$$

The revised model requires:

$$M_2 \longrightarrow D_{\text{new}} \tag{500}$$

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 equivalently:

$$\exists A \in \mathcal{U}_{\text{phys}}\, \exists s \in I_A, \quad \mathsf{NC}_A^{\text{phys}}(s). \tag{501}$$

By Eq. (64), this is exactly the condition $\exists A \in \mathcal{U}_{\text{phys}}\, \exists s \in I_A : \neg\, \text{PhysReal}_A^{+}(s)$.

A null difference:

$$D^{\text{obs}} = 0 \tag{502}$$

does not establish that contrary:

$$D^{\text{obs}} = 0 \not\Rightarrow \exists A \in \mathcal{U}_{\text{phys}}\, \exists s \in I_A, \quad \mathsf{NC}_A^{\text{phys}}(s). \tag{503}$$

Positive physical warrant for $\mathsf{NC}_A^{\text{phys}}(s)$ 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 denial of the universal common-stage co-realization asserted for the complete qualified population.

Different physical states, different clock outputs, spatial separation, delayed signals, or different observational access do not themselves establish that contrary.

Thus:

$$\text{DifferentPhysicalOutputs}(A, B) \not\Rightarrow \neg\, \text{CMA}\,. \tag{504}$$

Likewise:

$$\text{SignalDelay}(A, B) \not\Rightarrow \neg\, \text{CMA}\,. \tag{505}$$

A challenge to CMA must address the one-common-stage ontology itself.

A challenge to UCC must address memberwise physical-change actuality.

Their evidential burdens remain distinct.

25.12 Strong test condition

A strong discriminating application satisfies:

$$\begin{aligned}\text{StrongDiscriminatingTest} \implies\ & \text{ProtocolFrozen}\\ & \wedge \text{IndependentPhysicalBridge}\\ & \wedge \text{IndependentParameterProvenance}\\ & \wedge \text{ValidPhysicalSystemBoundaries}\\ & \wedge \text{ValidAcquisitionSupport}\\ & \wedge \text{ValidCovariance}\\ & \wedge \text{NoEvaluationLeakage}\\ & \wedge \text{IdentifiableModel}\\ & \wedge \text{PositiveDiscriminatingChannels}\\ & \wedge \text{NullControlChannels}\\ & \wedge \text{RivalPredictionSeparation}\\ & \wedge \text{IndependentEvaluation}\,.\end{aligned} \tag{506}$$

Where replication is physically appropriate and claimed:

$$\text{IndependentReplication} \tag{507}$$

is added as a further condition.

25.13 Scientific claim boundary

The formal existence of a foundational contrary and the existence of a direct finite experimental procedure are different propositions.

Thus:

$$\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{DirectFiniteExperimentFor}(F). \tag{508}$$

Similarly:

$$\text{FinitePositiveObservations} \not\Rightarrow \text{DeductiveConfirmationOfUniversalCommitment}\,. \tag{509}$$

This restraint applies to UCC and other universal commitments.

The absence of a simple finite direct test does not remove their formal contrary conditions.

Conversely, the existence of a formal contrary does not by itself prove that current experimental practice can identify that contrary without additional physical characterization.

26. Integrated Application-Bridge Summary

26.1 Five distinct levels

The V37/F17 bridge architecture consists of five distinct levels without collapsing their roles.

$$\begin{aligned} \text{Level I:} &\quad \text{FoundationalCommitment}, \\ \text{Level II:} &\quad \text{FoundationalDefinedRepresentation}, \\ \text{Level III:} &\quad \text{PhysicalEncodingDynamicsAndPrediction}, \\ \text{Level IV:} &\quad \text{MeasurementAndRecordBridge}, \\ \text{Level V:} &\quad \text{EmpiricalComparisonAndAttribution}\,. \end{aligned} \tag{510}$$

For example:

$$\mathrm{CMA} \wedge \mathrm{UCC} \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \mathrm{StageChangeBridge}_{\mathrm{C}}(s) \tag{511}$$

belongs to the foundational and defined-representation levels.

Level III is the typed physical application chain formed by the model-input bridge, the declared dynamics, and the model-output bridge in Eq. (103). 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 No upward identity transfer

No successful lower-level construction changes the logical type of the foundation.

Thus:

$$\mathrm{SuccessfulApplicationChain} \not\Rightarrow \mathrm{ApplicationOutput} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{512}$$

And:

$$\mathrm{SuccessfulMeasurementBridge} \not\Rightarrow \mathrm{Record} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{513}$$

And:

$$\mathrm{SuccessfulEmpiricalRecovery} \not\Rightarrow \mathrm{ModelParameter} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{514}$$

These non-transfer results are instances of the generalized Non-Transfer Principle.

26.3 No downward automatic derivation

The temporal definition $T_{\mathrm{ITOF}} = (\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$ does not by itself determine any specific physical dynamics, clock response, metric output, signal law, observation model, or experimental prediction:

$$\mathrm{TemporalDefinition}_{\mathrm{ITOF}} \nvdash \mathrm{SpecificApplicationPhysics}\,. \tag{515}$$

Likewise:

$$\mathrm{CMA} \nvdash \mathrm{SpecificClockDifference}, \tag{516}$$

and:

$$\mathrm{UCC} \nvdash \mathrm{SpecificNonzeroCarrierDifferential}\,. \tag{517}$$

System specificity permits physically different responses.

It does not manufacture a quantitative difference without an independently specified physical law.

26.4 Bridge closure before external-theory confrontation

Quantitative confrontation with an external physical theory requires the dependency chain:

$$\begin{aligned} \mathrm{FoundationalDifference} &\longrightarrow \mathrm{IndependentlySpecifiedPhysicalBridge} \\ &\longrightarrow \mathrm{DistinctAdvancePrediction} \\ &\longrightarrow \mathrm{PhysicalRecord} \\ &\longrightarrow \mathrm{ControlledComparison} \\ &\longrightarrow \mathrm{IdentifiableAttribution}\,. \end{aligned} \tag{518}$$

Without the second and third steps, foundational disagreement remains foundational disagreement.

It does not become an empirical victory merely by declaration.

The generalized Non-Transfer Principle fixes the type boundary governing such external-theory comparisons.

27. The 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.

V37/F17 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:

$$\mathrm{MathematicallyConsistent}_M(q) \tag{519}$$

state that q belongs to a mathematically consistent declared model M.

Let:

$$\mathrm{OperationalSuccess}_{P,M,D}(q) \tag{520}$$

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:

$$\boxed{\text{NTP}: \quad \text{MathematicallyConsistent}_M(q) \wedge \text{OperationalSuccess}_{P,M,D}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}.} \tag{521}$$

The principle protects the governing definition in Eq. (12).

27.2 Three separate transfers are prohibited

V37/F17 distinguishes three logically different transfer errors.

First:

$$\text{MathematicallyConsistent}_M(q) \not\Rightarrow \text{ActuallyPhysicallyRealized}(q). \tag{522}$$

Second:

$$\text{ActuallyPhysicallyRealized}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \tag{523}$$

Third:

$$\text{OperationalSuccess}_{P,M,D}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \tag{524}$$

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:

$$\text{NameContainsTime}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}. \tag{525}$$

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. (328). Even predictive success does not supply temporal identity:

$$\text{ModelEvolutionParameter}(\lambda_M; M) \wedge \text{OperationalSuccess}_{P,M,D}(\lambda_M) \not\Rightarrow \lambda_M \equiv_{\text{type}} T_{\text{ITOF}}. \tag{526}$$

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:

$$m_P = \mathcal{M}_P^{\mathrm{op}}(r_1, \ldots, r_n; \kappa_P) \not\Rightarrow m_P \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{527}$$

Higher precision likewise does not transfer type:

$$\mathrm{Precision}(m_P) \to \mathrm{VeryHigh} \not\Rightarrow m_P \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{528}$$

27.6 Coordinate Non-Transfer

For coordinate map:

$$\chi : \mathcal{E}_{\mathrm{phys}} \longrightarrow \mathbb{R}^n, \tag{529}$$

the coordinate representation of event e is not the event:

$$e \not\equiv_{\mathrm{type}} \chi(e). \tag{530}$$

Likewise, a coordinate component used to label model evolution remains type-distinct from time:

$$x^0 \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{531}$$

27.7 Geometrical Non-Transfer

Let:

$$(\mathcal{M}, g) \tag{532}$$

be a mathematical manifold–metric structure used in an external or application model.

Then:

$$\mathrm{GeometricalRepresentation}(\mathcal{M}, g) \not\Rightarrow (\mathcal{M}, g) \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{533}$$

Even if the geometrical model successfully predicts physical records:

$$\mathrm{OperationalSuccess}_{P,M,D}\,(\mathcal{M}, g) \not\Rightarrow (\mathcal{M}, g) \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{534}$$

27.8 Physical-history Non-Transfer

A physical history is not time:

$$\mathcal{H}_A \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{535}$$

The restricted ordering $\prec_{\mathrm{C}} |_{I_A}$ is the order component of the physical history and does not create an independent private time. In the governing ontology:

$$\forall A \in \mathcal{U}_{\mathrm{phys}}, \quad \neg\,\mathrm{PrivateTimeOf}(A). \tag{536}$$

27.9 Physical-realization-profile Non-Transfer

The complete-population common-stage physical-realization profile remains outside the definition of time by Eq. (162).

The restriction remains necessary because V37/F17 expands the theory of physical realization.

The expanded realization architecture does not identify time with a total physical state of the universe:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \mathrm{TotalPhysicalStateOfUniverse}\,. \tag{537}$$

The temporal architecture and the physical-realization architecture remain integrated but type-distinct.

28. Direct Confrontation with Relativistic Temporal Identifications

28.1 Foundational point of disagreement

Relativistic theories possess substantial calculational and predictive success in experimentally tested physical domains [3, 4, 5, 6]. V37/F17 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 [7, 8].

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:

$$\mathrm{DoesRelativisticModelPredictPhysicalRecordsSuccessfully?} \tag{538}$$

and:

$$\mathrm{IsRelativisticModelQuantityIdenticalWithITOFTime?} \tag{539}$$

The first is an empirical and quantitative question.

The second is definitional and ontological.

Hence:

$$\mathrm{RelativisticPredictionSuccessful} \not\Rightarrow \mathrm{RelativisticTemporalQuantity} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{540}$$

28.2 Foliation, spacetime representation, and CMA

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. V37/F17 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; CMA is the meaning-fixed ontological commitment that the complete then-realized qualified population is literally co-realized at one and the same common stage of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

Accordingly, representing CMA alongside a relativistic spacetime description requires an independently declared cross-representation bridge assigning the relevant physically realized manifestations to ITOF stages. 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 empirical success of those constructions. The existence of a usable foliation in a particular relativistic model therefore neither establishes CMA nor turns the foliation into $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

This statement 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. Nor does CMA postulate a temporal ether, rest medium, preferred inertial frame, velocity field, or material carrier.

The foundational conflict is therefore explicit rather than hidden. If a relativistic ontology is interpreted as denying any objective frame-independent universal common-stage co-realization, that ontological denial conflicts with CMA. If relativistic equations are used as independently sourced application-level physical models, their calculational role does not by itself settle that ontological question or transfer temporal identity to a spacetime foliation.

28.3 Relativistic quantity family

Let:

$$\mathcal{Q}_{\mathrm{rel}} := \left\{ \begin{array}{l} x_F^{\mu},\ t_F,\ g_{\mu\nu},\ ds^2,\ \tau[\gamma, g],\ \Sigma_{\lambda},\ \sim_F, \\ J^{+}(p),\ J^{-}(p),\ t_{\mathrm{cos}},\ t_{\mathrm{age}}, \\ \mathrm{ClockOutput},\ \mathrm{SynchronizationOutput} \end{array} \right\}. \tag{541}$$

These objects perform different mathematical, geometrical, physical-model, or operational roles. Their common inclusion in $\mathcal{Q}_{\mathrm{rel}}$ does not make them one type.

The governing ITOF conclusion is:

$$\boxed{\forall q \in \mathcal{Q}_{\mathrm{rel}}, \qquad q \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}.} \tag{542}$$

In particular:

$$t_F \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{543}$$

$$g_{\mu\nu} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{544}$$

$$ds^2 \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{545}$$

$$\tau[\gamma, g] \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \tag{546}$$

$$\Sigma_{\lambda} \not\equiv_{\mathrm{type}} s, \qquad s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \tag{547}$$

$$\sim_F \not\equiv_{\mathrm{type}} \mathrm{CosmicCoPresence}_{\mathrm{C}}, \tag{548}$$

$$\mathrm{ClockOutput} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{549}$$

No successful calculation changes these type relations.

28.4 Relativistic Non-Transfer

For $q \in \mathcal{Q}_{\mathrm{rel}}$, the generalized Non-Transfer Principle of Eq. (521) applies without a relativistic exception.

Even physical realization of a quantity's referent does not transfer temporal identity:

$$\mathrm{ActuallyPhysicallyRealizedReferent}(q) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{550}$$

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:

$$\begin{gathered}\text{coordinate time}, \quad \text{proper time}, \quad \text{time dilation}, \quad \text{cosmic time}, \\ \text{time coordinate}, \quad \text{time function}\end{gathered} \tag{551}$$

does not settle the ontological question posed by ITOF.

Thus:

$$\mathrm{StandardTerminology}(q, \text{“time”}) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{552}$$

The ITOF classification follows the construction and role of the quantity, not its conventional label.

29. Coordinate Representation, Invariance, and Physical Reality

29.1 Physical event and coordinate assignment

Let:

$$\mathcal{E}_{\mathrm{phys}} \tag{553}$$

be a declared family of physically realized events or manifestations.

For chart or frame F, let:

$$\chi_F : \mathcal{E}_{\mathrm{phys}} \longrightarrow \mathbb{R}^4. \tag{554}$$

For:

$$e \in \mathcal{E}_{\mathrm{phys}}, \tag{555}$$

the coordinate tuple is:

$$x_F^{\mu}(e) = \chi_F(e). \tag{556}$$

The physical manifestation is not its coordinates:

$$e \not\equiv_{\mathrm{type}} \chi_F(e). \tag{557}$$

Likewise:

$$\mathrm{PhysicalUniverse} \not\equiv_{\mathrm{type}} (\mathcal{M}, g). \tag{558}$$

A representation of physical reality is not identical with the physical totality represented.

29.2 Coordinate assignment does not produce a common cosmic change stage

Suppose:

$$\text{ManifestationAt}(A, \chi; s), \qquad s \in I_A. \tag{559}$$

A relativistic model may assign:

$$\chi_F(e) = \left(x_F^0, x_F^1, x_F^2, x_F^3\right). \tag{560}$$

It does not follow that:

$$x_F^0 \not\equiv_{\text{type}} s. \tag{561}$$

Nor:

$$x_F^0 \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{562}$$

A coordinate value may be operationally associated with a physical event. Even when a coordinate component is chosen so that its ordering agrees with $\prec_{\text{C}}$ on a declared domain, it remains an order representation in the sense of Eq. (24). Its numerical intervals are therefore not fixed by the bare cosmic order.

It does not become the common cosmic change stage itself.

29.3 Different meanings of invariance

V37/F17 explicitly distinguishes:

$$\text{PairwiseDefDistinct}\left(\text{InvariantCosmicOrdering}, \text{LorentzInvariance}, \text{GeneralCovariance}\right). \tag{563}$$

Invariant Cosmic Ordering means that:

$$\prec_{\text{C}} \tag{564}$$

is the one fixed universal earlier–later ordering of the common cosmic change-stage totality.

Lorentz invariance concerns transformation properties under Lorentz transformations.

General covariance concerns admissible coordinate representation of physical laws.

Neither defines:

$$T_{\text{ITOF}}. \tag{565}$$

Therefore:

$$\text{LorentzInvariant}(q) \not\Rightarrow q \equiv_{\text{type}} T_{\text{ITOF}}, \tag{566}$$

and:

$$\text{GenerallyCovariant}(M) \not\Rightarrow \text{TimeDefinedBy}(M). \tag{567}$$

29.4 Coordinate transformation does not transform the cosmic ordering

A special-relativistic transformation may contain:

$$t' = \gamma\left(t - \frac{vx}{c^2}\right), \qquad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}. \tag{568}$$

The transformation relates coordinate assignments.

It does not transform:

$$\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{569}$$

Thus:

$$t \neq t' \not\Rightarrow \mathrm{ITOFTimeTransformed}\,. \tag{570}$$

More generally:

$$\mathrm{CoordinateTransform}(F \to F') \not\Rightarrow \mathrm{Transform}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{571}$$

Different coordinate assignments do not generate different cosmic extensions.

30. Metric Geometry and Proper-Time Functionals

30.1 Metric interval

In a relativistic model:

$$ds^2 = g_{\mu\nu}\, dx^\mu dx^\nu. \tag{572}$$

The expression defines a geometrical model quantity under the adopted metric structure.

It is not:

$$ds^2 \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{573}$$

Nor is:

$$g_{\mu\nu} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{574}$$

Metric success therefore does not establish temporal identity:

$$\mathrm{MetricPredictionSuccessful} \not\Rightarrow g_{\mu\nu} \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{575}$$

30.2 Metric dependence on physical or coordinate variables

A metric may be represented as:

$$g_{\mu\nu} = g_{\mu\nu}(x). \tag{576}$$

It does not follow that:

$$g_{\mu\nu} = g_{\mu\nu}(x) \not\Rightarrow T_{\mathrm{ITOF}} = T_{\mathrm{ITOF}}(x). \tag{577}$$

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:

$$R^{\rho}{}_{\sigma\mu\nu} \neq 0. \tag{578}$$

This geometrical result does not imply:

$$R^{\rho}{}_{\sigma\mu\nu} \neq 0 \not\Rightarrow \text{ITOFTimeCurved}\,. \tag{579}$$

The ordered pair:

$$\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \tag{580}$$

is not assigned a curvature tensor by the definition of time.

30.4 Einstein field equation

A general-relativistic application may employ:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}. \tag{581}$$

V37/F17 does not deny the mathematical content or empirically warranted physical use of such equations [4, 5].

The relevant type conclusion remains:

$$\text{EinsteinFieldEquationSuccessfulOn}(D) \not\Rightarrow g_{\mu\nu} \equiv_{\text{type}} T_{\text{ITOF}}. \tag{582}$$

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:

$$\tau[\gamma, g] = \frac{1}{c} \int_{\gamma} \sqrt{-g_{\mu\nu}\, dx^{\mu} dx^{\nu}}. \tag{583}$$

The quantity depends on:

$$\gamma \quad \text{and} \quad g. \tag{584}$$

Therefore:

$$\tau = \tau[\gamma, g]. \tag{585}$$

ITOF therefore assigns the direct type relation:

$$\tau[\gamma, g] \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{586}$$

Different path-dependent values satisfy:

$$\tau[\gamma_1, g] \neq \tau[\gamma_2, g]. \tag{587}$$

That difference does not establish different temporal extensions:

$$\tau[\gamma_1, g] \neq \tau[\gamma_2, g] \not\Rightarrow \text{DistinctTemporalReferents}(\gamma_1, \gamma_2). \tag{588}$$

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:

$$\tau[\gamma_A, g] \tag{589}$$

is not the restriction:

$$\prec_{\mathrm{C}}|_{I_A}. \tag{590}$$

Thus:

$$\tau[\gamma_A, g] \not\equiv_{\text{type}} \prec_{\mathrm{C}}|_{I_A}. \tag{591}$$

Accordingly, the proper-time functional is not a private temporal extension belonging to the system:

$$\tau[\gamma_A, g] \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{592}$$

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:

$$N_{C,P} \approx K_{P,M}\left(\tau[\gamma, g]\right) \tag{593}$$

within the warranted domain of a relativistic model.

The conclusion is:

$$\text{QuantitativeAssociationSupported}\left(N_{C,P}, \tau[\gamma, g]\right). \tag{594}$$

It is not:

$$N_{C,P} \approx K_{P,M}(\tau[\gamma, g]) \not\Rightarrow \tau[\gamma, g] \equiv_{\text{type}} T_{\text{ITOF}}. \tag{595}$$

The relation is therefore an example of successful model-to-record association without ontological transfer.

31. Relativity of Simultaneity and the Cosmic Moment Axiom

31.1 Frame-dependent simultaneity

Let:

$$e_1 \sim_F e_2 \tag{596}$$

denote simultaneity assigned according to relativistic frame, chart, and synchronization structure F.

Different admissible frames may satisfy:

$$\exists e_1, e_2, F, F', \quad e_1 \sim_F e_2 \wedge \neg (e_1 \sim_{F'} e_2) . \tag{597}$$

For the standard Lorentz transformation along one spatial axis,

$$\Delta t' = \gamma \left(\Delta t - \frac{v \, \Delta x}{c^2} \right) . \tag{598}$$

Hence two spatially separated events satisfying $\Delta t = 0$ in one inertial coordinate system generally satisfy

$$\Delta t' = -\gamma \frac{v \, \Delta x}{c^2} \neq 0 \tag{599}$$

when $v\Delta x \neq 0$. V37/F17 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:

$$\sim_F \tag{600}$$

is a relativistic representational relation.

It is not:

$$\sim_F \not\equiv_{\text{type}} \text{CosmicCoPresence}_{\text{C}} . \tag{601}$$

31.2 CMA is not synchronization

CMA retains the governing definition in Eq. (55). It does not define common-stage unity through signal exchange, clock agreement, coordinate equality, Einstein synchronization, frame choice, or hypersurface construction.

Thus:

$$\text{SynchronizationConventionChanged} \not\Rightarrow \text{CosmicCoPresenceChanged} . \tag{602}$$

And:

$$\text{CoordinateAssignmentChanged} \not\Rightarrow \text{CommonCosmicChangeStageRealizationChanged} . \tag{603}$$

31.3 Lorentz-domain separation and the absence of a temporal ether

In a Minkowski representation a Lorentz transformation acts on spacetime coordinates or event representations, for example

$$x'^{\mu} = \Lambda^{\mu}{}_{\nu} x^{\nu}, \qquad \Lambda^{\mathsf{T}} \eta \Lambda = \eta. \tag{604}$$

No ITOF rule identifies this matrix action with an action on the temporal carrier $\mathcal{S}_{\text{C}}^{\text{tot}}$ or derives from it a map that replaces the governing order $\prec_{\text{C}}$. 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. (571).

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. CMA supplies a co-realization commitment, not a preferred inertial frame. In particular, the framework separately establishes Eqs. (633) and (634). 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 V37/F17 does not attempt to evade the foundational disagreement by recasting CMA 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 co-realization is a stronger ontological claim that conflicts directly with CMA.

31.4 Direct foundational conflict

A relativistic representation containing frame-dependent simultaneity does not by that mathematical fact alone negate CMA.

The direct conflict arises only when an ontological interpretation asserts that no frame-independent universal common cosmic-stage co-realization exists for the complete then-realized qualified physical-system population.

Let:

$$\mathrm{NoUniversalCommonStageOntology} \tag{605}$$

denote that stronger claim.

Then:

$$\mathrm{CMA} \wedge \mathrm{NoUniversalCommonStageOntology} \Longrightarrow \perp. \tag{606}$$

Equivalently, at stage-relative level:

$$\mathrm{CMA} \wedge \Big[\exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} : \neg\, \mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right)\Big] \Longrightarrow \perp. \tag{607}$$

This is a genuine foundational incompatibility of the two asserted ontologies.

It is not removed by redefining CMA as a synchronization convention, because CMA is not operationally defined.

31.5 The conflict is not yet an empirical discriminant

Foundational contradiction does not by itself produce a measurable separation:

$$\mathrm{FoundationalConflict} \nRightarrow \mathrm{EmpiricalDiscrimination}\,. \tag{608}$$

Empirical discrimination requires the bridge architecture established earlier:

$$\begin{aligned} \mathrm{FoundationalConflict} \wedge \mathrm{IndependentPhysicalBridges} \wedge \mathrm{SeparatedPredictions} \\ \wedge\, \mathrm{ValidObservation} \wedge \mathrm{IdentifiableAttribution}\,. \end{aligned} \tag{609}$$

Conceptual disagreement alone therefore does not constitute experimental refutation.

32. Common-Stage Realization, Signals, and Relativistic Causal Domains

Relativistic causal domains represent causal accessibility within the declared spacetime model. They remain distinct from CMA common-stage co-realization and from the general physical source–signal–record architecture of Section 39.

32.1 Common-stage realization is not instantaneous causation

For:

$$A, B \in \mathcal{S}_{\text{phys}}(s), \tag{610}$$

CMA gives common-stage co-realization.

It does not give:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \nvdash \text{InstantaneousCausalInfluence}(A, B; s). \tag{611}$$

Nor:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \nvdash \text{InstantaneousSignalTransfer}(A, B; s). \tag{612}$$

Nor:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right) \wedge A, B \in \mathcal{S}_{\text{phys}}(s) \nvdash \text{MutualObservationalAccess}(A, B; s). \tag{613}$$

CMA is not a hidden superluminal interaction postulate.

32.2 Relativistic causal domains

For modeled event p:

$$J^+(p), \qquad J^-(p) \tag{614}$$

represent causal-accessibility domains within the adopted spacetime model.

They are not:

$$J^\pm(p) \not\equiv_{\text{type}} \mathcal{S}_{\text{C}}^{\text{tot}}. \tag{615}$$

Nor:

$$J^\pm(p) \not\equiv_{\text{type}} \mathcal{E}_{\text{C}}. \tag{616}$$

Causal accessibility and universal ordering therefore remain distinct:

$$\text{CausallyAccessible}(e_1, e_2) \not\equiv_{\text{def}} \text{CosmicallyOrdered}(e_1, e_2). \tag{617}$$

32.3 No signal requirement for common-stage membership

Let:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \tag{618}$$

while:

$$\text{SignalNotYetReceived}(A, B; s). \tag{619}$$

Then:

$$\text{SignalNotYetReceived}(A, B; s) \nRightarrow B \notin \mathcal{S}_{\text{phys}}(s). \tag{620}$$

Under UCC:

$$\text{SignalNotYetReceived}(A, B; s) \nRightarrow \neg\,\text{PhysReal}_B^+(s). \tag{621}$$

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:

$$\text{Emission} \rightsquigarrow_{\text{phys}} \text{Propagation} \rightsquigarrow_{\text{phys}} \text{Reception} \rightsquigarrow_{\text{phys}} \text{RecordFormation} \tag{622}$$

contains changing physical systems, fields, interactions, and records.

It does not transport:

$$T_{\text{ITOF}}. \tag{623}$$

Thus:

$$\text{SignalPropagation}(A \to B) \nRightarrow \text{TimeTransported}(A \to B). \tag{624}$$

A finite record delay is a physical/operational property of the signal and acquisition chain.

It is not evidence of multiple temporal extensions.

33. Relativistic Foliations and the Preferred-Frame Objection

33.1 Mathematical foliation

Let:

$$\mathfrak{F} = \{\Sigma_\lambda\}_{\lambda \in \Lambda} \tag{625}$$

be a mathematical foliation where such a construction is defined [5, 9].

A hypersurface:

$$\Sigma_\lambda \tag{626}$$

is not automatically a common cosmic change stage:

$$\Sigma_\lambda \not\equiv_{\text{type}} s, \qquad s \in \mathcal{S}_{\text{C}}^{\text{tot}}. \tag{627}$$

Likewise:

$$\lambda \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{628}$$

33.2 A global time function does not establish ITOF ontology

If a mathematical or relativistic model possesses:

$$t_{\text{glob}} : \mathcal{M} \longrightarrow \mathbb{R}, \tag{629}$$

its existence does not establish:

$$\exists t_{\text{glob}} : \mathcal{M} \to \mathbb{R} \not\Rightarrow \text{ActuallyPhysicallyRealized}\left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right). \tag{630}$$

The model construction and ITOF temporal ontology remain different claims.

33.3 CMA does not select a unique relativistic foliation

Conversely:

$$\text{CMA} \nvdash \exists!\mathfrak{F}\ \text{ExactlyRepresents}\left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right). \tag{631}$$

V37/F17 does not identify a coordinate foliation with the common cosmic change-stage totality.

Any proposed association

$$\Sigma_\lambda \leftrightarrow s \tag{632}$$

is an additional model-level hypothesis requiring independent physical justification; CMA does not supply that association.

