Invariant Temporal Ordering Framework V24/F4: A Universal Theory of Temporal Succession, Realized Physical Change, and Relativistic Measurement

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Abstract

The Invariant Temporal Ordering Framework V24/F4 develops a universal, non-metric account of time from the one continuing, non-reversing extension of physically realized stages of change across physical systems. Its ontic starting point is a declared physical bearer and its non-enumerated domain of actual stages throughout the bearer's identity. Each stage is a bearer-attributable physical realization in the one extension; it is not created, derived, or conferred by observation, a record, or a later proof of change. Physical change obtains between ordered, identity-connected stages that admit bearer-complete comparison and are physically non-equivalent. Time expresses only the one extension and ordering of the realized stages across physical systems in the universe; it does not express the bearer-specific physical differences established between stages, their mechanisms, or their causes.

The extension is one and the same for all physical systems. Stages of different systems are related within it by objective absolute simultaneity. This is a direct relation between stages; it does not introduce a universal physical stage, reify an equivalence class as a temporal layer, or create a container or collective physical object. During every shared identity extent, the stages of two systems stand in a one-to-one, order-preserving absolute-simultaneity correspondence. Their complete physical conditions may differ, and the bearer-specific changes established across their respective ordered intervals may differ in content, mechanism, magnitude, and rate. Their completed identity-bounded stage cardinalities may differ only because their bearer identities begin or end at different positions in the one extension, not because one system realizes more stages than another during the same shared extent.

The framework is bearer-centred and type-disciplined. Systems bear identity, complete physical condition, and change; quantities, states, records, coordinates, proper-time functionals, and clock outputs remain attributed properties or representations. Mathematics and geometry are indispensable for analysis and measurement, but physical or temporal significance requires an explicit and empirically adequate bridge to material reality. One sound bearer-attributed physical difference can establish change without an ontological magnitude threshold or enumeration of all stages, whereas observational silence cannot establish bearer-complete physical equivalence. The

universal-change postulate states that change does not occur once and end while bearer identity continues. Investigators, instruments, records, and experimental environments are themselves physical systems within the same changing universe.

Relativity and ITOF confront one another at a direct ontological boundary. Relativistic formalism defines coordinates, metric intervals, proper time, curvature, causal relations, spacetime models, and clock comparisons. ITOF rejects the identification of any of these objects with time itself. The demonstrated success of relativistic equations validates the coordinate, metric, causal, signal, worldline, and material-system relations they define; it does not establish that time is a coordinate, a path functional, a curved geometrical object, a four-dimensional manifold, or a higher-dimensional constituent. ITOF separately asserts one objective universal prior–later order and direct objective absolute simultaneity, and rejects the inference from frame-dependent coordinate simultaneity to the nonexistence of objective simultaneity. These relations constitute objective temporal structure, though not a preferred inertial chart, universal clock, metric interval, signalling mechanism, reified temporal layer, or dynamical field. Particular absolute-simultaneity assignments require an independent, causally compatible, coordinate-independent physical bridge. Universal empirical closure remains an explicit scientific programme requiring complete class coverage and domain-valid bridges. No identity-preserving static tail is admitted as physically real or logically compatible with sustained change. It is mentioned only negatively: repeated equal records, observational silence, or a finite interval that is quiet only at the protocol or observational level cannot convert continuing stages into changeless continuation.

Contents

1. Foundational Position

ITOF separates four questions that are frequently compressed: what is physically realized, what constitutes physical change, how actual stages extend and succeed one another while change continues, and what time expresses. The framework does not replace the many dynamical laws of physics with one equation. It fixes the bearer, the complete-condition type, the criterion of physical change, the ontic status of realized stages, the temporal meaning assigned to extended succession, and the evidential obligations attached to universal claims [1, 9, 10, 11].

The construction follows five governing questions:

(1) What physical system is the bearer of the attributed condition and change?

(2) What physically realized references carry the bearer-relative complete condition?

(3) What grounds prior–later order and admissible physical comparison?

(4) What difference establishes physical change between already realized stages, and what can observation warrant without treating change as a property of one isolated stage?

(5) What does time express, how are the one universal prior–later order and direct absolute simultaneity related, and what physical and evidential routes support or defeat universal sustained change?

Governing definition of time, one extension, and absolute simultaneity.

Time expresses only the one extension and ordering of the realized stages across physical systems in the universe; it does not express the bearer-specific physical differences established between stages, their mechanisms, or their causes.

The extension is one for all physical systems. Stages of different systems are related by objective absolute simultaneity within it. Absolute simultaneity is a direct relation between stages; it does not create a universal physical stage or reify an absolute-simultaneity class as a temporal layer containing them.

Within every shared identity extent, stages correspond one-to-one and preserve the same prior–later progression. Their stage conditions need not be equal, and the bearer-specific changes established across their respective ordered intervals need not match. Their completed identity-bounded stage cardinalities can differ only because bearer identities begin or end at different positions in the one extension.

$$\mathrm{Stage}_A(o) \Longleftrightarrow o \in \mathcal{O}_A,$$
$$S_A^{\langle n\rangle} \prec_A S_A^{\langle n+1\rangle} \Longrightarrow (A, S_A^{\langle n\rangle}) \prec_{\mathrm{U}} (A, S_A^{\langle n+1\rangle}).$$
$$\cdots \prec_A S_A^{\langle n\rangle} \prec_A S_A^{\langle n+1\rangle} \prec_A S_A^{\langle n+2\rangle} \prec_A \cdots$$

$$(A, S_A) \sim_{\mathrm{abs}} (B, S_B) \quad \text{means that the two bearer stages are absolutely simultaneous.}$$

$$\mathsf{T}_{\mathrm{ITOF}} := \mathrm{DescriptiveMeaning}\begin{pmatrix}\text{the one universal extension and prior–later order,}\\ \text{including direct objective absolute simultaneity}\end{pmatrix}.$$

In the iconic sequence, each $S_A^{\langle n\rangle}$ denotes an actual stage of bearer A, and the superscript is only a local positional label within the displayed succession. It does not create, count, or detect the stage. The ordered objects are the physical stages themselves, not the complete physical conditions $X_A(o)$ carried by them. The symbols $\prec_{\mathrm{U}}$ and $\sim_{\mathrm{abs}}$ are defined below as direct relations within the one universal temporal extension.

The order of exposition is semantic rather than causal. The verbal definition of time is stated before the detailed change equations because temporal meaning is the central thesis of ITOF. The formal dependency is nevertheless explicit: actual bearer-attributed stages occupy the one universal prior–later and absolute-simultaneity structure; each stage carries the bearer's complete physical condition; physical change is defined between ordered same-bearer stages; sustained change continues throughout the identity-preserving succession; and time names the descriptive meaning of that one extension and order. No arrow runs from temporal meaning, absolute simultaneity, observation, or a record back to the physical production of stages or change.

Retrospective description is outside this dependency. An account of already realized past stages or records neither causes change nor supplies a premise for its continuation. Measurement and reconstruction provide limited access to physical realizations; they do not create them.

The recognition of physical change and of the succession of its extended stages belongs to ordinary human experience and precedes formal science. Growth, motion, ageing, decay, bodily transformation, the life course from birth through maturity and ageing to death, and environmental change are directly encountered as physical systems pass through earlier and later conditions. Scientific inquiry increases resolution, attribution, comparison, and access to changes that are slow, minute, internal, remote, or otherwise unavailable to unaided observation; it does not create the change or the succession it investigates.

1.1 Relation to V23/F3

V24/F4 revises and supersedes V23/F3 specifically with respect to objective universal simultaneity. V23/F3 did not postulate a direct objective absolute-simultaneity relation as part of the governing temporal structure; V24/F4 now postulates that relation together with one universal prior–later order. The distinction between coordinate simultaneity and temporal ontology is retained, while the framework's positive ontological commitment is changed explicitly [1].

1.2 Primitive and governed commitments

The one universal prior–later direction and objective absolute simultaneity are acknowledged as primitive relational features of the temporal structure. ITOF does not reduce them to a non-temporal substance or mechanism. Domain laws, signals, material continuity, causal structure, and measurement protocols may warrant assignments of bearer stages within that structure, but they do not create the structure or the stages. Relative to these primitives, the framework adopts the following dependency discipline:

$$
\begin{aligned}
\text{physical bearer with realized stages} &\longrightarrow \text{stage-carried complete conditions},\\
\text{ordered comparable non-equivalence} &\longrightarrow \text{physical change between stages},\\
\substack{\text{continued identity-bounded stage succession}\\ \text{with the sustained-change postulate}} &\longrightarrow \text{change throughout every non-zero stage interval},\\
\substack{\text{realized stages with}\\ (\prec_{\mathrm{U}},\sim_{\mathrm{abs}})} &\longrightarrow \substack{\text{one universal extension}\\ \text{and temporal meaning.}}
\end{aligned}
$$

This sequence contains no stage–change–stage cycle. Stage membership is fixed by actual bearer-attributable realization in the one extension; change is then judged between stages. Observation and records can warrant claims about change but cannot create stages or confine continuing change to one isolated stage rather than an ordered pair or supported interval.

The following statuses remain explicit throughout the manuscript:

- a *definition* fixes meaning within ITOF;
- a *type constraint* prevents invalid identification or transfer;
- a *postulate* states a universal physical commitment;
- a *conditional theorem* derives a conclusion from stated physical premises;
- a *domain bridge* is supplied by the relevant physical theory;
- an *evidential result* supports, weakens, or leaves a claim unresolved under a protocol; and
- a *negative constraint* excludes a physically unreal or logically incompatible construction, such as an identity-preserving static tail.

1.3 Economy and depth

Formal economy does not mean conceptual compression. A symbol is introduced only when it prevents a recurrent ambiguity or supports a genuine inference. The bearer-stage domain, complete-condition space, comparison domain, record domain, and representation domain remain distinct because they perform different logical functions. No second "realized-stage" domain is inserted between physical realization and change. Retrospective descriptions are kept outside the governing equations because they perform no physical or causal work. Each section has one dominant function and must not silently perform the work assigned to a later section.

2. Physical Systems, Identity, and Type Discipline

2.1 Bearer specification

Let OnticallyAdmissible(A) denote bearer admissibility as a physically obtaining condition, independent of present scientific access, and define

$$\mathbb{S}_{\mathrm{phys}} := \{A \mid \mathrm{OnticallyAdmissible}(A)\}. \tag{1}$$

The symbol $A \in \mathbb{S}_{\text{phys}}$ is an arbitrary placeholder for one ontically admissible bearer under analysis; it is not a global index and does not imply that all physical systems can be enumerated or are currently application-ready.

A bearer must be fixed independently of the result to be established. A minimal specification is

$$\text{Spec}(A) = (B_A, \iota_A, C_A, \chi_A^{\text{full}}), \tag{2}$$

where B_A is a physically grounded boundary or attribution rule, ι_A is the bearer-identity criterion, C_A fixes the physical content included in the complete condition of the bearer, and χ_A^{full} fixes the claim-independent bearer-complete ontology of physical comparison.

The boundary need not be a rigid spatial surface. For a localized object it may be material or geometric. For an open system it may be a control boundary through which matter, energy, or information-bearing physical signals pass. For a distributed system it may be a world-tube, field support, regional decomposition, or another covariantly specified attribution rule. For a lineage or evolving biological population it may be defined through physically grounded descent and continuity conditions. The form is domain dependent, but it is fixed before the observed outcome is used.

The identity criterion determines when later physical realizations are still attributable to the same bearer. Identity need not mean microscopic sameness. Conversely, when the declared criterion is no longer satisfied, the identity of that bearer ends even though matter, fields, components, products, or descendants continue in other systems. Its formal continuation relation is typed after the ontic-reference domain is introduced below.

The complete-condition rule C_A identifies the physical content attributed to the bearer independently of any comparison outcome. It may include constituents, internal degrees of freedom, fields, boundary conditions, kinematic properties, stresses, temperatures, chemical composition, genetic content, and bearer-attributable relational or coupling states. It excludes mere changes of notation, passive coordinate descriptions, and relations not physically attributed to the bearer.

The complete comparison specification χ_A^{full} is fixed with the bearer specification, independently of any experimental claim, protocol, selected projection, or observed result. It fixes the bearer-complete comparison content and any lawful transport, gauge, path, boundary re-identification, or redundancy rules required to judge equivalence or non-equivalence of complete conditions. Claim-specific specifications may guide access to selected content, but they do not alter the truth conditions of ontological change.

For a claim Q, a reduced description is defined by a pre-declared projection

$$X_{A,Q}(o) := \mathcal{P}_{A,Q}(X_A(o)), \tag{3}$$

whose content and losses are fixed before outcome inspection. Its associated claim-level comparison specification $\chi_{A,Q}$ governs only the projected or represented question. Non-equivalence in a sound projection can warrant non-equivalence of the complete condition through an explicit projection-to-bearer bridge; equivalence in the projection does not establish complete equivalence unless an independent completeness bridge covers every omitted distinguishing degree of freedom and relation.

Ontic admissibility must not be confused with present scientific readiness to test a particular claim. Let $\mathrm{ApplicationReady}(A; P, Q)$ mean that protocol P, claim Q, realization links, comparison rules, bridge laws, calibration, and uncertainty controls are presently specified well enough to issue a warranted judgment. Then

$$\begin{gathered}\mathrm{ApplicationReady}(A; P, Q) \Longrightarrow \mathrm{OnticallyAdmissible}(A), \\ \mathrm{OnticallyAdmissible}(A) \not\models \mathrm{ApplicationReady}(A; P, Q).\end{gathered} \tag{4}$$

A physically real bearer is not excluded from $\mathbb{S}_{\mathrm{phys}}$ merely because current science lacks a complete operational characterization.

2.2 Open, distributed, and exchanging systems

An open or distributed system remains a system when its identity and attribution rules are physically specified. Exchange with other systems is not a reason to dissolve the bearer into an unspecified environment. Incoming and outgoing matter, energy, momentum, radiation, stresses, fields, and information-bearing signals are attributed through the declared boundary and coupling rules. A system that influences another remains a system and performs a relational factor-role; influence does not replace its ontological identity.

2.3 Ontic realizations and complete conditions

For a selected bearer A, let $\mathcal{O}_A$ be the non-enumerated and non-exhaustively represented domain of physically realized stages attributable to that bearer throughout its identity. Ontic admissibility is completed by

$$\mathrm{OnticallyAdmissible}(A) \Longleftrightarrow \mathrm{PhysicalBearer}(A) \wedge \mathrm{SpecObtains}(A) \wedge \mathcal{O}_A \neq \varnothing, \tag{5}$$

where $\mathrm{SpecObtains}(A)$ means that a boundary or attribution rule, bearer-identity criterion, complete-condition content, and full ontological comparison structure physically obtain for the bearer. It does not require that investigators presently possess a complete model of them. An element $o \in \mathcal{O}_A$ is a physically instantiated stage capable of carrying the declared complete condition. Depending on the domain, its physical support may be localized or spatially distributed—for example, an event, worldline location, material or field region, covariant section, hypersurface assignment, or another physically grounded locus—provided that it constitutes one bearer-attributed realization at one position in the universal succession. A temporally extended history segment or world-tube spanning more than one prior–later position is a range of stages, not one stage. Stage status follows from actual bearer-attributable realization in the one extension, not from a later observation or proof of difference.

Only actual physical stages belong to $\mathcal{O}_A$. Possible trajectories, counterfactual branches, mathematical solution points, and uninstantiated model states may be important to prediction but are not actual stages merely because they are mathematically allowed. A sample, image, detector output, clock reading, or reconstructed point is a record or representation linked to a stage or to an evidentially delimited range of stages; it does not replace the physical stage.

The bearer-identity criterion ι_A induces the directed continuation relation

$$I_A := I_A^{\iota_A} \subseteq \mathcal{O}_A \times \mathcal{O}_A. \tag{6}$$

In this manuscript, $I_A(o_1, o_2)$ is the same-bearer continuation judgment induced by ι_A under the fixed specification $\mathrm{Spec}(A)$; it is not a symmetric relation detached from prior–later order. The domain $\mathcal{O}_A$ is formed as one connected bearer-identity domain:

$$\forall o_1, o_2 \in \mathcal{O}_A : \qquad o_1 \prec_A o_2 \Longrightarrow I_A(o_1, o_2). \tag{7}$$

Equation (7) is a formation constraint on $\mathcal{O}_A$, not an additional dynamical postulate. If the declared identity criterion ceases to obtain, later realizations are assigned to a successor bearer domain rather than inserted as a disconnected continuation of A. The identity relation is consequently compositionally coherent on ordered triples:

$$\begin{aligned} o_1 \prec_A o_2 \prec_A o_3 \wedge I_A(o_1, o_2) \wedge I_A(o_2, o_3) \\ \Longrightarrow I_A(o_1, o_3). \end{aligned} \tag{8}$$

Domain-specific and history-sensitive identity criteria remain admissible for biological, distributed, and open systems, but they must form one uninterrupted identity domain for each declared bearer rather than permit arbitrary relabeling or disappearance and later resumption of the same identity.

The complete physical condition is assigned in the formalism by the typed map

$$X_A : \mathcal{O}_A \longrightarrow \mathfrak{X}_A, \qquad X_A(o) \in \mathfrak{X}_A, \tag{9}$$

where $\mathfrak{X}_A$ is the bearer-relative condition space fixed by C_A and the applicable domain theory. This formulation does not require a universal state space or a bundle formalism. It requires only that the admissible condition content be fixed independently of the comparison outcome.

Bearer and stage discipline. The bearer, boundary, identity criterion, realized-stage domain, complete-condition content, and full ontological comparison specification are fixed without using the desired conclusion. Neither an index nor a clock tick, record, measured contrast, or reconstruction creates a physical stage. Change is judged between already realized stages; it does not confer stage status upon them.

2.4 Ontological type discipline: systems, states, quantities, and representations

The universal postulate ranges over physical systems, not over every noun or symbol in a model. A representation is a declared mathematical, geometrical, observational, or record-producing map associated with a physical bearer under specified conditions. It is not the bearer, its complete physical condition, realized change, a change stage, or time. Formal existence and internal consistency therefore remain type-distinct from physical instantiation:

$$\mathrm{FormallyConsistent}(\mathcal{M}) \not\models \mathrm{PhysicallyInstantiated}(\mathcal{M}). \tag{10}$$

A formally coherent object may retain mathematical meaning while carrying no established physical or ontological significance for the world unless a declared interpretation and empirically adequate physical bridge connect it to realized material conditions.

A correct application distinguishes at least four types:

$$\begin{aligned}
\mathrm{System}(A):&\quad A \text{ is the physically identified bearer},\\
\mathrm{StateOf}(s,A,o):&\quad s \text{ specifies or represents a condition of } A \text{ at } o,\\
\mathrm{QuantityOf}(q,A,o):&\quad q \text{ is a physical quantity attributed to } A \text{ at } o,\\
\mathrm{RepOf}(r,A,o;P):&\quad r \text{ represents selected content of } A\\
&\quad \text{at one warranted source stage under } P.
\end{aligned} \tag{11}$$

The displayed RepOf predicate is the singleton-support case. A record acquired, integrated, propagated, sampled, or reconstructed across more than one stage is typed instead by its non-empty source support $\mathrm{StageSupport}_{A,P}(r) \subseteq \mathcal{O}_A$; no one-stage link is presumed merely because one record symbol is used.

Accordingly,

System–property–representation separation

$$A \not\equiv_{\text{type}} X_A(o), \qquad A \not\equiv_{\text{type}} E_A(o), \qquad A \not\equiv_{\text{type}} \rho_A(o), \qquad A \not\equiv_{\text{type}} \widehat{R}_{A,P}(o), \tag{12}$$

$$\mathrm{AppearsInEquation}(y) \not\models \mathrm{System}(y). \tag{13}$$

Energy is a physical quantity, transfer, constraint, or witness; it is not an additional bearer merely by receiving a value:

$$E_A(o) \in \mathbb{R} \text{ or an appropriate quantity space} \qquad \not\Rightarrow \qquad E_A(o) \in \mathbb{S}_{\text{phys}}. \tag{14}$$

A non-systemic or non-structural physical factor, as used here, is a physically operative role, transfer, quantity, boundary condition, coupling, or constraint that is not independently specified as a bearer with its own identity criterion and realized-stage domain. Such a factor can condition, mediate, or witness change in a physical system, but the continuation and extension of change are not attributed to it as an independent bearer. Values and representations are likewise not bearers merely because they describe or register such factors. If an influencing entity is itself specified as a physical system, it belongs to $\mathbb{S}_{\text{phys}}$ in that capacity even while performing a factor-role in another relation.