33.4 No automatic preferred inertial frame

One universal cosmic ordering does not itself define a preferred inertial frame:

$$\text{CMA} \nvdash \text{PreferredInertialFrame}. \tag{633}$$

Likewise:

$$T_{\text{ITOF}} \not\equiv_{\text{type}} \text{PreferredVelocityField}. \tag{634}$$

Any claim of:

$$\begin{gathered}\text{preferred motion}, \quad \text{measurable anisotropy}, \quad \text{modified propagation}, \\ \text{preferred dynamical frame}, \quad \text{or frame-specific physical law}\end{gathered} \tag{635}$$

would be an additional physical hypothesis.

Such a hypothesis requires:

$$\text{IndependentPhysicalModel} \wedge \text{IndependentObservableConsequences} \wedge \text{EmpiricalEvaluation}. \tag{636}$$

It cannot be inferred merely from the existence of CMA.

34. Relativistic Clock Expressions and Physical Record Differences

34.1 Special-relativistic interval relation

A standard special-relativistic relation may be represented as:

$$\Delta\tau = \frac{\Delta t}{\gamma}. \tag{637}$$

Within V37/F17, this equation relates declared relativistic model quantities; it is not an equation for deformation or dilation of the ITOF temporal referent. Thus:

$$\Delta\tau \neq \Delta t \not\Rightarrow \mathrm{ITOFTimeDilated}\,. \tag{638}$$

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:

$$C_A, \qquad C_B \tag{639}$$

be two physical clock systems with:

$$\mathcal{H}_{C_A} = \left(I_{C_A}, \prec_{\mathrm{C}}|_{I_{C_A}}, X_{C_A}, \Delta^{\mathrm{phys}}_{C_A}\right), \tag{640}$$

$$\mathcal{H}_{C_B} = \left(I_{C_B}, \prec_{\mathrm{C}}|_{I_{C_B}}, X_{C_B}, \Delta^{\mathrm{phys}}_{C_B}\right). \tag{641}$$

Their physical histories may differ in:

$$\begin{gathered}\text{motion}, \quad \text{gravitational environment}, \quad \text{thermal conditions}, \\ \text{electromagnetic interactions}, \quad \text{mechanical conditions}, \quad \text{control}, \\ \text{interrogation}, \quad \text{signal transfer}, \quad \text{and other physical variables}.\end{gathered} \tag{642}$$

A later comparison may yield:

$$d^{\mathrm{obs}}_{AB} = \Gamma_A(N_A) - \Gamma_B(N_B) \neq 0. \tag{643}$$

The warranted direct conclusion is:

$$\mathrm{DifferentPhysicalClockRecords}(C_A, C_B). \tag{644}$$

The record difference does not establish unequal amounts of ITOF time:

$$d^{\mathrm{obs}}_{AB} \neq 0 \not\Rightarrow [\mathrm{LessTimeFor}(C_A) \vee \mathrm{MoreTimeFor}(C_B)]\,. \tag{645}$$

34.3 CMA and UCC in the separated-clock case

Where:

$$C_A, C_B \in \mathcal{S}_{\text{phys}}(s), \tag{646}$$

CMA gives:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right). \tag{647}$$

Independently, UCC gives:

$$\text{PhysReal}^{+}_{C_A}(s) \wedge \text{PhysReal}^{+}_{C_B}(s). \tag{648}$$

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:

$$\frac{\Delta\nu}{\nu} \simeq \frac{\Delta\Psi}{c^2}. \tag{649}$$

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:

$$\frac{\Delta\nu}{\nu} \neq 0 \not\Rightarrow \text{ITOFGravitationalTimeDilation}. \tag{650}$$

V37/F17 classifies:

$$\frac{\Delta\nu}{\nu} \tag{651}$$

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 [10]:

$$\begin{gathered}\text{satellite systems,}\quad \text{physical clocks,}\quad \text{orbital models,}\quad \text{signal propagation,}\\ \text{receivers,}\quad \text{coordinate assignments,}\quad \text{synchronization conventions,}\\ \text{relativistic corrections,}\quad \text{calibration,}\quad \text{and record processing.}\end{gathered} \tag{652}$$

If:

$$\text{NavigationError} \leq \varepsilon_{\text{nav}}, \tag{653}$$

then:

$$\text{GPSOperationalSuccess} \tag{654}$$

may be warranted within the declared domain.

It does not follow that:

$$\text{GPSOperationalSuccess} \not\Rightarrow t_{\text{GPS}} \equiv_{\text{type}} T_{\text{ITOF}}. \tag{655}$$

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. Relativistic Cosmological Parameters

35.1 Cosmological coordinate parameter

A relativistic cosmological model may employ:

$$ds^2 = -c^2 dt_{\text{cos}}^2 + a^2(t_{\text{cos}})\, d\Sigma_k^2. \tag{656}$$

The parameter:

$$t_{\text{cos}} \tag{657}$$

belongs to the declared cosmological model.

Even where it orders a useful family of model hypersurfaces:

$$t_{\text{cos}} \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{658}$$

35.2 Model-derived cosmological age

A cosmological model may calculate:

$$t_{\text{age}} = \int_{a_{\text{i}}}^{a_0} \frac{da}{aH(a; \Omega_i, \ldots)}. \tag{659}$$

This is a model-derived quantitative magnitude.

It does not enumerate the members of:

$$\mathcal{S}_{\text{C}}^{\text{tot}}. \tag{660}$$

Therefore:

$$\text{CosmologicalAgeComputed}(t_{\text{age}}) \not\Rightarrow \text{CommonCosmicChangeStagesCounted}\,. \tag{661}$$

Nor:

$$t_{\text{age}} \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{662}$$

35.3 Cosmic origin and cosmological model origin

Where V37/F17 retains the independent Cosmic Origin commitment:

$$\text{CosmicOrigin}, \tag{663}$$

it remains logically distinct from:

$$\text{RelativisticModelOriginParameter}\,. \tag{664}$$

Thus:

$$\text{CosmicOrigin} \not\equiv_{\text{def}} \text{RelativisticCosmologicalBoundary}\,. \tag{665}$$

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–Relativistic Observable Comparison Bridge

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.

V37/F17 therefore distinguishes:

$$\text{OntologicalIdentification} \not\equiv_{\text{def}} \text{EmpiricalComparison}\,. \tag{666}$$

The bridge is an empirical-comparison architecture, not an ontological merger of temporal definitions.

36.2 No derivational projection from the temporal definition into spacetime geometry

The definition:

$$T_{\text{ITOF}} = \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right) \tag{667}$$

does not itself derive:

$$g_{\mu\nu}, \quad ds^2, \quad \tau[\gamma, g], \quad J^{\pm}(p), \quad \Sigma_\lambda. \tag{668}$$

Therefore:

$$\text{TemporalDefinition}_{\text{ITOF}} \not\Rightarrow \text{RelativisticSpacetimeGeometry}\,. \tag{669}$$

Likewise, neither foundational commitment supplies the corresponding relativistic mathematical structure:

$$\text{CMA} \nvdash \text{RelativisticMetricStructureSpecified}, \tag{670}$$

$$\text{UCC} \nvdash \text{ProperTimeFunctionalSpecified}\,. \tag{671}$$

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:

$$\mathrm{ValidITOF} \not\Rightarrow \mathrm{RelativisticTemporalOntologyRecovered}\,. \tag{672}$$

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:

$$\mathrm{PhysicalCompetitionOn}(D) \Longrightarrow \mathrm{ObservableRecoveryOrDiscriminationOn}(D), \tag{673}$$

not:

$$\mathrm{TemporalOntologyIdentity}\,. \tag{674}$$

36.4 Two independent application branches

Let:

$$F_I \tag{675}$$

denote the relevant ITOF foundational commitments.

Let:

$$M_I \tag{676}$$

be an independently specified physical application model consistent with those commitments.

Let:

$$M_R \tag{677}$$

be the declared relativistic comparison model.

The ITOF branch is:

$$F_I \wedge M_I \wedge B_I^{\mathrm{phys}} \wedge \mathcal{P}_I \vdash \widehat{\mathbf{y}}^{\,I}. \tag{678}$$

The relativistic branch is:

$$M_R \wedge B_R^{\mathrm{phys}} \wedge \mathcal{P}_R \vdash \widehat{\mathbf{y}}^{\,R}. \tag{679}$$

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

$$\mathcal{Y}_{\mathrm{obs}}^{P,D} \subseteq \mathbb{R}^{m_{P,D}}, \qquad m_{P,D} \in \mathbb{N}_{>0}, \tag{680}$$

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:

$$\Pi_I^{P,D} : \widehat{\mathcal{Y}}_I \longrightarrow \mathcal{Y}_{\mathrm{obs}}^{P,D}, \tag{681}$$

$$\Pi_R^{P,D} : \widehat{\mathcal{Y}}_R \longrightarrow \mathcal{Y}_{\mathrm{obs}}^{P,D}. \tag{682}$$

Then:

$$\mathbf{y}_I^{P,D} = \Pi_I^{P,D}\left(\widehat{\mathbf{y}}^{\,I}\right), \tag{683}$$

$$\mathbf{y}_R^{P,D} = \Pi_R^{P,D}\left(\widehat{\mathbf{y}}^{\,R}\right). \tag{684}$$

The common empirical codomain permits comparison.

It does not create ontological identity between the theories.

36.6 Observable comparison bridge

Define the comparison architecture:

$$\boxed{\mathfrak{B}_{I:R}^{P,D} := \left(B_I^{\mathrm{phys}}, B_R^{\mathrm{phys}}, \Pi_I^{P,D}, \Pi_R^{P,D}, \mathcal{P}_I, \mathcal{P}_R, \Sigma_{I:R}\right).} \tag{685}$$

This is the V37/F17 ITOF–relativistic observable comparison bridge.

Its status is:

$$\mathrm{Status}\left(\mathfrak{B}_{I:R}^{P,D}\right) = \mathrm{ApplicationLevelEmpiricalComparisonArchitecture}. \tag{686}$$

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:

$$\mathrm{CoordinateAssigned}_F(e) \not\Rightarrow \mathrm{PhysicalAssociationWithCommonCosmicChangeStage}(e). \tag{687}$$

Likewise:

$$t_F(e) = t_0 \tag{688}$$

does not establish:

$$t_F(e) = t_0 \not\Rightarrow \mathrm{ExactCosmicChangeStageIdentified}(e). \tag{689}$$

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:

$$\text{CommonCosmicChangeStageDataClaim}_{P,M} \Longrightarrow \text{DeclaredPhysicalAssociationBridge}_{P,M}\,. \tag{690}$$

Let:

$$\mathcal{Q}^{\text{assoc}}_{P,M} \tag{691}$$

be the set of physically applicable association components selected from:

$$\begin{gathered}\text{source attribution},\quad \text{propagation/path model},\quad \text{detector interaction},\\ \text{record formation},\quad \text{reconstruction},\quad \text{calibration},\\ \text{system identification},\quad \text{uncertainty characterization}.\end{gathered} \tag{692}$$

Then:

$$\begin{aligned}\text{DeclaredPhysicalAssociationBridge}_{P,M} \Longrightarrow\ & \text{ApplicabilitySetFixedIndependently}_{P,M}\left(\mathcal{Q}^{\text{assoc}}_{P,M}\right)\\ & \wedge \forall q \in \mathcal{Q}^{\text{assoc}}_{P,M},\quad \text{DeclaredAndWarranted}_{P,M}(q).\end{aligned} \tag{693}$$

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:

$$\mathbf{y}^{P,D_{\text{rec}}}_{I,\text{rec}} = \Pi^{P,D_{\text{rec}}}_{I}\left(\widehat{\mathbf{y}}^{\,I}_{\text{rec}}\right), \tag{694}$$

$$\mathbf{y}^{P,D_{\text{rec}}}_{R,\text{rec}} = \Pi^{P,D_{\text{rec}}}_{R}\left(\widehat{\mathbf{y}}^{\,R}_{\text{rec}}\right). \tag{695}$$

A recovery condition may then be stated in that common empirical codomain:

$$\left\|\mathbf{y}^{P,D_{\text{rec}}}_{I,\text{rec}} - \mathbf{y}^{P,D_{\text{rec}}}_{R,\text{rec}}\right\|_{\Sigma^{-1}_{I:R}} \le \varepsilon_{\text{rec}}. \tag{696}$$

The comparison norm, covariance, and threshold must be declared in advance.

Successful recovery warrants:

$$\text{ITOFApplicationRecoversBenchmarkOn}(D_{\text{rec}}). \tag{697}$$

It does not establish:

$$\begin{aligned}&\text{ITOFApplicationRecoversBenchmarkOn}(D_{\text{rec}})\\ &\quad\not\Rightarrow \text{ITOFTemporalOntology} = \text{RelativisticTemporalOntology}\,.\end{aligned} \tag{698}$$

36.10 Recovery is not discrimination

If the common-observable predictions satisfy:

$$\mathbf{y}_I^{P,D} \approx \mathbf{y}_R^{P,D} \tag{699}$$

within the declared combined uncertainty, the two application models may be empirically indistinguishable on that domain.

Thus:

$$\text{BenchmarkRecovered} \not\Rightarrow \text{ITOFFoundationallyConfirmed}\,. \tag{700}$$

And:

$$\text{BenchmarkRecovered} \not\Rightarrow \text{RelativisticTemporalIdentityAccepted}\,. \tag{701}$$

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:

$$\Delta_{I:R}^{P,D} := \mathbf{y}_I^{P,D} - \mathbf{y}_R^{P,D}. \tag{702}$$

A necessary discrimination condition is:

$$\text{ResolvedPredictionSeparation}_{I:R} \Longrightarrow \left\| \Delta_{I:R}^{P,D} \right\|_{\Sigma_{I:R}^{-1}} > \eta_\star, \tag{703}$$

where:

$$\eta_\star > 0 \tag{704}$$

is a predeclared protocol threshold appropriate to the comparison.

The foundation does not assign one universal numerical value to $\eta_\star$.

36.12 Prediction separation must precede outcome inspection

Define the predeclared comparison specification:

$$\mathcal{Q}_{I:R}^{P,D} := \left(\mathbf{y}_I^{P,D}, \mathbf{y}_R^{P,D}, \Sigma_{I:R}, \eta_\star \right). \tag{705}$$

A prediction difference has genuine advance-discrimination status only if:

$$\text{AdvanceRelativityDiscrimination} \Longrightarrow \text{OutcomeIndependentSpecification}\left(\mathcal{Q}_{I:R}^{P,D} \right). \tag{706}$$

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:

$$\text{FairModelComparison}_{I:R} \Longrightarrow \text{BridgeRequirementsAppliedByDeclaredRole}\,. \tag{707}$$

This does not require identical physical premises for two different models.

It requires that:

$$\begin{gathered}\text{each necessary bridge be declared,}\\ \text{each parameter have provenance,}\\ \text{each uncertainty contribution be represented,}\\ \text{and no model receive outcome-dependent auxiliary freedom.}\end{gathered} \tag{708}$$

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

$$\mathbb{B}_I^{P,D} \neq \varnothing, \qquad \mathbb{B}_R^{P,D} \neq \varnothing \tag{709}$$

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:

$$\text{AdmissibleBridgeClasses}_{I:R}(P,D) \Longrightarrow \text{OutcomeIndependentMembershipRule}\left(\mathbb{B}_I^{P,D}, \mathbb{B}_R^{P,D}\right). \tag{710}$$

Residual bridge freedom is present when at least one branch admits more than one independently acceptable bridge realization:

$$\text{ResidualBridgeFreedom}_{I:R}(P,D) \Longleftrightarrow \left|\mathbb{B}_I^{P,D}\right| > 1 \ \vee \ \left|\mathbb{B}_R^{P,D}\right| > 1. \tag{711}$$

For $b_I \in \mathbb{B}_I^{P,D}$ and $b_R \in \mathbb{B}_R^{P,D}$, let

$$d_{I:R}^{P,D}(b_I, b_R) := \left\|\mathbf{y}_I^{P,D}(b_I) - \mathbf{y}_R^{P,D}(b_R)\right\|_{\Sigma^{-1}(b_I,b_R)}. \tag{712}$$

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. (712) is used, the applicable covariance must be positive definite on the evaluated observable subspace:

$$\forall b_I \in \mathbb{B}_I^{P,D}\ \forall b_R \in \mathbb{B}_R^{P,D}, \quad \Sigma(b_I, b_R) \succ 0. \tag{713}$$

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:

$$\delta_{I:R}^{P,D} := \inf_{\substack{b_I \in \mathbb{B}_I^{P,D} \\ b_R \in \mathbb{B}_R^{P,D}}} d_{I:R}^{P,D}(b_I, b_R). \tag{714}$$

For a predeclared threshold $\eta_\star > 0$, define:

$$\text{RobustBridgeSeparation}_{I:R}(P, D; \eta_\star) \iff \delta_{I:R}^{P,D} > \eta_\star. \tag{715}$$

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:

$$\begin{aligned} &\text{ResidualBridgeFreedom}_{I:R}(P, D) \wedge \text{Warrant}_{P,D}\left[\text{FoundationalDiscrimination}(F_I, F_R)\right] \\ &\quad \implies \text{RobustBridgeSeparation}_{I:R}(P, D; \eta_\star). \end{aligned} \tag{716}$$

If

$$\delta_{I:R}^{P,D} \leq \eta_\star, \tag{717}$$

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:

$$M_I \tag{718}$$

over:

$$M_R. \tag{719}$$

The immediate warranted claim is:

$$\text{DiscriminationFavours}(M_I) \implies \text{Warrant}\left[\text{ITOFApplicationModelSupportedOn}(D)\right]. \tag{720}$$

It does not automatically establish:

$$\text{DiscriminationFavours}(M_I) \not\Rightarrow \text{CMAEmpiricallyEstablished}. \tag{721}$$

Nor:

$$\text{DiscriminationFavours}(M_I) \not\Rightarrow \text{UCCEmpiricallyEstablished}. \tag{722}$$

A foundational conclusion requires identifiable dependence of the prediction difference on the relevant foundational difference.

36.16 Relativistic model success does not refute ITOF temporal type claims

Conversely, suppose:

$$\mathrm{DiscriminationFavours}(M_R). \tag{723}$$

The direct conclusion concerns the compared application models:

$$\mathrm{DiscriminationFavours}(M_R) \Longrightarrow \mathrm{ITOFApplicationModelRejectedOrRestrictedOn}(D) \tag{724}$$

where the comparison satisfies the declared protocol.

The result does not license replacement of the V37/F17 type assignments. They remain:

$$t_F \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}, \qquad \tau[\gamma, g] \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{725}$$

Empirical success of a physical representation and the definition of time remain logically different questions.

36.17 Condition for genuinely foundational discrimination

Let:

$$F_I \tag{726}$$

contain an ITOF foundational commitment and:

$$F_R \tag{727}$$

the explicitly declared rival foundational proposition.

A genuine foundational comparison requires:

$$F_I \wedge B_I \wedge \mathcal{P}_I \vdash O_I, \tag{728}$$

$$F_R \wedge B_R \wedge \mathcal{P}_R \vdash O_R. \tag{729}$$

Then:

$$\boxed{\begin{aligned} &\mathrm{Warrant}_{P,D}\left[\mathrm{FoundationalDiscrimination}(F_I, F_R)\right] \\ &\Longrightarrow \mathrm{OutcomeIndependentSpecification}(B_I, B_R, \mathcal{P}_I, \mathcal{P}_R) \\ &\quad \wedge \mathrm{ProtocolFrozen}(P) \\ &\quad \wedge \mathrm{NoEvaluationLeakage}(P, D) \\ &\quad \wedge \mathrm{PredictionSeparationBeyondCombinedUncertainty}(O_I, O_R; P, D) \\ &\quad \wedge \mathrm{FoundationalAttributionIdentifiable}(F_I, F_R; B_I, B_R, \mathcal{P}_I, \mathcal{P}_R; P, D). \end{aligned}} \tag{730}$$

Where residual bridge freedom remains, Eq. (716) 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:

$$\mathbf{y}_I^{P,D} \approx \mathbf{y}_R^{P,D} \approx \mathbf{y}_{\text{obs}}. \tag{731}$$

Then:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \tag{732}$$

may be warranted.

It does not follow that:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \not\Rightarrow T_{\text{ITOF}} \equiv_{\text{type}} \tau[\gamma, g]. \tag{733}$$

or:

$$\text{BothModelsEmpiricallyAdequateOn}(D) \not\Rightarrow \text{CosmicCoPresence}_{\text{C}} \equiv_{\text{type}} \sim_F. \tag{734}$$

Empirical equivalence on a finite domain is not ontological identity.

36.19 The tested application chain cannot be used as automatic refutation

Likewise, if:

$$\mathbf{y}_I^{P,D} \not\approx \mathbf{y}_{\text{obs}}, \tag{735}$$

the tested application chain may be inadequate on that domain.

It does not automatically follow that:

$$\neg T_{\text{ITOF}}, \qquad \neg\,\text{CMA}, \qquad \text{or} \qquad \neg\,\text{UCC}\,. \tag{736}$$

The foundational consequence must be derived, not presumed.

36.20 Bridge claim boundary

The admissible V37/F17 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. Formal Relativistic Conflict Register

37.1 Temporal identity conflict

ITOF:

$$T_{\mathrm{ITOF}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{737}$$

Relativistic temporal quantity under examination:

$$q_R \in \mathcal{Q}_{\mathrm{rel}}. \tag{738}$$

ITOF therefore assigns the direct type relation:

$$q_R \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{739}$$

37.2 Universal common-stage conflict

ITOF:

$$\mathrm{CMA}\,. \tag{740}$$

Direct rival:

$$\mathrm{NoUniversalCommonStageOntology}\,. \tag{741}$$

Therefore:

$$\mathrm{CMA} \wedge \mathrm{NoUniversalCommonStageOntology} \Longrightarrow \perp. \tag{742}$$

37.3 Private-time conflict

ITOF already fixes that many physical histories do not imply many times in Eq. (217). Any interpretation asserting that distinct physical-system path functionals are literally distinct temporal extensions conflicts with this type architecture.

Thus:

$$\mathrm{PathDependentMetricQuantity}(A) \not\Rightarrow \mathrm{PrivateTemporalExtension}(A). \tag{743}$$

37.4 Metric-time conflict

ITOF does not define a temporal metric:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \mathrm{MetricSpaceTimeQuantity}\,. \tag{744}$$

Therefore an ontology identifying time itself with metric interval conflicts with the governing ITOF definition.

37.5 Causal-time conflict

ITOF fixes the causal type boundary:

$$\neg\,\mathrm{TimeCausesPhysicalChange}\,. \tag{745}$$

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.

37.6 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:

$$\begin{aligned}\text{RelativisticConflictRegister} \not\Rightarrow\ &\text{EmpiricalRefutationOfRelativity}\\ &\vee \text{EmpiricalConfirmationOfITOF}\,.\end{aligned} \tag{746}$$

Those stronger conclusions require the observable comparison architecture of Section 36.

38. Relativity Confrontation Summary

38.1 Foundational conclusion

The V37/F17 type-level conclusion is:

$$\forall q \in \mathcal{Q}_{\text{rel}}, \qquad q \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{747}$$

The governing temporal definition remains Eq. (12).

CSPP supplies nonempty qualified population.

CMA supplies literal one-common-stage co-realization of the complete then-realized qualified population within the single universal stage domain.

UCC independently supplies system-specific physical-change actuality for every qualified system throughout its realized identity range.

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.

38.2 Type-level and empirical separation

V37/F17 therefore separates three levels that must not be conflated:

$$\begin{aligned}\text{FoundationalTemporalIdentity} &\not\equiv_{\text{def}} \text{RelativisticRepresentation},\\ \text{RelativisticRepresentation} &\not\equiv_{\text{def}} \text{PhysicalRecord},\\ \text{PhysicalRecordAgreement} &\not\equiv_{\text{def}} \text{TemporalIdentity}\,.\end{aligned} \tag{748}$$

The foundational disagreement remains direct.

The empirical comparison remains open to physical investigation.

No identity or merger between the competing temporal identifications is asserted.

38.3 What V37/F17 does claim

V37/F17 claims:

$$\begin{gathered}\text{one universal cosmic extension,}\\ \text{one invariant universal earlier–later ordering,}\\ \text{one common cosmic change-stage realization,}\\ \text{system-specific physical change,}\\ \text{system-specific physical causation,}\\ \text{and type-distinct physical and operational measurements.}\end{gathered} \tag{749}$$

It further claims that successful quantitative comparison with external physical theories must proceed through independently specified physical and observational bridges.

38.4 What V37/F17 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:

$$\text{TemporalDefinition}_{\text{ITOF}} \nvdash \text{RelativisticDomainSpecificDynamicsOrPredictions}\,. \tag{750}$$

Such predictions require physical application models.

Nor does V37/F17 claim that conceptual disagreement with relativistic temporal ontology constitutes experimental falsification of relativity.

38.5 Required future quantitative route

The scientifically admissible route is:

$$\begin{aligned}\text{ITOFFoundationalCommitment} &\longrightarrow \text{IndependentPhysicalApplicationModel}\\ &\longrightarrow \text{FrozenQuantitativePrediction}\\ &\longrightarrow \text{MeasurementAndRecordBridge}\\ &\longrightarrow \text{ObservableComparison}\\ &\longrightarrow \text{ModelDiscrimination}\\ &\longrightarrow \text{FoundationalAttributionWhereIdentifiable}\,.\end{aligned} \tag{751}$$

The route permits no ontological conclusion beyond the dependency actually established by the physical and observational derivation.

39. Signals, Light, 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.

39.1 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:

$$\begin{aligned} &\text{SourceChange} \rightsquigarrow_{\text{phys}} \text{Emission} \rightsquigarrow_{\text{phys}} \text{Propagation} \\ &\qquad \rightsquigarrow_{\text{phys}} \text{ReceiverInteraction} \rightsquigarrow_{\text{phys}} \text{RecordFormation}\,. \end{aligned} \tag{752}$$

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:

$$A \in \mathcal{S}_{\text{phys}}(s), \tag{753}$$

UCC gives:

$$\text{PhysReal}^{+}_{A}(s). \tag{754}$$

The physical signal chain therefore belongs to the system-specific physical realization architecture.

It is not a temporal transport chain.

39.2 Record-lag decomposition

A declared operational record lag may be represented as:

$$\begin{aligned} L^{\text{rec}}_{\Gamma} = {} & L^{\text{emit}}_{\Gamma} + L^{\text{prop}}_{\Gamma} + L^{\text{path}}_{\Gamma} \\ & + L^{\text{interaction}}_{\Gamma} + L^{\text{detect}}_{\Gamma} + L^{\text{process}}_{\Gamma}. \end{aligned} \tag{755}$$

Every term in this expression is an operationally or physically defined quantity under the declared signal model.

A positive lag:

$$L^{\text{rec}}_{\Gamma} > 0 \tag{756}$$

does not imply:

$$L^{\text{rec}}_{\Gamma} > 0 \nRightarrow \text{MultipleTemporalReferentsExist}\,. \tag{757}$$

Nor:

$$L^{\text{rec}}_{\Gamma} > 0 \nRightarrow \text{CosmicChangeStageDelayed}\,. \tag{758}$$

The delay belongs to the physical and operational chain.

39.3 Signals do not transport time

For a physical signal:

$$S : A \to B, \tag{759}$$

V37/F17 retains:

$$\text{SignalPropagation}(S) \not\Rightarrow \text{TimeTransported}(A \to B). \tag{760}$$

Likewise:

$$\text{SignalArrivalAt}(B; s) \not\Rightarrow \text{TimeArrivesAt}(B; s). \tag{761}$$

A signal may transport:

$$\begin{gathered}\text{energy}, \quad \text{momentum}, \quad \text{information-bearing physical variation}, \\ \text{or another physically warranted quantity},\end{gathered} \tag{762}$$

depending on the applicable physical theory.

It does not transport the universal cosmic extension.

39.4 Remote source and receiver

Let:

$$A_S \tag{763}$$

be a remote source system and:

$$A_D \tag{764}$$

a detector or receiving system.

A record r_D received by A_D may be physically attributable to an earlier source manifestation:

$$\text{ManifestationAt}(A_S, \chi_S; s_S). \tag{765}$$

The record remains:

$$r_D \not\equiv_{\text{type}} \chi_S, \tag{766}$$

and:

$$r_D \not\equiv_{\text{type}} s_S. \tag{767}$$

A valid physical source–record bridge may warrant:

$$\text{Warrant}_{P,M} \left[\exists s_S \in I_{A_S} \ \text{ManifestationAt}(A_S, \chi_S; s_S)\right]. \tag{768}$$

It does not thereby identify that exact member of $\mathcal{S}_{\text{C}}^{\text{tot}}$.

39.5 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:

$$s_S \prec_{\text{C}} s_D. \tag{769}$$

The record-arrival stage is not the source stage.

Nor does delayed access imply delayed physical participation by the remote system:

$$\text{RemoteAccessDelayed}(A_S, A_D) \nRightarrow \text{RemotePhysicalChangeDelayed}(A_S). \tag{770}$$

If both identities are realized at a later current common cosmic change stage a:

$$A_S, A_D \in \mathcal{S}_{\text{phys}}(a), \tag{771}$$

then CMA gives their common-stage co-realization at a, while UCC separately gives:

$$\text{PhysReal}^{+}_{A_S}(a) \wedge \text{PhysReal}^{+}_{A_D}(a). \tag{772}$$

The arrival of an older record at A_D does not place the presently realized source identity in a private past time.

39.6 Successive remote records

Let two source manifestations:

$$\chi_1, \qquad \chi_2 \tag{773}$$

belong to the same source identity A_S.

Suppose a warranted physical reconstruction establishes:

$$\exists s_1, s_2 \in I_{A_S}, \quad s_1 \prec_{\text{C}} s_2, \tag{774}$$

with:

$$\text{ManifestationAt}(A_S, \chi_1; s_1) \wedge \text{ManifestationAt}(A_S, \chi_2; s_2). \tag{775}$$

Let the reconstructed record separation satisfy:

$$\Delta_{\text{arr}} = \Delta_{\text{src}} + \Delta_{\text{prop}}. \tag{776}$$

Here:

$$\Delta_{\text{src}} \tag{777}$$

is an operational representation of source-development separation under the declared reconstruction model, while:

$$\Delta_{\text{prop}} \tag{778}$$

contains differential path, propagation, lensing, medium, source-motion, detector, and reconstruction contributions where physically applicable.

If:

$$|\Delta_{\text{prop}}| \le \varepsilon_{\text{prop}}, \tag{779}$$

then:

$$|\Delta_{\text{arr}} - \Delta_{\text{src}}| \le \varepsilon_{\text{prop}}. \tag{780}$$

This may warrant relative source development without identifying the exact stage pair:

$$\begin{aligned} &\mathrm{Warrant}_{P,M}\left[\exists s_1, s_2 \in I_{A_S}\ (s_1 \prec_{\mathrm{C}} s_2)\right] \\ &\quad \not\Rightarrow \mathrm{ExactCosmicChangeStagePairIdentified}_{P,M}(A_S; s_1, s_2). \end{aligned} \tag{781}$$

39.7 Large propagation delay and common-stage unity

A very large propagation delay does not enlarge or divide the common cosmic change stage:

$$L_\Gamma^{\mathrm{prop}} \gg 0 \not\Rightarrow \mathrm{CommonCosmicChangeStageSplit}\,. \tag{782}$$

Nor does:

$$L_\Gamma^{\mathrm{prop}} \gg 0 \not\Rightarrow \mathrm{RemoteSystemHasDifferentTime}\,. \tag{783}$$

Propagation delay concerns access to information-bearing physical records.

CMA concerns objective common-stage realization.

39.8 Light and radiation

A radiation pulse, photon-qualified entity, excitation, beam, field object, or other radiation-model object belongs to $\mathcal{U}_{\mathrm{phys}}$ only if it independently satisfies the applicable physical-system identity criterion.

Thus:

$$\mathrm{RadiationModelObject}(R) \not\Rightarrow \mathrm{PhysicalSystem}(R). \tag{784}$$

Where:

$$R \in \mathcal{U}_{\mathrm{phys}} \tag{785}$$

and:

$$R \in \mathcal{S}_{\mathrm{phys}}(s), \tag{786}$$

UCC gives:

$$\mathrm{PhysReal}_R^+(s). \tag{787}$$

Propagation, scattering, attenuation, interference, refraction, lensing, spectral change, path deviation, polarization change, and detector interaction remain physical phenomena.

Therefore:

$$\mathrm{OpticalPathDeviation}(R) \not\Rightarrow \mathrm{TimeBent}, \tag{788}$$

and:

$$\mathrm{RadiationArrivalDelay}(R) \not\Rightarrow \mathrm{TimeDelayed}\,. \tag{789}$$

39.9 Remote records within the complete physical-realization architecture

For a source stage s_S, the source system belongs to:

$$\mathfrak{R}_{\mathrm{C}}(s_S)\,. \tag{790}$$

At the later detector-record stage s_D, the detector and record-producing systems belong to:

$$\mathfrak{R}_{\mathrm{C}}(s_D)\,. \tag{791}$$

The physical source–record chain therefore connects physical realizations across the invariant order.

It does not identify the two stage-relative profiles:

$$s_S \prec_{\mathrm{C}} s_D \not\Rightarrow \mathfrak{R}_{\mathrm{C}}(s_S) = \mathfrak{R}_{\mathrm{C}}(s_D)\,. \tag{792}$$

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.

40. Quantum Representations, Records, and Physical-System Classification

40.1 Mathematical-form-neutral treatment

V37/F17 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 temporal referent remains:

$$T_{\mathrm{ITOF}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{793}$$

40.2 Quantum model objects are not automatically physical systems

A state vector:

$$|\psi\rangle, \tag{794}$$

density operator:

$$\rho, \tag{795}$$

operator:

$$\widehat{O}, \tag{796}$$

path amplitude, probability distribution, entanglement relation, or superposition notation is not automatically a numerical physical-system identity.

Thus:

$$\mathrm{ModelState}\left(|\psi\rangle\right) \not\Rightarrow \mathrm{PhysicalSystem}\left(|\psi\rangle\right), \tag{797}$$

and:

$$\mathrm{DensityOperator}(\rho) \not\Rightarrow \mathrm{PhysicalSystem}(\rho). \tag{798}$$

Likewise:

$$\text{QuantumOperator}(\widehat{O}) \nRightarrow \text{PhysicalSystem}(\widehat{O}). \tag{799}$$

Their model status must be distinguished from the physical-system identities they may represent.

40.3 Quantum model objects are not time

The generalized Non-Transfer Principle gives:

$$|\psi\rangle \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad \rho \not\equiv_{\text{type}} T_{\text{ITOF}}, \qquad \widehat{O} \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{800}$$

A parameter appearing in a quantum evolution equation remains governed by the model-parameter Non-Transfer rule.

For example, where:

$$i\hbar\frac{\partial}{\partial\lambda}|\psi(\lambda)\rangle = \widehat{H}|\psi(\lambda)\rangle, \tag{801}$$

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:

$$\lambda \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{802}$$

40.4 Joint quantum states and system number

For joint state q_{AB}:

$$\text{JointQuantumState}(q_{AB}) \nRightarrow \text{PhysicalSystemNumber}(q_{AB}). \tag{803}$$

A physically warranted classification may involve:

$$\begin{gathered}\text{two or more independently qualified systems,}\\ \text{one composite system,}\\ \text{a composite together with independently qualified subsystems,}\\ \text{or another physically justified identity architecture.}\end{gathered} \tag{804}$$

The hierarchical composition relation:

$$A \lhd_{\kappa,s} B \tag{805}$$

may be used only where the physical identity and composition criteria justify it.

Quantum-state notation alone does not decide that relation.

40.5 Entanglement does not create one private or shared model-time ontology

An entanglement relation does not by itself establish a private time or a second cosmic ordering:

$$\text{Entangled}_M(A, B) \nRightarrow \text{PrivateTime}(A, B), \tag{806}$$

$$\text{Entangled}_M(A, B) \nRightarrow \text{SecondCosmicOrdering}\,. \tag{807}$$

Where:

$$A, B \in \mathcal{S}_{\text{phys}}(s), \tag{808}$$

CMA supplies common-stage realization independently of the entanglement classification.

Where both are qualified physical systems, UCC supplies their respective system-specific physical changes.

40.6 Quantum measurement

Let a quantum measurement arrangement contain physical source, apparatus, interaction, detector, environment, and record-bearing systems.

Where those entities satisfy the governing physical-system criteria, their stage-relative realization belongs to:

$$\mathfrak{R}_{\mathrm{C}}(s)\,. \tag{809}$$

A detector outcome:

$$r_Q \tag{810}$$

is a physical record.

Thus:

$$r_Q \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{811}$$

A probability:

$$P(o|\psi, M) \tag{812}$$

is a model quantity:

$$P(o|\psi, M) \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{813}$$

40.7 Physical transformation versus representational update

If terminology such as "collapse" denotes an actual physical transformation of a qualified physical system, then:

$$\text{PhysicalCollapse}_M(A; s) \Longrightarrow \text{PhysReal}^+_A(s) \tag{814}$$

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:

$$\text{CollapseNotationChanged} \not\Rightarrow \text{PhysicalSystemIdentityChanged}\,. \tag{815}$$

And:

$$\text{CollapseNotationChanged} \not\Rightarrow \text{CosmicOrderingChanged}\,. \tag{816}$$

40.8 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 [26, 27, 28]. A delayed measurement setting or later correlation classification does not retroactively reverse the universal cosmic ordering.

Thus:

$$\text{LaterCorrelationClassification}(r) \not\Rightarrow \text{EarlierPhysicalRealizationAltered}\,. \tag{817}$$

Likewise:

$$\text{DelayedChoiceRecord}(r) \not\Rightarrow \exists \prec'_{\mathrm{C}} \neq \prec_{\mathrm{C}}\,. \tag{818}$$

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.

40.9 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:

$$\text{QuantumCorrelation}(A, B) \not\Rightarrow \text{SpecificPhysicalCausalMechanism}(A, B). \tag{819}$$

Nor does:

$$\text{QuantumCorrelation}(A, B) \not\Rightarrow \text{InstantaneousCausalSignal}(A, B). \tag{820}$$

CMA does not supply such a mechanism either.

The physical causal interpretation must remain independently warranted.

41. Higher-Dimensional, Coordinate, and Other Mathematical Representations

41.1 Mathematical dimension and physical realization

Let:

$$\mathcal{M}_n \tag{821}$$

be an n-dimensional mathematical manifold, embedding space, state space, configuration space, phase space, or coordinate representation.

Its mathematical consistency may satisfy:

$$\text{MathematicallyConsistent}(\mathcal{M}_n). \tag{822}$$

It does not follow that:

$$\text{MathematicallyConsistent}(\mathcal{M}_n) \not\Rightarrow \text{AllDimensionsPhysicallyReal}(\mathcal{M}_n). \tag{823}$$

The physical interpretation of dimensions is an additional model question.

41.2 Coordinate dimensions do not become time

For coordinate component:

$$x^j, \tag{824}$$

V37/F17 retains:

$$x^j \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{825}$$

An additional coordinate dimension therefore does not establish:

$$\text{AdditionalCoordinateDimensionInModel} \not\Rightarrow \text{AdditionalCosmicTimeExists}\,. \tag{826}$$

Nor does a model containing several time-like coordinates establish several ITOF temporal extensions merely from its mathematical signature:

$$\text{MultipleTimelikeCoordinatesInModel} \not\Rightarrow \text{MultipleITOFTemporalExtensions}\,. \tag{827}$$

41.3 State-space dimension is not cosmic-stage multiplicity

A high-dimensional state space:

$$\Omega_A \tag{828}$$

may be required to represent the physical state of system A.

Its dimension does not determine the cardinality or order type of:

$$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}. \tag{829}$$

Thus:

$$\dim(\Omega_A) = n \not\Rightarrow \left|\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\right| = n. \tag{830}$$

The same distinction applies to:

$$\Xi_A, \quad \mathcal{Y}_P, \quad \mathcal{Z}_{AB,P}, \tag{831}$$

and other application-level spaces.

41.4 Coordinate transformations

For:

$$x' = \Phi(x), \tag{832}$$

the transformation changes the mathematical representation, not the universal cosmic ordered pair. Thus:

$$x' = \Phi(x) \not\Rightarrow \text{ITOFTimeTransformed}\,. \tag{833}$$

41.5 Fixed coordinate does not establish physical stasis

For:

$$s_1, s_2 \in I_A \tag{834}$$

with:

$$s_1 \prec_{\mathrm{C}} s_2, \tag{835}$$

selected coordinate equality:

$$x_P(A; s_1) = x_P(A; s_2) \tag{836}$$

does not establish:

$$x_P(A; s_1) = x_P(A; s_2) \not\Rightarrow X_A(s_1) = X_A(s_2). \tag{837}$$

Under UCC, the selected coordinate equality leaves the governing positive-change consequence unchanged:

$$x_P(A; s_1) = x_P(A; s_2) \wedge s_2 \in I_A \wedge \mathrm{UCC} \Longrightarrow \mathrm{PhysReal}^+_A(s_2). \tag{838}$$

A system can remain at the same selected spatial coordinate while undergoing physical change.

41.6 General representation rule

For any mathematical representation:

$$\mathcal{R}_M(A), \tag{839}$$

V37/F17 adopts:

$$\mathrm{Represents}_M\left(\mathcal{R}_M(A), A\right) \not\Rightarrow \mathcal{R}_M(A) \equiv_{\mathrm{type}} A. \tag{840}$$

Likewise:

$$\mathrm{RepresentsTimeRelatedRecords}_M(q) \not\Rightarrow q \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{841}$$

This rule unifies the treatment of:

$$\begin{gathered}\text{coordinates,} \quad \text{state vectors,} \quad \text{metrics,} \quad \text{proper-time functionals,} \\ \text{higher-dimensional spaces,} \quad \text{clock readings,} \quad \text{statistical estimators,} \\ \text{and model-evolution parameters.}\end{gathered} \tag{842}$$

42. Scope, Limits, and Foundational Status

42.1 Layered architecture

V37/F17 contains several connected but logically distinct layers:

$$\begin{aligned}\mathcal{L}_{\mathrm{V37}} = \{\, & \mathrm{TemporalCore}, \mathrm{CosmicSuccession}, \mathrm{PopulationRealization}, \\ & \mathrm{SystemSpecificChange}, \mathrm{PhysicalCausation}, \mathrm{PhysicalRealizationProfile}, \\ & \mathrm{HierarchicalComposition}, \mathrm{IdentityHistory}, \mathrm{Lifecycle}, \\ & \mathrm{PopulationTransformation}, \mathrm{Comparison}, \mathrm{PhysicalDynamics}, \\ & \mathrm{OperationalMetrics}, \mathrm{ObservationAndAccess}, \\ & \mathrm{EmpiricalBridges}, \mathrm{QuantitativePhysicalBridge}, \\ & \mathrm{PredictiveSeparationScreen}, \mathrm{ExternalTheoryConfrontation}\}.\end{aligned} \tag{843}$$

These layers belong to one framework.

They do not possess one logical status.

42.2 Minimal temporal core

The minimal temporal definition remains Eq. (12).

No V37/F17 construction enlarges this ordered pair.

In particular:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{def}} \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}, \mathfrak{R}_{\mathrm{C}}(s), \mathfrak{K}, \mathfrak{M}_{\mathrm{phys}}, \mathfrak{O}\right). \tag{844}$$

42.3 Cosmic succession scope

The cosmic-succession commitments remain those fixed by Eqs. (18), (38), and (40).

These constrain the temporal architecture.

They do not produce:

$$\begin{aligned} &\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \wedge \mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \wedge \mathrm{NoTerminalStage}_{\mathrm{C}} \\ &\qquad \nvdash \mathrm{SpecificPhysicalDynamics}. \end{aligned} \tag{845}$$

Nor:

$$\mathrm{NoTerminalStage}_{\mathrm{C}} \nvdash \mathrm{UCC}, \qquad \mathrm{UCC} \nvdash \mathrm{NoTerminalStage}_{\mathrm{C}}. \tag{846}$$

42.4 Population-realization scope

The governing realization inputs remain:

$$\mathrm{CSPP}, \qquad \mathrm{CMA}, \qquad \mathrm{UCC}. \tag{847}$$

Their roles are respectively:

$$\begin{aligned} \mathrm{CSPP} &: \mathrm{PopulationNonemptiness}, \\ \mathrm{CMA} &: \mathrm{OneCommonCosmicChangeStage}, \\ \mathrm{UCC} &: \mathrm{UniversalSystemSpecificPhysicalChange}. \end{aligned} \tag{848}$$

They remain non-interchangeable and none is added to the definition of time. Together with the independently retained succession commitments, their integrated realization consequence is the single defined condition $\mathrm{UCSCR}_{\mathrm{C}}$ in Eq. (85). It packages their joint content without redefining any one of them and without becoming a physical dynamics law or an independent dynamics of time.

42.5 Scope of the V37 physical-realization profile

The complete-population common-stage physical-realization profile is a defined stage-relative architecture with complete qualified-population coverage. As fixed in Eq. (160), this completeness is not an exhaustive physical description of the universe at the stage. Domain-specific relations may enrich a physical model without becoming primitive members of the profile and without modifying the temporal ordered pair.

42.6 Causal scope

CRP retains the causal-realization condition fixed in Eq. (133).

The causal-source taxonomy remains:

$$\mathcal{C}_A^{\mathrm{act}}(s) = \mathcal{C}_A^{\mathrm{int}}(s) \cup \mathcal{C}_A^{\mathrm{ext\text{-}sys}}(s) \cup \mathcal{C}_A^{\mathrm{ext\text{-}fac}}(s). \tag{849}$$

No new V37/F17 construction becomes a fourth physical causal-source class.

Thus:

$$q \not\equiv_{\mathrm{type}} \mathrm{PhysicalCausalContributor} \tag{850}$$

for:

$$\begin{aligned} q \in \{&T_{\mathrm{ITOF}}, \mathcal{E}_{\mathrm{C}}, s, \prec_{\mathrm{C}}, \mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}, \mathrm{IntegratedCosmicSuccession}_{\mathrm{C}}, \mathrm{UCSCR}_{\mathrm{C}}, \mathrm{CRP}, \\ &\mathcal{H}_A, \mathrm{HistoricalPhysicalAccumulation}_A^{<s}, \mathfrak{R}_{\mathrm{C}}(s)\,, \mathrm{StageChangeBridge}_{\mathrm{C}}(s)\}. \end{aligned} \tag{851}$$

42.7 Hierarchical-composition scope

The relation:

$$A \lhd_{\kappa,s} B \tag{852}$$

states a declared stage-relative physical constituent relation between independently qualified numerical physical-system identities.

It imposes no universal unique decomposition, universal system tree, universal transitivity, or universal cross-level dynamics. Any such property requires a separately justified physical model and composition criterion.

42.8 Population-transformation scope

The sets:

$$\mathcal{P}_{r,s}, \qquad \mathcal{N}_{r\to s}, \qquad \mathcal{L}_{r\to s}, \qquad \mathcal{T}_{r,s} \tag{853}$$

classify identity-domain membership across an ordered stage pair.

Their definition as identity-membership classifications does not entail a population dynamics, conservation law, or successor closure:

$$\mathrm{PopulationClassificationSpecified}(r,s) \not\Rightarrow \mathrm{UniversalPopulationDynamics}(r,s), \tag{854}$$

$$\mathrm{PopulationClassificationSpecified}(r,s) \not\Rightarrow \mathrm{UniversalConservationOfSystemNumber}(r,s), \tag{855}$$

$$\mathrm{PopulationClassificationSpecified}(r,s) \not\Rightarrow \mathrm{UniversalSuccessorClosure}(r,s). \tag{856}$$

42.9 Physical-model scope

Mathematical-form neutrality means:

$$\mathrm{ITOFAdmissibility} \nvdash \mathrm{OneUniversalMathematicalDynamics}\,. \tag{857}$$

An admissible physical model must preserve the temporal type boundary and satisfy the applicable physical and empirical requirements.

For an arbitrary physical model M, the temporal definition alone does not derive the model law:

$$\mathrm{TemporalDefinition}_{\mathrm{ITOF}} \nvdash \mathrm{ModelLawSpecified}(\mathcal{L}_M; M). \tag{858}$$

42.10 Operational-metric scope

Operational metrics may be scientifically indispensable.

They remain constructed quantities:

$$m_P = \mathcal{M}_P^{\mathrm{op}}(r_1, \ldots, r_n; \kappa_P). \tag{859}$$

The temporal type boundary does not invalidate metric quantification:

$$\text{ITOFTemporalTypeBoundary} \not\Rightarrow \text{MetricQuantificationInvalid}\,. \tag{860}$$

It claims:

$$\text{MetricQuantificationUsefulOrAccurate} \not\Rightarrow m_P \equiv_{\text{type}} T_{\text{ITOF}}. \tag{861}$$

The distinction is ontological, not anti-quantitative.

42.11 Observational scope

A valid observation may warrant manifestation at some stage in I_A without identifying the exact cosmic stage or its exact global order position, as stated in Eqs. (413)–(415).

This epistemic restraint does not make the underlying common cosmic change stage physically indefinite.

42.12 Empirical scope

Failure of a tested application chain warrants only the conclusion supported by its declared dependency:

$$\text{TestedApplicationChainFailed} \not\Rightarrow \text{FoundationalITOFRefuted}\,. \tag{862}$$

Likewise:

$$\text{TestedApplicationChainRecovered} \not\Rightarrow \text{TemporalIdentityEstablished}\,. \tag{863}$$

A foundational conclusion requires an independently traceable foundation-to-observable derivation.

42.13 Relativistic scope

At the type level:

$$\forall q \in \mathcal{Q}_{\text{rel}}, \quad q \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{864}$$

At the empirical level, relativistic models and ITOF-admissible physical application models may be compared through:

$$\mathfrak{B}_{I:R}^{P,D} \tag{865}$$

where the required physical and observational conditions are independently specified.

The type-level disagreement does not require an observed anomaly.

The empirical superiority of either application model does require actual prediction and observation.

42.14 What V37/F17 does not yet provide

V37/F17 does not provide a universally derived microscopic dynamics for all physical systems, quantum-gravitational dynamics, a universal physical coupling law, a universal operational metric, an exact observational stage-identification procedure, or a unique experiment directly deciding every foundational commitment. The quantitative clock-response and Hamiltonian branches provide bounded application-level physics, and the predictive screening establishes a non-separation boundary, but no unique ITOF-specific Hamiltonian interaction or foundation-specific observable separation has been derived. Those limits are explicit and are not filled by terminological substitution, parameter relabeling, or post-hoc residual construction.

43. Central Commitments of V37/F17

The governing V37/F17 architecture can be summarized without replacing the detailed definitions and status distinctions established earlier.

I. Temporal identity.
The governing temporal identity is exactly the denotation fixed in Eq. (12). No physical-realization, metric, dynamical, causal, observational, or application component is added to that definition.

II. Invariant cosmic succession.
The same common cosmic-stage carrier is governed by Strict Cosmic Ordering, NoInterruption, and NoTerminalStage as fixed in Eqs. (18)–(40).
Strict ordering fixes irreversibility.
NoInterruption and NoTerminalStage separately govern uninterrupted and continuing succession in the non-metric sense defined earlier.

III. Population, common-stage unity, and universal change.
CSPP, CMA, and UCC retain distinct roles.
Their integrated succession-level consequence is stated once by $\mathrm{UCSCR_C}$ in Eq. (85): every admitted stage is nonempty, literally common to the complete then-realized qualified population, and change-realized by every member. The common stage is one while physical change remains bearer-specific. The condition assigns no dynamics, motion, or causal agency to time.

IV. Complete-population change coverage.
Under the governing definitions, UCC is exactly equivalent to the complete-population coverage relation in Eq. (81). This equality concerns system coverage.
It does not create one collective change content.

V. Foundational Stage-to-Change representation.
The conservative defined bridge remains exactly the construction in Eq. (92); it is not a causal, observational, synchronization, or predictive bridge.

VI. Physical causation.
CRP supplies nonempty physical causal realization for actual system-specific change as stated in Eq. (133).
The actual causal set remains exhausted by the three governed physical causal-source classes.

VII. Stage-relative physical-realization profile.
V37/F17 introduces:

$$\mathfrak{R}_{\mathrm{C}}(s) = (\mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s))\,. \tag{866}$$

Its completeness is completeness of the qualified population domain.
It does not imply universal physical-state equality, universal change content, universal causal mechanism, or complete observation.

VIII. Hierarchical physical systems.
Where:

$$A \lhd_{\kappa,s} B, \tag{867}$$

A and B remain distinct qualified physical-system identities.
UCC applies to each according to its own identity range and bearer-specific change.
Composition alone does not transfer state, change, cause, or identity across levels.

IX. Identity-bounded physical histories.
For every:

$$A \in \mathcal{U}_{\mathrm{phys}}, \tag{868}$$

the physical history is:

$$\mathcal{H}_A = \left(I_A, \prec_{\mathrm{C}}|_{I_A}, X_A, \Delta_A^{\mathrm{phys}}\right). \tag{869}$$

Physical histories are many.
Time is not.

X. Formation, ending, and conditional successors.
AFB governs the least identity member.
Identity ending remains a physical identity-ending transformation at the final member of the numerical identity range.
UEIE remains a separate universal lifecycle postulate and is not derived from UCC, CRP, or cosmic non-termination.
Successor production remains conditional on actual production of a new numerical identity.
No universal successor closure is introduced.

XI. Population transformation.
For:

$$r \prec_{\mathrm{C}} s, \tag{870}$$

population comparison may be represented through:

$$\mathcal{P}_{r,s}, \quad \mathcal{N}_{r\to s}, \quad \mathcal{L}_{r\to s}, \quad \mathcal{T}_{r,s}. \tag{871}$$

These are identity-domain classifications, not a motion of systems through time and not a universal population dynamics.

XII. Mathematical-form-neutral physical dynamics.
ITOF does not select one universal physical evolution equation.
Admissible models may employ distinct mathematical structures and parameters, provided their physical typing, provenance, domain, bridges, and observational roles are declared.

No model-evolution parameter becomes time by successful use.

XIII. System-specific physical directionalities.
For a declared physical criterion α, the descriptor

$$\mathfrak{A}_{A,\alpha} = (\mathcal{Y}_{A,\alpha}, Y_{A,\alpha}, \preccurlyeq_{A,\alpha}) \tag{872}$$

represents a system- and criterion-specific physical directionality. Alignment, plateau, recurrence, or criterion-relative reversal does not modify $\prec_{\mathrm{C}}$, and UCC does not impose one universal physical arrow.

XIV. Operational metric construction.
Metric outputs arise through physical records, model quantities, calibration, and declared comparison rules:

$$m_P = \mathcal{M}_P^{\mathrm{op}}(r_1, \ldots, r_n; \kappa_P), \qquad m_P \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{873}$$

Clocks are one important subclass of this architecture.

XV. Independent quantitative physical-model branch and predictive boundary.
The application-level mass-defect program $\mathfrak{Q}_{\mathrm{MD}}$ provides the weak-field response

$$\frac{\Delta\omega}{\omega_0} = \frac{\Delta\phi}{c^2} \tag{874}$$

and an independently sourced trapped-ion Hamiltonian branch. Published aluminium-ion and strontium benchmarks are recovered, and the reported 2025 six-mode $^{27}\mathrm{Al}^{+}$ secular-motion correction is reconstructed from published mode data. These results establish bounded application adequacy, not a new temporal component or a foundation-specific residual. The subsequent predictive screen establishes the dependency result that temporal-ontology difference alone cannot separate observable predictions when the complete physical-to-observable specification is held fixed, as formalized in Eq. (1003). No unique ITOF-specific Hamiltonian operator is therefore claimed without additional independently warranted physical content.

XVI. Observation and Exact-Change-Stage Restraint.
Observation may warrant physical occurrence and relative development without automatically identifying exact common cosmic change-stage membership or exact global order position.
Records remain physical outputs of changing physical acquisition systems.

XVII. Generalized Non-Transfer.
For any eligible model or operational quantity, the generalized Non-Transfer Principle remains Eq. (521).
This applies to clocks, coordinates, metrics, proper-time functionals, cosmological parameters, state vectors, dynamical parameters, comparison outputs, and other mathematical or operational constructions.

XVIII. Relativistic temporal nonidentity and quantitative confrontation.
For:

$$q \in \mathcal{Q}_{\mathrm{rel}}, \tag{875}$$

V37/F17 retains:

$$q \not\equiv_{\text{type}} T_{\text{ITOF}}. \tag{876}$$

Where a relativistic ontology denies universal objective common cosmic-stage co-realization, conflict with CMA is direct.
Quantitative comparison nevertheless requires independently specified physical and observational bridges.
No ontological identity is inferred from empirical agreement.