For an atom A, an attributed transition transfer between ordered comparable realizations witnesses non-equivalence of the atom:

$$\begin{gathered}
o_1 \prec_A o_2 \wedge I_A(o_1,o_2) \wedge ((o_1,o_2) \in \mathcal{K}_A) \wedge \mathrm{TransitionTransfer}_A(o_1,o_2) \neq 0\\
\wedge\, \mathrm{EndpointAttributionSound}_A(o_1,o_2) \Longrightarrow X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2).
\end{gathered} \tag{15}$$

The atom is the bearer. The transferred energy is a quantity and a witness of its transition, not a separate system addressed by the universal postulate.

The converse inferences fail:

$$E_A(o_1) = E_A(o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_2)\Big], \tag{16}$$

$$\Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2)\Big] \not\models E_A(o_1) \neq E_A(o_2). \tag{17}$$

The same discipline applies to momentum, charge, temperature, expectation values, quantum states, density operators, proper-time functionals, and geometric quantities. The physical carrier must be identified independently.

Typed scope rule for universal change. The universal sustained-change postulate ranges over all ontically admissible physical systems. Its interval statement becomes substantive wherever a non-zero identity-preserving stage interval is physically realized. Properties, transferred quantities, state vectors, density operators, vacuum labels, coordinates, equations, records, and measured values enter as conditions, representations, or evidence of a bearer's change. Any proposed exception must identify a genuine physical bearer, maintain its identity throughout the claimed continuation, and establish complete physical constancy rather than constancy of one selected quantity or representation.

3. Prior–Later Order, Absolute Simultaneity, and Physical Comparison

3.1 One universal extension and bearer-relative restriction

Ontic references are bearer typed. Define the bearer-attributed universal ontic domain by the disjoint union

$$\mathcal{O}_{\text{phys}} := \bigsqcup_{A \in \mathbb{S}_{\text{phys}}} (\{A\} \times \mathcal{O}_A), \qquad \jmath_A(o) := (A, o). \tag{18}$$

The tag A preserves bearer attribution and prevents realizations of different systems from being identified merely because they share a mathematical description. All formal domains are treated as sets relative to a fixed model-theoretic background adequate for the physical universe addressed by the framework; no physical conclusion depends on resolving unrestricted set-versus-proper-class questions.

ITOF postulates a direct objective relation of absolute simultaneity

$$\sim_{\text{abs}} \subseteq \mathcal{O}_{\text{phys}} \times \mathcal{O}_{\text{phys}}. \tag{19}$$

It is reflexive, symmetric, and transitive:

$$\begin{gathered} x \sim_{\text{abs}} x, \\ x \sim_{\text{abs}} y \Longrightarrow y \sim_{\text{abs}} x, \\ x \sim_{\text{abs}} y \wedge y \sim_{\text{abs}} z \Longrightarrow x \sim_{\text{abs}} z. \end{gathered} \tag{20}$$

The notation states a primitive direct relation of objective absolute simultaneity between bearer-attributed realized stages. It does not by itself posit a universal physical stage, temporal container, hypersurface, substance, or collective physical object. Absolutely simultaneous stages may differ completely in bearer, complete condition, physical change, clock reading, proper time, and physical process.

The one universal prior–later relation is

$$\prec_{\mathrm{U}} \subseteq \mathcal{O}_{\mathrm{phys}} \times \mathcal{O}_{\mathrm{phys}}. \tag{21}$$

Direct universal order and absolute simultaneity

$$\begin{aligned}
&\neg(x \prec_{\mathrm{U}} x),\\
&x \prec_{\mathrm{U}} y \wedge y \prec_{\mathrm{U}} z \Longrightarrow x \prec_{\mathrm{U}} z,\\
&x \prec_{\mathrm{U}} y \Longrightarrow \neg(y \prec_{\mathrm{U}} x) \wedge \neg(x \sim_{\mathrm{abs}} y),\\
&x \neq y \Longrightarrow (x \prec_{\mathrm{U}} y) \vee (x \sim_{\mathrm{abs}} y) \vee (y \prec_{\mathrm{U}} x),\\
&x \sim_{\mathrm{abs}} x' \wedge y \sim_{\mathrm{abs}} y' \Longrightarrow \big[x \prec_{\mathrm{U}} y \Longleftrightarrow x' \prec_{\mathrm{U}} y'\big].
\end{aligned} \tag{22}$$

The three alternatives in the fourth line are mutually exclusive. The final line makes prior–later placement compatible with replacement by absolutely simultaneous representatives. Consequently, a derived quotient representation is mathematically available:

$$\mathcal{Q}_{\mathrm{U}} := \mathcal{O}_{\mathrm{phys}}/\sim_{\mathrm{abs}}, \qquad [x]_{\sim_{\mathrm{abs}}} \lhd_{\mathrm{U}} [y]_{\sim_{\mathrm{abs}}} \Longleftrightarrow x \prec_{\mathrm{U}} y. \tag{23}$$

The compatibility axiom makes $\lhd_{\mathrm{U}}$ independent of the chosen representatives. This quotient is a derived representation only. ITOF does not treat $\mathcal{Q}_{\mathrm{U}}$, or any of its equivalence classes, as a universal physical stage, temporal layer, container, substance, or causally active object. The primitive ontology remains the direct relations $\sim_{\mathrm{abs}}$ and $\prec_{\mathrm{U}}$ between bearer-attributed stages.

Let $x \prec_{\mathrm{caus}} y$ denote a domain-valid strict physical causal precedence established independently. The temporal relations must preserve that direction and cannot place a non-identical causally related pair in absolute simultaneity:

$$\begin{aligned}
x \prec_{\mathrm{caus}} y &\Longrightarrow x \prec_{\mathrm{U}} y,\\
x \sim_{\mathrm{abs}} y &\Longrightarrow \neg(x \prec_{\mathrm{caus}} y) \wedge \neg(y \prec_{\mathrm{caus}} x).
\end{aligned} \tag{24}$$

This is a compatibility constraint. Relativistic causality does not determine absolute simultaneity for causally unrelated realizations.

For one declared bearer, two distinct realizations cannot occupy the same absolute-simultaneity position under the same bearer specification:

$$\jmath_A(o_1) \sim_{\mathrm{abs}} \jmath_A(o_2) \Longrightarrow o_1 = o_2. \tag{25}$$

The same-bearer relation used in the change definition is the restriction of the one universal order:

$$o_1 \prec_A o_2 \Longleftrightarrow \jmath_A(o_1) \prec_{\mathrm{U}} \jmath_A(o_2), \qquad o_1, o_2 \in \mathcal{O}_A. \tag{26}$$

Define the associated non-strict relation by

$$x \preceq_{\mathrm{U}} y \Longleftrightarrow (x \prec_{\mathrm{U}} y) \vee (x \sim_{\mathrm{abs}} y). \tag{27}$$

Thus $\prec_A \subseteq \mathcal{O}_A \times \mathcal{O}_A$ remains asymmetric and transitive. Domain-appropriate causal, dynamical, material-continuity, relativistic, lineage, and signal structures provide physical warrant for assigning or testing order and simultaneity relations; they do not generate the one extension by convention. The universal prior–later relation is a primitive temporal commitment of ITOF and is not derived from Lorentz or Poincaré transformations.

Direct relations without a universal stage. The extension is one for all physical systems. The relations $\prec_{\mathrm{U}}$ and $\sim_{\mathrm{abs}}$ act directly on bearer-attributed realizations and, on their stage-bearing restriction, directly on stages. No universal physical stage is introduced, and no equivalence class is reified as a temporal layer.

3.2 Ontological and claim-level comparison

Physical change requires one claim-independent bearer-complete ontology of comparison. The specification χ_A^{full}, fixed in $\mathrm{Spec}(A)$, determines which same-bearer pairs admit complete comparison, what transport, gauge, path, boundary re-identification, and redundancy rules are lawful, and how equivalence or non-equivalence of the complete condition is judged. Define

$$\mathcal{K}_A^{\mathrm{full}} \subseteq \mathcal{O}_A \times \mathcal{O}_A, \qquad \mathcal{K}_A := \mathcal{K}_A^{\mathrm{full}}. \tag{28}$$

For formal economy, every unindexed occurrence of $\mathcal{K}_A$, $\equiv_{\mathrm{phys}}$, or $\not\equiv_{\mathrm{phys}}$ in an ontological definition denotes the full specification χ_A^{full}, never a claim-relative projection.

The resulting legal comparison status is

$$\mathrm{CmpStatus}_A^{\mathrm{full}}(o_1, o_2) := \begin{cases} \text{equivalent}, & (o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2), \\ \text{non-equivalent}, & (o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2), \\ \text{undefined}, & (o_1, o_2) \notin \mathcal{K}_A. \end{cases} \tag{29}$$

Within the full comparison domain, physical equivalence and physical non-equivalence are mutually exclusive and jointly exhaustive:

$$\begin{aligned} (o_1, o_2) \in \mathcal{K}_A \Longrightarrow &\Big[X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2) \vee X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)\Big] \\ &\wedge \neg\Big[X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2) \wedge X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)\Big]. \end{aligned} \tag{30}$$

Outside $\mathcal{K}_A$, neither status is asserted: the full comparison is undefined, not equivalent by default.

A scientific claim Q may use a reduced specification $\chi_{A,Q}$ on the projection $X_{A,Q}$. It defines a claim-level domain

$$\mathcal{K}_{A,Q} \subseteq \mathcal{O}_A \times \mathcal{O}_A, \tag{31}$$

and projected judgments $\equiv_{A,Q}^{\mathrm{proj}}$ and $\not\equiv_{A,Q}^{\mathrm{proj}}$. These judgments can vary with the claim because the selected content can vary. They do not redefine Ch_A, Stage_A, $\mathrm{SC}(A)$, or $\mathrm{CmpComplete}_A$. A projected difference reaches the full ontological relation only through a sound bridge:

$$\begin{aligned}&(o_1, o_2) \in \mathcal{K}_{A,Q} \wedge X_{A,Q}(o_1) \not\equiv^{\mathrm{proj}}_{A,Q} X_{A,Q}(o_2) \\ &\quad \wedge \mathrm{ProjDiffSound}_{A,Q}(o_1, o_2) \Longrightarrow \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)\Big].\end{aligned} \tag{32}$$

Conversely, projected equivalence reaches complete physical equivalence only under a bearer-complete bridge:

$$\begin{aligned}&(o_1, o_2) \in \mathcal{K}_{A,Q} \wedge X_{A,Q}(o_1) \equiv^{\mathrm{proj}}_{A,Q} X_{A,Q}(o_2) \\ &\quad \wedge \mathrm{ProjComplete}_{A,Q}(o_1, o_2) \Longrightarrow \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big].\end{aligned} \tag{33}$$

The bridge premises are epistemic and claim specific; the resulting complete-condition judgment is ontological and is evaluated under χ_A^{full}.

Neither the full nor the claim-level specification may erase a real physical difference by convenient relabeling:

$$\mathrm{FormalRelabel}(X_A(o_1), X_A(o_2)) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big]. \tag{34}$$

Order, bearer identity, and full comparison are prerequisites for the change definition. None by itself classifies a reference as a stage of change.

4. Temporal Succession and the Meaning of Time

4.1 The one extended succession

ITOF uses the expression *change stage* for an actual bearer-attributable physical stage within the one extension. Stage status is not derived from observation or from participation in a subsequently proved difference. The formal type predicate and the stage domain are

$$\mathrm{Stage}_A(o) \Longleftrightarrow o \in \mathcal{O}_A, \qquad \mathcal{S}_A^{\mathrm{ch}} := \mathcal{O}_A.$$

The superscript "ch" is a mnemonic label for the framework's change-stage discourse. Membership is exactly membership in $\mathcal{O}_A$; it is not conditioned on a prior proof of difference between that stage and another stage, and it does not analytically imply $\mathrm{SC}(A)$.

A compact presentation of a selected part of the stage succession is

$$\cdots \prec_A S_A^{\langle 0\rangle} \prec_A S_A^{\langle 1\rangle} \prec_A S_A^{\langle 2\rangle} \prec_A S_A^{\langle 3\rangle} \prec_A \cdots, \tag{35}$$

where every displayed $S_A^{\langle i\rangle}$ denotes an actual stage $o \in \mathcal{O}_A$. The superscripts are iconic relational labels only. They do not enumerate all stages, imply discreteness, identify clock ticks, prove adjacency, or identify a unique ordered pair or interval over which an observed difference was realized. The notation $\preceq_A$ denotes the reflexive closure of $\prec_A$, used only to include interval endpoints.

Iconic extension of realized change stages

$$\boxed{\cdots \prec_A S_A^{\langle 0\rangle} \prec_A S_A^{\langle 1\rangle} \prec_A S_A^{\langle 2\rangle} \prec_A S_A^{\langle 3\rangle} \prec_A \cdots} \tag{36}$$

$$S_A^{\langle 0\rangle} \prec_A S_A^{\langle 1\rangle} \prec_A S_A^{\langle 2\rangle}. \tag{37}$$

The middle stage is later relative to its predecessor and prior relative to a further stage. This relational transition is the elementary pattern of extension. The same one extension contains the corresponding stages of every other bearer whose identity continues through that shared extent, related by objective absolute simultaneity. The displayed temporal chain describes only extension and prior–later order; it does not express the physical content of change or its causes.

The inherited strict-order properties are

$$S_1 \prec_A S_2 \Longrightarrow \neg(S_2 \prec_A S_1), \tag{38}$$

$$S_1 \prec_A S_2 \wedge S_2 \prec_A S_3 \Longrightarrow S_1 \prec_A S_3. \tag{39}$$

4.2 Governing definition

Governing definition of time. Time expresses only the one extension and ordering of the realized stages across physical systems in the universe; it does not express the bearer-specific physical differences established between stages, their mechanisms, or their causes.

Absolute simultaneity is internal to that one extension as a direct relation between stages of different systems. It does not constitute a universal physical stage, a reified temporal layer, a physical container, a metric, a cause, or an independent competing definition of time.

The physical condition associated with each stage is bearer-specific, and the changes established across each bearer's ordered stage intervals may differ in content, mechanism, magnitude, and rate. Stages stand in a one-to-one, order-preserving correspondence throughout every shared identity extent; equal cardinality follows as a set-theoretic consequence, while final identity-bounded cardinalities may differ only because bearer identities begin or end at different positions in the one extension.

The bearer-attributed domain of realized change stages is

$$\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}} := \bigsqcup_{A\in\mathbb{S}_{\mathrm{phys}}} (\{A\} \times \mathcal{S}^{\mathrm{ch}}_A) = \mathcal{O}_{\mathrm{phys}}. \tag{40}$$

4.3 Shared identity extent, order-preserving correspondence, and cardinality

For span construction only, define the local reflexive extension of identity continuation by

$$I_A^{\mathrm{sp}}(S_-, S_+) \Longleftrightarrow (S_- = S_+) \vee I_A(S_-, S_+). \tag{41}$$

This auxiliary relation permits a boundary position to be bounded by one and the same realized stage. It does not make the directed continuation relation I_A reflexive in the change definition.

For a bearer A, define that its stage-bearing identity spans a universal position $x \in \mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}$ when stages of A, related by I^{sp}_A, lie on or around that position in the one order:

$$\begin{aligned} \mathrm{IdStageSpan}_A(x) \iff \exists S_-, S_+ \in \mathcal{S}^{\mathrm{ch}}_A \Big[& I^{\mathrm{sp}}_A(S_-, S_+) \\ & \wedge \jmath_A(S_-) \preceq_{\mathrm{U}} x \\ & \wedge x \preceq_{\mathrm{U}} \jmath_A(S_+) \Big]. \end{aligned} \tag{42}$$

The identity span is an interval in the universal order: the same declared bearer identity cannot lapse and later resume across an intermediate universal position under one unchanged specification.

$$\begin{aligned} & x_1, x, x_2 \in \mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}} \wedge \mathrm{IdStageSpan}_A(x_1) \wedge \mathrm{IdStageSpan}_A(x_2) \\ & \wedge x_1 \prec_{\mathrm{U}} x \prec_{\mathrm{U}} x_2 \\ & \qquad \Longrightarrow \mathrm{IdStageSpan}_A(x). \end{aligned} \tag{43}$$

If the original bearer identity terminates, any later physical system is specified under its own identity rather than treated as a resumed segment of A.

Whenever a stage of any bearer lies within that identity extent, exactly one stage of A is absolutely simultaneous with it:

$$\forall x \in \mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}} : \quad \mathrm{IdStageSpan}_A(x) \Longrightarrow \exists! S \in \mathcal{S}^{\mathrm{ch}}_A : \ \jmath_A(S) \sim_{\mathrm{abs}} x. \tag{44}$$

This is a direct cross-bearer coverage condition. It states the common extension of stages while bearer identity continues; it does not introduce a containing universal stage or reify the correspondence as a temporal layer.

For two bearers A and B, define their shared identity-stage domains by

$$\begin{aligned} \mathcal{S}^{AB}_A &:= \left\{ S \in \mathcal{S}^{\mathrm{ch}}_A \mid \mathrm{IdStageSpan}_B(\jmath_A(S)) \right\}, \\ \mathcal{S}^{AB}_B &:= \left\{ T \in \mathcal{S}^{\mathrm{ch}}_B \mid \mathrm{IdStageSpan}_A(\jmath_B(T)) \right\}. \end{aligned} \tag{45}$$

The coverage condition and same-bearer uniqueness give a unique simultaneous partner in both directions:

$$\begin{aligned} \forall S \in \mathcal{S}^{AB}_A \ \exists! T \in \mathcal{S}^{AB}_B : \jmath_A(S) \sim_{\mathrm{abs}} \jmath_B(T), \\ \forall T \in \mathcal{S}^{AB}_B \ \exists! S \in \mathcal{S}^{AB}_A : \jmath_A(S) \sim_{\mathrm{abs}} \jmath_B(T). \end{aligned} \tag{46}$$

By Equation (43) and the restriction of the universal order to each bearer, both shared domains are order-convex:

$$\begin{aligned} S_1, S_2 \in \mathcal{S}^{AB}_A \wedge S_1 \prec_A S \prec_A S_2 \Longrightarrow S \in \mathcal{S}^{AB}_A, \\ T_1, T_2 \in \mathcal{S}^{AB}_B \wedge T_1 \prec_B T \prec_B T_2 \Longrightarrow T \in \mathcal{S}^{AB}_B. \end{aligned} \tag{47}$$

Hence absolute simultaneity defines the bijection

$$f_{AB} : \mathcal{S}^{AB}_A \xrightarrow{\sim} \mathcal{S}^{AB}_B, \qquad \jmath_A(S) \sim_{\mathrm{abs}} \jmath_B(f_{AB}(S)), \tag{48}$$

which preserves order:

$$S_1 \prec_A S_2 \iff f_{AB}(S_1) \prec_B f_{AB}(S_2), \qquad S_1, S_2 \in \mathcal{S}_A^{AB}. \tag{49}$$

Where three bearers overlap and all maps are defined, partner uniqueness and transitivity of absolute simultaneity require composition coherence:

$$\begin{aligned} S \in \mathcal{S}_A^{AB} \cap \mathcal{S}_A^{AC}, \qquad f_{AB}(S) \in \mathcal{S}_B^{BC} \\ \implies f_{AC}(S) = f_{BC}(f_{AB}(S))\,. \end{aligned} \tag{50}$$

The primary result is the one-to-one, order-preserving correspondence itself. As a set-theoretic consequence,

$$\mathrm{Card}\Big(\mathcal{S}_A^{AB}\Big) = \mathrm{Card}\Big(\mathcal{S}_B^{AB}\Big)\,. \tag{51}$$

This cardinality equality is not a duration, rate, magnitude, metric interval, or universal temporal amount. It does not imply equality of complete conditions or equality of the bearer-specific changes established across ordered intervals containing corresponding simultaneous stages.