44. Integrated Dependency Architecture

The dependency register distinguishes logical entailment from constructional dependence. Logical consequences use $\Longrightarrow$, $\Longleftrightarrow$, or $\vdash$ with explicit conjunction where the premises are propositions. For typed objects or data that enter a definition or application construction,

$$\langle Q_1, \ldots, Q_n \rangle \overset{\text{dep}}{\rightsquigarrow} R$$

denotes schematic dependency only: R depends on the listed typed inputs in the stated role. The symbol does not assert arithmetic addition, causal production, or logical entailment.

44.1 Temporal branch

The temporal branch is:

$$\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}} \overset{\text{definition}}{\Longrightarrow} T_{\text{ITOF}} = \mathcal{E}_{\text{C}} = \left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right). \tag{877}$$

Separately:

$$\text{StrictTotalOrder}\left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right) \wedge \text{NoInterruption}_{\text{C}}\left(\mathcal{S}_{\text{C}}^{\text{tot}}, \prec_{\text{C}}\right) \wedge \text{NoTerminalStage}_{\text{C}} \tag{878}$$

govern the ordering and actual succession of that already defined temporal referent.

They do not generate the time definition.

44.2 Physical-system branch

The physical-system branch is:

$$\langle \text{PhysicalSystem}, \text{ExistsAs} \rangle \overset{\text{dep}}{\rightsquigarrow} \langle \mathcal{U}_{\text{phys}}, I_A, \mathcal{S}_{\text{phys}}(s) \rangle. \tag{879}$$

CSPP then constrains:

$$\mathcal{S}_{\text{phys}}(s) \neq \varnothing. \tag{880}$$

CMA governs:

$$\text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(s); s\right). \tag{881}$$

UCC governs:

$$\forall A \in \mathcal{S}_{\text{phys}}(s), \quad \text{PhysReal}_A^{+}(s). \tag{882}$$

44.3 Change-coverage branch

The change branch is:

$$I_A \longrightarrow I_A^{\Delta} \longrightarrow \Delta_A^{\mathrm{phys}} \tag{883}$$

together with the UCC equivalence in Eq. (81).

Then:

$$\Big\langle \mathcal{B}_\Delta(s)\,, \{\Xi_A\}, \{\Delta_A^{\mathrm{phys}}(s)\}\Big\rangle \overset{\text{definition}}{\rightsquigarrow} \mathfrak{D}_{\mathrm{C}}(s)\,. \tag{884}$$

44.4 Universal common-stage change-realization branch

CSPP and UCC jointly yield the nonempty complete-population change coverage proved in Eq. (82). Adding CMA and the independently defined succession condition yields exactly the Universal Common-Stage Change Realization condition $\mathrm{UCSCR_C}$ fixed once in Eq. (85). This branch contains no new primitive, metric, scalar change variable, or physical dynamical law for time.

44.5 Stage-to-Change branch

The bridge branch is:

$$\mathrm{CMA} \wedge \mathrm{UCC} \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathrm{StageChangeBridge_C}(s). \tag{885}$$

No new primitive enters this equivalence.

44.6 State branch

The state branch is:

$$\langle I_A, X_A : I_A \to \Omega_A\rangle \overset{\text{definition}}{\rightsquigarrow} \mathfrak{X}_{\mathrm{C}}(s)\,. \tag{886}$$

The dependent state profile has complete population domain because:

$$A \in \mathcal{S}_{\mathrm{phys}}(s) \Longrightarrow s \in I_A. \tag{887}$$

44.7 Causal branch

The causal branch is:

$$\mathrm{PhysReal}_A^{+}(s) \wedge \mathrm{CRP} \Longrightarrow \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing. \tag{888}$$

Then:

$$\{\mathcal{C}_A^{\mathrm{act}}(s)\}_{A\in\mathcal{S}_{\mathrm{phys}}(s)} \overset{\text{definition}}{\Longrightarrow} \mathfrak{G}_{\mathrm{C}}(s)\,. \tag{889}$$

44.8 Physical-realization profile branch

The V37/F17 stage-relative profile construction is:

$$\begin{gathered}\langle \mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s)\rangle \\ \overset{\text{definition}}{\rightsquigarrow} \mathfrak{R}_{\mathrm{C}}(s)\,.\end{gathered} \tag{890}$$

Under UCSCR and CRP, every admitted stage has a nonempty complete qualified population, satisfies the Stage-to-Change Bridge, and has nonempty actual causal realization for every member, as stated in Eq. (167). No additional realization predicate is introduced.

44.9 Identity-history branch

The identity-history branch is:

$$\left\langle I_A, \prec_{\mathrm{C}}|_{I_A}, X_A, \Delta_A^{\mathrm{phys}} \right\rangle \overset{\text{definition}}{\rightsquigarrow} \mathcal{H}_A. \tag{891}$$

Identity-Realization Convexity constrains:

$$I_A. \tag{892}$$

AFB separately supplies:

$$f_A. \tag{893}$$

Neither principle creates a private temporal order.

44.10 Hierarchical-composition branch

The hierarchy branch is:

$$\langle \text{IdentityCriterion}, \text{SystemBoundary}, \text{CompositionCriterion}_\kappa \rangle \overset{\text{dep}}{\rightsquigarrow} A \triangleleft_{\kappa,s} B. \tag{894}$$

Then:

$$\{A \triangleleft_{\kappa,s} B\} \overset{\text{definition}}{\Longrightarrow} \mathfrak{K}_{\mathrm{C}}(s)\,. \tag{895}$$

Composition alone does not determine cross-level physical dynamics.

44.11 Lifecycle branch

The lifecycle branch remains:

$$\langle \text{IdentityEndingTransformation}, I_A, \prec_{\mathrm{C}} \rangle \overset{\text{dep}}{\rightsquigarrow} \mathrm{End}_A(e). \tag{896}$$

Under UCC:

$$\mathrm{End}_A(e) \wedge \mathrm{UCC} \Longrightarrow \Delta_A^{\mathrm{end}}(e) = \Delta_A^{\mathrm{phys}}(e). \tag{897}$$

PIECP independently constrains ending-specific causal attribution.

UEIE independently supplies universal eventual ending with strict earlier identity history.

Successor attribution requires:

$$\mathrm{End}_A(e) \wedge A \neq B \wedge f_B = e \wedge \text{PhysicalProductionLink}(A, B; e) \Longleftrightarrow \text{SuccAt}(A, B; e). \tag{898}$$

44.12 Population-transformation branch

For:

$$r \prec_{\mathrm{C}} s, \tag{899}$$

the identity ranges define:

$$\{I_A\}_{A\in\mathcal{U}_{\text{phys}}} \Longrightarrow \mathcal{P}_{r,s}, \mathcal{N}_{r\to s}, \mathcal{L}_{r\to s}, \mathcal{T}_{r,s}. \tag{900}$$

No universal physical evolution law follows from these set-theoretic classifications.

44.13 Independent quantitative clock-response branch

The mass-defect clock-response application depends on independently supplied physical premises and measured environmental inputs:

$$\langle \hbar\omega_0, M_e - M_g, \phi, g, \Delta h, \mathcal{S}_{\text{sys}}\rangle \overset{\text{dep}}{\rightsquigarrow} \mathfrak{Q}_{\text{MD}} \overset{\text{dep}}{\rightsquigarrow} \widehat{y}_{\text{MD}}, \tag{901}$$

where $\mathcal{S}_{\text{sys}}$ denotes the declared carrier-specific systematic-correction and uncertainty structure and $\widehat{y}_{\text{MD}}$ is the predicted response in the declared model domain. The observed record requires the separate acquisition or measurement bridge:

$$\left\langle \widehat{y}_{\text{MD}}, B^{\text{obs}}_{\text{MD}} \right\rangle \overset{\text{dep}}{\rightsquigarrow} y^{\text{obs}}_{\text{MD}}. \tag{902}$$

No dependency arrow is a temporal-identity map.

44.14 Predictive-separation screening branch

The predictive search adds a dependency boundary rather than a new physical law. For application branches I and R:

$$\text{SamePhysicalSpecification}_{P,D}(I, R) \Longrightarrow \mathbf{y}_I^{P,D} = \mathbf{y}_R^{P,D}. \tag{903}$$

Hence an observable separation requires at least one independently warranted physical or measurement difference that changes the predicted record. The foundational time definition, CMA, and UCC do not themselves supply such a difference. Candidate interactions introduced for screening remain application-level until an independent physical mechanism, parameter provenance, and admissible test domain are established.

44.15 Model and observation branch

An application model requires:

$$\langle \text{PhysicalModel}, \text{PhysicalBridge}, \text{ParameterProvenance}\rangle \overset{\text{dep}}{\rightsquigarrow} \text{PredictedPhysicalQuantity}\,. \tag{904}$$

Observation then requires:

$$\langle \text{PredictedOrActualPhysicalQuantity}, \text{AcquisitionBridge}\rangle \overset{\text{dep}}{\rightsquigarrow} \text{RecordOrObservable}\,. \tag{905}$$

Operational metric construction may then give:

$$\langle \text{Record}, \text{Calibration}, \text{ComparisonRule}\rangle \overset{\text{dep}}{\rightsquigarrow} m_P. \tag{906}$$

No arrow reverses automatically into temporal identity.

44.16 Empirical-attribution branch

For foundational commitment F:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F. \tag{907}$$

Only after independently valid:

$$\begin{gathered}\text{prediction separation}, \quad \text{uncertainty control}, \quad \text{protocol freeze}, \\ \text{and identifiable attribution}\end{gathered} \tag{908}$$

may an observed result acquire foundational discriminatory force.

44.17 No reverse dependency

The dependency architecture blocks the following reverse inferences:

$$\text{ClockRecordDifference} \not\Rightarrow \text{DifferentCosmicTimes}, \tag{909}$$

$$\text{ModelParameterSuccessful} \not\Rightarrow \text{ModelParameterIsTime}, \tag{910}$$

$$\text{End}_A(e) \nvdash \exists B \ \text{SuccAt}(A, B; e), \tag{911}$$

$$\text{UEIE} \nvdash \text{NoTerminalStage}_{\text{C}}, \tag{912}$$

$$\text{ApplicationModelFailure} \not\Rightarrow \text{FoundationalFailure}, \tag{913}$$

and:

$$\text{RelativisticModelSuccess} \not\Rightarrow \text{RelativisticQuantityIsTime}\,. \tag{914}$$

45. Physical Counterconditions and Contrary Conditions

45.1 Countercondition discipline

A foundational commitment is not protected from a genuinely warranted physical contrary. However:

$$\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{FailureToObserve}(F). \tag{915}$$

Likewise:

$$\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{ApplicationModelFailure}\,. \tag{916}$$

The principal direct contraries are:

45.2 Countercondition to Strict Cosmic Ordering

A direct contrary is:

$$\neg\,\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{917}$$

This may occur formally through violation of:

$$\text{irreflexivity}, \quad \text{transitivity}, \quad \text{or total comparability} \tag{918}$$

under the declared ordering type.

A physical recurrence of a selected system state does not establish this contrary.

45.3 Countercondition to CSPP

The direct contrary is:

$$\exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathcal{S}_{\mathrm{phys}}(s) = \varnothing. \tag{919}$$

Failure to detect any system at an observationally reconstructed condition does not establish the proposition.

45.4 Countercondition to NoInterruption

The governing contrary is:

$$\neg\,\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right). \tag{920}$$

Within the governing V37/F17 semantics, this contrary commits to an ontologically distinct temporal waiting state, suspension interval, or interruption layer outside $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ interposed in the actual succession. It is not defined by failure of density, discreteness, absence of adjacency, failure of metric continuity, or failure of topological continuity. NoInterruption retains its independent non-metric ontological status.

45.5 Countercondition to NoTerminalStage

A direct contrary is:

$$\exists g \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \nexists t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\,(g \prec_{\mathrm{C}} t). \tag{921}$$

Such g would be a terminal common cosmic change stage.

The ending of an individual physical-system identity does not satisfy this condition.

45.6 Countercondition to CMA

The direct contrary to CMA is:

$$\neg\,\mathrm{CMA} \iff \exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \neg\,\mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right). \tag{922}$$

The displayed contrary records rejection of CMA's governing one-common-stage co-realization commitment. It is not a freely toggleable model parameter under the same fixed common-stage semantics.

Different:

$$\text{physical states,}\quad \text{clock records,}\quad \text{spatial locations,}\quad \text{signal-arrival stages,} \\ \text{causal-accessibility relations,}\quad \text{or physical mechanisms} \tag{923}$$

do not by themselves establish this contrary.

45.7 Countercondition to UCC

The direct contrary is:

$$\exists A \in \mathcal{U}_{\text{phys}}\ \exists s \in I_A, \quad \mathsf{NC}_A^{\text{phys}}(s). \tag{924}$$

By Eq. (64), this is exactly equivalent to retaining $A \in \mathcal{U}_{\text{phys}}$ and $s \in I_A$ while denying $\text{PhysReal}_A^+(s)$.

Therefore it challenges UCC directly.

It need not challenge CMA. At a populated admitted stage, the stage-global condition $\text{GlobalChangeNull}_{\text{C}}(s)$ is stronger than a single memberwise UCC contrary. Under CSPP, one globally change-null admitted stage entails failure of UCC:

$$\text{CSPP} \wedge \exists s \in \mathcal{S}_{\text{C}}^{\text{tot}}\ \text{GlobalChangeNull}_{\text{C}}(s) \Longrightarrow \neg\,\text{UCC}\,. \tag{925}$$

Without CSPP, an empty admitted population could make $\mathcal{B}_\Delta(s) = \varnothing$ vacuous and therefore would not by itself identify the direct memberwise UCC contrary. Global change-nullness is consequently a derived cross-commitment condition, not a new independent foundational countercondition.

A null observation:

$$D^{\text{obs}} = 0 \tag{926}$$

is insufficient:

$$D^{\text{obs}} = 0 \not\Rightarrow \mathsf{NC}_A^{\text{phys}}(s). \tag{927}$$

45.8 Stage-to-Change has no independent contrary

Because:

$$\text{StageChangeBridge}_{\text{C}}(s) \tag{928}$$

is a defined conjunction, it introduces no independent physical countercondition.

Its failure occurs exactly where one of its defining components fails:

$$\neg\,\text{StageChangeBridge}_{\text{C}}(s) \Longleftrightarrow [\neg\,\text{CosmicCoPresence}_{\text{C}}\,(\mathcal{S}_{\text{phys}}(s); s)] \vee [\mathcal{B}_\Delta(s) \neq \mathcal{S}_{\text{phys}}(s)]\,. \tag{929}$$

The first disjunct concerns the CMA component.

The second concerns complete-population change coverage and therefore UCC.

No third bridge-specific physical contrary exists.

45.9 Countercondition to CRP

The direct contrary is:

$$\exists A \in \mathcal{U}_{\text{phys}}\ \exists s \in I_A, \quad \text{PhysReal}^{+}_{A}(s) \wedge \mathcal{C}^{\text{act}}_{A}(s) = \varnothing. \tag{930}$$

Failure to identify the operative causal contributor is not sufficient.

The contrary requires warranted physical absence of any admissible actual physical causal contributor.

45.10 The complete realization profile has no independent truth condition

The tuple:

$$\mathfrak{R}_{\text{C}}(s) \tag{931}$$

is a defined representation.

Its existence as notation is fixed by the definitions and typing conditions.

Therefore:

$$\text{ProfileNotationFailure} \not\equiv_{\text{def}} \text{PhysicalCountercondition}\,. \tag{932}$$

Physical challenge belongs to the commitments represented by the profile, not to the tuple notation itself.

45.11 Countercondition to Identity-Realization Convexity

The direct contrary remains:

$$\exists A \in \mathcal{U}_{\text{phys}}\ \exists r, s, t \in \mathcal{S}^{\text{tot}}_{\text{C}}, \quad r, t \in I_A, \quad r \prec_{\text{C}} s \prec_{\text{C}} t, \quad s \notin I_A. \tag{933}$$

The condition requires the same numerical physical-system identity on both sides of the gap.

A newly formed later system that resembles the earlier system does not satisfy the contrary unless numerical identity across the gap is independently established.

45.12 Countercondition to AFB

AFB fails if some realized numerical identity has no unique least member:

$$\exists A \in \mathcal{U}_{\text{phys}}, \quad \neg\exists! f_A \in I_A \left[\nexists r \in I_A \left(r \prec_{\text{C}} f_A\right)\right]. \tag{934}$$

Observational inability to identify f_A exactly does not establish this condition.

45.13 Countercondition to UEIE

The direct contrary is:

$$\exists A \in \mathcal{U}_{\text{phys}}, \quad \neg\exists e \in I_A \left[\text{End}_A(e) \wedge \exists r \in I_A \left(r \prec_{\text{C}} e\right)\right]. \tag{935}$$

This requires physical warrant concerning the lifecycle of the numerical identity.

Failure to observe an ending is insufficient.

45.14 Countercondition to PIECP

A direct contrary is:

$$\begin{aligned}\exists A \in \mathcal{U}_{\text{phys}}\ \exists e \in \mathcal{S}_{\text{C}}^{\text{tot}}, \quad &\text{End}_A(e) \\ &\wedge \neg\exists c \in \mathcal{C}_A^{\text{act}}(e)\ \text{PhysicallyContributes}\left(c; \text{IdentityEndingTransformation}(A; e)\right).\end{aligned} \tag{936}$$

Failure of a model to resolve the contributor is not the same condition.

45.15 Failure of a successor attribution

No universal successor closure exists.

Therefore:

$$\neg\exists B\ \text{SuccAt}(A, B; e) \tag{937}$$

does not constitute a foundational failure.

A particular asserted successor relation fails where at least one defining condition fails:

$$\neg\,\text{End}_A(e) \vee A = B \vee f_B \neq e \vee \neg\,\text{PhysicalProductionLink}(A, B; e). \tag{938}$$

45.16 Composition-relation failure

Because:

$$A \lhd_{\kappa,s} B \tag{939}$$

is a defined stage-relative relation, a specific composition attribution fails where the declared criterion does not establish the required constituent relation.

Thus:

$$\text{CompositionClaimFailed}_{\kappa}(A, B; s) \not\equiv_{\text{def}} \text{ITOFFoundationalFailure}\,. \tag{940}$$

The hierarchical module does not assert that every system must possess a qualified subsystem.

45.17 Cross-Level Non-Transfer challenge

The Cross-Level Non-Transfer Principle states that composition alone is insufficient to establish cross-level determination.

A physical application may nevertheless derive:

$$\text{PhysicallyDetermines}_{M,\kappa}\left(\Delta_A^{\text{phys}}(s); \Delta_B^{\text{phys}}(s)\right) \tag{941}$$

from additional physical premises.

Such a derivation does not contradict the principle because the dependence is not supplied by composition alone.

A challenge would require demonstrating:

$$A \lhd_{\kappa,s} B \vdash \text{PhysicallyDetermines}\left(\Delta_A^{\text{phys}}(s); \Delta_B^{\text{phys}}(s)\right) \tag{942}$$

from the composition relation itself under the same declared semantics.

45.18 Countercondition to a physical application model

For predeclared application model M, failure of its declared empirical criterion warrants:

$$\text{ApplicationModelRejectedOrRestricted}(M, D). \tag{943}$$

It does not automatically warrant:

$$\neg T_{\text{ITOF}}, \qquad \neg\,\text{CMA}, \qquad \neg\,\text{UCC}, \qquad \neg\,\text{CRP}\,. \tag{944}$$

The inferential consequence follows the actual dependency chain.

45.19 Challenge to the Non-Transfer Principle

NTP does not claim that temporal identity can never be established for any quantity by any conceivable argument.

It claims that:

$$\text{MathematicallyConsistent}_M(q) \wedge \text{OperationalSuccess}_{P,M,D}(q) \tag{945}$$

is insufficient by itself.

Therefore an argument against NTP must provide an independent identity basis:

$$\text{IndependentTemporalIdentityArgument}(q, T_{\text{ITOF}}), \tag{946}$$

not merely:

$$\text{OperationalSuccess}(q). \tag{947}$$

This makes the principle a restriction on inference rather than a prohibition against evidence.

45.20 Relativistic empirical failure and foundational conflict

A failed relativistic application does not by itself prove ITOF:

$$\text{RelativisticApplicationFailure} \not\Rightarrow \text{ITOFFoundationallyEstablished}\,. \tag{948}$$

Likewise, a successful relativistic application does not by itself refute the ITOF temporal type definition:

$$\text{RelativisticApplicationSuccess} \not\Rightarrow T_{\text{ITOF}} \equiv_{\text{type}} q_{\text{rel}}. \tag{949}$$

The foundational conflict concerns the asserted ontology.

The empirical comparison concerns independently derived observable consequences.

46. Compact Countercondition Summary

The principal V37/F17 physical and logical challenge conditions may be summarized as follows.

$$
\boxed{\begin{aligned}
\neg\,\mathrm{StrictCosmicOrdering} &: \neg\,\mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right), \\
\neg\,\mathrm{CSPP} &: \exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathcal{S}_{\mathrm{phys}}(s) = \varnothing, \\
\neg\,\mathrm{NoInterruption}_{\mathrm{C}} &: \neg\,\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right), \\
\neg\,\mathrm{NoTerminalStage}_{\mathrm{C}} &: \exists g \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \nexists t \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}(g \prec_{\mathrm{C}} t), \\
\neg\,\mathrm{CMA} &: \exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \neg\,\mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right), \\
\neg\,\mathrm{UCC} &: \exists A \in \mathcal{U}_{\mathrm{phys}}\, \exists s \in I_A, \quad \mathsf{NC}_A^{\mathrm{phys}}(s), \\
\neg\,\mathrm{CRP} &: \exists A, s, \quad \mathrm{PhysReal}_A^{+}(s) \wedge \mathcal{C}_A^{\mathrm{act}}(s) = \varnothing.
\end{aligned}} \tag{950}
$$

Because UCSCR is a defined integrated condition rather than an independent postulate, its contrary is exactly failure of at least one defining conjunct:

$$
\boxed{\neg\,\mathrm{UCSCR}_{\mathrm{C}} \iff \neg\,\mathrm{IntegratedCosmicSuccession}_{\mathrm{C}} \vee \neg\,\mathrm{CMA} \vee \neg\,\mathrm{CSPP} \vee \neg\,\mathrm{UCC}\,.} \tag{951}
$$

Equivalently, using the definition of Integrated Cosmic Succession, UCSCR fails if NoInterruption, NoTerminalStage, CMA, CSPP, or UCC fails. No additional UCSCR-specific countercondition is introduced.

For identity and lifecycle, the direct contraries are those stated in Eqs. (933), (934), (935), and (936). They respectively concern an internal identity-range gap, absence of a unique least identity member, absence of the UEIE ending condition, and an actual ending lacking an ending-specific physical contributor.

Defined constructions:

$$
\begin{gathered}
\mathrm{IntegratedCosmicSuccession}_{\mathrm{C}}, \quad \mathrm{UCSCR}_{\mathrm{C}}, \\
\mathrm{StageChangeBridge}_{\mathrm{C}}, \quad \mathfrak{R}_{\mathrm{C}}(s)\,, \\
\mathsf{NC}_A^{\mathrm{phys}}(s), \\
\mathfrak{K}_{\mathrm{C}}(s)\,, \quad \mathfrak{P}_{\mathrm{C}}^{\mathrm{pop}}(r, s), \\
\mathcal{M}_P^{\mathrm{op}}
\end{gathered} \tag{952}
$$

have no additional independent foundational countercondition beyond failure of their defining conditions or failure of an asserted application claim.

This distinction prevents V37/F17 from multiplying foundational commitments merely because its representational architecture is richer than V36/F16.

47. Independent Quantitative Physical Program: Mass-Defect Clock Response

47.1 Status and physical provenance

The mathematical-form-neutral dynamics and bridge architecture admits physical models whose governing laws have independent physical provenance. This section instantiates that architecture with a quantitative atomic-clock response branch based on the internal-energy mass defect and weak gravitational coupling. The branch is denoted

$$\mathfrak{Q}_{\mathrm{MD}} \tag{953}$$

and has the status

$$\mathrm{Status}\,(\mathfrak{Q}_{\mathrm{MD}}) = \mathrm{ApplicationLevelPhysicalModelBranch}\,. \tag{954}$$

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, UCC, or the Stage-to-Change Bridge. 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 [14, 15].

Accordingly,

$$\mathfrak{Q}_{\mathrm{MD}} \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{955}$$

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 $\Gamma_{37}^{\mathrm{fund}}$ denote the conjunction of the governing V37/F17 foundational commitments actually invoked by the declared application. This premise shorthand is distinct from the framework-level tuple $\mathfrak{F}_{37}$ defined in Eq. (9) 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.

47.2 Two-level carrier and mass-defect relation

Consider a clock carrier with internal states $|g\rangle$ and $|e\rangle$, unperturbed energies $E_g^{(0)}$ and $E_e^{(0)}$, and unperturbed angular transition frequency

$$\hbar\omega_0 = E_e^{(0)} - E_g^{(0)}. \tag{956}$$

Let the corresponding rest masses be M_g and M_e. Mass-energy equivalence gives

$$\boxed{M_e - M_g = \frac{\hbar\omega_0}{c^2}.} \tag{957}$$

The difference is a physical mass defect associated with the different internal energies of the same clock carrier. It is not a difference of times or cosmic stages.

47.3 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

$$E_j(\phi) = M_j c^2 + M_j \phi = M_j c^2 \left(1 + \frac{\phi}{c^2}\right). \tag{958}$$

Using Eq. (957), the transition frequency becomes

$$\boxed{\omega(\phi) = \frac{E_e(\phi) - E_g(\phi)}{\hbar} = \omega_0 \left(1 + \frac{\phi}{c^2}\right).} \tag{959}$$

For two locations $\mathbf{r}_1$ and $\mathbf{r}_2$, define the model fractional response relative to the unperturbed transition frequency by

$$\boxed{y_{12}^{\mathrm{MD}} := \frac{\omega(\phi_1) - \omega(\phi_2)}{\omega_0} = \frac{\phi_1 - \phi_2}{c^2}.} \tag{960}$$

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

$$g_h(h) := \frac{\partial \phi}{\partial h}(h), \tag{961}$$

which has dimensions of acceleration. Taylor's theorem gives, for some ξ between h and $h + \Delta h$,

$$\phi(h + \Delta h) - \phi(h) = g_h(h)\, \Delta h + \frac{1}{2} \frac{\partial^2 \phi}{\partial h^2}(\xi)(\Delta h)^2. \tag{962}$$

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

$$\boxed{y_h^{\mathrm{MD}} = \frac{g_h\, \Delta h}{c^2}, \qquad \kappa_h^{\mathrm{MD}} := \frac{y_h^{\mathrm{MD}}}{\Delta h} = \frac{g_h}{c^2}.} \tag{963}$$

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.

47.4 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

$$y_{12}^{\mathrm{obs}} = y_{12}^{\mathrm{MD}} + \sum_{k=1}^{K} s_{k,12} + \varepsilon_{12}, \tag{964}$$

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, link, and calibration contributions. The membership of that family and the associated correction and uncertainty models are protocol- and carrier-specific.

A benchmark claim using a corrected published result requires

$$\begin{aligned}\text{BenchmarkAdmissible} \implies\ & \text{InputsExternallySpecified} \\ & \wedge \text{SystematicCorrectionsDeclared} \\ & \wedge \text{UncertaintyDeclared}\,.\end{aligned} \tag{965}$$

No unreported adjustment of g_h, Δh, or the coefficient in Eq. (963) is permitted after inspection of the target clock result.

47.5 Benchmark A: 0.33-m aluminium-ion clock comparison

Status: the clock result below is an externally reported measurement; the V37/F17 comparison value is calculated from independently supplied published inputs under the declared weak-field model.

Chou et al. reported a height change of

$$\Delta h_A = 0.33 \text{ m} \tag{966}$$

and a measured fractional frequency change

$$y_A^{\text{obs}} = (4.1 \pm 1.6) \times 10^{-17} \tag{967}$$

in a comparison of two $^{27}\text{Al}^+$ optical clocks [13].

Using only the published nominal local value $g_{h,A} = 9.80 \text{ m s}^{-2}$ for the upward height coordinate, the height change, and the exact value of c, Eq. (963) gives

$$y_A^{\text{MD}} = \frac{(9.80)(0.33)}{c^2} = 3.5983 \times 10^{-17}. \tag{968}$$

Using the published quoted uncertainty as the benchmark standard deviation, the nominal standardized residual is

$$z_A := \frac{y_A^{\text{obs}} - y_A^{\text{MD}}}{1.6 \times 10^{-17}} = 0.314. \tag{969}$$

This is a published-input consistency benchmark, not a reconstruction of the raw clock record or its full covariance.

47.6 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

$$a_B = -9.796 \text{ m s}^{-2} \tag{970}$$

for the coordinate convention of their vertically oriented ^{87}Sr optical-lattice-clock sample and a predicted weak-field fractional frequency gradient of approximately -1.09×10^{-19} mm^{-1} [22]. Equation (963) gives directly

$$\kappa_B^{\mathrm{MD}} = \frac{a_B}{c^2}\left(10^{-3}\ \mathrm{m/mm}\right) = -1.08995 \times 10^{-19}\ \mathrm{mm}^{-1}. \tag{971}$$

The same work reports a corrected campaign gradient

$$\kappa_{B,1}^{\mathrm{obs}} = -9.8(2.3) \times 10^{-20}\ \mathrm{mm}^{-1} \tag{972}$$

and a corrected synchronous two-region determination

$$\kappa_{B,2}^{\mathrm{obs}} = -1.28(27) \times 10^{-19}\ \mathrm{mm}^{-1}. \tag{973}$$

The corresponding nominal standardized residuals are

$$z_{B,1} = \frac{\kappa_{B,1}^{\mathrm{obs}} - \kappa_B^{\mathrm{MD}}}{2.3 \times 10^{-20}} = 0.478. \tag{974}$$

$$z_{B,2} = \frac{\kappa_{B,2}^{\mathrm{obs}} - \kappa_B^{\mathrm{MD}}}{2.7 \times 10^{-20}} = -0.704. \tag{975}$$

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.

47.7 Cross-carrier benchmark meaning

The aluminium-ion and strontium benchmarks involve different atomic clock carriers, different apparatuses, and different local gravitational fields. Under the mass-defect response law, carrier independence concerns the response coefficient conditional on the same local physical potential gradient. For a carrier class A realized at location $\mathbf{r}$,

$$\kappa_h^{(A)}(\mathbf{r}) = \frac{g_h(\mathbf{r})}{c^2} \tag{976}$$

for every carrier 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 carrier-independence relation at their quoted precision.

This result warrants only the bounded claim

$$\mathrm{MassDefectClockResponseBenchmarkRecovered}\left(D_{\mathrm{Al}^+}, D_{\mathrm{Sr}}\right). \tag{977}$$

It does not establish UCC, CMA, the ITOF temporal definition, or any universal claim outside the tested physical domains.

47.8 Benchmark recovery is not relativistic discrimination

The leading weak-field relation in Eq. (960) 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,

$$\mathbf{y}_{\mathrm{MD}}^{(2),P,D} = \mathbf{y}_{R}^{(2),P,D}. \tag{978}$$

No equality of uncalculated higher-order terms follows from this relation. Consequently,

$$\mathrm{BenchmarkRecovered} \not\Rightarrow \mathrm{FoundationalDiscrimination}\,(\mathrm{ITOF}, \mathrm{Relativity})\,. \tag{979}$$

The quantitative importance of $\mathfrak{Q}_{\mathrm{MD}}$ 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}.

47.9 Hamiltonian carrier 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 V37/F17 adopts, as an independently sourced application model, the leading internal–external Hamiltonian structure derived for a charged composite clock carrier in external electromagnetic and weak gravitational fields [15]. In the notation used here, the relevant decomposition is

$$\boxed{\widehat{H} = \widehat{H}_{\mathrm{com}} + \widehat{H}_{\mathrm{int}} + \widehat{H}_{\mathrm{at-emf}} + \widehat{H}_{\mathrm{metric}} + \widehat{H}_{\mathrm{MD}}.} \tag{980}$$

The diagonal mass-defect coupling between center-of-mass and internal degrees of freedom is

$$\boxed{\widehat{H}_{\mathrm{MD}} = \left(M\phi(\widehat{\mathbf{R}}) - \frac{\widehat{\overline{\mathbf{P}}}^2}{2M} \right) \otimes \frac{\widehat{H}_{\mathrm{int}}^{(0)}}{Mc^2}.} \tag{981}$$

Here M is the carrier rest mass used in the external Hamiltonian, $\widehat{\mathbf{R}}$ is its center-of-mass position, $\widehat{\overline{\mathbf{P}}}$ is the mechanically coupled center-of-mass momentum, and $\widehat{H}_{\mathrm{int}}^{(0)}$ 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. (981).

Define the external response operator

$$\widehat{K}_{\mathrm{ext}} := \phi(\widehat{\mathbf{R}}) - \frac{\widehat{\overline{\mathbf{P}}}^2}{2M^2}. \tag{982}$$

For a two-level transition satisfying Eq. (956), first-order diagonal perturbation theory in c^{-2} gives the instantaneous fractional transition response

$$y_H(t) = \frac{1}{c^2}\,\mathrm{Tr}_{\mathrm{ext}}\left[\rho_{\mathrm{ext}}(t)\widehat{K}_{\mathrm{ext}}\right]. \tag{983}$$

For interrogation interval $[0,T]$, the corresponding cycle-averaged branch is

$$\overline{y}_H(T) := \frac{1}{Tc^2}\int_0^T \mathrm{Tr}_{\mathrm{ext}}\left[\rho_{\mathrm{ext}}(t)\widehat{K}_{\mathrm{ext}}\right] dt. \tag{984}$$

This expression contains the gravitational contribution through $\phi(\widehat{\mathbf{R}})$ and the motional second-order contribution through $\widehat{\overline{\mathbf{P}}}^2$. 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.

47.10 Established Hamiltonian content does not generate a new 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 [15]. Within that broader framework, Eq. (981) is the retained leading diagonal internal–external mass-defect coupling under the stated approximation; the isolated displayed $\widehat{H}_{\mathrm{MD}}$ 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 [14]; those proposals are not promoted here to governing V37/F17 predictions.

Accordingly, the V37/F17 temporal core together with the established physical Hamiltonian does not supply an independently nonzero additional residual:

$$\left[\Gamma_{37}^{\mathrm{fund}} \wedge \mathrm{BaseHamiltonianSpecified}\left(\widehat{H}_{\mathrm{base}}\right)\right] \nvdash \delta y_X \neq 0, \tag{985}$$

where $\widehat{H}_{\mathrm{base}}$ denotes the independently warranted standard Hamiltonian for the declared carrier and apparatus. This is a dependency boundary, not a claim that every possible physical extension must have zero residual.

47.11 Hamiltonian benchmark C: reconstructed secular-motion shift

Status: this subsection reconstructs a published systematic correction from published modal inputs; it is not an independent measurement or an advance ITOF prediction.

A direct modal benchmark is supplied by the 2025 NIST $^{27}\mathrm{Al}^{+}$ quantum-logic clock [16]. 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

$$y_{\mathrm{sec}}^{\mathrm{modal}} := \sum_{\alpha=1}^{6} s_\alpha \left(\bar{n}_\alpha + \frac{1}{2}\right). \tag{986}$$

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,

$$y_{\text{sec}}^{\text{modal}} = -114.6142 \times 10^{-19}. \tag{987}$$

Using only the reported occupation-number uncertainties and the published modal coefficients, the corresponding propagated uncertainty is

$$\sigma_{\text{sec}}^{(\bar{n})} = \left[\sum_{\alpha=1}^{6} (s_\alpha \sigma_{\bar{n},\alpha})^2 \right]^{1/2} = 3.80135 \times 10^{-19}. \tag{988}$$

Rounding to the precision of the published clock evaluation gives

$$y_{\text{sec}}^{\text{modal}} = -(114.6 \pm 3.8) \times 10^{-19}, \tag{989}$$

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.

47.12 Independent nonstandard Hamiltonian residual family

A genuinely new residual requires an independently specified physical interaction beyond $\widehat{H}_{\text{base}}$. Let

$$\widehat{H}_{\text{test}} := \widehat{H}_{\text{base}} + \lambda_X \widehat{O}_X, \tag{990}$$

where $\widehat{O}_X$ is a physically typed operator and λ_X has independent physical provenance. Their dimensions must be declared for each candidate so that $\lambda_X \widehat{O}_X$ 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

$$D_X(t) := \text{Tr}_{\text{ext}} \left[\rho_{\text{ext}}(t) \big(\langle e|\widehat{O}_X|e\rangle - \langle g|\widehat{O}_X|g\rangle \big) \right]. \tag{991}$$

After the internal-state matrix elements are taken, the bracketed difference in Eq. (991) is an operator on the external carrier space. The external trace therefore gives the state-dependent transition-energy contribution per unit λ_X. The induced cycle-averaged fractional residual is then

$$\delta y_X(T) = \frac{\lambda_X}{\hbar \omega_0 T} \int_0^T D_X(t)\, dt. \tag{992}$$

No advance prediction follows unless the operator, coupling, carrier state, apparatus parameters, domain, and acquisition bridge are fixed independently of the evaluation outcome. In particular,

$$\Gamma_{37}^{\text{fund}} \nvdash \lambda_X \neq 0. \tag{993}$$

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 $\widehat{H}_{\text{base}}$ in the same declared protocol. For a rival prediction y_R, model-level resolved separation requires

$$|y_{\text{base}} + \delta y_X - y_R| > \eta_\star, \tag{994}$$

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.

47.13 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 [17]. For a harmonically trapped clock carrier, let

$$\epsilon_m := \frac{\hbar\omega_m}{Mc^2}, \tag{995}$$

where ω_m is the motional angular frequency. The cited Hamiltonian model predicts, for the motional ground state,

$$y_{\mathrm{vSODS}} = -\frac{\epsilon_m}{4}, \tag{996}$$

and for a squeezed motional state with squeeze parameter r, to the stated leading order,

$$y_{\mathrm{sqSODS}} \simeq -\frac{\epsilon_m}{4}\cosh(2r). \tag{997}$$

The same model predicts a motion–clock entanglement signature in the Ramsey visibility. In its leading small-parameter form,

$$\mathcal{V} \simeq 1 - \frac{(\epsilon_m \omega_0 T)^2}{16}\sinh^2(2r). \tag{998}$$

For the $^{27}\mathrm{Al}^+$ 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 V37/F17 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:

$$\mathrm{QuantumMotionalClockEffectObserved} \not\Rightarrow \tau \equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{999}$$

47.14 Quantitative claim boundary

The program now contains a weak-field gravitational branch, a trapped-ion Hamiltonian carrier 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

$$
\begin{aligned}
&\text{QuantitativePhysicalBridgeSpecified}\\
&\wedge \text{HamiltonianCarrierBranchSpecified}\\
&\wedge \text{BenchmarkRecoveryDemonstrated}\\
&\wedge \text{PublishedMotionalBenchmarkReconstructed}\\
&\wedge \neg\, \text{ITOFSpecificResidualDerived}\\
&\wedge \neg\, \text{FoundationSpecificPredictionSeparationDemonstrated}\,.
\end{aligned}
\tag{1000}
$$

The distinction between quantitative physical adequacy and foundational discrimination is preserved.

48. Predictive Separation Boundary: Non-Separation Proposition and Candidate Screening

48.1 Purpose and claim boundary

The quantitative program has established physical benchmark recovery and a Hamiltonian carrier 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 V37/F17 temporal definition remains unchanged?

This section classifies candidate interactions under the stated physical and inferential constraints. A candidate is not promoted to a governing V37/F17 postulate merely because it would produce a measurable difference.

48.2 Physical-Prediction Non-Separation under Identical Physical-to-Observable Specification

Using the governing-premise shorthand $\Gamma_{37}^{\text{fund}}$ fixed in Section 47, 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

$$
\begin{aligned}
\mathfrak{S}_J^{P,D} := \Big(&\text{PhysicalTarget}_J, \text{StatePreparation}_J, \text{PhysicalParameters}_J, \text{SystemBoundaries}_J,\\
&\mathcal{B}_J^{\text{in}}, \text{Dyn}_J, \mathcal{B}_J^{\text{out}}, \text{AuxiliaryPhysicalPremises}_J,\\
&\mathcal{B}_{J;P,D}^{\text{obs}}, \text{AcquisitionModel}_J, \text{Calibration}_J, \text{UncertaintyModel}_J\Big).
\end{aligned}
\tag{1001}
$$

The temporal ontological interpretation is not a component of $\mathfrak{S}_J^{P,D}$. Define

$$
\text{SamePhysicalSpecification}_{P,D}(I,R) \iff \mathfrak{S}_I^{P,D} = \mathfrak{S}_R^{P,D}. \tag{1002}
$$

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. In this section, $\mathbf{y}_J^{P,D}$ 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 48.1 (Physical-Prediction Non-Separation under Identical Physical-to-Observable Specification)**.** If the only difference between the two branches is the temporal ontological interpretation while $\mathrm{SamePhysicalSpecification}_{P,D}(I,R)$ holds, then no observable prediction separation follows from that ontological difference alone:

$$\mathrm{SamePhysicalSpecification}_{P,D}(I,R) \Longrightarrow \mathbf{y}_I^{P,D} = \mathbf{y}_R^{P,D}. \tag{1003}$$

Consequently,

$$\Delta_{I:R}^{P,D} = 0, \qquad \delta_{I:R}^{P,D} = 0, \tag{1004}$$

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. (1002), 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. (1003), an observable prediction separation requires a difference in the complete physically operative specification:

$$\mathbf{y}_I^{P,D} \neq \mathbf{y}_R^{P,D} \Longrightarrow \mathfrak{S}_I^{P,D} \neq \mathfrak{S}_R^{P,D}. \tag{1005}$$

For a claimed novel physical prediction, the differing component must also be prediction-relevant and independently warranted. This condition is necessary, not sufficient. The V37/F17 temporal definition, CMA, and UCC do not by themselves specify such an additional physically operative difference.

48.3 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. V37/F17 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 carrier momentum relative to the laboratory apparatus.

For a nonrelativistic carrier in this application-level screening model, define

$$\widehat{\mathbf{v}}_n := \mathbf{V}_n + \frac{\widehat{\mathbf{p}}}{M}. \tag{1006}$$

For a spin-independent, parity-even response constructed only from this relative carrier velocity and the scalar internal clock energy, the leading nonconstant rotational scalar is parameterized by

$$\boxed{\widehat{H}^{(2)}_{\mathrm{SR}} := \xi_2\, \widehat{H}^{(0)}_{\mathrm{int}} \frac{\widehat{\mathbf{v}}_n^2}{c^2}.} \tag{1007}$$

Here ξ_2 is a dimensionless physical coupling. It is not fixed by the time definition:

$$\Gamma^{\mathrm{fund}}_{37} \nvdash (\xi_2 \neq 0)\,. \tag{1008}$$

Expanding Eq. (1007) gives

$$\widehat{H}^{(2)}_{\mathrm{SR}} = \xi_2 \widehat{H}^{(0)}_{\mathrm{int}} \left[\frac{V_n^2}{c^2} + \frac{2\mathbf{V}_n\!\cdot\!\widehat{\mathbf{p}}}{Mc^2} + \frac{\widehat{\mathbf{p}}^2}{M^2c^2}\right]. \tag{1009}$$

This decomposition separates a preferred-frame kinematic term, a motion–frame cross term, and a quantum or classical motional-energy term.

48.4 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 [19]. Optical-clock comparisons also constrain orientation-dependent electron-sector Lorentz-violation coefficients at levels reaching approximately 10^{-21} for the reported combinations [20], and more general matter–gravity clock comparisons constrain additional SME coefficient combinations [21].

Therefore Eq. (1007) is not a unique ITOF signature. Let $\alpha^{\mathrm{RMS}}_{\mathrm{vio}}$ denote the quadratic time-dilation-violation coefficient in the convention used for the clock-network bound of Ref. [19]. Under the conditional normalization

$$\xi_2 \equiv \alpha^{\mathrm{RMS}}_{\mathrm{vio}}, \tag{1010}$$

the existing clock-network constraint gives the screening bound

$$\boxed{|\xi_2| \lesssim 1.1 \times 10^{-8}.} \tag{1011}$$

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 $\widehat{\mathbf{p}}^2$ 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.

48.5 Conditional quantum-motional scale under the quadratic screening normalization

For one harmonic motional mode of angular frequency ω_m, the ground state satisfies

$$\left\langle \frac{\widehat{\mathbf{p}}^2}{M^2} \right\rangle_0 = \frac{\hbar\omega_m}{2M}. \tag{1012}$$

The corresponding magnitude of the quadratic stage-referenced quantum-motional fractional response is bounded by

$$|\delta y^{(2)}_{\mathrm{SR},0}| \leq |\xi_2| \frac{\hbar\omega_m}{2Mc^2}. \tag{1013}$$

For a squeezed state with squeeze parameter r, the phase-averaged momentum variance introduces the factor $\cosh(2r)$, giving

$$|\delta y^{(2)}_{\mathrm{SR,sq}}| \leq |\xi_2| \frac{\hbar\omega_m}{2Mc^2} \cosh(2r). \tag{1014}$$

Using $^{27}\mathrm{Al}^+$, $\omega_m = 2\pi \times 20\,\mathrm{MHz}$, $r = 2.26$, and the conditional bound in Eq. (1011), the numerical screening values are

$$|\delta y^{(2)}_{\mathrm{SR},0}| \lesssim 1.81 \times 10^{-26}, \tag{1015}$$

and

$$|\delta y^{(2)}_{\mathrm{SR,sq}}| \lesssim 8.31 \times 10^{-25}. \tag{1016}$$

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.

48.6 Higher-order preferred-stage scalar candidates

A formally possible next term is

$$\widehat{H}^{(4)}_{\mathrm{SR}} := \xi_4 \widehat{H}^{(0)}_{\mathrm{int}} \left(\frac{\widehat{\mathbf{v}}_n^{\,2}}{c^2} \right)^2. \tag{1017}$$

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. V37/F17 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 [18], 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.

48.7 Coherence-only state-functionals are not an admissible shortcut

A proposed residual depending directly on a state functional such as $\rho_{\mathrm{off-diagonal}}$, 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,

$$\mathrm{DesiredQuantumOnlyResidual} \not\Rightarrow \mathrm{AdmissibleLinearHamiltonianInteraction}\,. \tag{1018}$$

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.

48.8 Complete-population coupling is not a minimal consequence of CMA

A different proposal would couple a local system directly to a functional of the complete common-stage population or of $\mathfrak{R}_{\mathrm{C}}(s)$. A schematic expression would be

$$\widehat{H}_A^{\mathrm{pop}}(s) = g_A\, F(\mathfrak{R}_{\mathrm{C}}(s))\, \widehat{O}_A. \tag{1019}$$

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 V37/F17 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.

48.9 Differentiable-foliation couplings require structure not supplied by V37/F17

A metric application could introduce a smooth stage-association scalar and a unit timelike normal, then construct expansion, shear, acceleration, or extrinsic-curvature tensors. V37/F17 itself does not require a differentiable stage parameter, a metric on $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$, adjacency, or topology. Consequently, terms depending on derivatives of a foliation field are not derivable from the bare temporal ordered pair. In particular:

$$\mathrm{TemporalDefinition}_{\mathrm{ITOF}} \nvdash \mathrm{FoliationDerivativeStructuresSpecified}\,. \tag{1020}$$

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.

48.10 Result of the minimal predictive search

The candidate screening produces the following bounded result:

$$\begin{aligned}&\mathrm{PhysicalPredictionNonSeparationEstablished}\\ &\wedge \mathrm{QuadraticPreferredStageCandidateClassified}\\ &\wedge \mathrm{QuadraticQuantumEnhancementInsufficientUnderExistingBound}\\ &\wedge \mathrm{HigherOrderCandidateNotIndependentlyMotivated}\\ &\wedge \mathrm{StateFunctionalShortcutRejected}\\ &\wedge \mathrm{PopulationWideCausalCouplingNotDerivedFromCMA}\\ &\wedge \mathrm{DifferentiableFoliationCouplingNotDerivedFromBareOrder}\\ &\wedge \neg\, \mathrm{UniqueITOFSpecificHamiltonianOperatorDerived}\,.\end{aligned} \tag{1021}$$

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.

49. Open Physical Research Program

49.1 Foundational completion is not completion of physical theory

V37/F17 develops a foundational temporal and physical-realization architecture and now includes the domain-specific quantitative mass-defect clock-response branch of Section 47.

That benchmark branch does not amount to a complete dynamics of all physical phenomena.

The distinction is:

$$\mathrm{FoundationalArchitectureSpecified} \not\Rightarrow \mathrm{CompletePhysicalTheoryOfNatureSpecified}\,. \tag{1022}$$

In particular, the governing temporal definition

$$T_{\mathrm{ITOF}} = \mathcal{E}_{\mathrm{C}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right) \tag{1023}$$

does not determine one universal law of system-specific physical change.

Likewise, the complete-population common-stage physical-realization profile

$$\mathfrak{R}_{\mathrm{C}}(s) = (\mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s)\,, \mathfrak{D}_{\mathrm{C}}(s)\,, \mathfrak{G}_{\mathrm{C}}(s)) \tag{1024}$$

does not supply one universal equation transforming one such profile into another.

49.2 First open problem: domain-specific physical dynamics beyond the benchmark branch

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

$$M_{\mathcal{A}} \tag{1025}$$

with a sufficiently explicit typed application chain connecting system-specific physical inputs to model realizations, predictions, and records.

The required route is:

$$\begin{aligned} \mathrm{DeclaredPhysicalSystems} &\longrightarrow \mathrm{TypedPhysicalInputs} \\ &\longrightarrow \mathrm{ModelEncoding} \\ &\longrightarrow \mathrm{PhysicalDynamics} \\ &\longrightarrow \mathrm{AdvancePrediction} \\ &\longrightarrow \mathrm{MeasurementAndAcquisition} \\ &\longrightarrow \mathrm{PhysicalRecord}\,. \end{aligned} \tag{1026}$$

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.

49.3 Second open problem: physical realization across system levels

The hierarchy relation

$$A \triangleleft_{\kappa,s} B \tag{1027}$$

makes cross-level questions explicit without answering them universally.

Future physical work may investigate:

$$\begin{gathered} \text{how subsystem change contributes to composite change,} \\ \text{how composite constraints affect constituent change,} \\ \text{how causal contributions are redistributed under changing boundaries,} \\ \text{and how new numerical identities emerge from physical reorganization.} \end{gathered} \tag{1028}$$

Any quantitative cross-level rule requires its own physical derivation.

Composition alone is insufficient.

49.4 Third open problem: population transformation

The stage-pair population descriptor

$$\mathfrak{P}_{\mathrm{C}}^{\mathrm{pop}}(r,s) \tag{1029}$$

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:

$$\begin{gathered}\text{formation,}\quad\text{decay,}\quad\text{fusion,}\quad\text{fission,}\quad\text{reorganization,}\\ \text{biological formation and ending,}\quad\text{astrophysical transformation,}\\ \text{chemical transformation,}\quad\text{and other identity-changing physical processes.}\end{gathered} \tag{1030}$$

No universal population conservation or successor law is presupposed.

49.5 Fourth open problem: domain-specific physical directionalities

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.

49.6 Fifth open problem: operational metrics

V37/F17 defines the general operational architecture

$$m_P = \mathcal{M}_P^{\mathrm{op}}\left(r_1,\ldots,r_n;\kappa_P\right). \tag{1031}$$

A major future task is to classify physically important metric constructions according to:

$$\begin{gathered}\text{record source,}\quad\text{calibration,}\quad\text{comparison rule,}\quad\text{model dependence,}\\ \text{physical sensitivity,}\quad\text{systematic effects,}\quad\text{uncertainty,}\quad\text{and predictive role.}\end{gathered} \tag{1032}$$

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. (33) further requires that any claimed metric interval specify the additional physical or mathematical structure that fixes its scale beyond bare earlier–later order.

49.7 Sixth open problem: independently warranted carrier-specific residual physics

The quantitative program in Section 47 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 carrier motion and confinement can be treated quantitatively without redefining time, but the established Hamiltonian does not itself generate an ITOF-specific residual.

Any stronger carrier-specific program must therefore identify a physical interaction beyond the declared base Hamiltonian and specify

$$\begin{aligned}\mathfrak{M}_C^X = \Big(&\mathrm{ClockSystemBoundary}, \widehat{H}_{\mathrm{base}}, \lambda_X \widehat{O}_X, \mathrm{StatePreparation}, \\ &\mathrm{ParameterProvenance}, \mathrm{AcquisitionModel}, \\ &\mathrm{UncertaintyStructure}, \mathrm{PredictionCriterion}\Big).\end{aligned} \tag{1033}$$

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. (996)–(998) provides a near-term experimental domain for testing internal–external quantum clock dynamics while preserving this attribution boundary. The minimal candidate screening in Section 48 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.

49.8 Seventh open problem: independent ITOF–relativistic prediction separation

A foundation-sensitive empirical program requires a domain $D^\star$ 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:

$$\delta_{I:R}^{P,D^\star} > \eta_\star, \tag{1034}$$

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:

$$\mathrm{FoundationalDisagreement} \not\Rightarrow \mathrm{ObservableDiscrimination}\,. \tag{1035}$$

This remains one of the principal unresolved physical tasks of the framework.

49.9 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:

$$\begin{gathered}\text{a foundational temporal commitment,}\\ \text{a physical response law,}\\ \text{a parameter choice,}\\ \text{an approximation,}\\ \text{a measurement bridge,}\\ \text{or another auxiliary physical assumption.}\end{gathered} \tag{1036}$$

Therefore:

$$\text{ObservableModelSeparation} \not\Rightarrow \text{FoundationalAttributionIdentified}\,. \tag{1037}$$

The attribution problem is a distinct stage of theory testing.

49.10 Ninth open problem: empirical access to UCC

The formal contrary to UCC is:

$$\exists A \in \mathcal{U}_{\text{phys}}\ \exists s \in I_A, \quad \mathsf{NC}_A^{\text{phys}}(s). \tag{1038}$$

By Eq. (64), this is exactly equivalent to $\exists A \in \mathcal{U}_{\text{phys}}\ \exists s \in I_A : \neg\,\text{PhysReal}_A^{+}(s)$.

The central empirical difficulty is not stating the contrary.

It is obtaining sufficiently complete physical warrant for total physical non-change of the qualified system at the relevant realized stage.

Future work must therefore distinguish the following conditions, with $r, s \in I_A$ and $r \prec_{\text{C}} s$ wherever the pairwise predicate is used:

$$\begin{gathered}\text{NoResolvedChange},\\ \text{NoResolvedDifference}_{P,M}(A; r, s),\\ \text{CriterionRelativeStability},\\ \mathsf{NC}_A^{\text{phys}}(s).\end{gathered} \tag{1039}$$

Only the final condition constitutes the direct UCC contrary. The first three may coexist with actual bearer-specific physical change and therefore do not constitute a numerical or observational substitute for complete physical non-change.

The derived global condition $\neg\,\text{GlobalChangeNull}_{\text{C}}(s)$ is stronger in scope: it concerns the complete qualified population at an admitted stage. Finite non-detection across selected systems or variables does not establish $\text{GlobalChangeNull}_{\text{C}}(s)$, and finite positive observations do not deductively confirm its universal absence across $\mathcal{S}_{\text{C}}^{\text{tot}}$. Its empirical use therefore inherits the same bridge, coverage, and attribution restraints that govern UCC.

49.11 Tenth open problem: empirical access to CMA

CMA concerns one objective common cosmic change-stage realization.

Its direct contrary is:

$$\exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \neg\,\mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right). \tag{1040}$$

Future work must not substitute:

$$\begin{gathered}\text{clock disagreement}, \quad \text{coordinate disagreement}, \quad \text{signal delay}, \\ \text{spatial separation}, \quad \text{or frame-dependent record assignments}\end{gathered} \tag{1041}$$

for this stronger ontological contrary.

Any empirical route to CMA must state explicitly how the observable is derived from the common-stage claim rather than from an auxiliary physical model alone.

49.12 Eleventh open problem: physical identity criteria

The framework uses numerical physical-system identity but does not supply one universal empirical identity criterion for all classes of physical systems.

Future domain-specific work must specify:

$$\mathrm{IdentityCriterion}_{\mathcal{A}} \tag{1042}$$

for each relevant physical-system class $\mathcal{A}$.