Define the identity-bounded stage cardinality of bearer A by

$$N_A^{\mathrm{st}} := \mathrm{Card}\Big(\mathcal{S}_A^{\mathrm{ch}}\Big)\,. \tag{52}$$

This cardinality becomes completed with respect to A only after the identity of A terminates; completion does not imply finiteness or countability. If two bearers have different completed identity-bounded stage cardinalities, at least one has stages outside their shared identity extent:

$$N_A^{\mathrm{st}} \neq N_B^{\mathrm{st}} \implies (\mathcal{S}_A^{\mathrm{ch}} \setminus \mathcal{S}_A^{AB} \neq \varnothing) \vee (\mathcal{S}_B^{\mathrm{ch}} \setminus \mathcal{S}_B^{AB} \neq \varnothing). \tag{53}$$

Thus any difference in completed identity-bounded stage cardinality arises from different identity beginnings or endings within the one extension. It does not arise from a failure of one-to-one stage correspondence during the same shared extent.

One extension without a universal stage. The extension is one for all physical systems. Absolute simultaneity directly relates their stages, and every shared identity extent carries a one-to-one order-preserving correspondence. No universal physical stage or reified temporal layer is introduced. The physical conditions carried by simultaneous stages remain bearer-specific, and the changes established across the respective ordered intervals may differ; a difference in completed identity-bounded stage cardinality is an identity-boundary difference.

The structure constructor and the truth-valued extension predicate are type-distinct:

$$\mathrm{ExtStruct}[D, \prec, \sim] := (D, \prec, \sim), \tag{54}$$

$$
\mathrm{IsUniversalExtSucc}[D,\prec,\sim] \iff \begin{cases} \prec \ \text{is strict, transitive, and non-reversing on } D, \\ \sim \ \text{is an absolute-simultaneity equivalence relation on } D, \\ \prec \ \text{and} \ \sim \ \text{satisfy exclusive temporal trichotomy on } D, \\ \prec \ \text{is compatible with} \ \sim\text{-replacement}, \\ \exists x_0, x_1, x_2 \in D \ [x_0 \prec x_1 \land x_1 \prec x_2] \end{cases} \tag{55}
$$

The predicate requires an actually realized extension beyond one ordered pair. It adds no metric, count, adjacency, equal spacing, universal rate, clock value, or collective universal stage.

One universal extension, direct order, and absolute simultaneity

$$
\begin{aligned}
\mathcal{E}_{\mathrm{U}} &:= \mathrm{ExtStruct}\left[\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}, \prec_{\mathrm{U}}\restriction_{\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}}, \sim_{\mathrm{abs}}\restriction_{\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}}\right], \\
&\mathrm{IsUniversalExtSucc}\left[\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}, \prec_{\mathrm{U}}\restriction_{\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}}, \sim_{\mathrm{abs}}\restriction_{\mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}}}\right], \\
\mathsf{T}_{\mathrm{ITOF}} &:= \mathrm{DescriptiveMeaning}(\mathcal{E}_{\mathrm{U}}), \\
S_1 \prec_A S_2 &\iff (A, S_1) \prec_{\mathrm{U}} (A, S_2), \quad S_1, S_2 \in \mathcal{S}^{\mathrm{ch}}_A, \\
(A, S_A) \sim_{\mathrm{abs}} (B, S_B) &\iff \text{the two bearer stages are absolutely simultaneous.}
\end{aligned} \tag{56}
$$

The structure acts directly on bearer-attributed stages. It neither equalizes their physical content nor permits a failure of one-to-one stage correspondence within one shared identity extent.

The type boundaries are

$$
\begin{aligned}
\mathsf{T}_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} X_A, &\quad \mathsf{T}_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \mathrm{Ch}_A, \\
\mathsf{T}_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} N_{C,P}, &\quad \mathsf{T}_{\mathrm{ITOF}} \not\equiv_{\mathrm{type}} \tau[\gamma].
\end{aligned} \tag{57}
$$

The same boundary excludes the physical causes and mechanisms of change: they belong to bearer dynamics and engagements, not to $\mathsf{T}_{\mathrm{ITOF}}$.

4.4 Why two stages do not define time

Two ordered stages are the minimum analytic comparison required to establish one physical difference, not the definition of time:

$$
\mathrm{Ch}_A(o_1, o_2) \implies [o_1, o_2 \in \mathcal{O}_A \land o_1 \prec_A o_2]. \tag{58}
$$

The implication records the type and order already required by the change predicate; it does not derive either stage. One pair does not exhaust extension. Time concerns the one continued succession in which later stages become prior relative to further stages.

4.5 Invariant succession and absolute simultaneity

In ITOF, *invariant* denotes only the fixed, non-reversing succession among the extended stages of change. If one realized stage is prior to another, the former remains prior and the latter remains later; their prior–later relation cannot reverse. The term does not mean that physical states are unchanging, and it is not defined here as invariance under observers, coordinates, redescriptions, or a transformation group.

Invariant succession. Across the continuing succession of stages, bearer conditions remain subject to physical change, while the realized succession itself remains fixed from prior to later. Absolute simultaneity is a distinct objective relation within the one extension; it is not part of the definition of invariance.

$$\mathrm{InvCosmicSucc} \iff \forall x, y \in \mathcal{S}^{\mathrm{ch}}_{\mathrm{phys}} : \quad x \prec_{\mathrm{U}} y \implies \neg(y \prec_{\mathrm{U}} x). \tag{59}$$

This non-reversal condition formalizes the intended invariance of temporal succession. It repeats no claim of physical immobility and asserts no unproved symmetry under Lorentz, Poincaré, coordinate, or representational transformations.

Absolute simultaneity continues to supply the direct cross-bearer relation used in the one-extension construction. Its mathematical equivalence classes may be represented through Equation (23), but neither those classes nor that representation changes the meaning of invariant succession.

For stages of different bearers, absolute simultaneity licenses no cross-bearer judgment of physical sameness. The bearer-complete equivalence relation $\equiv_{\mathrm{phys}}$ is normally same-bearer typed unless a separately defined cross-bearer comparison bridge is supplied. Absolute simultaneity fixes common placement in the one extension, not equality of physical content; its independent separation from clock-output equality is stated in Equation (159).

The stronger claim that every non-zero identity-preserving stage interval contains realized change belongs to the universal-change postulate.

4.6 No temporal agency

Time does not enter a system, transfer energy, exert a force, change a coupling, select an outcome, or receive a reaction. Physical explanation must identify bearer processes and engagements.

4.7 Non-metricity and measurement

The temporal definition fixes the one extension, universal ordering, and direct objective absolute simultaneity of realized stages. It does not assign numerical distances, equal spacing, durations, or a universal clock value. Operational quantities and numerical comparisons are constructed from physical systems, models, clocks, signals, and conventions; they are not substituted for the non-metric temporal structure expressed by time.

4.8 No observational beginning or end

The first represented stage need not be the first physically realized stage, and the last represented stage need not be the final one. Either coincidence requires independent physical establishment. Protocol boundaries delimit access, not the extension described by time.

5. Physical Change Between Realized Stages

5.1 Physical change between stages

For a declared system A, physical change is defined between physically realized stages in $\mathcal{O}_A$:

Physical change of an arbitrary system

$$\begin{aligned}\mathrm{Ch}_A(o_1, o_2) \iff &(o_1, o_2 \in \mathcal{O}_A) \wedge (o_1 \prec_A o_2) \\ &\wedge I_A(o_1, o_2) \wedge ((o_1, o_2) \in \mathcal{K}_A) \wedge (X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)).\end{aligned} \tag{60}$$

Order alone does not prove change; the two stages must remain attributable to the same declared bearer through I_A; a formal difference between descriptions does not prove physical non-equivalence; and non-equivalence is not asserted when the full ontological comparison is undefined. In this definition, $\mathcal{K}_A$, $\equiv_{\mathrm{phys}}$, and $\not\equiv_{\mathrm{phys}}$ are the claim-independent relations fixed by χ_A^{full}.

5.2 Realized stage status

A stage is an actual bearer-attributable physical realization within the one extension. Its status is fixed by membership in the bearer's realized-stage domain:

Realized-stage predicate

$$\mathrm{Stage}_A(o) \iff o \in \mathcal{O}_A. \tag{61}$$

$$\mathcal{S}_A^{\mathrm{ch}} := \mathcal{O}_A. \tag{62}$$

This definition does not identify a stage with a label, clock tick, record, dataset row, or reconstructed point. Those objects require a physical linkage to a stage or to a range of stages. Nor does the definition imply that investigators can enumerate all stages or infer a unique change interval merely from the stage at which a difference first became noticeable.

Two ordered stages are the minimum analytic requirement for one direct comparison. They need not be adjacent among unresolved stages, and no finite protocol can enumerate all stages. A condition realized later occupies a later order-position even when its content is physically equivalent to an earlier condition. A later stage becomes prior relative to a further stage.

Recurrence of condition does not collapse stage identity

$$\begin{matrix} o_1, o_2, o_3 \in \mathcal{O}_A, \\ o_1 \prec_A o_2 \prec_A o_3, \end{matrix} \implies \mathrm{Stage}_A(o_1) \wedge \mathrm{Stage}_A(o_2) \wedge \mathrm{Stage}_A(o_3). \tag{63}$$

$$\begin{gathered} o_1 \prec_A o_2 \prec_A o_3 \wedge \mathrm{Ch}_A(o_1, o_2) \wedge \mathrm{Ch}_A(o_2, o_3) \\ \wedge\, (o_1, o_3) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_3) \implies o_1 \neq o_3. \end{gathered} \tag{64}$$

Physical equivalence of an earlier and a later condition does not identify their stages. Recurrence does not erase the intervening changes, the distinct later realization, or the non-reversing order-position.

5.3 Any actual physical difference is sufficient

The definition contains no lower ontological threshold. If P_0 is a genuine part or region of A, let $X_A^{P_0}(o)$ denote the physical content attributed to that part within the complete bearer condition $X_A(o)$; it is not the condition of a separately typed bearer evaluated on references of A. Let $\mathrm{PartDiff}_{A,P_0}(o_1, o_2)$ denote a physically attributed and admissibly compared difference in that part-content. This part-specific predicate is type-distinct from $\not\equiv_{\mathrm{phys}}$, which is reserved for bearer-complete conditions. Then

$$\begin{gathered} P_0 \subseteq_{C_A} A \wedge \big((o_1, o_2) \in \mathcal{K}_A\big) \wedge \mathrm{PartBridgeSound}_{P_0 \to A}(o_1, o_2) \\ \wedge\, \mathrm{PartDiff}_{A,P_0}(o_1, o_2) \implies X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2). \end{gathered} \tag{65}$$

Internal, local, surface, boundary, compositional, relational, and genetic differences can therefore establish change without destroying bearer identity when the part attribution, part-level comparison, and bridge are sound.

5.4 Observation is not constitutive

Let r_1, r_2 be records whose warranted source supports are non-empty subsets of $\mathcal{O}_A$. Define the represented observational range by the order-convex hull

$$\mathcal{I}_{A,P}(r_1, r_2) := \mathrm{Conv}_{\prec_A}\Big(\mathrm{StageSupport}_{A,P}(r_1) \cup \mathrm{StageSupport}_{A,P}(r_2)\Big) \subseteq \mathcal{O}_A. \tag{66}$$

A sound positive observation can establish that a noticeable physical change is present in that represented range, but it does not isolate a unique ordered pair or stage interval over which the change relation is warranted:

Realized change and the limits of observation

$$\neg\,\mathrm{ObservedChange}_{A,P}(r_1,r_2) \not\models \neg\exists u,v \in \mathcal{I}_{A,P}(r_1,r_2) : \mathrm{Ch}_A(u,v). \tag{67}$$

$$\begin{aligned}&\mathrm{ObservedChange}_{A,P}(r_1,r_2) \wedge \mathrm{ObservationBridgeSound}_{A,P}(r_1,r_2)\\ &\quad\Longrightarrow \exists u,v \in \mathcal{I}_{A,P}(r_1,r_2) : \mathrm{Ch}_A(u,v).\end{aligned} \tag{68}$$

$$\mathrm{ObservedChange}_{A,P}(r_1,r_2) \not\models \exists!(u,v) \in \mathcal{I}_{A,P}(r_1,r_2)^2 : \mathrm{Ch}_A(u,v). \tag{69}$$

If protocol P has a last warranted source stage o_P^+, write $\mathrm{LastSupportedStage}_{A,P}(o_P^+)$. Then

$$\begin{aligned}&\mathrm{EndOfProtocol}_P \wedge \mathrm{LastSupportedStage}_{A,P}(o_P^+)\\ &\quad\not\models \neg\exists u,v \in \mathcal{O}_A : \left[o_P^+ \preceq_A u \prec_A v \wedge I_A(u,v) \wedge \mathrm{Ch}_A(u,v)\right].\end{aligned} \tag{70}$$

A noticed change is a realized physical change that has become accessible to a protocol; it is not a second ontological kind of change. A realized change may be noticeable or may remain unresolved. Because change continues through stages while bearer identity continues, a sound observation establishes the noticed difference without identifying a unique ordered pair or interval over which the physical difference was realized. Investigation begins and ends within the same continuing physical succession; it does not set the beginning or end of the bearer's stages. Investigators, instruments, and records are themselves physical systems within that succession.

5.5 Physical quantities as witnesses, not bearers

For an atom A, a sound energy witness yields change only with the required attribution and comparison premises:

$$\begin{aligned}&o_1 \prec_A o_2 \wedge I_A(o_1,o_2) \wedge \big((o_1,o_2) \in \mathcal{K}_A\big) \wedge \mathrm{EnergyWitnessSound}_A(o_1,o_2) \wedge \Delta E_A(o_1,o_2) \neq 0\\ &\quad\Longrightarrow \mathrm{Ch}_A(o_1,o_2).\end{aligned} \tag{71}$$

Energy is a quantity, transfer, or witness associated with the bearer, not a second system. The converse fails:

$$\Delta E_A(o_1,o_2) = 0 \not\models \neg\,\mathrm{Ch}_A(o_1,o_2). \tag{72}$$

6. Identity, Past Description, and Records

Identity belongs to the bearer specification and constrains attribution across physical realizations. It is not supplied by a retrospective narrative. When the criterion ι_A induces a continuing relation I_A, later realizations may be attributed to the same system even though its complete condition changes. When the criterion fails, the original bearer ends under that specification; continuing matter, fields, components, products, or descendants are assigned to successor systems.

Retrospective descriptions are evidential only. Descriptions of physically realized past stages, changes, and records have no causal, dynamical, constitutive, or explanatory role in producing change. They are excluded from the governing definitions of physical change, sustained change, realized-stage membership, and temporal meaning.

6.1 Past description and observational windows

A past description may organize already realized change stages, records, and warranted order relations for explanatory or evidential purposes. It does not create the order, complete condition, or change that it describes. A finite observational window can establish particular changes when its bridges are sound, but it cannot establish the first physical change of a bearer, the final realization, or the total number of stages.

The first and last records in a protocol may coincide with actual physical boundaries only when those boundaries are independently established. Otherwise they delimit access. Many unresolved realizations may occur between two represented references.

6.2 Protocol-level reconstruction

Let a protocol P produce a finite or access-limited reconstruction

$$\widehat{\mathcal{R}}_{A,P} := (\widehat{O}_{A,P}, \widehat{\prec}_{A,P}, \widehat{R}_{A,P}), \tag{73}$$

where $\widehat{O}_{A,P}$ is a represented-reference support, $\widehat{\prec}_{A,P}$ is the protocol-supported order, and $\widehat{R}_{A,P}$ contains measured or reconstructed content. This is a representation, not a second ontic domain.

The represented support is linked to, but is not a subset of, the ontic domain. Introduce a protocol-relative partial realization map

$$\lambda_{A,P} : \widehat{O}_{A,P} \rightharpoonup \mathcal{O}_A, \tag{74}$$

and define documented realization linkage by

$$\text{RealizationLinked}_P(\hat{o}, o) \iff \lambda_{A,P}(\hat{o}) = o, \qquad o \in \mathcal{O}_A. \tag{75}$$

A documented link can warrant that the represented support concerns a physical stage $o \in \mathcal{O}_A$; it does not create that stage or imply that a record uniquely isolates the ordered pair or supported interval over which the noticed physical difference was realized. Two reconstructions are compatible only if they preserve bearer attribution, order on their common support, condition interpretation, and the conclusion under review:

$$\text{CompatibleRep}(\widehat{\mathcal{R}}_{A,P}, \widehat{\mathcal{R}}_{A,P'}). \tag{76}$$

The type chain is

$$\text{physical realization} \longrightarrow \text{record or signal} \longrightarrow \widehat{\mathcal{R}}_{A,P} \longrightarrow \text{qualified inference.} \tag{77}$$

No arrow reverses automatically.

6.3 Outcome-independent selection

A protocol window, model interval, lineage segment, or sampled region must be selected independently of the desired result. Truncation may not be used to hide a later difference or manufacture constancy. Overlapping bearers may share physical material or records while retaining distinct attribution rules; conclusions must remain bearer typed.

6.4 Identity termination and successors

Identity termination does not entail the cessation of physical change. No later stage remains related to the original system by I_A; continuing matter, fields, components, products, or descendants are assigned to one or more successor bearers with their own specifications and realized-stage domains. Once a successor is physically identified as a system, the universal sustained-change postulate applies to it under its own identity. Particular claims about the form or magnitude of its change still require bearer-specific physical and evidential bridges. No equation involving a descriptive past is required to express this transition.

6.5 No complete enumeration

The physically realized stages are not presented as a database that an observer can exhaust. The coincident domains $\mathcal{O}_A = \mathcal{S}_A^{\mathrm{ch}}$ are ontological scopes of application, not observational inventories or completed enumerations available to an investigator. A protocol reconstruction is always access limited:

$$\widehat{\mathcal{R}}_{A,P} \not\equiv_{\mathrm{type}} \text{physical reality of } A. \tag{78}$$

Its first and last represented references establish only the limits of the evidence. One sound ordered difference is sufficient to establish one realized change without identifying or counting every intervening realization:

$$\exists o_1, o_2 \in \mathcal{O}_A : \ \mathrm{Ch}_A(o_1, o_2). \tag{79}$$

This existential witness does not require an enumeration of the stage domain. By contrast, absence of a noticed difference cannot establish absence of realized change across unobserved stages and channels. Failure to enumerate the domain is therefore not evidence of bearer-complete physical constancy.

7. Continuity, Discreteness, and Representation

7.1 Indices are not ontology

A finite display may select references

$$o_A^{\langle 0 \rangle} \prec_A o_A^{\langle 1 \rangle} \prec_A \cdots \prec_A o_A^{\langle n \rangle}, \tag{80}$$

but the labels do not assert that reality is fundamentally discrete, that every stage is represented, or that n counts all change stages. Stage notation marks selected actual stages; it does not create them or imply that a protocol can locate every intervening stage.

7.2 No smallest change interval

ITOF imposes no universal smallest change magnitude or interval. Domain theories may be discrete, continuous, stochastic, quantum, or hybrid. The expression *continuing extension* denotes the non-cessation of realized stage succession while bearer identity continues; it does not impose order density, topological continuity, adjacency, or a universal minimum interval. The ontological criterion is physical non-equivalence under admissible comparison, not the mathematical granularity of one representation.

7.3 Coarse graining

For a coarse representation $\mathcal{G}$,

$$\mathcal{G}(X_A(o_1)) = \mathcal{G}(X_A(o_2)) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_2)\Big]. \tag{81}$$

A coarse cell may merge physically distinct conditions. It cannot be used to classify the bearer as physically unchanged without a completeness bridge.

7.4 Dense realization and sparse access

A protocol ordinarily links only a finite or sparse part of the realized-reference domain:

$$\text{Im}(\lambda_{A,P}) \subsetneq \mathcal{O}_A \quad \text{for an access-limited protocol.} \tag{82}$$

This is a relation between the image of a representation-to-realization map and the ontic domain, not a type identity between represented support and physical realizations. Sparse access neither creates nor removes unresolved change stages.

7.5 Continuity of identity

Identity continuity need not be represented by mathematical continuity of every selected variable:

$$\begin{aligned} \text{DiscontinuousRepresentation} &\not\models \text{IdentityFailure}(A), \\ \text{SmoothRepresentation} &\not\models \text{IdentityPreservation}(A). \end{aligned} \tag{83}$$

Identity remains a domain-dependent physical criterion.

8. Universality Across Heterogeneous Physical Systems

The universal claim is not uniformity of state content. Each bearer has its own specification, realization domain, condition space, comparison rules, and domain laws. The common structure is typed:

$$A \in \mathbb{S}_{\text{phys}}, \quad o \in \mathcal{O}_A, \quad X_A(o) \in \mathfrak{X}_A, \quad \text{Ch}_A(o_1, o_2), \quad \text{Stage}_A(o).$$

Heterogeneity is preserved:

$$A \neq B \not\models [\mathfrak{X}_A = \mathfrak{X}_B \ \lor \ \mathcal{K}_A = \mathcal{K}_B \ \lor \ \text{Dynamics}_A = \text{Dynamics}_B] \,. \tag{84}$$

Universality combines two commitments: the same bearer-centred type discipline is quantified over arbitrary systems, and all bearer-attributed realizations occupy the same universal prior–later and absolute-simultaneity structure. This does not force all systems into one state space, one dynamics, one clock, one common completed identity-bounded stage cardinality, or one physical condition. Stage correspondence is one-to-one throughout a shared identity extent; completed identity-bounded cardinalities can differ with identity boundaries.

9. Formal Consequences of the Core Construction

The core construction blocks several invalid shortcuts. Order does not entail change:

$$o_1 \prec_A o_2 \not\models \text{Ch}_A(o_1, o_2). \tag{85}$$

A record does not become a source stage or a source-stage range. In the singleton-support case, and separately for a represented realization link,

$$\begin{gathered} \text{RepOf}(r, A, o; P) \not\models r = o, \\ \text{RealizationLinked}_P(\widehat{o}, o) \Longrightarrow o \in \mathcal{O}_A. \end{gathered} \tag{86}$$

For a general record, $r \not\equiv_{\text{type}} \text{StageSupport}_{A,P}(r)$; the record remains distinct from every element and from the set of stages that support its source claim. The second implication warrants source-stage linkage when its bridge is sound; it does not derive the stage, equate it with the record, or identify a unique ordered pair or interval over which the noticed physical difference was realized. Physical change is judged between already realized stages. Absolute simultaneity does not entail common physical content. Stage correspondence is one-to-one throughout every shared identity extent, while a bearer's completed identity-bounded stage cardinality may differ only because its identity begins or ends at a different position in the one extension. No retrospective description supplies a premise in this chain.

10. Realized-Stage Semantics and Boundary Cases

This section verifies that realized-stage ontology preserves the intended temporal meaning without confusing physical stages with records, representations, or observations.

10.1 Three distinct ontological levels

The construction separates: (i) the bearer A; (ii) an actual physical stage $o \in \mathcal{O}_A$ carrying $X_A(o)$; and (iii) the complete physical condition carried by that stage. These types must not be compressed:

$$A \not\equiv_{\text{type}} o, \qquad o \not\equiv_{\text{type}} X_A(o), \qquad \text{Stage}_A(o) \iff o \in \mathcal{O}_A. \tag{87}$$

The stage predicate states domain membership; it does not manufacture a new object or depend on a later proof of change.

10.2 Non-circular dependency

The governed dependency is

$$(\text{Spec}(A), \mathcal{O}_A, X_A, \iota_A, I_A, \prec_A, \chi_A^{\text{full}}, \mathcal{K}_A, \equiv_{\text{phys}}, \not\equiv_{\text{phys}}) \longrightarrow \text{Ch}_A\,. \tag{88}$$

Here $\mathcal{O}_A$ is already the realized-stage domain. No stage–change–stage cycle arises: physical realization fixes stage membership, and the change predicate judges non-equivalence between ordered stages.

10.3 Physical difference and stage distinction

If $\text{Ch}_A(o_1, o_2)$, the references are distinct ordered stages and their difference is physical rather than nominal:

$$\text{Ch}_A(o_1, o_2) \Longrightarrow [o_1, o_2 \in \mathcal{O}_A \wedge o_1 \neq o_2 \wedge X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2)]\,. \tag{89}$$

The converse from two stages to direct change between them is not automatic. Direct change still requires Equation (60).

10.4 First and last accessible records

A first or last surviving record delimits access, not the stage domain:

$$\text{FirstRecord}_P(\hat{o}) \not\models \text{FirstRealization}(o), \qquad \text{LastRecord}_P(\hat{o}) \not\models \text{FinalRealization}(o). \tag{90}$$

A record may be linked to one stage or to a range of stages, depending on the physical acquisition process. In neither case does its position in an archive create the source stage.

10.5 Intermediate unresolved stages

Suppose a protocol links records to $o_1 \prec_A o_2$ and establishes $\text{Ch}_A(o_1, o_2)$. It does not follow that no other stages occurred between them:

$$\text{Ch}_A(o_1, o_2) \not\models \neg\exists u \in \mathcal{O}_A\,[o_1 \prec_A u \prec_A o_2]. \tag{91}$$

Nor does the absence of separate records for intermediate stages imply that they were physically identical or absent. Continuing change can remain unresolved across many stages before a difference becomes noticeable.

No identity-preserving static tail is admitted. A later stage reached through continuing change remains distinct even when its complete condition recurs, as fixed by Equations (63)–(64).

10.6 Stage extension and sustained change

Sustained change has stronger quantifier scope than the existence of a finite observed chain. The interval form, stated here for immediate semantic closure and repeated in the dedicated postulate section, is:

$$\begin{aligned} \mathrm{SC}(A) \iff \forall o_1, o_2 \in \mathcal{O}_A : \quad & [o_1 \prec_A o_2 \wedge I_A(o_1, o_2)] \\ & \Rightarrow \exists u, v \in \mathcal{O}_A \left[o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge \mathrm{Ch}_A(u, v)\right]. \end{aligned} \tag{92}$$

The equation does not treat change as a property of one isolated stage, require adjacent or enumerable stages, assign a metric, or imply observational accessibility. It states that no identity-preserving interval of the continuing succession is physically changeless. One-to-one stage correspondence throughout a shared identity extent follows separately from the absolute-simultaneity structure in Equations (46)–(51).

10.7 Identity termination

If identity does not continue beyond o, the legal identity relation yields the exact boundary condition

$$\neg\, \mathrm{IdCont}_A(o) \iff \neg \exists u \in \mathcal{O}_A \big[o \prec_A u \wedge I_A(o, u)\big]. \tag{93}$$

Accordingly, $\mathrm{SC}(A)$ imposes no later-stage obligation on the terminated bearer. Continuing matter, fields, components, products, or descendants are assigned to successor systems. Once such a successor is physically specified as a system, the universal postulate applies to it under its own identity; particular empirical claims remain bearer specific.

10.8 Descriptive past is downstream

A retrospective description may collect propositions of the form $o \in \mathcal{O}_A$, $o_1 \prec_A o_2$, and $\mathrm{Ch}_A(o_1, o_2)$ only after their physical or evidential grounds are established. It does not enter their definitions, supply a cause, or condition sustained change. Conversely, physical stages and change can occur without being recorded or reconstructed.

10.9 Measurement closure without stage-domain typing

Evidence can warrant a physical difference between linked stages under a declared claim-level specification:

$$\left.\begin{array}{c} \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [o_1, o_2 \in \mathcal{O}_A \wedge o_1 \prec_A o_2]\,, \\ \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [I_A(o_1, o_2)]\,, \qquad \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [(o_1, o_2) \in \mathcal{K}_{A,Q}]\,, \\ \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \left[X_{A,Q}(o_1) \not\equiv^{\mathrm{proj}}_{A,Q} X_{A,Q}(o_2)\right], \\ \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \left[\mathrm{ProjDiffSound}_{A,Q}(o_1, o_2)\right] \end{array}\right. \Longrightarrow \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [\mathrm{Ch}_A(o_1, o_2)]\,. \tag{94}$$

The evidence warrants the noticed difference and its bearer attribution. It does not create the stages and, because change continues across unresolved stages, does not normally identify a unique ordered pair or interval over which the physical difference was realized.

10.10 Temporal semantic closure

The temporal definition maps the one-extension, direct-order, and absolute-simultaneity structure to its descriptive meaning without reproducing physical content:

$$\text{DescriptiveMeaning} : \mathcal{E}_{\mathrm{U}} \longmapsto \mathsf{T}_{\mathrm{ITOF}}. \tag{95}$$

The output contains no energy, state vector, physical stage content, causal mechanism, or cause of physical change.

10.11 Stage content and completed identity-bounded cardinality

Realized stages retain bearer attribution. The physical conditions carried by absolutely simultaneous stages can differ between systems, and the changes established across the systems' respective ordered intervals can likewise differ. By Equations (46)–(51), stages correspond one-to-one and preserve order throughout every shared identity extent, with equal cardinality only as a set-theoretic consequence. The universal relations $\prec_{\mathrm{U}}$ and $\sim_{\mathrm{abs}}$ do not turn that consequence into duration, rate, magnitude, or metric, and they do not equalize complete physical conditions, change magnitude, clock readings, or proper-time values.

The identity-bounded cardinality N_A^{st} is defined in Equation (52). It becomes complete with respect to that bearer identity only after the identity terminates; completion does not imply finiteness or countability, and the cardinality is not a temporal amount. Unequal completed cardinalities are attributable to different identity beginnings or endings in the one extension, not to a failure of one-to-one correspondence during the same shared extent.

10.12 Audit criterion

Every equation using a stage symbol must restrict that symbol to $\mathcal{O}_A = \mathcal{S}_A^{\mathrm{ch}}$, explicitly or by inherited typing. Every change equation must display or inherit order, same-bearer identity continuation, admissible comparison, and complete-condition non-equivalence. Every record equation must keep the record, its recording bearer, and its source-stage support distinct. This criterion governs the remaining applications and appendices.

11. Worked Application Patterns

The following patterns apply the realized-stage architecture without altering the domain physics. They are not additional definitions; they are templates for checking that each application starts from a declared bearer and actual stages, then establishes change through a sound bearer-level bridge.

11.1 Atomic emission or absorption

Let A be an atom and $o_1 \prec_A o_2$ two physically realized references. The observation of emitted or absorbed radiation does not make radiation energy a bearer and does not classify the endpoints as stages by itself. The derivation is

$$\begin{aligned}&\mathrm{AtomSpecified}(A) \wedge o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \wedge \mathrm{TransitionTransfer}_A(o_1, o_2) \neq 0 \\ &\wedge \mathrm{EndpointAttributionSound}_A(o_1, o_2) \Longrightarrow \mathrm{Ch}_A(o_1, o_2).\end{aligned} \tag{96}$$

The implication belongs to atomic and measurement physics; the endpoints are already actual stages of the atom. Equal energy at the endpoints would not establish complete equivalence, because other bearer-attributable components can differ.

11.2 Localized material change

Let P_0 be a surface, boundary region, defect zone, or local component of material bearer A. A local physical difference establishes bearer change only through the declared part-to-bearer rule:

$$\begin{aligned}&P_0 \subseteq_{C_A} A \wedge o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \wedge \mathrm{PartBridgeSound}_{P_0 \to A}(o_1, o_2) \\ &\wedge \mathrm{PartDiff}_{A,P_0}(o_1, o_2) \Longrightarrow \mathrm{Ch}_A(o_1, o_2).\end{aligned} \tag{97}$$

The derivation does not require total structural reconstruction. A physically attributable local difference is sufficient even when the macroscopic identity and most measured properties remain unchanged.

11.3 Genetic difference

For a declared biological bearer, genetic content may be one component of the complete condition. If the bearer level and sampling relation are fixed, then

$$\begin{aligned}&\mathrm{GeneticBearerFixed}(A) \wedge \mathrm{SampleAttributionSound}_A(o_1, o_2) \wedge o_1 \prec_A o_2 \\ &\wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \wedge G_A(o_1) \neq G_A(o_2) \\ &\wedge \mathrm{GeneticBridgeSound}_A(o_1, o_2) \Longrightarrow \mathrm{Ch}_A(o_1, o_2).\end{aligned} \tag{98}$$

The linked source realizations are stages by their membership in $\mathcal{O}_A$; the genetic bridge establishes change between them. The inference must control mosaicism, contamination, sequencing error, lineage ambiguity, and a mismatch between molecular, cellular, tissue, and organismal bearer levels. Phenotypic change is not required for the genetic difference to be physically real.

11.4 Clock-system change

A clock reading is an output of clock bearer C under a declared readout protocol P. If two readings are linked to ontic realizations and the readout bridge is sound,

$$\begin{aligned}&c_1 \prec_C c_2 \wedge I_C(c_1, c_2) \wedge (c_1, c_2) \in \mathcal{K}_C \wedge \mathrm{ReadoutBridgeSound}_{C,P}(c_1, c_2) \\ &\wedge N_{C,P}(c_1) \neq N_{C,P}(c_2) \Longrightarrow \mathrm{Ch}_C(c_1, c_2) \Longrightarrow \mathrm{Stage}_C(c_1) \wedge \mathrm{Stage}_C(c_2).\end{aligned} \tag{99}$$

This is a change claim about the clock system. It does not identify the numerical reading with time, nor does it assign the clock's stages to another bearer.

11.5 Remote astrophysical records

Let A be a remote source. Detector records r_1, r_2 are not source stages. The inference requires source attribution, emission reconstruction, propagation control, and a sound condition bridge:

$$\begin{array}{c} \mathrm{SourceLinked}_P(r_1, o_1), \quad \mathrm{SourceLinked}_P(r_2, o_2), \\ o_1 \prec_A o_2, \quad I_A(o_1, o_2), \quad (o_1, o_2) \in \mathcal{K}_A, \\ \mathrm{PropagationControlled}_P(r_1, r_2), \quad \mathrm{DifferenceBridgeSound}_A(r_1, r_2) \end{array} \Vdash_{P,\alpha} \mathrm{Ch}_A(o_1, o_2). \tag{100}$$

Only the linked source stages belong to the source bearer; detector records remain records of the detector system. Arrival separation, emission separation, and propagation difference remain distinct physical or operational quantities.

11.6 Quantum stationary representation

Suppose a model assigns a stationary representation to bearer A. The equation

$$\rho_A(o_1) = \rho_A(o_2)$$

does not decide whether the full comparison status of (o_1, o_2) is equivalent. A no-change conclusion requires a completeness bridge; a change conclusion requires a sound witness of non-equivalence. Thus the two admissible routes are

$$\begin{aligned} &\rho_A(o_1) = \rho_A(o_2) \wedge \mathrm{RepresentationComplete}_A(o_1, o_2) \\ &\quad \Longrightarrow \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big], \\ &\mathrm{QuantumWitnessSound}_A(o_1, o_2) \wedge W_A(o_1) \neq W_A(o_2) \\ &\quad \Longrightarrow \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)\Big]. \end{aligned} \tag{101}$$

Here $\mathrm{RepresentationComplete}_A(o_1, o_2)$ abbreviates an independently justified bridge showing that the quantum representation captures every physically relevant distinguishing component and relation and warrants $(o_1, o_2) \in \mathcal{K}_A$. The predicate $\mathrm{QuantumWitnessSound}_A(o_1, o_2)$ likewise includes sound bearer attribution, realization linkage, admissible full comparison, and a valid route from the selected quantum witness to complete-condition non-equivalence. Without one of these bridges the result is indeterminate. A change conclusion follows only on the second route or through another sound bearer-level witness; stage membership is independent of that conclusion.

11.7 Periodic return

Let $o_0 \prec_A o_1 \prec_A o_2$, with $(o_0, o_2) \in \mathcal{K}_A$, $X_A(o_0) \equiv_{\mathrm{phys}} X_A(o_2)$, and intermediate non-equivalence. Then

$$\mathrm{Ch}_A(o_0, o_1) \wedge \mathrm{Ch}_A(o_1, o_2) \Longrightarrow o_0 \neq o_2. \tag{102}$$

Endpoint equivalence does not merge o_0 and o_2, erase o_1, or reverse order. The time definition describes the extension and ordering of the realized stages, not the endpoint distance in a chosen state representation.

11.8 Identity termination

Assume $o_1 \prec_A o_2$ and that o_2 is the last realization still attributable to A under I_A. Both o_1 and o_2 are stages of A by membership in $\mathcal{O}_A$. But a later realization u of a successor bearer B is not placed in $\mathcal{O}_A$:

$$\text{IdentityFailure}_A(o_2) \wedge \text{Successor}(B, A) \Longrightarrow u \in \mathcal{O}_B \quad \text{and} \quad u \notin \mathcal{O}_A. \tag{103}$$

Here u denotes the successor realization. Continued physical change is analyzed under B's specification; it is not manufactured by extending the identity of A.

11.9 Subthreshold difference

Suppose a validated physical distance d_A satisfies

$$0 < d_A(X_A(o_1), X_A(o_2)) < \varepsilon^{\text{phys}}_{A,P}.$$

The difference is ontically sufficient for change even when protocol P does not register it:

$$\begin{aligned} &o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \wedge d_A(X_A(o_1), X_A(o_2)) > 0 \\ &\Longrightarrow \text{Ch}_A(o_1, o_2), \end{aligned} \tag{104}$$

while

$$\text{Undetected}_P(o_1, o_2) \tag{105}$$

remains an epistemic statement about the protocol.

11.10 No identity-preserving static tail

An identity-preserving static tail is rejected as physically unreal and logically incompatible with sustained change. It is mentioned only in the negative: continued stages under preserved identity cannot form a changeless continuation. Repeated records, observational silence, or unresolved differences do not establish such a continuation; they show only the limits of the protocol.

11.11 Pattern summary

Every worked case follows the same disciplined sequence:

$$\begin{gathered} \text{fix bearer and realized stages} \longrightarrow \text{establish order and comparison}, \\ \text{establish physical non-equivalence} \longrightarrow \text{warrant realized change}, \\ {\scriptstyle \begin{matrix}\text{follow the already realized succession} \\ \text{under preserved identity}\end{matrix}} \longrightarrow {\scriptstyle \begin{matrix}\text{test sustained change} \\ \text{on each non-zero interval}\end{matrix}}, \\ \text{apply temporal definition} \longrightarrow \text{describe extension and order only}. \end{gathered} \tag{106}$$

No step inserts a retrospective description into the system's dynamics, and no step uses temporal meaning as a cause or proof of change.

12. Universal Physical Change and Its Proof Architecture

12.1 The postulate

Universal sustained-change postulate. ITOF postulates that physical change in a system does not occur once and then end while the bearer's identity remains preserved. Every non-zero interval of the bearer's identity-preserving stage succession contains realized physical change, whether or not that change is noticeable to an observer or resolvable by a protocol. The postulate ranges over physical systems throughout the universe. It does not assign an independent extension of change stages to non-systemic or non-structural physical factors considered only as roles, transfers, operative quantities, boundary conditions, couplings, or constraints; nor does it assign such extension to values or representations. A physical system that acts as a factor remains included in the postulate as a system. The postulate concerns the continuation and extension of change across physical systems. Its causes and mechanisms remain physical questions for the relevant bearer, interactions, and domain laws; they are not supplied by the postulate or by time.

Let $\mathrm{IdCont}_A(o)$ mean that the identity criterion for A remains physically applicable to at least one actually realized later reference:

$$\mathrm{IdCont}_A(o) \iff \exists u \in \mathcal{O}_A \big[o \prec_A u \wedge I_A(o,u) \big]. \tag{107}$$

The predicate is ontological rather than observational. It is a lawlike condition evaluated wherever later identity continuation is physically realized; it is not a prediction inferred solely from the latest available record, does not presuppose a completed future record, and introduces no retrospective-description variable.

A bearer has non-trivial identity extension when at least one ordered same-bearer pair is physically realized:

$$\mathrm{IdExtended}(A) \iff \exists o, u \in \mathcal{O}_A \big[o \prec_A u \wedge I_A(o,u) \big]. \tag{108}$$

The postulate ranges over the full physical-system domain $\mathbb{S}_{\mathrm{phys}}$; no physical-system class is removed from its scope. The identity-extension antecedent states the minimum realized range on which a proposition about *sustained* change has non-zero content. It is an application condition inside the universal statement, not a restriction to a privileged subset of systems:

$$\forall A \in \mathbb{S}_{\mathrm{phys}} : \quad \mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A). \tag{109}$$

A bearer for which no ordered same-identity pair is available does not constitute a static exception; the sustained-interval claim is simply not instantiated until such an identity-preserving interval is physically realized. Non-systemic or non-structural physical factors considered only as roles, transfers, operative quantities, boundary conditions, couplings, or constraints remain outside $\mathbb{S}_{\mathrm{phys}}$; values and representations are also not bearers. A physical system acting in a factor-role remains included as a system.