The criterion should distinguish:

$$\begin{gathered}\text{continued numerical identity}, \quad \text{functional alteration}, \quad \text{component replacement}, \\ \text{formation of a new identity}, \quad \text{ending of an old identity}, \quad \text{and successor production.}\end{gathered} \tag{1043}$$

Without such a criterion, formation and ending claims remain underdetermined.

49.13 Research-program restraint

The open program is governed by:

$$\mathrm{OpenProblem} \not\Rightarrow \mathrm{CurrentITOFFailure}. \tag{1044}$$

But also:

$$\mathrm{OpenProblem} \not\Rightarrow \mathrm{AlreadySolvedByFoundationalDefinition}. \tag{1045}$$

Unresolved physical questions remain unresolved.

They must not be filled by semantic assertion.

50. General Conclusion: Temporal Identity, Physical Realization, and Quantitative Bridge Discipline

V37/F17 retains the V36/F16 temporal referent without adding a physical, metric, dynamical, observational, computational, or empirical component to its definition:

Time denotes the one universal cosmic extension of common cosmic change stages, constituted by their invariant universal earlier–later ordering and succession.

$$\boxed{T_{\mathrm{ITOF}} = \mathcal{E}_{\mathrm{C}} = \left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right).} \tag{1046}$$

Strict Cosmic Ordering fixes irreversibility; NoInterruption and NoTerminalStage separately govern uninterrupted and continuing succession. The temporal core remains non-metric: neither the order nor those succession commitments determine a canonical duration, stage spacing, density, topology, or differentiable parameterization.

The governing realization commitments remain distinct and non-interchangeable: CSPP, CMA, and UCC. CSPP supplies a nonempty qualified population, CMA supplies literal one-common-stage co-realization for the complete then-realized population within the single universal stage domain, and UCC supplies bearer-specific physical change throughout each realized identity range. Equivalently,

$$\mathrm{UCC} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \forall s \in I_A, \quad \neg \mathsf{NC}_A^{\mathrm{phys}}(s). \tag{1047}$$

This exclusion is qualitative: it neither assigns a universal scalar magnitude to change nor makes a zero result in selected variables equivalent to complete physical non-change. Numerical descriptions of small or large change require a declared system-specific or comparison map. At the cosmic population level, the derived result in Eq. (82) shows that no admitted stage is globally change-null under CSPP and UCC. Adding CMA, NoInterruption, and NoTerminalStage yields the single integrated $\mathrm{UCSCR_C}$ condition of Eq. (85): every admitted stage is nonempty, literally common to the complete then-realized qualified population, with every member realizing bearer-specific physical change. This is a derived realization statement, not a claim that time is a physical dynamical system, causal agent, moving carrier, or universal scalar process. Its stage-relative unity preserves physical multiplicity rather than imposing physical uniformity. V37/F17 makes that multiplicity explicit through

$$\mathfrak{R}_{\mathrm{C}}(s) = (\mathcal{S}_{\mathrm{phys}}(s), \mathfrak{X}_{\mathrm{C}}(s), \mathfrak{D}_{\mathrm{C}}(s), \mathfrak{G}_{\mathrm{C}}(s)), \qquad \mathfrak{R}_{\mathrm{C}}(s) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}}. \tag{1048}$$

The profile is population-complete but not an exhaustive universe state, a universal change quantity, or a universal causal mechanism. Hierarchical composition, identity-bounded histories, formation and ending, population transformation, cross-system comparison, physical directionalities, and operational metrics remain typed physical constructions within the same cosmic ordering.

The Stage-to-Change Bridge remains the internal conservative representation of CMA-governed common-stage unity together with UCC-equivalent complete-population change coverage. It is not an empirical bridge. The full path to an observable requires distinct layers:

$$F \wedge B_F^{\mathrm{phys}} \wedge B_F^{\mathrm{obs}} \wedge \mathcal{P}_F^{\mathrm{aux}} \vdash O_F, \tag{1049}$$

with covariance, protocol control, prediction separation, and attribution added for empirical assessment. This typing resolves a central inferential boundary: common-stage realization does not become a physical cause, a physical model does not become a measurement map, and a successful observable does not retroactively transfer temporal identity to the quantities used to produce it.

Mathematical-form neutrality extends to deterministic, stochastic, quantum, field-theoretic, geometrical, and numerical models. Each remains subject to the same requirements of physical typing, parameter provenance, domain declaration, model-to-prediction separation, measurement specification, and empirical attribution.

The quantitative physical program demonstrates how this bridge discipline works in practice. The independently sourced mass-defect branch recovers the weak-field response $\Delta\omega/\omega_0 = \Delta\phi/c^2$; V37/F17 adopts an independently established trapped-ion Hamiltonian branch, separately reconstructs the published 2025 six-mode $^{27}\mathrm{Al}^+$ secular-motion correction from published modal inputs, and supplies a controlled quantum-motional forward domain. These are genuine quantitative application results, but they do not create an ITOF-specific residual. The predictive search makes the limitation formal:

$$\mathrm{SamePhysicalSpecification}_{P,D}(I,R) \Longrightarrow \mathbf{y}_I^{P,D} = \mathbf{y}_R^{P,D}. \tag{1050}$$

Therefore a novel ITOF-specific observable requires independently warranted physical content that changes at least one prediction-relevant component of the complete physically operative specification. The screened quadratic preferred-stage candidate is not unique to ITOF and is already tightly constrained; higher-order, state-functional, population-wide, and foliation-derivative shortcuts are not promoted without an independent physical mechanism. This preserves a strict distinction between a foundational ontology, an ITOF-inspired phenomenological model, and a prediction actually entailed by an adopted physical extension.

The current empirical status is therefore explicit rather than rhetorical. V37/F17 contains quantitatively testable physical application branches and formal counterconditions for its governing commitments, but it does not claim that the present clock benchmarks already constitute a foundation-specific experimental separation from relativity. Direct empirical attribution to CMA or to another foundational difference requires an independently warranted bridge that transmits that difference into a distinct observable prediction. Failure of a declared application model can reject or restrict that model without retroactively negating every upstream foundational statement; conversely, benchmark recovery cannot establish the foundation when the rival branch predicts the same observable. This is the precise sense in which the framework is empirically disciplined without converting an unresolved foundational test into a manufactured prediction.

Three foundational burdens remain explicitly open in the present version. First, NoInterruption remains a separately declared non-metric ontological succession postulate for which V37/F17 does not presently supply an independent direct empirical operationalization. Second, UCC remains a universal foundational postulate whose direct contrary requires positive warrant for complete physical non-change of a qualified system at a realized stage; finite null results or criterion-relative stability do not establish that contrary, and benchmark recovery does not establish UCC. Third, UEIE remains an independent lifecycle postulate over the qualified physical-system domain $\mathcal{U}_{\mathrm{phys}}$; it is not derived from UCC, CRP, non-termination, or the temporal definition, and concrete application requires a domain-specific numerical-identity criterion adequate to the system class under study. These are declared boundaries of current warrant, not hidden consequences of the quantitative application program.

The generalized Non-Transfer Principle applies throughout. Clocks, coordinate parameters, proper-time functionals, metric intervals, dynamical parameters, quantum representations, operational metrics, computational outputs, and other successful physical or computational quantities remain the quantities they are; their utility does not make them time. Relativistic temporal identification is therefore still rejected at the type level. Empirical confrontation, however, requires independent application branches and a common observable domain. A genuinely foundation-sensitive comparison must establish advance prediction, uncertainty-controlled separation, and attribution that survives admissible bridge freedom, summarized by the declared condition

$$\delta_{I:R}^{P,D} > \eta_\star \tag{1051}$$

for the chosen protocol and domain.

The substantive advance of V37/F17 is consequently twofold. First, it extends the mature temporal ontology of V36/F16 into a typed architecture of complete- population physical realization without changing what time denotes. Second, it adds a disciplined quantitative bridge architecture that can recover physical benchmarks, host Hamiltonian and other independently specified physical application models, screen candidate extensions, and state exactly when an empirical result would or would not bear on the foundation. The framework therefore ends V37/F17 with a sharper boundary than a merely longer formalism: one universal temporal referent, physically plural realization within that referent, and an explicit rule that novel foundational prediction must arise from independently warranted physical content rather than from semantic substitution.

A. Statement Status and Direct Dependency Register

Table 1: Logical status and direct role of principal V37/F17 statements and constructions.

Item	Status	Direct dependency or role
$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Primitive carrier/totality	Formal universal common cosmic-stage carrier. Its admitted members possess the literal full-theory common-cosmic-change-stage role under the governing CSPP–CMA–UCC architecture; bare membership does not analytically entail UCC.
$\prec_{\mathrm{C}}$	Primitive ordering relation	Universal earlier–later relation on $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.
Strict Cosmic Ordering	Foundational axiom	Requires $\prec_{\mathrm{C}}$ to be a strict total order on $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

Item	Status	Direct dependency or role
Order-representation non-metricity	Derived mathematical result	Any supplied order representation remains non-unique under strictly increasing reparameterization; the strict order alone therefore does not determine a canonical scalar interval magnitude.
$\mathrm{NoInterruption}_{\mathrm{C}}$	Foundational postulate	Independent non-metric commitment that the actual common cosmic-stage succession contains no independent interruption layer.
$\mathrm{NoTerminalStage}_{\mathrm{C}}$	Foundational postulate	Requires every admitted common cosmic change stage to have some later member.
T_{ITOF}	Governing definition	$T_{\mathrm{ITOF}} := \mathcal{E}_{\mathrm{C}} := (\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}})$. Time denotes the one universal cosmic extension of common cosmic change stages, constituted by their invariant universal earlier–later ordering and succession.
CosmicOrigin	Independent cosmological postulate	Optional commitment that $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ possesses one unique least member.
$\mathcal{U}_{\mathrm{phys}}$	Defined physical-system totality	Qualified numerical physical-system identities possessing at least one realized identity member in $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.
I_A	Defined identity-realization range	Common cosmic change stages at which numerical identity A is physically realized; not a private time.
$\mathcal{S}_{\mathrm{phys}}(s)$	Defined population	Complete qualified physical-system population realized at s.
$\mathrm{CosmicCoPresence}_{\mathrm{C}}(P; s)$	Meaning-fixed semantic–ontological relation symbol	Expresses literal objective one-common-stage co-realization of the declared qualified-system set at stage s; it is not definitionally identical to stage-population membership, not a causal relation, and not a freely tunable model parameter under the admissible common-stage semantics.
CSPP	Foundational postulate	Requires $\mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing$ for every $s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.

Item	Status	Direct dependency or role
CMA	Governing foundational axiom	Fixes literal one-common-cosmic-change-stage realization for the complete then-realized qualified population.
UCC	Foundational postulate	Requires system-specific physical change for every qualified system at every member of its realized identity range; equivalently excludes complete physical non-change at every such pair without introducing a universal scalar magnitude. Its universal empirical burden is not discharged by finite non-detection, selected-variable null results, or benchmark recovery.
Complete physical non-change	Defined qualitative contrary predicate	Equivalent to $\neg\,\mathrm{PhysReal}^{+}_{A}(s)$ for $s \in I_A$; its existence at any qualified realized pair is the direct UCC countercondition. It is not a universal numerical zero.
I^{Δ}_{A}	Defined actual-change subset	Members of I_A at which actual physical change is realized; equals I_A under UCC.
$\Delta^{\mathrm{phys}}_{A}$	Typed physical-change map	$\Delta^{\mathrm{phys}}_{A} : I^{\Delta}_{A} \to \Xi_A$; preserves bearer-specific change content and countermodel typing.
$\mathcal{B}_{\Delta}(s)$	Defined population subset	Change-realizing members of $\mathcal{S}_{\mathrm{phys}}(s)$; equality with the entire population at every s is equivalent to UCC.
$\mathrm{GlobalChangeNull}_{\mathrm{C}}(s)$	Defined stage-relative null predicate	Holds exactly when $\mathcal{B}_{\Delta}(s) = \varnothing$. Under CSPP and UCC it is false at every admitted stage. It does not denote a universal numerical zero.
$\mathrm{UCSCR}_{\mathrm{C}}$	Defined integrated realization condition	Integrated Universal Common-Stage Change Realization. It integrates the succession commitments with CMA, CSPP, and UCC; it is not a dynamics of time, a causal law, or a universal change magnitude.
$\mathfrak{D}_{\mathrm{C}}(s)$	Defined construction	Dependent system-indexed physical-change-content profile.

Item	Status	Direct dependency or role
$\mathrm{StageChangeBridge}_{\mathrm{C}}(s)$	Defined foundational representation	CMA common-stage clause plus UCC-equivalent complete-population change coverage; not an independent axiom, cause, synchronization rule, or observation bridge.
$X_A : I_A \to \Omega_A$	Defined physical-state map	System-specific physical state realized at each member of I_A.
$\mathfrak{X}_{\mathrm{C}}(s)$	New V37 defined construction	Dependent complete-population profile of system-specific physical states.
CRP	Foundational physical principle	Requires nonempty actual physical causal realization for every actual system-specific physical change.
$\mathfrak{G}_{\mathrm{C}}(s)$	New V37 defined construction	Complete-population mapping from each realized system to its actual causal set.
$\mathfrak{R}_{\mathrm{C}}(s)$	New V37 defined construction	Integrates population, state profile, change profile, and causal-realization profile without becoming a temporal object.
$\mathfrak{R}_{\mathrm{C}}^{[M]}(s)$	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.
UCSCR–CRP stage-relative realization consequence	Derived consequence	Under UCSCR together with CRP, every admitted stage is nonempty, satisfies the Stage-to-Change Bridge, and has nonempty actual causal realization for every qualified member; no additional realization predicate is introduced.
$A \lhd_{\kappa,s} B$	New V37 defined physical relation	Stage-relative constituent/subsystem relation under declared physical composition criterion κ; does not itself provide cross-level dynamics.
$\mathfrak{K}_{\mathrm{C}}(s)$	New V37 defined construction	Collection of warranted stage-relative constituent relations among qualified physical-system identities.

Item	Status	Direct dependency or role
Cross-Level Non-Transfer	V37 physical/type principle	Composition alone does not transfer state, physical-change content, causal determination, or numerical identity across system levels.
Identity-Realization Convexity	Foundational identity principle	Prevents an internal gap in one numerical identity range.
AFB	Independent identity postulate	Requires one unique least identity member for every qualified physical-system identity.
$\mathcal{H}_A$	Formal history representation	$(I_A, \prec_{\mathrm{C}} \|_{I_A}, X_A, \Delta_A^{\mathrm{phys}})$; 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.
$\mathrm{End}_A(e)$	Defined identity-ending predicate	Physical identity-ending transformation at the final member of numerical identity A.
PIECP	Independent ending-specific causal principle	Requires at least one actual causal contributor to contribute specifically to the identity-ending transformation.
UEIE	Independent universal lifecycle postulate	Requires eventual identity ending together with nonempty strict pre-ending identity history. Its application is limited to qualified numerical identities under a declared system-class identity criterion; no universal empirical identity criterion is supplied.
$\mathrm{SuccAt}(A, B; e)$	Defined conditional relation	New numerical identity B is physically produced through the ending transformation of A at e.
$\mathcal{P}_{r,s}$	New V37 defined set	Systems whose numerical identities are realized at both ordered endpoints.
$\mathcal{N}_{r\to s}$	New V37 defined set	Systems absent at r and realized at s.
$\mathcal{L}_{r\to s}$	New V37 defined set	Systems realized at r and absent at s.

Item	Status	Direct dependency or role
$\mathcal{T}_{r,s}$	New V37 defined 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.
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.
$\mathfrak{A}_{A,\alpha}$	New V37 application-level defined 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.
$\mathcal{M}_P^{\mathrm{op}}$	New V37 application-level defined 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.
Foundational empirical bridge	V37 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.

Item	Status	Direct dependency or role
$\mathfrak{Q}_{\mathrm{MD}}$	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.
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.
$\mathcal{Q}_{\mathrm{rel}}$	External model family	Relativistic coordinate, metric, proper-time, simultaneity, foliation, cosmological, and related quantities tested for temporal nonidentity.
$\mathfrak{B}_{I:R}^{P,D}$	New V37 empirical-comparison architecture	Connects independently specified ITOF and relativistic application branches to one observable comparison domain without temporal-identity merger.
$\delta_{I:R}^{P,D}$	New V37 methodological comparison quantity	Infimum prediction separation across independently admissible ITOF and relativistic bridge classes; used to test whether separation survives residual bridge freedom.

B. Core Symbol and Notation Register

Table 2: Core V37/F17 notation and governing meanings.

Symbol	Type	Meaning
T_{ITOF}	Temporal referent	Time in ITOF V37/F17.
$\mathcal{E}_{\mathrm{C}}$	Temporal referent	The same one universal non-metric cosmic extension denoted by T_{ITOF}.
$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$	Carrier	Formal universal common cosmic-stage totality.
$\prec_{\mathrm{C}}$	Strict order	Invariant universal earlier–later relation.
ι	Order-representation map	Optional injective representation of the cosmic order in a declared ordered label domain; its labels and numerical intervals are not time.
s_{C}^{0}	Boundary symbol	Unique least cosmic stage where Cosmic Origin is separately adopted.
$\mathcal{U}_{\mathrm{phys}}$	Physical-system totality	Qualified numerical physical-system identities realized at one or more members of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$.
I_A	Identity range	Members of $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$ 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.
$\mathcal{S}_{\mathrm{phys}}(s)$	Population	Complete qualified physical-system population realized at s.
CSPP	Postulate symbol	Cosmic Change-Stage Population Postulate.
CMA	Axiom symbol	Cosmic Moment Axiom.
UCC	Postulate symbol	Universal Change Continuity.
$\mathrm{UCSCR}_{\mathrm{C}}$	Defined realization condition	Integrated Universal Common-Stage Change Realization; the integrated conjunction of cosmic succession, CMA, CSPP, and UCC.
$\mathrm{PhysReal}_A^{+}(s)$	Physical relation	Actual system-specific physical change realized by A at s.
Ξ_A	Change-content type	System-specific codomain for physical-change content.
$\Delta_A^{\mathrm{phys}}(s)$	Physical-change content	System-specific physical content of change for an actual-change pair.

Symbol	Type	Meaning
$\mathcal{B}_\Delta(s)$	Population subset	Change-realizing members of the stage-relative population.
$\mathfrak{D}_{\mathrm{C}}(s)$	Dependent profile	System-indexed family of physical-change contents.
$\mathrm{StageChangeBridge}_{\mathrm{C}}(s)$	Defined foundational bridge	Common-stage realization plus complete-population 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.
$\mathfrak{X}_{\mathrm{C}}(s)$	V37 state profile	Complete-population dependent family of system-specific physical states.
$\mathfrak{C}_A(s)$	Causal profile	Internal, external-system, and external-factor physical contributor classes.
$\mathcal{C}_A^{\mathrm{act}}(s)$	Actual causal set	Union of the actual physical causal contributors for the change of A at s.
$\mathfrak{G}_{\mathrm{C}}(s)$	V37 causal profile	Population-indexed family of actual causal sets.
$\mathfrak{R}_{\mathrm{C}}(s)$	V37 realization profile	Population, physical-state, physical-change, and causal-realization architecture at common cosmic change stage s.
$\mathfrak{R}_{\mathrm{C}}^{[M]}(s)$	Relational augmentation	Model-relative enrichment of the complete-population realization profile by additional independently warranted physical relations.
$A \lhd_{\kappa,s} B$	Composition relation	Qualified physical-system identity A is physically realized as a proper constituent or subsystem of B under criterion κ at s.
$\mathfrak{K}_{\mathrm{C}}(s)$	Composition profile	Collection of warranted stage-relative constituent relations.
f_A	Formation boundary	Unique least identity member under AFB.
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.

Symbol	Type	Meaning
$\mathcal{P}_{r,s}$	Population set	Identities realized at both r and s.
$\mathcal{N}_{r\to s}$	Population set	Identities absent at r and realized at s.
$\mathcal{L}_{r\to s}$	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.
$\mathrm{Cmp}_{AB,P}(s)$	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.
$\mathrm{ArrowAligned}_{A,\alpha}(J)$	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.
$\mathcal{M}_P^{\mathrm{op}}$	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.
$\mathfrak{P}^{\star}$	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.
$\mathcal{Q}_{\mathrm{rel}}$	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.

Symbol	Type	Meaning
$\delta_{I:R}^{P,D}$	Robust separation margin	Infimum common-observable prediction separation over independently admissible bridge classes for the two comparison branches.

C. Formal Model Constructions and Independence Results

C.1 Purpose and logical status

The constructions in this appendix test logical dependency, definitional conservativity, and satisfiability.

They are not empirical cosmological models.

They are not proposed microscopic dynamics.

They are not additional physical postulates.

For commitments Γ and P:

$$\mathrm{Model}\,[\Gamma \wedge \neg P] \Longrightarrow \Gamma \nvdash P. \tag{1052}$$

Conversely:

$$\mathrm{FormalModelExists}(M) \nRightarrow \mathrm{PhysicallyRealized}(M). \tag{1053}$$

A witness may violate a governing V37/F17 commitment for dependency analysis.

Such a witness is not thereby an admissible full physical realization of V37/F17.

C.2 Typed realization-core signature

For dependency analysis, retain the minimal typed realization-core signature:

$$\begin{gathered}\Sigma_{37}^{\mathrm{core}} := \Big\langle \mathsf{S}_{\mathrm{C}}, \mathsf{U}_{\mathrm{phys}}; \prec_{\mathrm{C}}, \mathrm{ExistsAs}, \mathrm{PhysReal}^{+}, \mathrm{CosmicCoPresence}_{\mathrm{C}} \Big\rangle, \\ \prec_{\mathrm{C}} \subseteq \mathsf{S}_{\mathrm{C}} \times \mathsf{S}_{\mathrm{C}}, \\ \mathrm{ExistsAs} \subseteq \mathsf{U}_{\mathrm{phys}} \times \mathsf{S}_{\mathrm{C}}, \\ \mathrm{PhysReal}^{+} \subseteq \mathsf{U}_{\mathrm{phys}} \times \mathsf{S}_{\mathrm{C}}, \\ \mathrm{CosmicCoPresence}_{\mathrm{C}} \subseteq \mathcal{P}(\mathsf{U}_{\mathrm{phys}}) \times \mathsf{S}_{\mathrm{C}}.\end{gathered} \tag{1054}$$

The indexed notation:

$$\mathrm{PhysReal}_{A}^{+}(s) \tag{1055}$$

is the curried form of:

$$\mathrm{PhysReal}^{+}(A,s). \tag{1056}$$

The objects:

$$I_A, \quad I_A^{\Delta}, \quad \mathcal{S}_{\mathrm{phys}}(s), \quad \mathcal{B}_{\Delta}(s) \tag{1057}$$

remain defined constructions. The symbol $\mathrm{CosmicCoPresence}_{\mathrm{C}}$ is retained in the typed signature to express the meaning-fixed semantic–ontological one-common-stage content stated in Eq. (53). Its syntactic primitiveness means only that this content is not definitionally generated by the population constructions; it is not a freely variable model parameter or an independently toggleable ontic degree of freedom under fixed common-stage semantics. The admissible-model class constrains its interpretation to the declared literal co-realization meaning. Dependency models may vary the physical-change assignment to test CMA–UCC separation; a model that replaces literal common-stage co-realization by mutually private system-stage domains instead changes the CMA/common-stage ontology being tested.

The V37/F17 state, change, causal-realization, and complete-population physical- realization profiles are defined constructions; they are not promoted to independently variable primitives.

Likewise:

$$\mathrm{StageChangeBridge}_{\mathrm{C}}(s) \tag{1058}$$

remains a conservative defined representation.

C.3 Domain admissibility

The defined physical-system totality requires:

$$\mathrm{DomainAdmissible}_{37} \iff \forall A \in \mathcal{U}_{\mathrm{phys}}\ \exists s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}\ \ \mathrm{ExistsAs}(A,s). \tag{1059}$$

This is not an additional physical postulate.

It enforces the definition of $\mathcal{U}_{\mathrm{phys}}$.

C.4 Governing realization-core model

A governing V37/F17 realization-core model satisfies:

$$\begin{aligned}\mathfrak{M} \models \mathfrak{G}_{37}^{\mathrm{core}} \iff\ & \mathrm{DomainAdmissible}_{37}\\ & \wedge \mathrm{StrictTotalOrder}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right)\\ & \wedge \mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \prec_{\mathrm{C}}\right)\\ & \wedge \mathrm{NoTerminalStage}_{\mathrm{C}}\\ & \wedge \mathrm{CSPP}\\ & \wedge \mathrm{CMA}\\ & \wedge \mathrm{UCC}\,.\end{aligned} \tag{1060}$$

CRP, identity, lifecycle, observational, composition, and application modules may then be added according to their declared logical statuses.

The displayed core is not claimed to be a complete first-order axiomatization of the entire theory.

C.5 A relative joint-satisfiability witness

The construction below is a relative satisfiability witness. In particular, the primitive non-metric NoInterruption commitment is assumed to have an admissible interpretation satisfying its declared succession semantics. The witness does not reduce NoInterruption to density, adjacency, topology, differentiability, metric continuity, or an independent empirical criterion. Its role is only to demonstrate joint satisfiability of the displayed commitments relative to that admissible interpretation.

Let:

$$\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} = \mathbb{N}_0 = \{0, 1, 2, \ldots\} \tag{1061}$$

with:

$$m \prec_{\mathrm{C}} n \Longleftrightarrow m < n. \tag{1062}$$

Then:

$$\mathrm{StrictTotalOrder}\left(\mathbb{N}_0, <\right) \tag{1063}$$

holds.

Within the declared admissible interpretation, impose:

$$\mathrm{NoInterruption}_{\mathrm{C}}\left(\mathbb{N}_0, <\right). \tag{1064}$$

Also:

$$\forall n \in \mathbb{N}_0\ \exists m \in \mathbb{N}_0\ (n < m), \tag{1065}$$

so NoTerminalStage holds.

The optional Cosmic Origin commitment may be satisfied by:

$$s_{\mathrm{C}}^{0} = 0. \tag{1066}$$

Let:

$$\mathcal{U}_{\mathrm{phys}} = \{A_0, A_1, A_2, \ldots\}. \tag{1067}$$

Assign:

$$I_{A_k} = \{0, 1, \ldots, k+1\}. \tag{1068}$$

Every range is convex and possesses:

$$f_{A_k} = 0 \tag{1069}$$

and:

$$e_{A_k} = k + 1. \tag{1070}$$

Assign:

$$\text{IdentityEndingTransformation}\left(A_k; k+1\right) \tag{1071}$$

for every k.

Then:

$$\text{End}_{A_k}(k+1). \tag{1072}$$

At stage n:

$$\mathcal{S}_{\text{phys}}(n) = \left\{A_k \mid k+1 \geq n\right\}. \tag{1073}$$

For every n:

$$\mathcal{S}_{\text{phys}}(n) \neq \varnothing, \tag{1074}$$

so CSPP holds.

Under the fixed governing CMA semantics:

$$\forall n \in \mathbb{N}_0, \quad \text{CosmicCoPresence}_{\text{C}}\left(\mathcal{S}_{\text{phys}}(n); n\right). \tag{1075}$$

Independently assign:

$$\forall k \, \forall n \in I_{A_k}, \quad \text{PhysReal}^{+}_{A_k}(n). \tag{1076}$$

Thus UCC holds. Together with the already established CSPP,

$$\forall n \in \mathbb{N}_0, \quad \mathcal{B}_{\Delta}(n) = \mathcal{S}_{\text{phys}}(n) \neq \varnothing. \tag{1077}$$

and therefore

$$\forall n \in \mathbb{N}_0, \quad \neg\, \text{GlobalChangeNull}_{\text{C}}(n). \tag{1078}$$

Since the witness also satisfies CMA, NoInterruption, and NoTerminalStage,

$$\text{UCSCR}_{\text{C}}. \tag{1079}$$

This is a derived check on the same witness, not an additional assignment.

For each pair (A_k, n), choose a nonempty actual causal set:

$$\mathcal{C}^{\mathrm{act}}_{A_k}(n) = \{c_{k,n}\}. \tag{1080}$$

Assign:

$$\mathrm{PhysicallyContributes}\left(c_{k,n}; \Delta^{\mathrm{phys}}_{A_k}(n)\right). \tag{1081}$$

CRP is therefore satisfied.

At the ending member assign:

$$\mathrm{PhysicallyContributes}\left(c_{k,k+1}; \mathrm{IdentityEndingTransformation}(A_k; k+1)\right). \tag{1082}$$

PIECP holds.