The systemwise postulate is

Sustained change without retrospective dependence

$$\begin{aligned}\mathrm{SC}(A) \Longleftrightarrow \forall o_1, o_2 \in \mathcal{O}_A :\quad & [o_1 \prec_A o_2 \wedge I_A(o_1, o_2)] \\ & \Rightarrow \exists u, v \in \mathcal{O}_A \ [o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge \mathrm{Ch}_A(u, v)].\end{aligned} \tag{110}$$

$$\forall A \in \mathbb{S}_{\text{phys}} : \quad \mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A), \tag{111}$$

which restates Equation (109) inside the governing box.

The formula is an identity-preserving interval statement. It does not treat change as a property located in one isolated stage; it requires only that every non-zero stage interval within the continuing identity contain at least one ordered pair for which bearer-complete physical non-equivalence is realized. The predicate $\mathrm{Ch}_A(u, v)$ carries same-bearer identity, prior–later order, admissible comparison, and complete-condition non-equivalence. The antecedent $\mathrm{IdExtended}(A)$ prevents a sustained-interval assertion from being treated as a substantive result when no non-zero same-identity interval is physically realized, without excluding any physical-system class from the universal scope.

The stage succession is physically realized independently of the postulate; $\mathrm{SC}(A)$ does not create or generate its stages. It is evaluated over the identity-bounded succession and asserts change throughout every non-zero interval of that succession. Write

$$\mathrm{ContinuedExtSucc}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A] \Longleftrightarrow \mathrm{IdBoundedGenOrd}_{\iota_A}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A]. \tag{112}$$

Here $\mathrm{ContinuedExtSucc}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A]$ denotes the identity-bounded strict total order of all realized change stages under the bearer criterion ι_A. The term *continued* describes the realized succession while identity remains applicable; it does not mean that the postulate produces the stages. Physical division does not branch time: coexisting components remain within the complete condition of one bearer, or independently attributable successors receive new bearer tags. The definition allows the boundary case in which one change pair is realized and bearer identity then terminates; it therefore does not by itself assert the three-stage extension required by ExtSucc. Genuine extension beyond one changed pair follows only when the identity range contains at least three ordered realized stages:

$$\begin{aligned}&\mathrm{SC}(A) \wedge \exists S_0, S_1, S_2 \in \mathcal{S}_A^{\mathrm{ch}} \, [S_0 \prec_A S_1 \prec_A S_2] \\ &\qquad \Longrightarrow \mathrm{ExtSucc}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A].\end{aligned} \tag{113}$$

Neither notation requires continuation after the identity of A terminates. The converse does not follow from a finite already-realized segment:

$$\mathrm{FiniteExtSucc}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A] \not\models \mathrm{SC}(A). \tag{114}$$

A finite set of realized changes does not prove that change continues throughout every later identity-preserving realization.

12.2 Why the postulate is not analytic

The postulate is not obtained from the definition of time, the definition of change, or the stage predicate. Those definitions state meanings and local criteria. Universal sustained change requires physical support from domain laws, effective causes, evidence, and class coverage. Its universal quantifier leaves the claim open to direct adverse evidence: one physically realized, identity-preserving non-zero continuation whose relevant comparisons are complete and whose complete conditions remain equivalent throughout would contradict $\mathrm{SC}(A)$. Incomplete access yields indeterminacy, not confirmation and not refutation. The identity-preserving static tail is excluded only negatively as incompatible with the postulate, not retained as an alternative physical construction.

12.3 Ordered proof programme

The proof programme proceeds in three routes. First, it identifies effective internal processes and actual external engagements whose effects reach the bearer. Second, it tests change through observations, measurements, and records. Third, it confronts difficult candidate classes and attempts to exclude complete identity-preserving physical constancy.

12.4 First route: effective causes of change

A domain-valid effective cause bridge has the form

$$\begin{aligned} o \prec_A o' \wedge I_A(o,o') \wedge (o,o') \in \mathcal{K}_A \wedge \mathcal{C}_A^{\mathrm{eff}}(o,o') \wedge \mathrm{CauseBridgeSound}_A(o,o') \\ \Longrightarrow \mathrm{Ch}_A(o,o'). \end{aligned} \tag{115}$$

A sufficient class route must cover every non-zero identity-preserving stage interval:

$$\begin{aligned} &\Big[\forall A \in \mathcal{C}_k\ \forall o_1, o_2 \in \mathcal{O}_A :\ \big(o_1 \prec_A o_2 \wedge I_A(o_1,o_2)\big) \Rightarrow \exists u, v \in \mathcal{O}_A \\ &\qquad \big[o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge I_A(u,v) \wedge (u,v) \in \mathcal{K}_A \\ &\qquad\quad \wedge\, \mathcal{C}_A^{\mathrm{eff}}(u,v) \wedge \mathrm{CauseBridgeSound}_A(u,v)\big]\Big] \\ &\qquad\qquad \Longrightarrow \forall A \in \mathcal{C}_k :\quad \big[\mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A)\big]. \end{aligned} \tag{116}$$

The cause predicate does not replace the domain bridge or comparison premises, and the interval quantifiers do not identify a unique ordered pair or subinterval over which every realized difference occurs.

12.5 Internal processes

Internal operation includes physically realized interactions among constituents, transport, reaction, relaxation, quantum coupling, field evolution, metabolism, repair, mutation, stress redistribution, and other bearer-specific processes. Which process is sufficient for change is supplied by the relevant physical theory.

12.6 External engagements and the identity of influencing systems

An influencing system retains its identity as a system while performing a factor-role:

$$\mathrm{System}(B) \wedge \mathrm{Influences}(B, A) \Longrightarrow \mathrm{System}(B) \wedge \mathrm{FactorRole}(B \to A). \tag{117}$$

12.7 Permanent neutrality and exact cancellation

A universal proof must exclude permanent neutrality and exact eternal cancellation of every physically attributable channel, not merely fail to detect a change:

$$\neg\, \mathrm{ProvedChange}(A) \not\models \mathrm{WarrantedCompleteConstancy}(A). \tag{118}$$

12.8 Second route: finite evidence

A sound finite witness can establish particular change:

$$\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [o_1, o_2 \in \mathcal{O}_A \wedge \mathrm{Ch}_A(o_1, o_2)]\,. \tag{119}$$

Finite evidence does not establish every later continuation, but it can test the physical bridges used by the universal programme.

12.9 Third route: difficult-class exclusion

For a physical class $\mathcal{C}_k$, the target is

$$\forall A \in \mathcal{C}_k : \quad [\mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A)]. \tag{120}$$

Universal synthesis additionally requires a bearer-complete cover

$$\mathbb{S}_{\mathrm{phys}} = \bigcup_{k \in K} \mathcal{C}_k. \tag{121}$$

12.10 Negative exclusion of a static tail

The universal postulate excludes an identity-preserving changeless continuation. Before complete physical equivalence can be quantified over a later continuation, the relevant comparisons must be admissibly defined. Let

$$\begin{aligned} \mathrm{CmpComplete}_A(o_*) \Longleftrightarrow \forall u, v \in \mathcal{O}_A : \quad & [o_* \preceq_A u \prec_A v \wedge I_A(u, v)] \\ & \Longrightarrow (u, v) \in \mathcal{K}_A. \end{aligned} \tag{122}$$

This is a comparison-completeness condition only; it does not define or admit a static physical object.

The exclusion is then stated directly and only in negative form:

No identity-preserving static tail

$$\begin{aligned}\forall A \in \mathbb{S}_{\text{phys}}\ \forall o_* \in \mathcal{O}_A: \quad & \mathrm{SC}(A) \wedge \mathrm{IdCont}_A(o_*) \wedge \mathrm{CmpComplete}_A(o_*) \\ & \Longrightarrow \neg \begin{bmatrix} \forall u, v \in \mathcal{O}_A: & o_* \preceq_A u \prec_A v \wedge I_A(u,v) \\ & \Longrightarrow X_A(u) \equiv_{\text{phys}} X_A(v) \end{bmatrix}. \end{aligned} \tag{123}$$

This is not a positive definition of a static object or an admitted physical branch. It records that, where the later continuation is bearer-completely comparable, continuing identity and continuing stages cannot remain physically equivalent throughout under $\mathrm{SC}(A)$. A later stage may recur to a condition physically equivalent to an earlier one, but recurrence remains later and does not erase intervening change.

A finite quiet window or repeated equal record does not establish either complete comparison or complete constancy:

$$\mathrm{NoResolvedDifference}_{P,I}(A) \not\models \begin{bmatrix} \mathrm{CmpComplete}_A(o_*) \\ \wedge \begin{pmatrix} \forall u, v \in \mathcal{O}_A: & o_* \preceq_A u \prec_A v \wedge I_A(u,v) \\ & \Longrightarrow X_A(u) \equiv_{\text{phys}} X_A(v) \end{pmatrix} \end{bmatrix}. \tag{124}$$

Here $\mathrm{NoResolvedDifference}_{P,I}(A)$ is a bounded protocol-level null result on window I, not a bearer-complete judgment over continuing stages. Incomplete comparison yields indeterminacy about what the protocol resolved, not a physically real static tail.

12.11 Present proof status

The manuscript supplies a formally articulated universal-proof architecture whose universal empirical closure remains explicitly open. Completion of that closure requires complete bearer-class coverage and domain-valid cause and comparison bridges. No positive static-tail construction is retained. The only relevant statement is the negative exclusion of an identity-preserving static tail, and observational silence is never treated as evidence of absolute changelessness.

13. Physical Realization: Constitution and Engagement

Every realized later condition depends on the physical constitution of the bearer and on the engagements that operate on or through it. Internal and external are not alternative sources selected after the outcome. They are relational descriptions of one realized physical process.

The interval-operative engagement term $\Xi_A[o_1, o_2]$, introduced with the complete-condition rule, contains the physically supported engagements relevant to the continuation of A between two ontic realizations. By construction, it does not duplicate bearer-attributable relational or coupling states already recorded in the endpoint conditions. A domain theory may represent the later condition by

$$X_A(o_2) \in \mathfrak{R}_A(X_A(o_1), \Xi_A[o_1, o_2])\,, \tag{125}$$

where $\mathfrak{R}_A$ is a domain-specific realization relation. It may be deterministic, stochastic, quantum, field-theoretic, thermodynamic, biological, or effective [16]. Equation (125) does not replace those theories. It records the general attribution structure shared by them.

13.1 The complete system conditions every result

The internal constitution of A includes the structure, constituents, cohesion, resistance, tolerances, stored energy, internal fields, and operative relations that determine how engagements are realized. The same external input can yield different outcomes in systems with different constitutions. Conversely, the same system can yield different outcomes under different engagements.

The later condition is therefore not produced by an external factor acting on an otherwise contentless object. Nor is it produced by an isolated internal essence independent of the physical world. Realized change belongs to the complete system under the actual physical conditions that reach and operate through it.

13.2 Response is not an extra component

The term *response* describes how the bearer deals with the engagements that reach it, given its complete constitution. It is not a separate material constituent, an intermediate stage inserted between two conditions, or an independent term that must be added to every physical equation. The realized later condition is the physical result; response is a semantic description of the system-dependent manner of realization.

This distinction prevents double counting. If elasticity, resistance, reaction rates, coupling strengths, and tolerances are already included in $X_A(o_1)$ and the domain laws, adding an independent “response variable” without new physical content would duplicate what the system already is.

13.3 Systems as factors in relations

A physical system may function as a factor in relation to another system while remaining a system with its own realized physical past. A star is a system and can also be a radiative or gravitational factor for a planet. A detector is a system and can function as a factor in the measurement interaction. A human-built device is physically constituted and can affect other systems without acquiring a special ontological category.

Influence is relational and conditional. Not every system affects every other system, and the existence of two systems does not imply an operative coupling between them. A physically supported path, field, transfer, contact, signal, or other mechanism is required for attribution.

13.4 Internal operation without a newly identified external perturbation

A system can change through internal operation even when no new external perturbation is identified during the selected interval. Radioactive decay, internal relaxation, chemical rearrangement, defect migration, metabolic operation, and intrinsic field dynamics provide familiar forms. The claim is not that the system is detached from all physical conditions; it is that the operative source of the resolved difference is attributed to the internal structure and dynamics already included in the bearer description.

The internal/external distinction is therefore analytical, not ontological duplication. Both descriptions refer to physical content and relations. Time is not added to either side as an agent.

14. Laws, Models, Probability, and Physical Attribution

ITOF is an ontological and temporal framework rather than a universal dynamical equation for all bearers. The physical continuation of each system is realized under its physical constitution, interactions, and boundary conditions, and is described or predicted by the relevant domain theories, effective models, and empirically warranted laws. The framework specifies how the physically realized continuations represented by those theories enter an ontology of change and temporal order.

14.1 Deterministic descriptions

In a deterministic model, an initial condition and the operative physical relations may select one continuation. Equation (125) then reduces, at the chosen level of description, to a single-valued evolution rule. The model parameter used in that rule can be a coordinate time, proper time, affine parameter, phase, sequence index, or another physical-theory parameter.

ITOF locates that parameter within the domain theory's dynamical or representational apparatus. Temporal meaning is reserved for the one universal extension and the invariant, non-reversing succession of realized change stages across physical systems. The model parameter quantifies, labels, or organizes physical development; it neither creates that succession nor alters its temporal meaning.

14.2 Stochastic and quantum descriptions

A stochastic model may assign a transition kernel

$$\mathbb{P}_A(dx_2 \mid X_A(o_1), \Xi_A[o_1, o_2])\,, \qquad x_2 \in \mathfrak{X}_A \tag{126}$$

rather than a unique later condition. Here x_2 is a candidate later condition in the bearer-relative condition space $\mathfrak{X}_A$, and the differential notation denotes a probability measure on such candidates conditional on the prior complete condition and the declared interval-operative engagements. The realized value $X_A(o_2)$, when one is selected by the adopted physical ontology, is not identical to the distribution over candidates. The distribution represents warranted possibilities, propensities, frequencies, or statistical structure according to the adopted physical interpretation. It is not automatically identical to the ontic-reference domain.

The same discipline applies to quantum theory. A state vector, density operator, amplitude, path-integral construction, branch structure, hidden-variable structure, or event record can play different ontological and predictive roles under different interpretations. ITOF does not add a collapse mechanism and does not select in advance a single-outcome, many-branch, relational, histories-based, hidden-variable, collapse, or other quantum ontology. This non-selection is not ontological indifference. The adopted interpretation must state explicitly which physical structures are realized, which bearers they belong to, which realized stages carry their conditions, and whether a proposed collapse, branch, trajectory, or update is physical or merely representational or epistemic. Once that declaration is made, ITOF applies its identity, order, comparison, and sustained-change criteria to the declared physical content.

Thus, the formal probability space is not automatically identified with the ontic-reference domain of the bearer, but neither is it automatically excluded from physical ontology. The mapping is interpretation dependent and must be explicit. A physically realized, bearer-complete changeless continuation would be a direct challenge to the sustained-change postulate; ITOF may not protect the postulate by inventing unspecified hidden change. Where representation completeness or physical realization remains unresolved, the result remains unresolved at bearer level rather than becoming either complete constancy or established change.

14.3 Effective theories and levels of description

An effective model can be valid within a scale and domain even when it omits finer degrees of freedom. Its variables may establish change in the represented physical quantities. They establish complete physical constancy only if the effective description is demonstrated complete for that claim.

This asymmetry is important. A difference in one sound physical variable is enough to prove non-equivalence. Constancy of a limited variable is not enough to prove equivalence of the complete condition. The evidential burden for bearer-complete physical equivalence throughout continuation is therefore stronger than the burden for witnessed change.

14.4 Causation and temporal order

A causal relation is not identified with temporal order, although causal processes normally contain or imply ordered physical relations. The statement that one physical event causes another includes domain-specific dependence, mechanism, intervention, or lawlike structure beyond the bare fact that one is prior to the other.

ITOF therefore does not derive causation from the universal prior–later relation or from absolute-simultaneity placement. Nor does it treat temporal meaning, universal ordering, or synchronization as the cause that drives systems from one condition to another. Causal and dynamical efficacy belongs to physical systems, fields, interactions, and realized constraints. Physical change distinguishes the complete conditions carried by ordered realized stages. Time then expresses the one universal extension, the invariant non-reversing succession of those stages, and the distinct absolute-simultaneity relation; no equality of physical conditions, clock readings, or numerical stage labels is inferred.

14.5 Derivative discipline

A derivative belongs to a declared dynamical or representational model. It can establish constancy or variation of the differentiated model object only under the stated parameterization, function-space, connected-domain, and regularity assumptions. It does not define time, directly define physical change, or create change stages. Its ontological use requires an explicit realization, attribution, order-preservation, and difference-soundness or completeness bridge to the bearer's physical condition:

$$\begin{gathered}\left[I_\xi \text{ is connected} \wedge z \text{ is differentiable on } I_\xi \wedge \forall \xi \in I_\xi : \frac{dz}{d\xi}(\xi) = 0\right] \\ \Longrightarrow \mathrm{Const}_{I_\xi}(z), \\ \mathrm{Const}_{I_\xi}(z) \not\models \mathrm{WarrantedCompleteConstancy}(A).\end{gathered} \tag{127}$$

Here $\mathrm{Const}_{I_\xi}(z)$ means that the differentiated model object has one constant value throughout the declared connected domain I_ξ in the relevant function space. It is a statement about z, not about the complete bearer condition. Likewise, a non-zero derivative can support change only when the represented variation is physically attributed to the bearer and cannot be produced merely by reparameterization, coordinate change, gauge choice, calibration change, or another representational transformation. A temporal evolution parameter in a domain model remains a model parameter and is not identical to the ontological meaning $\mathsf{T}_{\mathrm{ITOF}}$.

14.6 Model failure and ontological restraint

When a model fails to predict a record, several conclusions are possible: the model may be inadequate, the bearer may be misspecified, the record may be faulty, or an omitted physical process may be active. The failure does not automatically become evidence that time itself changed or acted.

Likewise, success of a model does not prove that every mathematical element of the representation is a separate physical entity. Ontological attribution requires additional argument. This restraint is applied equally to clocks, coordinates, probability distributions, spacetime metrics, and reconstructed past conditions.

Physical authority of mathematics and geometry. Mathematics and geometry are indispensable instruments of physical analysis, measurement, and prediction. Their internal consistency, however, does not by itself establish physical instantiation or ontological identity. When a construction is used to describe material or physical reality, its physical authority depends on a declared interpretation, a sound attribution bridge, and empirically adequate correspondence with realized physical conditions. Without that correspondence it may remain mathematically meaningful, but it carries no established physical or temporal ontology.

15. Physical Attribution, Quantities, and Representation

The universal postulate applies to physical systems. Many apparent counterexamples or overextensions arise because a property, state label, mathematical object, or measurement is treated as though it were an independent bearer. This section states the attribution rules that must govern every application.

15.1 Representation is subordinate to physical realization

For a declared representation protocol P, write

$$\mathcal{R}_{A,P} : \mathfrak{X}_A \longrightarrow \mathcal{Y}_{A,P}, \qquad Y_{A,P}(o) := \mathcal{R}_{A,P}(X_A(o))\,. \tag{128}$$

Here the declared protocol index P includes the relevant realization-linkage, apparatus, calibration, environmental, and processing conditions required for the represented claim. Equation (128) is a typed representation map, not a claim that a material record is causally determined by $X_A(o)$ alone; the changing instrument and record remain separately specified physical systems where their dynamics matter. In the independently warranted singleton-support case, the physical bearer, its complete condition, its representation, and the corresponding material record remain distinct:

$$A \not\equiv_{\text{type}} X_A(o), \qquad X_A(o) \not\equiv_{\text{type}} Y_{A,P}(o), \qquad Y_{A,P}(o) \not\equiv_{\text{type}} \mathrm{Rec}_{A,P}(o). \tag{129}$$

Representational equality does not establish physical equivalence,

$$Y_{A,P}(o_1) = Y_{A,P}(o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_2)\Big], \tag{130}$$

and representational difference does not establish physical change without a sound bearer and realization bridge:

$$Y_{A,P}(o_1) \neq Y_{A,P}(o_2) \not\models \mathrm{Ch}_A(o_1, o_2). \tag{131}$$

Multiple faithful descriptions may represent one physical realization, while a change of coordinates, gauge, basis, units, calibration, or symbolic convention can change a representation without creating a physical stage. Representation is therefore epistemically indispensable but ontologically subordinate: it can warrant claims about physical reality only under declared linkage and soundness conditions.