Because every I_{A_k} contains $0 < k+1$, UEIE also holds.

C.6 State and change profiles in the consistency witness

For each A_k, let:

$$\Omega_{A_k} = \mathbb{N}_0 \tag{1083}$$

and define:

$$X_{A_k}(n) = n + k. \tag{1084}$$

Let:

$$\Xi_{A_k} = \mathbb{N}_0 \times \{k\} \tag{1085}$$

and:

$$\Delta^{\mathrm{phys}}_{A_k}(n) = (n, k). \tag{1086}$$

Then Eq. (1077) supplies the complete change-realizing population at every n.

The state profile:

$$\mathfrak{X}_{\mathrm{C}}(n) = (A_k \mapsto n + k)_{A_k \in \mathcal{S}_{\mathrm{phys}}(n)} \tag{1087}$$

is well defined.

The change profile:

$$\mathfrak{D}_{\mathrm{C}}(n) = (A_k \mapsto (n, k))_{A_k \in \mathcal{S}_{\mathrm{phys}}(n)} \tag{1088}$$

is well defined.

The causal-realization profile:

$$\mathfrak{G}_{\mathrm{C}}(n) = (A_k \mapsto \{c_{k,n}\})_{A_k \in \mathcal{S}_{\mathrm{phys}}(n)} \tag{1089}$$

is well defined.

Hence:

$$\mathfrak{R}_{\mathrm{C}}(n) = (\mathcal{S}_{\mathrm{phys}}(n), \mathfrak{X}_{\mathrm{C}}(n)\,, \mathfrak{D}_{\mathrm{C}}(n)\,, \mathfrak{G}_{\mathrm{C}}(n)) \tag{1090}$$

exists at every n.

Therefore the witness satisfies, at every n, the nonempty population, Stage-to-Change, and nonempty causal-realization conditions of Eq. (167). No additional temporal object or realization predicate is introduced.

C.7 Successor production remains unnecessary

Assign:

$$\forall k, j, \quad \neg\, \mathrm{PhysicalProductionLink}\,(A_k, A_j; k+1)\,. \tag{1091}$$

Then:

$$\forall k, j, \quad \neg\, \mathrm{SuccAt}\,(A_k, A_j; k+1)\,. \tag{1092}$$

Nevertheless the witness satisfies:

$$\begin{gathered}\mathrm{StrictTotalOrder}, \quad \mathrm{NoInterruption}_{\mathrm{C}}(\mathbb{N}_0, <)\,, \quad \mathrm{NoTerminalStage}_{\mathrm{C}}, \quad \mathrm{CSPP}, \quad \mathrm{CMA}, \\ \mathrm{UCC}, \quad \mathrm{CRP}, \quad \mathrm{IdentityRealizationConvexity}, \quad \mathrm{AFB}, \quad \mathrm{UEIE}, \quad \mathrm{PIECP}, \\ \text{and the complete V37/F17 physical-realization profile construction.}\end{gathered} \tag{1093}$$

The construction is only a satisfiability witness.

Its countable physical population and state assignments are not proposed as a physical cosmology.

C.8 The V37 realization profile is a conservative construction

Suppose all component functions:

$$\mathcal{S}_{\mathrm{phys}}(s), \quad \mathfrak{X}_{\mathrm{C}}(s)\,, \quad \mathfrak{D}_{\mathrm{C}}(s)\,, \quad \mathfrak{G}_{\mathrm{C}}(s) \tag{1094}$$

are already fixed.

Then:

$$\mathfrak{R}_{\mathrm{C}}(s) \tag{1095}$$

is uniquely fixed by definition.

Therefore:

$$\text{ComponentInterpretationsFixed} \Longrightarrow \text{RealizationProfileUniquelyDetermined}\,. \tag{1096}$$

The profile introduces no additional independent truth assignment.

In particular, the profile is not a temporal primitive:

$$\mathfrak{R}_{\mathrm{C}}(s) \not\equiv_{\text{type}} \text{TemporalPrimitive}\,. \tag{1097}$$

C.9 Complete profile coverage does not imply one universal physical state

Consider two qualified systems A and B realized at the same stage s.

Let:

$$\Omega_A = \mathbb{R}, \qquad \Omega_B = \mathbb{R}^3. \tag{1098}$$

Assign:

$$X_A(s) = 1, \qquad X_B(s) = (0, 1, 2). \tag{1099}$$

The complete state profile:

$$\mathfrak{X}_{\mathrm{C}}(s) = (A \mapsto 1, B \mapsto (0, 1, 2)) \tag{1100}$$

is well defined.

Yet:

$$\Omega_A \neq \Omega_B. \tag{1101}$$

Therefore:

$$\text{CompleteStateProfileCoverage} \nvDash \text{OneUniversalPhysicalStateSpace}\,. \tag{1102}$$

C.10 Complete change coverage does not imply one universal change codomain

Let:

$$\Xi_A = \mathbb{R}, \qquad \Xi_B = \mathbb{R}^2. \tag{1103}$$

Assign actual change to both systems.

Then:

$$\mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) = \{A, B\} \tag{1104}$$

may hold while:

$$\Xi_A \neq \Xi_B. \tag{1105}$$

Thus:

$$\mathcal{B}_\Delta(s) = \mathcal{S}_{\text{phys}}(s) \nvdash \exists \Xi_{\text{univ}}\ \forall X \in \mathcal{S}_{\text{phys}}(s), \quad \Xi_X = \Xi_{\text{univ}}. \tag{1106}$$

C.11 Composition does not imply cross-level change identity

Let:

$$A \triangleleft_{\kappa,s} B. \tag{1107}$$

Assign:

$$\Xi_A = \mathbb{R}, \qquad \Xi_B = \mathbb{R}^3. \tag{1108}$$

Under UCC both systems change.

Nevertheless:

$$\Delta_A^{\text{phys}}(s) \not\equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \tag{1109}$$

Hence:

$$A \triangleleft_{\kappa,s} B \nvdash \Delta_A^{\text{phys}}(s) \equiv_{\text{type}} \Delta_B^{\text{phys}}(s). \tag{1110}$$

C.12 Composition does not imply cross-level causal determination

Consider two typed structures $\mathfrak{M}_1$ and $\mathfrak{M}_2$ with the same:

$$A, \quad B, \quad s, \quad A \triangleleft_{\kappa,s} B, \quad X_A(s), \quad X_B(s), \quad \Delta_A^{\text{phys}}(s). \tag{1111}$$

Let the structures differ only in the admissible causal realization assigned to B:

$$\mathcal{C}_{B,1}^{\text{act}}(s) \neq \mathcal{C}_{B,2}^{\text{act}}(s). \tag{1112}$$

Both may satisfy CRP.

Therefore the composition relation alone does not determine the composite causal profile:

$$A \triangleleft_{\kappa,s} B \nvdash \mathcal{C}_B^{\text{act}}(s) = F_\kappa\left(\mathcal{C}_A^{\text{act}}(s)\right). \tag{1113}$$

Any such F_κ requires additional physical premises.

C.13 Common-stage co-realization does not entail interaction

Let:

$$A, B \in \mathcal{S}_{\text{phys}}(s) \tag{1114}$$

and retain CMA.

Assign:

$$\neg\,\text{PhysicalInteraction}(A, B; s). \tag{1115}$$

This does not violate CMA.

Hence:

$$\text{CMA} \nvdash \text{UniversalPairwisePhysicalInteraction}\,. \tag{1116}$$

Likewise assign:

$$\neg\,\text{SignalAccessible}(A, B; s). \tag{1117}$$

Then:

$$\text{CMA} \nvdash \text{UniversalInstantaneousSignalAccessibility}\,. \tag{1118}$$

C.14 Population transformation does not require adjacent stages

Take:

$$0 \prec_{\text{C}} 1 \prec_{\text{C}} 2. \tag{1119}$$

Compare the nonadjacent endpoints:

$$r = 0, \qquad s = 2. \tag{1120}$$

The sets:

$$\mathcal{P}_{0,2}, \qquad \mathcal{N}_{0\to 2}, \qquad \mathcal{L}_{0\to 2}, \qquad \mathcal{T}_{0,2} \tag{1121}$$

remain well defined.

Therefore:

$$\text{PopulationTransformationDescriptorDefined}(r, s) \nvdash \text{Adjacent}(r, s). \tag{1122}$$

C.15 Population transformation does not imply population motion

The pairwise descriptor is constructed entirely from correctly typed identity-domain membership statements of the form

$$A \in \mathcal{U}_{\text{phys}}, \qquad u \in \mathcal{S}_{\text{C}}^{\text{tot}}, \qquad \nu \in I_A, \tag{1123}$$

with ν 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:

$$\text{Defined}(\mathfrak{P}_{\text{C}}^{\text{pop}}(r,s)) \nvdash \text{PopulationMovesFrom}(r,s). \tag{1124}$$

C.16 Population transformation does not require universal successor closure

The principal consistency witness already permits identity ending without any assigned successor relation. Let Γ_{pop} denote the defining formulas of the population-transformation architecture. Then:

$$\Gamma_{\text{pop}} \cup \{\text{End}_A(e)\} \nvdash \exists B\ \text{SuccAt}(A,B;e). \tag{1125}$$

Population differences across ordered stages therefore do not require every departing identity to generate a newly formed successor.

C.17 Operational metric construction does not imply temporal identity

Consider two physically admissible calibration conventions:

$$m_P = \mathcal{M}_P^{\text{op}}(r_1, r_2; \kappa_P), \tag{1126}$$

$$m'_P = 2m_P. \tag{1127}$$

The two representations may encode the same ordered physical records under different unit scales.

The universal cosmic ordering is unchanged.

Thus:

$$m_P \neq m'_P \nRightarrow \text{DifferentTemporalReferents}(P, P'). \tag{1128}$$

More importantly:

$$\text{OperationalMetricSuccessfullyConstructed} \nvdash m_P \equiv_{\text{type}} T_{\text{ITOF}}. \tag{1129}$$

C.18 Successful model parameter does not acquire temporal identity

Let one application model use parameter:

$$\lambda \tag{1130}$$

and an equivalent reparameterization use:

$$\lambda' = 2\lambda. \tag{1131}$$

Suppose both representations predict exactly the same physical observables after the corresponding transformation of the model equations.

Then:

$$\mathrm{Success}(\lambda) \wedge \mathrm{Success}(\lambda'). \tag{1132}$$

Operational success alone cannot identify both distinct numerical parameters with the same temporal referent.

Therefore:

$$\text{SuccessfulEvolutionParameter} \nvdash \text{TemporalIdentity}\,. \tag{1133}$$

C.19 Non-injective observation remains possible

Let:

$$s_0 \prec_{\mathrm{C}} s_1 \prec_{\mathrm{C}} s_2 \prec_{\mathrm{C}} s_3 \tag{1134}$$

belong to I_A.

Define:

$$\mathcal{O}_{P,\varepsilon} : I_A \longrightarrow \{0, 1\} \tag{1135}$$

with:

$$\mathcal{O}_{P,\varepsilon}(s) = \begin{cases} 0, & \mathrm{Response}_P(A; s) < \varepsilon, \\ 1, & \mathrm{Response}_P(A; s) \geq \varepsilon. \end{cases} \tag{1136}$$

Suppose:

$$\mathcal{O}_{P,\varepsilon}(s_0) = \mathcal{O}_{P,\varepsilon}(s_1) = 0 \tag{1137}$$

and:

$$\mathcal{O}_{P,\varepsilon}(s_2) = \mathcal{O}_{P,\varepsilon}(s_3) = 1. \tag{1138}$$

Then the map is non-injective.

Therefore:

$$\mathcal{O}_{P,\varepsilon}(s) = 1 \nRightarrow \text{ExactCosmicChangeStageIdentified}(s). \tag{1139}$$

This remains one formal source of Exact-Change-Stage Restraint.

C.20 Selected state reconstruction does not imply unique stage reconstruction

Suppose:

$$\widehat{X}_{A;P,M}(r) = X^\star. \tag{1140}$$

If:

$$\exists s_1, s_2 \in I_A, \quad s_1 \neq s_2, \quad X_A(s_1) = X_A(s_2) = X^\star, \tag{1141}$$

then:

$$\text{UniqueSelectedStateReconstruction} \not\Rightarrow \text{UniqueCosmicChangeStageIdentification}\,. \tag{1142}$$

State recurrence and cosmic-stage identity remain distinct.

C.21 Model discrimination does not automatically identify foundational failure

Suppose:

$$M_1 \neq M_2 \tag{1143}$$

and:

$$\text{DiscriminationFavours}(M_1). \tag{1144}$$

Let both models contain application-level bridge assumptions not deductively fixed by their respective foundational commitments.

Then model discrimination establishes:

$$\text{ApplicationModelSupportOrRestriction} \tag{1145}$$

without logically isolating a foundational premise.

Therefore:

$$\text{ModelDiscrimination} \nvdash \text{FoundationalAttribution}\,. \tag{1146}$$

The additional attribution burden of Section 25 is therefore non-redundant.

C.22 CMA and UCC retain their V36 governing distinction

V37/F17 preserves:

$$\mathrm{CMA} \not\equiv_{\mathrm{def}} \mathrm{UCC}\,. \tag{1147}$$

A typed dependency structure may retain the declared common-stage carrier, ordering, and CMA semantics while assigning:

$$\neg\,\mathrm{PhysReal}^{+}_{A}(s) \tag{1148}$$

to at least one qualified realized pair.

Then:

$$\mathrm{CMA} \nvDash \mathrm{UCC}\,. \tag{1149}$$

Such a dependency witness is not an admissible full V37/F17 realization.

It is not a physically admissible changeless common cosmic change stage.

The reverse model-theoretic non-entailment is not asserted merely for formal symmetry under fixed common-stage meanings.

C.23 Retained principal independence results

V37/F17 retains the following validated V36/F16 independence results [1]. Their stated premise sets are preserved, while the principal new V37/F17 profiles and bridge objects are defined constructions; they therefore do not silently add premises to the reduced dependency claims listed below. Where a new V37 relation is irrelevant to a witness, it may be left uninstantiated or interpreted conservatively according to its declared domain.

The retained results are:

$$\mathrm{UCC} \nvDash \mathrm{UEIE}, \tag{1150}$$

$$\{\mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}\} \nvDash \mathrm{CosmicOrigin}, \tag{1151}$$

$$\{\mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}, \mathrm{IdentityRealizationConvexity}\} \nvDash \mathrm{AFB}, \tag{1152}$$

$$\{\mathrm{CRP}, \mathrm{End}_A(e)\} \nvDash \mathrm{PIECP}, \tag{1153}$$

$$\{\mathrm{End}_A(e), \mathrm{UCC}, \mathrm{CRP}, \mathrm{PIECP}\} \nvDash \exists B\ \mathrm{SuccAt}(A, B; e), \tag{1154}$$

$$\mathrm{CSPP} \nvDash \mathrm{UCC}, \tag{1155}$$

$$\mathrm{CMA} \nvDash \mathrm{UCC}, \tag{1156}$$

$$\{I_A^{<s} \neq \varnothing, \mathrm{UCC}\} \nvDash \mathrm{End}_A(s), \tag{1157}$$

$$\mathrm{CumulativePhysicalResultThrough}_A(s) \nvDash \mathrm{End}_A(s), \tag{1158}$$

$$\mathrm{OperationalRecovery} \nvDash \mathrm{TemporalIdentity}\,. \tag{1159}$$

The V37 additions preserve these separations rather than hiding new equivalences inside the enlarged physical-realization architecture.

C.24 Retained direct derivations

V37/F17 also preserves genuine derivations.

From strict total ordering:

$$r \prec_{\mathrm{C}} s \Longrightarrow \neg \left(s \prec_{\mathrm{C}} r\right). \tag{1160}$$

From NoTerminalStage:

$$\mathrm{NoTerminalStage}_{\mathrm{C}} \Longrightarrow \nexists g \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}} \ \mathrm{Greatest}_{\prec_{\mathrm{C}}}(g). \tag{1161}$$

For nonempty strictly totally ordered $\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}$:

$$\mathrm{NoTerminalStage}_{\mathrm{C}} \Longrightarrow \mathrm{Infinite}(\mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}). \tag{1162}$$

From AFB and UCC:

$$\mathrm{AFB} \wedge \mathrm{UCC} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}}, \quad \mathrm{FormationChange}_A(f_A). \tag{1163}$$

From ending and UCC:

$$\mathrm{End}_A(e) \wedge \mathrm{UCC} \Longrightarrow \mathrm{PhysReal}_A^{+}(e). \tag{1164}$$

From UCC and CRP:

$$\mathrm{UCC} \wedge \mathrm{CRP} \Longrightarrow \forall A \in \mathcal{U}_{\mathrm{phys}} \ \forall s \in I_A, \quad \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing. \tag{1165}$$

From CSPP, CMA, and UCC:

$$\forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \left[\mathcal{S}_{\mathrm{phys}}(s) \neq \varnothing \wedge \mathrm{CosmicCoPresence}_{\mathrm{C}}\left(\mathcal{S}_{\mathrm{phys}}(s); s\right) \wedge \mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s)\right]. \tag{1166}$$

From UCSCR and CRP, Eq. (167) supplies the corresponding nonempty stage-relative population, Stage-to-Change condition, and nonempty causal realization for every member. This identifies the causal completion of the integrated realization condition 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 V37/F17.

Table 3: Principal governing equations of V37/F17.

Role	Reference	Status
Definition of time	Eq. (12)	Governing definition.

Role	Reference	Status
Strict cosmic ordering	Eq. (18)	Foundational axiom.
Order-representation non-metricity	Eqs. (24)–(33)	Derived representation-level result; no global numerical representation is required by the temporal definition.
NoInterruption	Eq. (38)	Independent foundational succession postulate.
NoTerminalStage	Eq. (40)	Independent foundational succession postulate.
Integrated Cosmic Succession	Eq. (41)	Defined conjunction of NoInterruption and NoTerminalStage; not a new postulate.
Qualified physical-system totality	Eq. (46)	Definition.
Identity-realization range	Eq. (47)	Definition.
Stage-relative population	Eq. (49)	Definition.
CSPP	Eq. (52)	Foundational postulate.
CMA	Eq. (55)	Governing foundational axiom.
UCC	Eq. (62)	Foundational postulate.
Actual-change subset	Eq. (60)	Definition.
Complete-population change coverage	Eq. (81)	Derived equivalence with UCC.
Integrated Universal Common-Stage Change Realization	Eqs. (85)–(86)	Defined integrated realization condition; equivalent to Integrated Cosmic Succession together with CMA, CSPP, and UCC under the governing definitions.
System-change profile	Eq. (90)	Defined construction.
Stage-to-Change Bridge	Eq. (92)	Conservative defined representation.
State profile	Eq. (120)	New V37 defined construction.
CRP	Eq. (133)	Foundational physical principle.
Causal-realization profile	Eq. (138)	New V37 defined construction.
Complete physical-realization profile	Eq. (147)	New V37 defined construction.

Role	**Reference**	**Status**
Relationally augmented realization profile	Eq. (157)	Application-level extension of the complete-population realization profile.
Hierarchical constituent relation	Eq. (170)	New V37 typed physical relation.
Physical history	Eq. (211)	Formal representation.
Identity ending	Eq. (240)	Definition.
PIECP	Eq. (254)	Independent ending-specific physical principle.
UEIE	Eq. (261)	Independent lifecycle postulate.
Direct successor	Eq. (265)	Conditional defined relation.
Endpoint-persistent population	Eq. (280)	New V37 definition.
Later-endpoint entrant population	Eq. (283)	New V37 definition.
Earlier-endpoint departing population	Eq. (286)	New V37 definition.
Intermediate-only identities	Eq. (292)	New V37 definition.
System-specific physical directionality	Eqs. (346)–(352)	New V37 criterion-indexed physical construction; not a temporal-order identity.
Operational metric map	Eq. (360)	Application-level construction.
Exact-Change-Stage Restraint	Eqs. (413)–(415)	Epistemic principle.
Generalized Non-Transfer Principle	Eq. (521)	Foundational type principle.
Relativistic temporal nonidentity	Eq. (542)	Direct external type position.
ITOF–relativistic comparison bridge	Eq. (685)	Application-level empirical-comparison architecture.
Bridge-robust separation margin	Eq. (714)	Methodological comparison quantity over independently admissible bridge classes.
Foundational discrimination burden	Eq. (730)	Methodological inferential condition.

E. Historical-Critical Transition from V36/F16 to V37/F17

E.1 Direct predecessor

V36/F16 is the immediate governing predecessor of V37/F17 [1].

V37/F17 stands in historical-critical succession to V36/F16. Predecessor status alone confers no governing authority. A V36/F16 statement has governing status in V37/F17 only where V37/F17 explicitly retains, restates, or derivationally preserves it under the V37/F17 definitions, typing rules, dependency architecture, and scientific-claim boundaries.

E.2 The definition of time is retained

V36/F16 fixed the same ordered-pair temporal identity retained by V37/F17. Formally:

$$T^{(37)}_{\mathrm{ITOF}} = T^{(36)}_{\mathrm{ITOF}} = \mathcal{E}_{\mathrm{C}} = \left(\mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \prec_{\mathrm{C}}\right). \tag{1167}$$

The governing denotation is retained without semantic re-centering; its wording is fixed in Eq. (12) and is not replaced by any V37/F17 physical-realization or application construction.

E.3 The ordered pair is unchanged

The temporal pair remains:

$$\left(\mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \prec_{\mathrm{C}}\right). \tag{1168}$$

No third temporal component is added; in particular, $\mathfrak{R}_{\mathrm{C}}(s)$ is not appended to the temporal pair.

E.4 Strict ordering and cosmic-succession commitments are retained

V37/F17 retains:

$$\mathrm{StrictTotalOrder}\left(\mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \prec_{\mathrm{C}}\right), \qquad \mathrm{NoInterruption}_{\mathrm{C}}\left(\mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \prec_{\mathrm{C}}\right), \qquad \mathrm{NoTerminalStage}_{\mathrm{C}}. \tag{1169}$$

Their V36/F16 logical roles are preserved.

NoInterruption remains non-metric.

NoTerminalStage remains independent of physical-system lifecycle closure.

Cosmic Origin remains a separately stated cosmological commitment rather than a member of the minimal temporal definition.

E.5 CSPP, CMA, and UCC are retained

The governing roles of CSPP, CMA, and UCC are retained from V36/F16 without merger. CSPP continues to supply population nonemptiness. CMA continues to supply literal one-common-stage co-realization within the single universal stage domain. UCC continues to supply system-specific physical-change actuality. V37/F17 refines the explicit typing and dependency notation used for the CMA co-realization predicate, but this refinement does not alter CMA's governing ontological content or convert it into a freely variable predicate under fixed common-stage semantics.

The distinction:

$$\mathrm{CMA} \not\equiv_{\mathrm{def}} \mathrm{UCC}, \qquad \mathrm{CMA} \nvdash \mathrm{UCC} \tag{1170}$$

remains governing.

E.6 Complete-population change coverage is retained

The V36/F16 equivalence:

$$\mathrm{UCC} \iff \forall s \in \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \quad \mathcal{B}_{\Delta}(s) = \mathcal{S}_{\mathrm{phys}}(s) \tag{1171}$$

is retained unchanged.

V37/F17 does not replace it with a collective change variable.

E.7 Stage-to-Change retains its status

The Stage-to-Change Bridge remains the construction fixed in Eq. (92). Its status remains:

$$\mathrm{ConservativeDefinedRepresentation}\,. \tag{1172}$$

V37/F17 distinguishes this internal foundational bridge from physical-model, observation, and foundational-empirical bridges.

It does not change the Stage-to-Change Bridge into one of those later bridge types.

E.8 CRP and causal-source typing are retained

The V36/F16 causal principle:

$$\mathrm{PhysReal}_A^{+}(s) \Longrightarrow \mathcal{C}_A^{\mathrm{act}}(s) \neq \varnothing \tag{1173}$$

is retained.

The three physical causal-source classes remain:

$$\mathcal{C}_A^{\mathrm{int}}(s), \qquad \mathcal{C}_A^{\text{ext-sys}}(s), \qquad \mathcal{C}_A^{\text{ext-fac}}(s). \tag{1174}$$

No V37 construction creates a fourth causal-source class.

E.9 Identity, history, ending, and successor rules are retained

V37/F17 retains:

$$\begin{gathered} I_A, \quad \mathrm{IdentityRealizationConvexity}, \quad \mathrm{AFB}, \quad \mathcal{H}_A, \\ \mathrm{End}_A(e), \quad \mathrm{PIECP}, \quad \mathrm{UEIE}, \quad \mathrm{SuccAt}(A, B; e). \end{gathered} \tag{1175}$$

It also retains:

$$\mathrm{End}_A(e) \nvdash \exists B\ \mathrm{SuccAt}(A, B; e). \tag{1176}$$

Historical physical accumulation and the present cumulative physical resultant remain distinct.

Neither becomes a new causal source.

E.10 Observation and Non-Transfer are retained

V37/F17 retains:

$$\mathrm{ValidObservedManifestation} \not\Rightarrow \mathrm{ExactCosmicChangeStageIdentified} \tag{1177}$$

and the Non-Transfer Principle in Eq. (521). The latter is generalized beyond its earlier clock and relativistic applications to operational metrics, model parameters, comparison outputs, and the broader V37 representation architecture.

E.11 New V37 defined constructions

The principal newly defined constructions are:

$$\begin{gathered}
\mathfrak{X}_{\mathrm{C}}(s)\,, \\
\mathfrak{G}_{\mathrm{C}}(s)\,, \\
\mathfrak{R}_{\mathrm{C}}(s)\,, \\
A \lhd_{\kappa,s} B, \\
\mathfrak{K}_{\mathrm{C}}(s)\,, \\
\mathcal{P}_{r,s}, \quad \mathcal{N}_{r\to s}, \quad \mathcal{L}_{r\to s}, \quad \mathcal{T}_{r,s}, \\
\mathrm{Cmp}_{AB,P}(s), \\
\mathcal{M}_P^{\mathrm{op}}, \\
\mathfrak{B}_F^{P,D}, \\
\mathfrak{B}_{I:R}^{P,D}.
\end{gathered} \tag{1178}$$

These constructions enlarge the formal architecture of physical realization, comparison, and empirical connection.

They do not enlarge the temporal ordered pair.

E.12 New V37 derived integration

Integrated Universal Common-Stage Change Realization is collected once as $\mathrm{UCSCR}_{\mathrm{C}}$ by Eq. (85), with its governing equivalence stated separately in Eq. (86). Under CRP, the direct stage-relative consequences are stated without creating another independent foundational condition in Eq. (167). UCSCR integrates stage unity, population nonemptiness, memberwise change actuality, and succession; CRP separately supplies physical causal realization. Neither changes the temporal ordered pair or creates a new universal change postulate.

E.13 New application-level quantitative instantiation

V37/F17 further instantiates its mathematical-form-neutral application architecture with the quantitative clock-response program of Section 47. The program is not inherited as a temporal postulate from V36/F16. Its physical premises are independently sourced; its weak-field response is checked against published gravitational-clock benchmarks, it adopts an independently established trapped-ion Hamiltonian branch, and it separately reconstructs a published six-mode secular-motion correction from published modal inputs. No ITOF-specific residual is introduced without an independently warranted additional physical interaction. Its status remains application-level:

$$\mathrm{Status}\,(\mathfrak{Q}_{\mathrm{MD}}) = \mathrm{ApplicationLevelPhysicalModelBranch}\,. \tag{1179}$$

It supplies quantitative benchmark recovery and a Hamiltonian motional branch without altering the V36/F16 time definition retained by V37/F17. The later predictive-separation screen further establishes that temporal-ontology difference alone does not alter an observable when the complete physical-to-observable specification is unchanged; its screened preferred-stage candidates are not promoted to governing postulates.

E.14 No new universal physical-change postulate is introduced

The V37/F17 additions do not require a new universal postulate of physical change beyond UCC. Thus:

$$\mathrm{NewV37PhysicalRealizationArchitecture} \not\Rightarrow \mathrm{NewUniversalChangePostulate}\,. \tag{1180}$$

Likewise, V37/F17 introduces no universal state-equality, causal-uniformity, system-number conservation, cross-level dynamics, metric, or successor-closure postulate.

E.15 Why V37/F17 is not merely a longer V36/F16

The V37/F17 transition is a formal expansion of the physical-realization architecture rather than an accumulation of additional examples.

V36/F16 established a mature temporal referent and made complete-population system-specific physical-change coverage explicit.

V37/F17 extends that architecture from:

$$\mathrm{CompletePopulationChangeCoverage} \tag{1181}$$

to a single universal common-stage change-realization condition $\mathrm{UCSCR_C}$, integrated with the typed architecture of complete-population physical realization. This is a conceptual and dependency-level strengthening, not an enlargement of the temporal ordered pair.

The new architecture integrates:

$$\begin{gathered}\text{population,}\quad\text{state,}\quad\text{system-specific change,}\quad\text{causal realization,}\\\text{hierarchical physical identity,}\quad\text{population transformation,}\\\text{cross-system comparison,}\quad\text{mathematical-form-neutral dynamics,}\\\text{system-specific physical directionalities,}\quad\text{operational metric construction,}\\\text{mathematical-form-neutral physical-model roles,}\quad\text{explicit model-to-observation bridges,}\\\text{and quantitative predictive-separation screening.}\end{gathered}\tag{1182}$$

The resulting theory has a wider explanatory and formal domain while preserving the V36/F16 temporal definition.

E.16 Relativity confrontation advances without temporal-identity merger

V36/F16 already rejected transfer of temporal identity to relativistic quantities.

V37/F17 retains that rejection and adds the general two-branch empirical comparison architecture:

$$\mathfrak{B}^{P,D}_{I:R}.\tag{1183}$$

This allows a future ITOF physical application model and a relativistic model to be compared in one observable space while their temporal ontologies remain distinct.

The transition is therefore:

$$\begin{aligned}\text{V36/F16:}\quad&\text{direct temporal nonidentity}\\&+\text{bounded application-level discrimination;}\\\text{V37/F17:}\quad&\text{the same direct temporal nonidentity}\\&+\text{typed physical encoding–dynamics–prediction–measurement architecture}\\&+\text{explicit common-observable comparison}\\&+\text{bridge-robust prediction-separation criterion}\\&+\text{stronger foundational attribution conditions.}\end{aligned}\tag{1184}$$

No temporal-identity merger or hybrid temporal ontology is introduced.

V37/F17 retains only those V36/F16 foundational governing commitments that are explicitly restated or derivationally preserved under the V37/F17 definitions, typing rules, dependency architecture, and scientific-claim boundaries. Predecessor status alone confers no governing authority. Auxiliary constructions and expository devices are retained only where V37/F17 expressly re-adopts or revalidates them; the reference-stage order-prefix clarification above is one such revalidated auxiliary clarification, not a new component of time.

E.17 Net V36/F16 to V37/F17 transition

The transition may be summarized as:

$$
\begin{aligned}
\text{V36/F16} \quad &= \text{mature universal cosmic-extension ontology} \\
&\quad + \text{CSPP–CMA–UCC separation} \\
&\quad + \text{complete-population change coverage} \\
&\quad + \text{system-indexed change profile} \\
&\quad + \text{conservative Stage-to-Change representation} \\
&\quad + \text{identity, causal, observational, quantitative, and Non-Transfer discipline;} \\
\text{V37/F17} \quad &= \substack{\text{V36/F16 foundational commitments explicitly restated or} \\ \text{derivationally revalidated under V37/F17}} \\
&\quad + \text{complete-population common-stage physical-realization architecture} \\
&\quad + \text{relationally extensible physical-realization profiles} \\
&\quad + \text{hierarchical physical-system composition} \\
&\quad + \text{population-transformation representation} \\
&\quad + \text{general cross-system comparison architecture} \\
&\quad + \text{mathematical-form-neutral physical dynamics} \\
&\quad + \text{order-representation non-metricity} \\
&\quad + \text{system-specific physical-directionality architecture} \\
&\quad + \text{general operational metric construction} \\
&\quad + \text{independently sourced gravitational clock-response program} \\
&\quad + \text{trapped-ion Hamiltonian and quantum-motional application branch} \\
&\quad + \text{generalized foundational empirical bridge} \\
&\quad + \text{bridge-robust ITOF–relativistic observable comparison architecture.}
\end{aligned} \tag{1185}
$$

The temporal referent is retained.

The theory surrounding that referent becomes broader, more integrated, and more explicitly universal in its treatment of physical realization.

F. Framework Identity and Admissible Extensions

F.1 Identity-preserving temporal conditions

A physical extension or application presented as V37/F17-admissible must preserve the temporal identity fixed by Eq. (12).

It must also preserve Strict Cosmic Ordering, NoInterruption, and NoTerminalStage as specified in Eqs. (18)–(40).

An application that replaces the temporal referent with another quantity is not an identity-preserving V37/F17 application.

F.2 Identity-preserving realization conditions

An admissible extension must preserve:

$$\forall A \in \mathcal{U}_{\mathrm{phys}}, \quad I_A \subseteq \mathcal{S}_{\mathrm{C}}^{\mathrm{tot}}, \tag{1186}$$

together with:

$$\mathrm{CSPP}, \qquad \mathrm{CMA}, \qquad \mathrm{UCC}\,. \tag{1187}$$

It must preserve the CMA–UCC definitional distinction and the UCC complete-population equivalence fixed in Eqs. (71) and (81).

No independent per-system temporal order may be introduced as an ordinary application-level refinement.

F.3 Identity-preserving physical typing

An admissible extension must preserve the distinction between:

$$\begin{gathered}\text{time}, \quad \text{common cosmic change stage}, \quad \text{physical system}, \quad \text{physical state}, \\ \text{physical change}, \quad \text{causal contributor}, \quad \text{physical history}, \quad \text{record}, \\ \text{operational metric}, \quad \text{coordinate}, \quad \text{model parameter}, \quad \text{model geometry}.\end{gathered} \tag{1188}$$

In particular, the extension must preserve the causal-source boundary:

$$T_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \mathrm{PhysicalCausalContributor}\,. \tag{1189}$$

F.4 Identity-preserving physical-realization architecture

A V37/F17 application may refine the physical content represented inside:

$$\mathfrak{R}_{\mathrm{C}}(s) \tag{1190}$$

and may add independently warranted model-relative relations through $\mathfrak{R}_{\mathrm{C}}^{[M]}(s)$. Neither construction may be reinterpreted as time.

Thus:

$$\mathfrak{R}_{\mathrm{C}}(s) \not\equiv_{\mathrm{type}} T_{\mathrm{ITOF}} \tag{1191}$$

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.

F.5 What may vary

Subject to physical warrant, explicit typing, parameter provenance, and appropriate empirical evaluation, V37/F17 permits variation in:

$$\begin{gathered}\mathrm{SystemClass}, \quad \mathrm{SystemBoundary}, \quad \mathrm{IdentityCriterion}, \\ \mathrm{CompositionCriterion}, \quad \mathrm{StateSpace}, \quad \mathrm{ChangeContentType}, \\ \mathrm{PhysicalDynamics}, \quad \mathrm{CausalModel}, \quad \mathrm{ComparisonMap}, \\ \mathrm{SignalModel}, \quad \mathrm{ObservationModel}, \quad \mathrm{ClockResponseModel}, \\ \mathrm{OperationalMetric}, \quad \mathrm{ExperimentalProtocol}\,.\end{gathered} \tag{1192}$$

No single application model is permanently built into the definition of time.

F.6 What would constitute a foundational revision

The following substitutions would alter the governing identity of V37/F17 rather than constitute ordinary application-level extension:

$$\begin{aligned} T_{\mathrm{ITOF}} &\longrightarrow \mathrm{ClockOutput}, \\ T_{\mathrm{ITOF}} &\longrightarrow \mathrm{CoordinateTime}, \\ T_{\mathrm{ITOF}} &\longrightarrow \mathrm{MetricInterval}, \\ T_{\mathrm{ITOF}} &\longrightarrow \mathrm{ProperTimeFunctional}, \\ T_{\mathrm{ITOF}} &\longrightarrow \mathrm{PhysicalRealizationProfile}, \\ \mathrm{OneCommonCosmicStageTotality} &\longrightarrow \mathrm{IndependentPerSystemTimes}, \\ \mathrm{PhysicalCausation} &\longrightarrow \mathrm{TimeAsCauseOfChange}, \\ \mathrm{HistoricalPhysicalAccumulation} &\longrightarrow \mathrm{FourthPhysicalCausalSource}\,. \end{aligned} \tag{1193}$$

Removal of a governing axiom or postulate such as Strict Cosmic Ordering, CMA, UCC, NoInterruption, or NoTerminalStage would likewise require explicit presentation as a foundational revision.

F.7 Admissible extension condition

Let E be a proposed extension.

Define the structural admissibility burden:

$$
\begin{aligned}
\text{AdmissibleExtension}_{37}(E) \implies\ & \text{TemporalCorePreserved}(E) \\
& \wedge \text{CommonStageArchitecturePreserved}(E) \\
& \wedge \text{CMAUCCDistinctionPreserved}(E) \\
& \wedge \text{PhysicalTypingExplicit}(E) \\
& \wedge \text{IdentityCriteriaExplicitWhereUsed}(E) \\
& \wedge \text{CausalTypingPreserved}(E) \\
& \wedge \text{NonTransferPreserved}(E) \\
& \wedge \text{ProvenanceDeclared}(E).
\end{aligned}
\tag{1194}
$$

Where E produces an empirical prediction:

$$
\text{PredictiveExtension}_{37}(E) \implies \text{AdmissibleExtension}_{37}(E) \wedge \text{PredeclaredEmpiricalProtocol}(E). \tag{1195}
$$

Where foundational discrimination is claimed, the stronger attribution burden also applies.

F.8 Framework identity is not textual immobility

Preserving V37/F17 identity does not require preserving every sentence, notation choice, example, application model, or explanatory order forever.

Thus:

$$
\text{FrameworkIdentityPreserved} \not\Rightarrow \text{EveryWordingFrozen}\,. \tag{1196}
$$

Future versions may legitimately improve:

$$
\begin{gathered}
\text{formalization}, \quad \text{explanatory structure}, \quad \text{physical applications}, \quad \text{empirical bridges}, \\
\text{notation}, \quad \text{model comparison}, \quad \text{and experimental methodology}
\end{gathered}
\tag{1197}
$$

provided any change to a governing foundational commitment is stated explicitly rather than introduced without explicit foundational status.

G. Scientific Claim Boundary and Falsification Discipline

G.1 Formal countercondition and empirical procedure

V37/F17 retains the governing distinction:

$$
\text{FormalCountercondition}(F) \not\equiv_{\text{def}} \text{DirectFiniteExperimentFor}(F). \tag{1198}
$$

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.

G.2 Universal commitments and finite evidence

For universal foundational statement F:

$$\text{FinitePositiveObservations} \not\Rightarrow \text{DeductiveProof}(F). \tag{1199}$$

Likewise:

$$\text{FiniteNullObservation} \not\Rightarrow \text{PhysicalCounterexample}(F). \tag{1200}$$

The inferential relation depends on what the observation actually establishes.

G.3 Application-level failure

For application model M, let:

$$\mathfrak{P}_M^\star \tag{1201}$$

be its predeclared evaluation protocol.

Advance-prediction status requires:

$$\begin{aligned} \text{AdvancePrediction}(M) \implies & \ \text{ProtocolFrozen}\left(\mathfrak{P}_M^\star\right) \\ & \wedge \text{IndependentParameterProvenance}(M) \\ & \wedge \text{NoEvaluationLeakage}\left(\mathfrak{P}_M^\star, D_M\right). \end{aligned} \tag{1202}$$

If the prediction fails under the declared rule:

$$\text{ApplicationModelRejectedOrRestricted}(M, D_M) \tag{1203}$$

is the immediate conclusion.

G.4 Foundation-level failure

A failed observable reaches foundational commitment F only where:

$$F \wedge B_F^{\text{phys}} \wedge B_F^{\text{obs}} \wedge \mathcal{P}_F^{\text{aux}} \vdash O_F \tag{1204}$$

and the failed result cannot be assigned to an independently unsettled bridge, auxiliary, measurement, parameter, approximation, or uncertainty component.

Thus:

$$\neg O_F + \text{AttributionIdentifiableTo}(F) \implies \text{FoundationalChallenge}(F). \tag{1205}$$

Without attribution identifiability:

$$\neg O_F \not\Rightarrow \neg F. \tag{1206}$$

G.5 Post-hoc revision status

The no-post-hoc rule of Eq. (499) remains applicable: a scientifically legitimate revised model does not alter the historical status of the original advance prediction and requires new independent evaluation.

G.6 Bounded support

Where a predeclared test favours application model M:

$$\text{DiscriminationFavours}(M, D) \Longrightarrow \text{Warrant}\left[\text{PhysicalApplicationModelSupportedOn}(M, D)\right]. \tag{1207}$$

The conclusion remains bounded to the inferential level actually tested.

It does not automatically establish:

$$\text{DiscriminationFavours}(M, D) \not\Rightarrow \text{OperationalQuantityIsTime}\,. \tag{1208}$$

or every universal foundational commitment.

G.7 Final scientific inference rule

The governing scientific discipline is:

$$\boxed{\begin{gathered}\text{Scientific inference propagates only through explicitly declared}\\ \text{logical dependency, a typed physical application chain, observational support,}\\ \text{uncertainty structure, and warranted evidential scope.}\end{gathered}} \tag{1209}$$

H. Modular Architecture of V37/F17

H.1 Temporal definition module

Define:

$$\mathfrak{T}^{37}_{\text{def}} = \left\{\mathcal{S}^{\text{tot}}_{\text{C}}, \prec_{\text{C}}, T_{\text{ITOF}}\right\}. \tag{1210}$$

Only this module fixes the entity denoted by time.

H.2 Ordering and succession modules

Define:

$$\mathfrak{T}^{37}_{\mathrm{order}} = \left\{\mathrm{StrictTotalOrder}\left(\mathcal{S}^{\mathrm{tot}}_{\mathrm{C}}, \prec_{\mathrm{C}}\right)\right\}, \tag{1211}$$

and:

$$\mathfrak{T}^{37}_{\mathrm{succ}} = \{\mathrm{NoInterruption}_{\mathrm{C}}, \mathrm{NoTerminalStage}_{\mathrm{C}}, \mathrm{IntegratedCosmicSuccession}_{\mathrm{C}}\}. \tag{1212}$$

For organizational reference:

$$\mathfrak{T}^{37}_{\mathrm{temporal}} = \mathfrak{T}^{37}_{\mathrm{def}} \cup \mathfrak{T}^{37}_{\mathrm{order}} \cup \mathfrak{T}^{37}_{\mathrm{succ}}. \tag{1213}$$

The union is organizational.

It does not make every member definitional.

H.3 Common physical-realization module

Define:

$$\begin{aligned}\mathfrak{T}^{37}_{\mathrm{real}} = \Big\{&\mathcal{U}_{\mathrm{phys}}, I_A, \mathcal{S}_{\mathrm{phys}}(s), \mathrm{CSPP}, \mathrm{CMA}, \mathrm{UCC}, \mathrm{UCSCR}_{\mathrm{C}},\\ &I^{\Delta}_A, \mathcal{B}_{\Delta}(s), \mathfrak{D}_{\mathrm{C}}(s), \mathrm{StageChangeBridge}_{\mathrm{C}}(s), \mathrm{CRP},\\ &\mathfrak{X}_{\mathrm{C}}(s), \mathfrak{G}_{\mathrm{C}}(s), \mathfrak{R}_{\mathrm{C}}(s)\Big\}.\end{aligned} \tag{1214}$$

This is the principal module expanded beyond V36/F16. UCSCR is listed here for organizational reference while its definition cross-references the succession module. It remains a defined integration, not a new realization postulate and not a layer added to the definition of time.

H.4 Composition module

Define:

$$\mathfrak{T}^{37}_{\mathrm{comp}} = \{\lhd_{\kappa,s}, \mathfrak{K}_{\mathrm{C}}(s), \mathrm{CrossLevelNonTransfer}\}. \tag{1215}$$

H.5 Identity-history module

Define:

$$\begin{aligned}\mathfrak{T}^{37}_{\mathrm{id}} = \Big\{&\mathrm{IdentityRealizationConvexity}, \mathrm{AFB}, X_A, \mathcal{H}_A,\\ &\mathrm{HistoricalPhysicalAccumulation}^{<s}_A, \mathrm{CumulativePhysicalResultThrough}_A(s)\Big\}.\end{aligned} \tag{1216}$$

H.6 Lifecycle module

Define:

$$\mathfrak{T}^{37}_{\mathrm{life}} = \left\{\mathrm{End}_A(e), \Delta^{\mathrm{end}}_A(e), \mathrm{PIECP}, \mathrm{UEIE}, \mathrm{SuccAt}(A, B; e)\right\}. \tag{1217}$$

H.7 Population-transformation module

Define:

$$\mathfrak{T}^{37}_{\mathrm{pop}} = \{\mathcal{P}_{r,s}, \mathcal{N}_{r\to s}, \mathcal{L}_{r\to s}, \mathcal{T}_{r,s}, \mathfrak{P}^{\mathrm{pop}}_{\mathrm{C}}(r,s)\}\,. \tag{1218}$$

H.8 Representation and physical-model module

Define:

$$\begin{aligned}\mathfrak{T}^{37}_{\mathrm{model}} = \{\, & \mathrm{AdmissiblePhysicalModel}, \mathcal{B}^{\mathrm{in}}_{M}, \mathrm{Dyn}_{M}, \mathcal{B}^{\mathrm{out}}_{M},\\ & \mathrm{ModelEvolutionParameter}, \mathrm{CrossSystemComparison}, \mathfrak{A}_{A,\alpha}, \mathrm{ArrowAligned}_{A,\alpha}, \mathcal{M}^{\mathrm{op}},\\ & \mathfrak{Q}_{\mathrm{MD}}, \mathrm{PredictiveSeparationScreen}\}.\end{aligned} \tag{1219}$$

H.9 Observation module

Define:

$$\mathfrak{T}^{37}_{\mathrm{obs}} = \left\{\mathrm{ManifestationAt}, \mathcal{O}, \mathcal{B}^{\mathrm{obs}}_{P,M}, J^{\mathrm{phys}}_{r}, \mathrm{ExactChangeStageRestraint}\right\}. \tag{1220}$$

H.10 Empirical bridge module

Define:

$$\mathfrak{T}^{37}_{\mathrm{emp}} = \{\mathfrak{P}^{\star}, \mathrm{FoundationalEmpiricalBridge}, \mathrm{FoundationalAttribution}, \mathrm{PredictionSeparation}\}\,. \tag{1221}$$

H.11 External-theory and Non-Transfer module

Define:

$$\mathfrak{T}^{37}_{\mathrm{ext}} = \left\{\mathrm{NTP}, \mathcal{Q}_{\mathrm{rel}}, \mathfrak{B}^{P,D}_{I:R}, \delta^{P,D}_{I:R}\right\}. \tag{1222}$$

H.12 Governing modular architecture

The governing V37/F17 architecture, excluding the optional Cosmic Origin augmentation, may be represented as an ordered family of typed modules:

$$\begin{aligned}\mathfrak{F}^{\mathrm{gov}}_{\mathrm{V37}} := \Big\langle & \mathfrak{T}^{37}_{\mathrm{temporal}}, \mathfrak{T}^{37}_{\mathrm{real}}, \mathfrak{T}^{37}_{\mathrm{comp}}, \mathfrak{T}^{37}_{\mathrm{id}}, \mathfrak{T}^{37}_{\mathrm{life}},\\ & \mathfrak{T}^{37}_{\mathrm{pop}}, \mathfrak{T}^{37}_{\mathrm{model}}, \mathfrak{T}^{37}_{\mathrm{obs}}, \mathfrak{T}^{37}_{\mathrm{emp}}, \mathfrak{T}^{37}_{\mathrm{ext}}\Big\rangle.\end{aligned} \tag{1223}$$

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.

If Cosmic Origin is included as the separately stated optional cosmological module, define the augmented architecture by:

$$\mathfrak{F}_{\mathrm{V37}}^{(+\mathrm{Origin})} := \left\langle \mathfrak{F}_{\mathrm{V37}}^{\mathrm{gov}}, \mathrm{CosmicOrigin} \right\rangle. \tag{1224}$$

The full framework tuple is not the definition of time:

$$\mathfrak{F}_{\mathrm{V37}}^{\mathrm{gov}} \not\equiv_{\mathrm{def}} T_{\mathrm{ITOF}}. \tag{1225}$$

I. Reference Architecture and Historical Record

The governing historical sequence of ITOF is documented through the project's versioned manuscripts and consolidated archive records.

V36/F16 is the immediate foundational predecessor of V37/F17 [1].

The broader project archive records the earlier historical sequence and permits older definitions, dependencies, and formulations to be distinguished from the present governing theory [2].

The reference basis therefore comprises:

$$\begin{gathered} \mathrm{ImmediateV36Predecessor}, \\ \mathrm{ConsolidatedHistoricalITOFRecord}, \\ \mathrm{ExternalScientificLiterature}. \end{gathered} \tag{1226}$$

The first identifies the direct governing predecessor.

The second preserves historical traceability.

The third supplies external scientific and mathematical context where relevant.

No earlier ITOF version overrides a governing V37/F17 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.

References

[1] Y. Ghandour, *Invariant Temporal Ordering Framework V36/F16: Universal Cosmic Extension, Common Cosmic Change Stages, and System-Specific Physical Change*, ITOF Foundation Series XVI (F16), Foundational Preprint, 2026. Project records: https://doi.org/10.17605/OSF.IO/CWYFX; https://doi.org/10.5281/zenodo.19542538.

[2] Y. Ghandour, *Invariant Temporal Ordering Framework (ITOF): Project and Archive Records*, OSF and Zenodo, 2026. Project and archive identifiers: DOI: 10.17605/OSF.IO/CWYFX; DOI: 10.5281/zenodo.19542538.

[3] A. Einstein, "Zur Elektrodynamik bewegter Körper," *Annalen der Physik*, vol. 17, pp. 891–921, 1905. DOI: 10.1002/andp.19053221004.

[4] A. Einstein, "Die Grundlage der allgemeinen Relativitätstheorie," *Annalen der Physik*, vol. 49, pp. 769–822, 1916. DOI: 10.1002/andp.19163540702.

[5] R. M. Wald, *General Relativity*, University of Chicago Press, 1984.

[6] H. R. Brown, *Physical Relativity: Space-Time Structure from a Dynamical Perspective*, Oxford University Press, 2005. DOI: 10.1093/0199275831.001.0001.

[7] T. Maudlin, *Philosophy of Physics: Space and Time*, Princeton University Press, 2012.

[8] C. Callender, *What Makes Time Special?*, Oxford University Press, 2017. DOI: 10.1093/oso/9780198797302.001.0001.

[9] A. N. Bernal and M. Sánchez, "Smoothness of Time Functions and the Metric Splitting of Globally Hyperbolic Spacetimes," *Communications in Mathematical Physics*, vol. 257, pp. 43–50, 2005. DOI: 10.1007/s00220-005-1346-1.

[10] N. Ashby, "Relativity in the Global Positioning System," *Living Reviews in Relativity*, vol. 6, art. 1, 2003. DOI: 10.12942/lrr-2003-1.

[11] J. Guéna, M. Abgrall, D. Rovera, P. Rosenbusch, M. E. Tobar, Ph. Laurent, A. Clairon, and S. Bize, "Improved Tests of Local Position Invariance Using ^{87}Rb and ^{133}Cs Fountains," *Physical Review Letters*, vol. 109, art. 080801, 2012. DOI: 10.1103/PhysRevLett.109.080801.

[12] R. Lange, N. Huntemann, J. M. Rahm, C. Sanner, H. Shao, B. Lipphardt, Chr. Tamm, S. Weyers, and E. Peik, "Improved Limits for Violations of Local Position Invariance from Atomic Clock Comparisons," *Physical Review Letters*, vol. 126, art. 011102, 2021. DOI: 10.1103/PhysRevLett.126.011102.

[13] C. W. Chou, D. B. Hume, T. Rosenband, and D. J. Wineland, "Optical Clocks and Relativity," *Science*, vol. 329, pp. 1630–1633, 2010. DOI: 10.1126/science.1192720.

[14] V. I. Yudin and A. V. Taichenachev, "Mass Defect Effects in Atomic Clocks," *Laser Physics Letters*, vol. 15, art. 035703, 2018. DOI: 10.1088/1612-202X/aa9aa5.

[15] V. J. Martínez-Lahuerta, S. Eilers, T. E. Mehlstäubler, P. O. Schmidt, and K. Hammerer, "Ab Initio Quantum Theory of Mass Defect and Time Dilation in Trapped-Ion Optical Clocks," *Physical Review A*, vol. 106, art. 032803, 2022. DOI: 10.1103/PhysRevA.106.032803.

[16] M. C. Marshall et al., "High-Stability Single-Ion Clock with 5.5×10^{-19} Systematic Uncertainty," *Physical Review Letters*, vol. 135, art. 033201, 2025. DOI: 10.1103/hb3c-dk28.

[17] G. Sorci, J. Foo, D. Leibfried, C. Sanner, and I. Pikovski, "Quantum Signatures of Proper

Time in Optical Ion Clocks," *Physical Review Letters*, vol. 136, art. 163602, 2026. DOI: 10.1103/qhj9-pc2b.

[18] V. A. Kostelecký and Z. Li, "Backgrounds in Gravitational Effective Field Theory," *Physical Review D*, vol. 103, art. 024059, 2021. DOI: 10.1103/PhysRevD.103.024059.

[19] P. Delva et al., "Test of Special Relativity Using a Fiber Network of Optical Clocks," *Physical Review Letters*, vol. 118, art. 221102, 2017. DOI: 10.1103/PhysRevLett.118.221102.

[20] C. Sanner, N. Huntemann, R. Lange, C. Tamm, E. Peik, M. S. Safronova, and S. G. Porsev, "Optical Clock Comparison for Lorentz Symmetry Testing," *Nature*, vol. 567, pp. 204–208, 2019. DOI: 10.1038/s41586-019-0972-2.

[21] C.-G. Qin, Y.-J. Tan, X.-Y. Lu, T. Liu, Y.-R. Yang, Q. Li, and C.-G. Shao, "Constraints on Violation of Lorentz Symmetry with Clock-Comparison Redshift Experiments," *Physical Review D*, vol. 111, art. 055008, 2025. DOI: 10.1103/PhysRevD.111.055008.

[22] T. Bothwell et al., "Resolving the Gravitational Redshift Across a Millimetre-Scale Atomic Sample," *Nature*, vol. 602, pp. 420–424, 2022. DOI: 10.1038/s41586-021-04349-7.

[23] X. Zheng, J. Dolde, V. Lochab, B. N. Merriman, H. Li, and S. Kolkowitz, "Differential Clock Comparisons with a Multiplexed Optical Lattice Clock," *Nature*, vol. 602, pp. 425–430, 2022. DOI: 10.1038/s41586-021-04344-y.

[24] X. Zheng, J. Dolde, M. C. Cambria, H. M. Lim, and S. Kolkowitz, "A Lab-Based Test of the Gravitational Redshift with a Miniature Clock Network," *Nature Communications*, vol. 14, art. 4886, 2023. DOI: 10.1038/s41467-023-40629-8.

[25] V. A. Dzuba, V. V. Flambaum, and J. K. Webb, "Calculations of the Relativistic Effects in Many-Electron Atoms and Space-Time Variation of Fundamental Constants," *Physical Review A*, vol. 59, pp. 230–237, 1999. DOI: 10.1103/PhysRevA.59.230.

[26] V. Jacques, E. Wu, F. Grosshans, F. Treussart, P. Grangier, A. Aspect, and J.-F. Roch, "Experimental Realization of Wheeler's Delayed-Choice Gedanken Experiment," *Science*, vol. 315, no. 5814, pp. 966–968, 2007. DOI: 10.1126/science.1136303.

[27] Y.-H. Kim, R. Yu, S. P. Kulik, Y. Shih, and M. O. Scully, "Delayed "Choice" Quantum Eraser," *Physical Review Letters*, vol. 84, no. 1, pp. 1–5, 2000. DOI: 10.1103/PhysRevLett.84.1.

[28] X.-s. Ma, J. Kofler, A. Qarry, N. Tetik, T. Scheidl, R. Ursin, S. Ramelow, T. Herbst, L. Ratschbacher, A. Fedrizzi, T. Jennewein, and A. Zeilinger, "Quantum Erasure with Causally Disconnected Choice," *Proceedings of the National Academy of Sciences*, vol. 110, no. 4, pp. 1221–1226, 2013. DOI: 10.1073/pnas.1213201110.