15.2 Bearer-first attribution

Every claim of change or complete physical constancy must begin with a declared bearer:

$$A \in \mathbb{S}_{\text{phys}}. \tag{132}$$

Only after A has been fixed may a quantity Q_A, state representation R_A, record r_A, or geometric relation be interpreted. A bare numerical change

$$Q_1 \neq Q_2 \tag{133}$$

has no complete ontological meaning until the physical bearer, realization conditions, units, calibration, and attribution route are stated.

The bearer-first rule prevents two opposite errors. The first is reification: treating energy, temperature, a wavefunction, or a coordinate as a system because it has a symbol and changes numerically. The second is erasure: treating a system as unchanged because one selected quantity is conserved or one representation is stationary.

15.3 Systems and quantities

For a physical quantity Q_A attributed to A,

$$Q_A \not\equiv_{\text{type}} A. \tag{134}$$

The quantity can be indispensable to the system description and can provide a sufficient witness of change, yet it does not inherit system identity merely through attribution. Energy is the most frequent case. If an atom emits a photon, the atomic system changes and the emitted radiation is part of the resulting physical relation. The statement

$$\Delta E_A \neq 0 \tag{135}$$

is evidence about A; it does not introduce a new bearer called "the energy" to which the universal postulate is separately applied.

Conservation laws do not weaken this conclusion. A conserved total quantity can be redistributed among components, forms, modes, or subsystems while the complete condition changes. Thus

$$Q_A(o_1) = Q_A(o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_2)\Big]. \tag{136}$$

The same rule applies to momentum, charge, baryon number where applicable, mass-energy, temperature, entropy, and other physical quantities. Their exact interpretation remains theory dependent.

15.4 Quantum states and physical bearers

A quantum state vector or density operator is written with a bearer index:

$$|\psi_A\rangle, \qquad \rho_A. \tag{137}$$

These objects represent or encode the state of a physical system under a theoretical model. They are not second systems beside the atom, molecule, field apparatus, or composite bearer. Therefore

$$|\psi_A\rangle, \rho_A \notin \mathbb{S}_{\text{phys}} \tag{138}$$

unless one has separately defined a physical system whose identity is not merely the mathematical object.

A change in the state representation can support a change claim when the representation and physical bridge are adequate. Here RepresentationSound$(\rho_A; o_1, o_2)$ abbreviates correct bearer attribution, realization linkage, representational comparison, and a sound bridge from represented difference to complete-condition non-equivalence. The change conclusion additionally requires evidence that the physically grounded order obtains and that comparison is admissible:

$$\begin{aligned}&\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \Big[o_1 \prec_A o_2 \wedge I_A(o_1,o_2) \wedge (o_1,o_2) \in \mathcal{K}_A\Big],\\ &\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \Big[\rho_A(o_1) \neq \rho_A(o_2) \wedge \mathrm{RepresentationSound}(\rho_A; o_1, o_2)\Big] \\ &\qquad \Longrightarrow \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \Big[X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2) \wedge \mathrm{Ch}_A(o_1,o_2)\Big].\end{aligned} \tag{139}$$

The reverse inference is generally invalid. Equality of ρ_A can describe equality of a reduced or ensemble representation while unrepresented correlations, trajectories, environmental conditions, or bearer components differ. A completeness theorem is required before representational equality is promoted to complete physical equivalence.

The global phase of a pure state illustrates the opposite danger. A changing formal phase can be physically unobservable under the relevant model. Formal difference alone does not establish physical non-equivalence:

$$|\psi_A\rangle \neq e^{i\phi}|\psi_A\rangle \quad \text{as vectors when } e^{i\phi} \neq 1, \qquad [|\psi_A\rangle] = [e^{i\phi}|\psi_A\rangle] \text{ in } \mathbb{P}(\mathcal{H}_A). \tag{140}$$

The two vectors represent the same ray, so their symbolic or vector inequality alone supplies no bearer-level physical difference and no change-stage conclusion. Physical distinguishability, not symbolic inequality, governs the change criterion.

15.5 Vacuum and field descriptions

A vacuum state is a state defined within a field theory. It is not automatically an independently bounded physical system. If a cavity field, region, apparatus-field composite, or identity-coherent configuration is proposed as a bearer, its boundary and identity must be declared. The universal postulate then applies to that bearer, not to the word "vacuum" or a ket label detached from physical realization.

This distinction is especially important in arguments from vacuum fluctuations. Non-zero variances, correlation functions, or zero-point energies can be physically significant, but they do not by themselves prove a succession of physically distinguishable complete conditions. Conversely, a stationary vacuum representation does not establish that every physical configuration associated with the model remains physically unchanged. The bridge from representation to bearer must be stated in either direction.

15.6 Geometric and relativistic quantities

Coordinates, metric components, curvature scalars, path lengths, areas, volumes, and proper-time functionals are mathematical or operational quantities. They can represent physical relations and support exceptionally precise measurement, but they are not independent bearers merely because they occur in successful equations:

$$x^\mu,\ g_{\mu\nu},\ R,\ \tau[\gamma] \notin \mathbb{S}_{\text{phys}}. \tag{141}$$

A measured geometric difference must be attributed to a physical configuration, relation, path, field, or instrument. A changing distance between bodies can establish change in their relational configuration when the distance definition and bridge are sound; it does not make "distance" an independently existing system.

Within ITOF, a spacetime manifold is not identified with a literal physical container whose temporal dimension bends or is distorted. It is a mathematical-geometric representation of interval, causal, and dynamical relations among physical bearers. A geometric quantity may be operationally valid for the relation it measures while remaining incomplete as a description of the bearer's full physical condition. Coordinate dependence, idealization, foliation choice, and omitted physical content therefore block automatic transfer from geometric measurement to bearer-complete ontology. If a geometric representation and independently warranted bearer-complete evidence diverge, the representation, bridge, or domain of application must be re-examined; the measured quantity is not promoted into physical reality beyond what its operational definition establishes.

15.7 Records, samples, and reconstructed states

A record is a physical system or physical state of a recording system that stands in an evidential relation to another occurrence. A detector count, photograph, spectrum, memory bit, tissue sample, sequencing read, telescope image, and clock display can all be bearers in their own right when their own physical changes are analysed. When used as evidence about a source A, however, the record remains distinct from every source stage. Its warranted source support may be one stage or a non-empty range of stages:

$$\mathrm{StageSupport}_{A,P}(r) \in \mathcal{P}(\mathcal{O}_A) \setminus \{\varnothing\}. \tag{142}$$

The singleton case represents a physically justified one-stage link; the non-singleton case represents acquisition, integration, propagation, or reconstruction over a stage range. The record is not identical with its source support. This prevents the first surviving record from being inferred to be the first source stage, or the first record showing a noticeable difference from being treated as the unique locus of a change relation that is established only across ordered stages. Record destruction likewise does not erase the source's past physical stages or changes.

A material sample requires the same distinction. The sample can be a present physical system and can also carry evidence about an earlier state of the sampled source. Its own current condition and its evidential relation to the source are separate claims.

15.8 No transfer by shared numerical range

Two quantities can share the real numbers as a codomain and remain different by physical type. Clock reading, coordinate time, temperature, energy, and a statistical score can all be numerical without becoming one physical quantity. Therefore

$$Q_1, Q_2 : \mathcal{D} \to \mathbb{R} \not\models Q_1 \equiv_{\mathrm{type}} Q_2. \tag{143}$$

Likewise, successful prediction of one quantity does not establish an ontology for another. A bridge must specify the source quantity, target claim, physical mechanism or representation, conditions of validity, and adverse outcomes.

15.9 Attribution audit

Before any equation is used to support universal change, the following questions must be answered:

(1) Which symbol denotes the physical system?

(2) Which symbols denote its properties, states, measurements, or representations?

(3) Is the difference physically attributable to the declared system?

(4) Does equality of the selected quantity cover the complete condition?

(5) Is the inference ontological, dynamical, operational, or evidential?

(6) What bridge would fail if the apparent difference were an artefact?

(7) Does the argument remain valid when the system acts as a factor for another system?

Attribution rule. A quantity, state representation, geometric measure, or record can establish change only through a valid attribution to a physical system. It does not become the system, and its equality does not establish bearer-complete physical equivalence unless representational completeness has independently been proved.

16. Identity, Persistence, Transformation, and Failure

Physical change is more general than damage, degradation, failure, or identity loss. A bearer can change while preserving its identity, principal function, outward form, and classification. A local difference can be physically real even when it is neutral under the criterion that matters for a particular application.

Outcome classes must therefore be declared separately from change. Let Q be a criterion such as structural integrity, function, performance, viability, or identity. A later condition may be classified relative to Q as beneficial, neutral, degrading, failed, or indeterminate. These classifications presuppose that the physical comparison has already been made; they do not define change itself.

16.1 Persistence through change

Identity criteria are often tolerant rather than exact. A clock remains the same clock despite microscopic wear; a glacier remains the same glacier despite flow and mass exchange; an organism remains the same organism despite molecular turnover. Such persistence does not imply that the complete physical condition remains equivalent.

The theory therefore distinguishes:

(i) persistence of the bearer under I_A;

(ii) equivalence or non-equivalence of its complete physical condition;

(iii) preservation or loss of a selected function; and

(iv) termination of the bearer identity.

These relations may coincide in some events but are not identical by definition.

16.2 Failure as an outcome of accumulated or abrupt change

Failure occurs when a declared functional, structural, or identity criterion is no longer satisfied. It may arise abruptly or after an accumulation of small changes. A delayed visible failure can disclose earlier physical evolution that remained below the resolution of the selected observations.

This does not license retrospective invention of an unsupported past sequence. Earlier change must be supported by physical mechanisms, records, reconstructions, or domain laws. The later failure is evidence that the earlier complete condition was not indefinitely immune, but the detailed path requires independent warrant.

16.3 Transformation beyond identity

When the identity of A ends, attribution to that bearer ends under the declared specification. Subsequent realizations belong to successor bearers. Fragmentation, phase transformation, biological death, stellar collapse, or disassembly can therefore be represented without claiming that the original bearer persists unchanged under a new name.

This distinction protects both continuity and termination. ITOF does not require every system to remain identifiable forever for realized-stage succession to extend across physical reality through other continuing bearers.

17. Measurement, Records, and Reconstruction

Physical realization and access to physical realization are different. Measurement, records, and reconstruction provide disciplined access to selected aspects of a realized condition. They do not create the condition they represent and do not become the realized-stage order or its temporal meaning.

The researcher and the experiment are inside physical change

Let $\mathcal{X}_P := \{H, D, R, E\}$ denote the researcher, measuring device, material record carrier, and experimental environment involved in protocol P. Then

$$\mathcal{X}_P \subseteq \mathbb{S}_{\text{phys}}, \qquad \forall B \in \mathcal{X}_P : \ \text{IdExtended}(B) \Longrightarrow \text{SC}(B). \tag{144}$$

Their realized changes do not substitute for evidence about the target bearer:

$$\exists B \in \mathcal{X}_P \ \exists b_1, b_2 \in \mathcal{O}_B : \ \text{Ch}_B(b_1, b_2) \not\models \text{Ch}_A(o_1, o_2). \tag{145}$$

The researcher is therefore a changing physical system within the same universal succession, not a changeless standpoint outside it. The researcher's own material and biological history supplies a direct instance of ordered change, while the target claim still requires target-attributed evidence.

17.1 Representation levels

Let a physical condition produce an ideal representation $R_A(o)$ under a declared model, and let an instrument or analysis return a measured estimate $\widehat{R}_A(o)$. Schematically,

$$X_A(o) \longrightarrow R_A(o) \longrightarrow \widehat{R}_A(o). \tag{146}$$

The first arrow depends on the representation model; the second depends on the instrument, sampling, calibration, noise, and inference procedure. When one declared protocol P is in force, $R_A(o)$ and $\widehat{R}_A(o)$ abbreviate $R_{A,P}(o)$ and $\widehat{R}_{A,P}(o)$. The indexed notation is retained in protocol reconstruction structures and whenever several protocols are compared.

Layered evidence bridge. A record-based conclusion must keep distinct the complete condition $X_A(o)$, its ideal domain representation $R_A(o)$, the measured or inferred estimate $\widehat{R}_A(o)$, the registered decision under uncertainty, and the resulting physical warrant. The detection-soundness bridge licenses the step from a finite-data decision to non-equivalence in the ideal representation. The difference-soundness bridge licenses the further step from ideal representational non-equivalence to physical non-equivalence of complete conditions. The reverse direction is stronger: registered representational equivalence warrants complete physical equivalence only when an independently justified *representation-completeness bridge* establishes that every physically relevant distinguishing degree of freedom and relation is captured, modulo declared gauge, coordinate, labeling, and redundancy rules.

In the compact equation below, BridgeSound abbreviates the two soundness steps together with bearer attribution, realization linkage, calibration, artifact control, and the registered uncertainty model; the abbreviation does not collapse their distinct inferential roles.

A representational difference can warrant a physical non-equivalence claim only when the bridge is sound:

$$\begin{aligned} &\widehat{R}_A(o_1) \not\approx_{P,\alpha} \widehat{R}_A(o_2) \wedge ((o_1, o_2) \in \mathcal{K}_A) \\ &\wedge \ \text{BridgeSound}(A, o_1, o_2; P, \alpha) \quad \Vdash_{P,\alpha} \quad X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2). \end{aligned} \tag{147}$$

Here $\Vdash_{P,\alpha}$ is an epistemic warrant relation under protocol P, error or credibility control α, and the recorded bridge conditions. It is deliberately not ordinary logical implication. A decision made under a non-zero error model can justify asserting physical non-equivalence without making the evidence logically infallible.

Canonical evidential closure to realized change

Using the same evidential-premise notation, $\mathcal{E}_{P,\alpha}$ here includes the registered evidence, order, realization-link, comparison, calibration, and uncertainty premises for the change claim. Closure under the definition of change preserves the warrant qualifier:

$$\begin{aligned} &\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} (o_1 \prec_A o_2), \quad \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} I_A(o_1, o_2), \\ &\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} ((o_1, o_2) \in \mathcal{K}_A), \\ &\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} [X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2)] \\ &\qquad\qquad \Longrightarrow \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \text{Ch}_A(o_1, o_2). \end{aligned} \tag{148}$$

The ontological proposition $X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2)$ and the evidential warrant for asserting it therefore have different types. The first concerns the physical conditions; the second concerns what a protocol licenses investigators to conclude. ITOF retains the ontological definition of change while requiring the epistemic status of every empirical witness to remain explicit.

The bridge requires at least bearer attribution, realization attribution, calibration, uncertainty control, exclusion of relevant artifacts, and a demonstrated link between the represented quantity and the physical content whose difference is claimed [12, 13]. If the measured variable is incomplete, its constancy cannot establish complete physical constancy. If the error model is misspecified, the warrant fails even when the numerical contrast is large.

17.2 Direct records

A direct record is a physical record causally or operationally linked to a realized occurrence. Examples include an in situ detector output, a material sample tied to a known collection event, a calibrated image, or a clock reading linked to a physical cycle. Directness does not eliminate interpretation. The record still requires source attribution, instrument modeling, and uncertainty assessment.

Two records can support change when they refer to ordered realized occurrences of the same bearer and establish a physically meaningful difference. The records need not contain the whole condition; they must contain a sound witness of non-equivalence.

17.3 Reconstructed past conditions

A reconstruction infers an earlier or otherwise inaccessible condition from later records and a model. It is not a direct record of the reconstructed occurrence. Its warrant depends on identifiability, model adequacy, uncertainty, sensitivity to alternative admissible models, and linkage of the reconstructed output to the specified ontic realization.

For an ancestral or earlier condition $X_A(o_a)$, a reconstruction procedure g may yield the represented estimate $\widehat{R}_A^{\mathrm{anc}}(o_a;g)$, while $\widehat{R}_A^{\mathrm{desc}}(o_d;g)$ denotes the measured or inferred descendant estimate representing $X_A(o_d)$. Both sides require explicit realization linkage and a branch-specific difference-soundness bridge. The admissible evidential statement is

$$\begin{aligned}&\mathrm{AncestorLinked}\big(\widehat{R}_A^{\mathrm{anc}}(o_a;g),o_a,g\big)\wedge\mathrm{DescendantLinked}\big(\widehat{R}_A^{\mathrm{desc}}(o_d;g),o_d,g\big)\\&\wedge\ \big((o_a,o_d)\in\mathcal{K}_A\big)\wedge\ \mathrm{DecisionSound}(g,\alpha)\wedge\ \mathrm{BridgeSound}(A,o_a,o_d;g,\alpha)\\&\wedge\ \widehat{R}_A^{\mathrm{anc}}(o_a;g)\not\approx_{g,\alpha}\widehat{R}_A^{\mathrm{desc}}(o_d;g)\\&\qquad\qquad\Vdash_{g,\alpha}\Big[X_A(o_a)\not\equiv_{\mathrm{phys}}X_A(o_d)\Big].\end{aligned} \tag{149}$$

The first link certifies that the reconstruction output is attributed to the specified ancestral realization. The second certifies that the comparison estimate belongs to the specified descendant realization and bearer. The decision rule records the uncertainty model, threshold or credibility criterion, and robustness requirements. In this branch, BridgeSound includes the registered reconstruction model and the difference-soundness bridge from represented non-equivalence to the declared physical non-equivalence claim. The conclusion is warranted under those conditions; it is not converted into necessary ontological truth by notation alone.

A single unsupported point estimate is insufficient. Posterior width, lineage uncertainty, model sensitivity, sampling bias, sequencing error, descendant-sample attribution, and non-identifiability must be included where relevant [14, 15]. Where several lineage trees or reconstruction models remain admissible, the claimed difference must be stable across the admissible family or its model dependence must be reported as part of the conclusion.

17.4 Observation thresholds and delayed resolution

A difference may be physically real before it is resolved by a particular protocol. Where a domain admits a calibrated physical difference measure d_A on $\mathcal{K}_A$, it must satisfy

$$(o_1,o_2)\in\mathcal{K}_A\wedge d_A(X_A(o_1),X_A(o_2))>0\Longrightarrow X_A(o_1)\not\equiv_{\mathrm{phys}}X_A(o_2)$$

for the declared comparison; no such measure is assumed universally. Let $\epsilon_{A,P}^{\mathrm{phys}}$ denote the protocol-induced physical sensitivity bound defined only when a validated calibration-and-representation bridge maps the protocol threshold ϵ_P into that same physical comparison space and the units of d_A. When no such validated bridge is available, $\epsilon_{A,P}^{\mathrm{phys}}$ is undefined and the following physical-space inequality cannot be invoked:

$$(o_1,o_2)\in\mathcal{K}_A,\qquad 0<d_A(X_A(o_1),X_A(o_2))<\epsilon_{A,P}^{\mathrm{phys}}. \tag{150}$$

When the bridge is valid, Equation (150) can describe a physically non-zero condition difference that the protocol does not distinguish. The distance-like quantity d_A and the calibrated bound $\epsilon_{A,P}^{\mathrm{phys}}$ are domain specific and do not belong to the definition of time. The untransformed protocol threshold ϵ_P remains a threshold in the represented or measured space, as used in Equation (154).

Non-detection therefore supports a bounded statement about the protocol, not a universal statement of physical identity. Improved resolution, repeated measurements, independent channels, or later consequences may reveal a change that was previously unresolved.

17.5 Convergent evidence

Several records or reconstructions strengthen a retrospective conclusion only when they are genuinely independent or when their shared dependencies are explicitly modeled. Repeating the same source through several processing pipelines does not automatically create independent confirmation. Shared instruments, calibration chains, datasets, models, or realization assignments must be disclosed.

Convergence is strongest when distinct physical channels, instruments, or reconstruction methods support one identity-coherent ordered reconstruction of past realizations and their uncertainty models are mutually compatible. The audit conditions are stated in Appendix C.

18. Ontological Claims and Evidential Warrant

The foundational relations of ITOF are ontological: a bearer has a realized condition, two conditions are physically equivalent or non-equivalent when the comparison is defined, and a realized change either occurs or does not occur. Scientific access to those relations is epistemic. Records, estimates, likelihoods, posterior distributions, and decisions supply warrant under stated procedures; they are not identical to the physical relations they support.

18.1 Why ordinary implication is too strong

Suppose a protocol controls its error at a non-zero level α. Even when all calibration and attribution conditions are satisfied, the decision remains fallible in the formal sense encoded by the error model. Writing ordinary logical implication from the decision to physical truth would erase that fact. The warrant notation in Equations (147) and (149) preserves both scientific force and logical accuracy.

This distinction does not weaken empirical science into mere opinion. A warrant can be strong, reproducible, quantitatively controlled, and convergent across independent channels. It means only that the inferential status is reported honestly. The physical proposition is what the evidence concerns; the warrant relation states why investigators are justified in accepting it.

18.2 Direct access, mediated access, and reconstruction

Different evidential routes impose different burdens. A direct in situ record can have a short attribution chain, but it still requires calibration, realization linkage, and artifact control. A remote signal adds source and propagation attribution. A past reconstruction adds model adequacy, identifiability, and robustness to alternative admissible reconstructions. These are differences in inferential architecture, not different ontologies of change.

A useful hierarchy is

$$\begin{aligned}\text{physical condition} &\longrightarrow \text{record formation} \longrightarrow \text{data reduction}\\ &\longrightarrow \text{decision} \longrightarrow \text{warranted ontological claim.}\end{aligned} \tag{151}$$

Each arrow can fail independently. Good measurement practice therefore reports not only the final contrast but also the bearer, realization, source, instrument, uncertainty, and model assumptions that make the contrast relevant to the physical claim.

18.3 Acceptance, revision, and adverse evidence

A warranted conclusion is defeasible in the scientific sense. New calibration information, a revised source attribution, a better model, or an uncovered dependency can weaken or overturn it. This possibility does not alter the realized physical past; it alters justified access to that past.

Conversely, unresolved evidence does not imply that the physical world is indeterminate in the same sense. The epistemic result may be indeterminate because the available procedure does not decide the ontological question. ITOF therefore distinguishes three levels: physical equivalence or non-equivalence where the comparison is defined, evidential warrant for asserting either relation, and suspension of judgment where warrant is insufficient.

> **Evidence rule.** Empirical and reconstructed evidence warrants ontological claims under declared protocols and uncertainty models. It does not become strict logical entailment merely because the resulting claim is physically meaningful.

Because $\Vdash_{P,\alpha}$ is defeasible warrant rather than classical implication, separate warrants may be conjoined only when they belong to one registered protocol or compatible model family, are jointly consistent, and have a controlled dependence structure. Under those conditions,

$$\begin{aligned}
&\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} (o_1 \prec_A o_2),\\
&\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} I_A(o_1, o_2),\\
&\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \big((o_1, o_2) \in \mathcal{K}_A\big),\\
&\mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \big(X_A(o_1) \not\equiv_{\text{phys}} X_A(o_2)\big)\\
&\qquad\qquad \Longrightarrow \mathcal{E}_{P,\alpha} \Vdash_{P,\alpha} \text{Ch}_A(o_1, o_2).
\end{aligned} \tag{152}$$

If the premises arise from incompatible models, uncontrolled shared data, or mutually inconsistent realization assignments, the conjunction is not licensed and no warranted change conclusion follows.

19. The Evidential Asymmetry Between Change and Bearer-Complete Equivalence

One sound, attributable physical difference is sufficient to establish change over the represented interval. The burden for bearer-complete equivalence throughout continuation is radically stronger. It requires that the complete condition be fixed, that the representation be complete for the claim, that all physically attributable channels be covered, and that no later identity-preserving continuation realizes a difference.

19.1 Positive witness

For a bearer A, one validated witness W can support

$$W_A(o_1) \neq W_A(o_2) \wedge \mathrm{BridgeSound}(W, A) \Longrightarrow \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)\Big]. \quad (153)$$

The witness may be energetic, structural, compositional, spectral, genetic, geometric, relational, or another domain-valid quantity. It need not describe every component of the complete condition.

19.2 Null result

A null result has three possible interpretations: the physical conditions are equivalent with respect to the represented claim; the protocol is under-resolved or insensitive; or the result is presently indeterminate. Accordingly,

$$\widehat{X}_{A,P}(r_1) \equiv_P \widehat{X}_{A,P}(r_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big]. \quad (154)$$

A negative claim must state detection limits, model dependence, false-negative controls, and the physical channels not accessed by the protocol.

19.3 Finite windows

A finite interval can disprove complete physical equivalence throughout that interval if change is observed. It cannot prove that the system was unchanging before the first record or will remain unchanging after the last record. The protocol boundaries satisfy

$$r_{\mathrm{first}} \not\equiv_{\mathrm{type}} S_{\mathrm{first}}, \qquad r_{\mathrm{last}} \not\equiv_{\mathrm{type}} S_{\mathrm{last}}. \quad (155)$$

The first and last terms on the left are records selected by an investigation; the right-hand expressions denote claims about the system's past physical realizations.

19.4 Bearer-complete equivalence burden

The only adverse condition capable of defeating sustained change for a bearer requires all of the following: preserved system identity, a complete and outcome-independent condition definition, physically grounded later continuation, comparison completeness for the relevant claims, and established equivalence across every attributable component. A stationary value, average, state label, or finite sequence of null measurements does not meet this burden.

Evidential asymmetry and the negative exclusion of a static tail. One sound, bearer-attributed physical difference is sufficient to establish one realized change between ordered stages. No enumeration of all stages is required. By contrast, repeated records, observational silence, or a finite collection of equal or unresolved readings cannot establish complete physical equivalence throughout later identity-preserving continuation. Change may remain below the sensitivity, scope, or resolving power of the protocol, and the first record in which a difference becomes noticeable does not identify a unique ordered pair or interval over which continuing change was realized. No absolute static tail is admitted as a physical continuation, and no positive static-tail construction is retained.

20. Clocks and Quantitative Timekeeping

A clock, in operational use, is a physical timekeeping system constituted either by a manufactured apparatus or by a physically registered natural process, whose selected evolution is converted by a declared protocol into standardized numerical records. For a clock bearer C, the protocol-indexed reading is

$$N_{C,P}(c) := \Phi_{C,P}(X_C(c))\,, \qquad c \in \mathcal{O}_C. \tag{156}$$

The complete condition includes accumulated phase, count, memory state, control variables, physically stored calibration states, and bearer-attributable couplings. A calibration rule, unit convention, interpretive convention, epoch choice, and conversion map belong to protocol P or to $\Phi_{C,P}$, not to the clock's complete physical condition merely because they are used to interpret its output. No separate retrospective variable is needed in the governing equation.

Clock ontology principle. A clock is a physical timekeeping system; in manufactured form it is a material symbolic instrument and a physical bearer. Where its identity is non-trivially extended, it falls within ITOF's sustained-change postulate: its realized change depends jointly on its complete internal constitution and on the external physical factors, systems, boundary conditions, and couplings whose effects reach it, like any other physical system. Its calibrated symbols and readings count, order, and compare selected physical processes. They neither measure nor express time itself. When a clock signal is physically coupled into a feedback or control system, it acts only as an ordinary physical input through that coupling, not as temporal agency.

Two clocks may produce different native readings because their physical conditions, paths, controls, external physical factors, boundary conditions, couplings, proper times, or readout protocols differ. Let $c_i \in \mathcal{O}_{C_i}$, let P_i be the native readout protocol of clock C_i, and let the comparison protocol P_{12} provide conversion maps into one common numerical codomain:

$$\Gamma_{i,P_{12}} : \mathrm{Range}(N_{C_i,P_i}) \longrightarrow \mathbb{R}_{P_{12}}, \qquad i \in \{1,2\}. \tag{157}$$

The operational difference is then

$$\Delta N_{12}^{P_{12}}(c_1, c_2) := \Gamma_{1,P_{12}}(N_{C_1,P_1}(c_1)) - \Gamma_{2,P_{12}}(N_{C_2,P_2}(c_2))\,. \tag{158}$$

The protocol P_{12} fixes the common unit, scale, epoch or phase reference, transport convention, and uncertainty model. This is a protocol-grounded difference between physical outputs, not a difference in the one extension, universal ordering, or absolute-simultaneity relation expressed by $\mathsf{T}_{\mathrm{ITOF}}$.

Absolute simultaneity and clock synchronization are type-distinct:

$$\begin{aligned}(C_1, c_1) \sim_{\mathrm{abs}} (C_2, c_2) &\not\models \Delta N_{12}^{P_{12}}(c_1, c_2) = 0,\\ \Delta N_{12}^{P_{12}}(c_1, c_2) = 0 &\not\models (C_1, c_1) \sim_{\mathrm{abs}} (C_2, c_2).\end{aligned} \tag{159}$$

A comparison protocol can calibrate, transport, and compare clock outputs; it does not create objective absolute simultaneity. Conversely, absolute simultaneity does not prescribe equality of the outputs of physically different clocks.

20.1 What clocks measure

Clocks operationalize duration by counting or accumulating a chosen physical process. They do not measure time itself; their numerical outputs are material-symbolic readings of the selected clock process under a calibration protocol. A tick is a record generated by that process; it is not automatically a stage of the clock and is never a change stage of every system under comparison.

20.2 Drift and malfunction

Drift, malfunction, missed counts, and calibration error are properties of the clock system, the external physical factors, systems, boundary conditions, and couplings whose effects reach it, or the protocol. They are not disturbances of time itself.

21. Metric Quantification, Rates, and Cross-System Comparison

21.1 Operational interval

Using the typed clock readout in Equation (156), an operational interval internal to clock C is

$$\Delta N_{C,P}(c_1, c_2) := N_{C,P}(c_2) - N_{C,P}(c_1), \qquad c_1, c_2 \in \mathcal{O}_C. \tag{160}$$

This quantity belongs jointly to the clock bearer and the declared readout protocol.

21.2 Rates

Let $o_1^A, o_2^A \in \mathcal{O}_A$ be realizations of the measured bearer and $c_1, c_2 \in \mathcal{O}_C$ realizations of the clock bearer. A protocol-link relation $\Lambda_{A,C,P}(o_i^A, c_i)$ registers which clock realization is paired with each bearer realization; it is not bearer identity and does not replace either bearer's realized succession. A valid rate comparison requires the two bearer references and the two clock references to be ordered consistently under the same protocol linkage. When those order and linkage premises hold and the clock denominator is non-zero, an average operational rate is

$$\overline{v}^{P}_{Q_A|C} := \frac{Q_A(o_2^A) - Q_A(o_1^A)}{N_{C,P}(c_2) - N_{C,P}(c_1)} \quad \text{for} \quad \begin{cases} o_1^A \prec_A o_2^A, \\ c_1 \prec_C c_2, \\ \Lambda_{A,C,P}(o_1^A, c_1), \\ \Lambda_{A,C,P}(o_2^A, c_2), \\ N_{C,P}(c_2) \neq N_{C,P}(c_1). \end{cases} \tag{161}$$

The paired links identify the earlier bearer realization with the earlier clock realization and the later bearer realization with the later clock realization under P. This is an operational comparison of a physical quantity of A with a protocol-indexed output of C; it does not redefine the extension or ordering expressed by time.

21.3 Cross-system comparison

Cross-system comparison requires explicit signal, calibration, transport, coordinate, and relativistic conventions. Such a protocol does not create absolute simultaneity; it can provide only protocol-limited operational access to the objective relation that is ontologically prior to the comparison procedure. A bridge from measured records or clock outputs to a claim that two stages are absolutely simultaneous must be stated independently.

21.4 No stage counting by clocks

$$\mathrm{TickRecord}_C(o_C) \not\models \mathrm{Stage}_A(o), \qquad \Delta N_{C,P}(c_1, c_2) \not\models \mathrm{Card}\Big(\mathcal{S}_A^{\mathrm{ch}}\Big)\,. \tag{162}$$

A clock tick is a bearer-specific record. It does not by itself establish that an ontic realization of another bearer participates in physical change, and clock counts neither enumerate that bearer's realized stages nor establish the number of unresolved changes. Equality of clock readings likewise does not define absolute simultaneity.

22. Direct Ontological Confrontation with Relativity

The exact boundary. Relativistic equations define and relate coordinates, metric intervals, worldlines, curvature tensors, signals, frequency ratios, and clock outputs. ITOF does not deny those mathematical objects or the physical relations established through them. It rejects the further ontological transfer by which any of them is identified with time itself. In ITOF, time is the descriptive meaning of the one universal extension and ordering of realized stages, including direct objective absolute simultaneity. Geometry can represent physical relations; it is not temporal ontology.

This is a direct disagreement, not a defensive qualification of relativity. The tested success of a formalism warrants the relations its equations, instruments, and physical bridges establish. It does not by itself warrant an identity claim between the representing structure and time. The burden of proof therefore lies on every proposed transfer: which defined object transforms, accumulates, curves, redshifts, or differs, and which equation establishes that this object is time rather than a coordinate, metric quantity, worldline functional, signal relation, or material-system output? Relativity and ITOF meet at this ontological boundary [2, 3, 6, 7, 8].

The answer must be read from the governing equation and measurement chain. A coordinate belongs to a chart; a metric belongs to a geometric model and its physical interpretation; proper time is a functional of a timelike worldline and metric; curvature belongs to the metric and connection; a clock reading belongs to a material bearer and protocol; a frequency ratio belongs to emitters, receivers, signals, propagation, and comparison conventions. None of these objects is identical with T_{ITOF}.

22.1 Relativistic success does not establish temporal identity

Mathematical consistency, covariance, predictive accuracy, and successful measurement are scientifically decisive for the claims they support. They do not erase distinctions of type. A successful Lorentzian model can establish highly accurate relations among trajectories, fields, signals, clock systems, and metric quantities without establishing that the manifold, one of its coordinates, or a path integral is time. Equation (10) applies without exception: successful physical instantiation validates the represented relations through the relevant bridge; it does not convert every formal object in the representation into an independently existing constituent of reality.

Accordingly, ITOF does not argue that relativistic calculations are invalid because their temporal ontology is rejected. It argues that calculation and ontology are different inferential levels. The former does not entail the latter:

$$\text{RelativisticSuccess}(F, P) \not\models \big[\mathsf{T}_{\text{ITOF}} \equiv_{\text{type}} \text{Geometry}(F)\big]. \tag{163}$$

22.2 Lorentz transformations: coordinates transform, not time

For standard inertial coordinates,

$$\begin{aligned} t' &= \gamma_v \left(t - \frac{vx}{c^2} \right), \\ x' &= \gamma_v (x - vt), \qquad \gamma_v = \frac{1}{\sqrt{1 - v^2/c^2}}. \end{aligned} \tag{164}$$

These equations transform coordinate assignments between inertial frames. Their typed action is

$$(t, x) \longmapsto (t', x'), \qquad (t, x) \longmapsto (t', x') \not\models \mathsf{T}_{\text{ITOF}} \longmapsto \mathsf{T}'_{\text{ITOF}}. \tag{165}$$

The symbol t is a chart coordinate within the relativistic representation. Its transformation is not a transformation of the one universal extension, its prior–later order, or the objective absolute-simultaneity relation. Calling t a “time coordinate” states its role in the chart; it does not establish identity with time in the ITOF sense.

22.3 Proper time, clocks, and redshift: defined quantities, not time itself

For a timelike worldline γ in a metric field g with signature $(-+++)$, proper time is

$$\tau[\gamma, g] = \frac{1}{c} \int_\gamma \sqrt{-g_{\mu\nu}\, dx^\mu dx^\nu}. \tag{166}$$

This is a path-dependent scalar functional defined by the metric and worldline. A clock reading $N_{C,P}$ is a protocol-indexed physical output of a clock bearer. A gravitational or kinematic redshift is a relation among physical emitters, receivers, signals, paths, motions, and metric conditions. The standard terminology "proper time" does not settle the ontological identity of the quantity it names.

Relativistic quantities are not ITOF time

$$x^0,\ g_{\mu\nu},\ R^\rho{}_{\sigma\mu\nu},\ \tau[\gamma, g],\ N_{C,P} \not\equiv_{\text{type}} \mathsf{T}_{\text{ITOF}}. \tag{167}$$

Consequently,

Metric or clock difference is not modification of time

$$\begin{aligned} \tau[\gamma_1, g] \neq \tau[\gamma_2, g] &\not\models \text{Modification}(\mathsf{T}_{\text{ITOF}}), \\ \Delta N_{12}^{P_{12}}(c_1, c_2) \neq 0 &\not\models \text{Modification}(\mathsf{T}_{\text{ITOF}}). \end{aligned} \tag{168}$$

The differences on the left are genuine differences in their defined metric and physical quantities. ITOF rejects only the unsupported step that redescribes those differences as expansion, contraction, slowing, acceleration, or deformation of time itself.

22.4 Curvature: the metric geometry curves, not time

General relativity relates geometric and material quantities through field equations such as

$$G_{\mu\nu} + \Lambda_{\text{cosm}} g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}. \tag{169}$$

The geometric side is constructed from the metric, connection, and curvature tensors. The equation does not contain a separate physical object T_{ITOF} that bends, stretches, or is acted upon. Therefore,

$$\text{Curvature}(g, \nabla) \not\models \text{Modification}(\mathsf{T}_{\text{ITOF}}). \tag{170}$$

"Spacetime curvature" is precise geometric language for Lorentzian metric structure and its physical application. "Time curves" is an additional ontological interpretation, not a result stated by the curvature tensor. In ITOF, the metric geometry can govern represented trajectories, geodesic deviation, signal propagation, and clock comparison without becoming time.

22.5 Spacetime and dimensionality: representation is not ontological identity

A standard relativistic spacetime model is a four-dimensional differentiable manifold $\mathcal{M}$ equipped with Lorentzian metric structure. The Lorentzian signature distinguishes locally one timelike type of direction and three spacelike types of direction, while coordinate labels and their causal character depend on the chart and region. Collecting four coordinates within one mathematical representation is powerful, but membership in one coordinate tuple does not establish ontological sameness. The geometrical unification therefore does not prove that time is a spatial-like physical dimension or that the manifold is a temporal substance.

The ITOF type boundary is

$$\mathcal{M} \not\equiv_{\text{type}} \mathsf{T}_{\text{ITOF}}, \qquad g_{\mu\nu} \not\equiv_{\text{type}} \mathsf{T}_{\text{ITOF}}, \qquad \dim(\mathcal{M}) \not\equiv_{\text{type}} \mathsf{T}_{\text{ITOF}}. \tag{171}$$

This does not deny the physical applicability of spacetime geometry. It denies the inference from successful geometrical representation to identity with time.

The same discipline applies more strongly to higher-dimensional extensions. Standard special and general relativity do not by themselves establish additional physical dimensions; five- and higher-dimensional structures enter extended theories through further hypotheses, historically including the Kaluza and Klein constructions [4, 5]. Formal admissibility, unification power, or dimensional elegance is not sufficient evidence that an n-dimensional model $\mathcal{M}_n$ is physically instantiated:

$$\text{FormallyAdmissible}(\mathcal{M}_n) \not\models \text{PhysicallyInstantiated}(\mathcal{M}_n), \tag{172}$$

A dimensional claim acquires physical authority only through independently warranted physical bridges and discriminating empirical consequences. ITOF therefore rejects both the identification of time with the fourth coordinate and the elevation of higher-dimensional mathematical structure into physical ontology without such support.

22.6 Coordinate simultaneity does not disprove absolute simultaneity

Standard Lorentzian relativity does not provide a frame-independent global simultaneity relation for arbitrary spacelike-separated events. Einstein synchronization defines an operational simultaneity relation within a selected inertial frame, and coordinate simultaneity changes under Lorentz transformation. ITOF accepts that result and rejects the ontological inference commonly drawn from it: frame dependence of coordinate simultaneity does not prove the nonexistence of objective absolute simultaneity.

ITOF postulates the direct objective relation $\sim_{\text{abs}}$ between stages and one strict, transitive, non-reversing universal prior–later relation $\prec_{\text{U}}$. These relations act within the one extension; they do not ontologically constitute reified temporal layers, a universal physical stage, or a containing temporal object. This is a substantive departure from standard Lorentzian temporal ontology, not an interpretation extracted from Lorentz transformations.

To keep the types explicit, let $\mathcal{G}_F$ be the representation target admitted by frame, chart, or covariant description F, including point events and, where physically appropriate, represented material regions, field regions, sections, or hypersurface assignments. Let $\mathcal{M}_F \subseteq \mathcal{G}_F$ denote its point-event sector. Then

$$\begin{aligned} \rho_F &: \mathcal{O}_{\text{phys}} \rightharpoonup \mathcal{G}_F, \\ t_F &: \mathcal{M}_F \longrightarrow \mathbb{R}, \\ \mathcal{O}^F_{\text{pt}} &:= \{x \in \operatorname{Dom}(\rho_F) \mid \rho_F(x) \in \mathcal{M}_F\}. \end{aligned} \tag{173}$$

Coordinate simultaneity and objective absolute simultaneity are type-distinct:

$$\begin{aligned} t_F(\rho_F(x_1)) = t_F(\rho_F(x_2)) \not\models x_1 \sim_{\text{abs}} x_2, \\ x_1 \sim_{\text{abs}} x_2 \not\models t_F(\rho_F(x_1)) = t_F(\rho_F(x_2))\,, \end{aligned} \qquad x_1, x_2 \in \mathcal{O}^F_{\text{pt}}. \tag{174}$$

The first non-entailment blocks the conversion of coordinate equality into ontology. The second blocks the demand that objective simultaneity must appear as equal coordinate labels in every frame.

For represented point events, established strict relativistic causal precedence must be preserved by the universal order, while absolutely simultaneous distinct stages cannot stand in strict causal precedence. With $J^+_F(p)$ denoting the relativistic causal future of represented point event p,

$$\begin{aligned} & x_1, x_2 \in \mathcal{O}^F_{\text{pt}}, \quad \rho_F(x_2) \in J^+_F(\rho_F(x_1)), \quad \rho_F(x_1) \notin J^+_F(\rho_F(x_2)) \\ & \qquad \Longrightarrow x_1 \prec_{\mathrm{U}} x_2, \\ & x_1 \sim_{\text{abs}} x_2 \wedge \rho_F(x_1) \neq \rho_F(x_2) \\ & \qquad \Longrightarrow \rho_F(x_2) \notin J^+_F(\rho_F(x_1)) \wedge \rho_F(x_1) \notin J^+_F(\rho_F(x_2)). \end{aligned} \tag{175}$$

Relativistic causality constrains admissible assignments but does not determine the absolute-simultaneity relation for causally unrelated stages. A particular assignment requires an independently justified, coordinate-independent, causally compatible physical bridge; coordinate equality, clock equality, or signal convention alone cannot establish it.

22.7 Covariance, Lorentz and Poincaré symmetry, and the theoretical boundary

Coordinate covariance concerns the form of equations under admissible changes of representation, while Lorentz and Poincaré symmetry constrain relativistic coordinates, fields, laws, and observables in their proper domains. Neither symmetry establishes that coordinate time is time itself, that spacetime geometry exhausts temporal ontology, or that frame-dependent coordinate simultaneity prohibits objective simultaneity. The primitive ITOF relations $(\sim_{\text{abs}}, \prec_{\mathrm{U}})$ are therefore not derived from those symmetries and are not subject to an ontological veto from them.

V24/F4 does not claim that $\sim_{\text{abs}}$ and $\prec_{\mathrm{U}}$ are invariant under the full Poincaré group. Such a theorem would require an explicitly defined group action on $\mathcal{O}_{\text{phys}}$ and a proof that both relations are preserved. Any physical compatibility or conflict must be established by an explicit bridge and a discriminating prediction, not by terminology.

Objective absolute simultaneity does not identify a preferred inertial coordinate chart. It does, however, posit a preferred objective temporal relation: some stages are absolutely simultaneous and others stand in one universal prior–later order. ITOF states this disagreement directly rather than reducing it to a coordinate convention.

22.8 The identity of ITOF in the relativistic comparison

ITOF is not an interpretive appendix to relativity. It is an independent temporal theory with a different ontological starting point. Relativity determines coordinate, metric, causal, dynamical, signal, worldline, redshift, and clock relations. ITOF determines what time means and asserts one universal extension, one universal prior–later order, and direct objective absolute simultaneity between stages.

Accordingly, ITOF rejects the following identifications:

$$\begin{aligned} \mathcal{R}_{\mathrm{rel}} := \{&\text{coordinate, metric interval, proper-time functional,} \\ &\text{Lorentzian manifold, curvature tensor, clock output}\}, \\ &\forall Q \in \mathcal{R}_{\mathrm{rel}}, \qquad Q \not\equiv_{\mathrm{type}} \mathsf{T}_{\mathrm{ITOF}}. \end{aligned} \tag{176}$$

Where interpretations identify time with any of those objects, ITOF rejects the identification. Where the relativity of coordinate simultaneity is elevated into a denial of objective simultaneity, ITOF rejects the inference. Where four- or higher-dimensional geometry is elevated from representation into physical ontology without an independent bridge, ITOF rejects the elevation. These are direct disagreements. Respect for the demonstrated results of relativistic physics requires assigning each result to the object actually defined and measured, not extending it beyond its evidential type.

23. Light, Distance, and Remote Physical Records

Light is treated as a physical carrier of records. A source, detector, and propagation environment are physical systems or factors whose relations determine what can be inferred from received radiation. The propagation of a record does not make time a substance transported from the source to the detector.

Consider two source records α and β. In one declared coordinate or clock-reading convention, define

$$\Pi^{\xi} := t^{\xi}_{\mathrm{arr}} - t^{\xi}_{\mathrm{emit}}, \qquad \Delta\Pi^{\alpha\beta} := \Pi^{\beta} - \Pi^{\alpha}, \qquad \xi \in \{\alpha, \beta\}. \tag{177}$$

With $\Delta t^{\alpha\beta} := t^{\beta} - t^{\alpha}$, it follows identically that

$$\Delta t^{\alpha\beta}_{\mathrm{arr}} = \Delta t^{\alpha\beta}_{\mathrm{emit}} + \Delta\Pi^{\alpha\beta}. \tag{178}$$

The propagation term includes the source–detector geometry, motion, spacetime structure, path, and medium relevant to the declared convention. Contributions common to both records cancel in the difference; only $\Delta\Pi^{\alpha\beta}$ alters their arrival spacing. If the effective propagation conditions are the same, $\Delta\Pi^{\alpha\beta} \approx 0$, so the arrival spacing approximates the emission spacing and can support an ordered inference about past source realizations when source attribution, propagation, detection, and uncertainty are controlled.

23.1 Continuous flux and successive records

An emitting source normally produces a continuing optical or electromagnetic flux. The physically useful objects of analysis are not isolated metaphysical "pieces of light," but successive records encoded in that flux and registered by a detector. Their source attribution depends on emission physics, propagation, instrumental response, and the reconstruction model.

When a star, planet, galaxy, or transient source changes, later emitted records can carry information about later source realizations. The detector receives them after their respective propagation durations. The ordered record sequence can support an ordered account of past source realizations when source identity, propagation corrections, detector calibration, and uncertainty are controlled.

Distance therefore limits access, signal strength, resolution, and reconstruction quality. It does not convert physical source change into a change of time. The measured intervals belong to the physical processes of emission, propagation, detection, and clock comparison.

23.2 Propagation differences and apparent variability

Not every variation in a received record is a source change. Lensing, scattering, absorption, instrumental drift, changing geometry, and detector noise may alter the received signal. A valid bridge must distinguish source-state variation from propagation and detection effects.

Conversely, correcting for propagation does not remove the source's realized physical development. When independent observations and physical models show that the variation is attributable to the source, the received records can warrant physical non-equivalence of source conditions even though the source itself is not directly accessible.

24. Small, Localized, and Genetic Change

A central consequence of the change definition is that physical difference need not reorganize the entire bearer. The relevant question is whether a physically attributable part of the complete condition differs, not whether every part differs or whether the difference is visible at the macroscopic scale.

24.1 Localized physical difference

Equation (65) provides the general rule. If a sound component comparison establishes a non-null physical difference and the component belongs to the complete condition of the declared bearer, the bearer is physically non-equivalent across the compared ontic realizations.

The rule applies to defects, mutations, molecular rearrangements, local stresses, surface alterations, field gradients, compositional changes, and boundary displacements. It does not imply that any detected anomaly belongs to the bearer. Attribution, contamination control, and the possibility of measurement artifacts must be resolved first.

A localized difference can coexist with extensive continuity. Most molecules, cells, structural elements, or field regions may remain equivalent. ITOF therefore avoids the false alternative between perfect constancy and complete transformation.

24.2 Smallness and physical reality

The existence of change is independent of a chosen numerical threshold. A threshold is required for a particular decision procedure, not for physical actuality. When the effect is smaller than the instrument resolution, the justified conclusion is that the protocol did not resolve the difference.

This point is particularly important for slow physical aging, fatigue, early-stage degradation, small genetic variants, weak geophysical deformation, and gradual astrophysical evolution. A later measurement may reveal a difference that was physically realized earlier but remained below the previous threshold. The new evidence improves access; it does not retroactively create the change.

24.3 Genetic records and lineage change

Genetic material is physical. A warranted difference in the genetic condition of an identity-coherent cell lineage, tissue, organism, or population is therefore a physical difference in the declared bearer. The bearer must be stated precisely because a mutation in one lineage does not automatically establish the same claim for the entire organism or population.

Direct sequencing supports a genetic change claim when sample identity, collection order, lineage attribution, sequencing quality, variant calling, and contamination controls are adequate. Ancestral reconstructions require additional conditions: the reconstruction output must be linked to the intended ancestral realization, the uncertainty model must be recorded, and the difference must remain robust across admissible lineage trees or reconstruction models.

Somatic genetic studies illustrate how substantial accumulated physical differences can exist beneath outward continuity. Normal skin and blood can retain their macroscopic and functional identities while cell lineages accumulate ordered mutations [37, 38]. These cases demonstrate identity-preserving change; they do not imply that every genetic difference is functional, visible, adaptive, harmful, or identity terminating.

24.4 Genes, phenotype, and system level

A genetic difference and a phenotypic difference are distinct claims. A mutation may have no resolved phenotypic effect, may act only under particular conditions, or may contribute to a later outcome through interactions with other changes. The absence of an overt phenotype does not erase the genetic difference, while the presence of a phenotype does not identify its genetic cause without additional evidence.

The system level must remain explicit. Change in a genome, cell, tissue, organism, and population occurs in different bearers with related but non-identical physical developments. ITOF preserves those distinctions rather than merging them into a single generic "biological change."

Recent comparative and population-scale genomics reinforces the methodological point that mutation, lesion persistence, clonal expansion, and methylation change are attributed to cells, tissues, organisms, lineages, or declared genomic bearers rather than to an abstract "gene value" detached from a system. Somatic mutation rates differ across mammalian species, while the resulting somatic mutation burden accumulates over the life course [39]; germline mutation rates also vary markedly across vertebrates [40]. Persistent DNA lesions can survive multiple cell cycles and later generate mutations [41], while population-scale sequencing reveals continuing somatic mutation and selection in normal tissues [42]. Together these studies provide high-resolution evidence for localized, retained, and continuing physical differences in living systems.

25. Stable, Periodic, Equilibrium, and Stationary Systems

Three levels of stationary analysis. Stationary results must separate: (i) a claim that selected or represented quantities remain constant; (ii) a theory-mediated stationary model whose relevance depends on realization linkage and an independently justified completeness bridge; and (iii) finite operational stability within declared sensitivity and coverage. None of these, alone or together without bearer-complete physical warrant, establishes changeless continuation. ITOF admits no identity-preserving static tail; a bounded null result proves only the limits of the stated test.

Apparently stable systems are decisive tests because they distinguish a reduced stationary description from complete physical constancy. ITOF does not assume that every stationary representation conceals change. It asks whether the representation is complete for the bearer and whether the stationary condition is realized throughout an identity-preserving continuation.

Governing derivative rule. A derivative states variation or constancy of the differentiated model object relative to a declared parameter and regularity structure. It does not define time, physical change, or change stages. A zero derivative establishes constancy of that represented object under the model assumptions; complete bearer constancy requires an independently justified completeness bridge. A non-zero derivative supports physical change only through sound realization linkage, bearer attribution, order, and a bridge excluding merely representational variation.

25.1 Stationary quantum representations

For a differentiable density-operator trajectory represented on a declared model interval I by unitary von Neumann evolution with a self-adjoint Hamiltonian $\widehat{\mathsf{H}}(t)$,

$$\frac{d\rho}{dt} = -\frac{i}{\hbar}[\widehat{\mathsf{H}}(t), \rho(t)], \qquad [\widehat{\mathsf{H}}(t), \rho(t)] = 0 \text{ for all } t \in I \Longrightarrow \rho(t) = \rho(t_0) \text{ for all } t, t_0 \in I. \quad (179)$$

Here t is the temporal evolution parameter of the quantum model; it is not identical to the ontological temporal meaning $\mathsf{T}_{\mathrm{ITOF}}$. The equation establishes stationarity of the represented density operator throughout the declared interval under the specified unitary model evolution. This is a precise mathematical and model-level physical result. It does not by itself classify the declared bearer as physically closed. Whether the model is physically complete depends on whether any driving, control, external field, preparation relation, or coupling responsible for the specification or parameter dependence of $\widehat{\mathsf{H}}(t)$ is included in the bearer and complete-condition description.

Equation (179) alone establishes stationarity only of the represented density operator under the declared dynamics. If an independently validated completeness bridge establishes that ρ exhausts the complete physical condition of the declared bearer and all relevant relations, the Hamiltonian and boundary conditions remain appropriate, identity is preserved, and the required full comparisons are admissible, equality of ρ across the range can warrant complete physical equivalence across that range. Bearer-complete equivalence throughout one non-zero identity-preserving interval would constitute adverse evidence against SC(A). If physically relevant preparation relations, fields, couplings, detector interactions, decay channels, or other content are excluded from ρ or the bearer specification, the result remains incomplete at bearer level.

ITOF does not redefine a stationary state as changing in order to protect the postulate. It requires the same comparison discipline used elsewhere. Quantum-jump and single-molecule experiments illustrate that stationary or ensemble descriptions can coexist with resolved event sequences under monitoring [18, 19, 48], but those examples do not prove that every stationary quantum bearer exhibits such monitored change.

25.1.1 Bearer-level audit of atomic and quantum cases

The subject of the change judgment is the physical bearer, not the energy eigenvalue or state symbol. For an atom A, the relation

$$\widehat{\mathsf{H}}_A|E_n\rangle = E_n|E_n\rangle \tag{180}$$

classifies a represented state relative to the declared Hamiltonian. It does not create a second system called E_n, and it does not make the ket an independent bearer. Any stationary claim must concern a declared identity-preserving range of actual stages, not a sequence created by records or model labels. Let $\mathcal{O}_A^I \subseteq \mathcal{O}_A$ denote that range. The eigenrelation alone does not entail complete-condition equivalence across it:

$$\begin{aligned} &\widehat{\mathsf{H}}_A|E_n\rangle = E_n|E_n\rangle \\ &\quad \not\models \forall o_1, o_2 \in \mathcal{O}_A^I : \begin{bmatrix} o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \\ \implies \mathrm{CmpStatus}_A^{\mathrm{full}}(o_1, o_2) = \mathrm{equivalent} \end{bmatrix}. \end{aligned} \tag{181}$$

The atom's complete physical condition, admissible comparison, and continued identity must be specified and assessed independently of the eigenvalue relation. This is a negative non-entailment statement: it does not define or admit a static continuation. A stationary representation or a finite interval of represented constancy cannot overturn the sustained-change postulate without the bearer-complete realization, identity, and comparison premises stated above.

If the atom emits a photon, absorbs radiation, transfers energy through a collision, changes an internal correlation, or undergoes another soundly attributed transition, the atom has changed. The associated quantity or carrier is evidence within the physical process, not a substitute bearer. For a resolved transition-specific emission whose endpoint realizations bracket the atomic transition and exclude a compensating return,

$$\begin{aligned} &o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \\ &\wedge \mathrm{ResolvedEmissionTransition}_A(o_1, o_2) \Longrightarrow X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2), \end{aligned} \tag{182}$$

where the resolved-transition predicate supplies the transition-specific physical attribution and excludes a compensating return between the declared endpoints. The energy carried by the emitted radiation may quantify one aspect of the transition; it is not the object to which the atom's sustained-change postulate is transferred.

A stationary energy value is weaker than complete stationarity. Even where

$$\mathrm{Tr}\big(\rho_A(o_1)\widehat{\mathsf{H}}_A\big) = \mathrm{Tr}\big(\rho_A(o_2)\widehat{\mathsf{H}}_A\big), \tag{183}$$

the bearer may differ in observables, correlations, relations, spatial content, or environmental entanglement not fixed by that equality. Exact stationarity of ρ_A is stronger, but it establishes complete physical constancy only when ρ_A is shown to be complete for the independently declared bearer and all relevant physical relations. Under fixed observables and independently sound completeness bridges, the theory distinguishes the following hierarchy:

$$\begin{aligned} \text{complete physical constancy} &\Longrightarrow \text{complete-representation constancy} \\ &\Longrightarrow \text{selected-quantity constancy.} \end{aligned} \tag{184}$$

The displayed implications run from the stronger condition above to progressively weaker consequences below, under the stated fixed representation and attribution conditions; neither reverse implication is generally valid.

Ground states, thermal stationary states, dark states, decoherence-free subspaces, and open-system steady states must be audited under this hierarchy. A protected subspace may still contain internal unitary evolution; a steady density operator may coexist with individual event trajectories or non-zero fluxes; a dark state may be dark only relative to specified channels. These possibilities do not guarantee hidden change, but they show why the model object and the complete bearer condition cannot be identified without proof.

The quantum vacuum is not admitted as an independent system merely because a vacuum state appears in a field theory. The state symbol describes a theoretical state of a field or algebraic construction. If a field, regional field configuration, cavity, detector–field assembly, or other physical entity is independently specified as a bearer, its complete condition may be tested. The vacuum label itself is not added to $\mathbb{S}_{\mathrm{phys}}$ as a separate bearer requiring an independent universal-change proof.

Quantum challenge discipline. A stationary quantum result challenges universal sustained change only to the extent that it concerns a genuine physical bearer rather than an eigenvalue, energy quantity, ket, density operator, or vacuum label; is physically realized under preserved bearer identity; uses a representation demonstrated complete for the bearer and all physically attributable relations; and warrants complete equivalence throughout at least one non-zero identity-preserving interval. Anything weaker remains a stationary quantity, stationary representation, bounded operational result, or indeterminate case. No such result is reformulated as a positive static-tail object.

25.2 Classical fixed points

A reduced classical model with differentiable z may satisfy, throughout a declared connected model interval I_ξ,

$$\frac{dz}{d\xi} = 0 \quad \text{for all } \xi \in I_\xi \Longrightarrow z(\xi) = z(\xi_0) \quad \text{for all } \xi, \xi_0 \in I_\xi. \tag{185}$$

The parameter ξ belongs to the model and supplies the analytical structure with respect to which the derivative is defined; it is not identical to the ontological temporal meaning $\mathsf{T}_{\mathrm{ITOF}}$. The equation establishes constancy of the represented variable z throughout the declared interval under the stated model assumptions.

A model-level or coarse-grained fixed point does not establish complete physical equivalence, cessation of change, or a changeless identity-preserving continuation. Bearer-level completeness, physical realization, and valid comparison must be examined without converting the fixed point into a positive static-tail construction.

25.3 Equilibrium and steady states

Thermodynamic equilibrium, dynamical equilibrium, and non-equilibrium steady states are distinct. An equilibrium macrostate can contain microscopic activity; a steady state can preserve selected averages while sustaining fluxes; a mechanical balance can maintain zero net force while internal stresses or environmental relations vary.

The word *stable* therefore requires a declared criterion. Stability may concern bounded response, return after perturbation, persistence of function, constancy of a macrovariable, or preservation of identity. None of these meanings is automatically identical to complete physical constancy.

25.4 Periodic and recurrent systems

For admissibly comparable ontic realizations, a periodic process may return to an equivalent condition after each cycle:

$$(o_n, o_{n+p}) \in \mathcal{K}_A, \qquad X_A(o_{n+p}) \equiv_{\text{phys}} X_A(o_n) \tag{186}$$

for an appropriate period p. This recurrence does not reverse the prior–later order. If intermediate conditions differ, the system realizes change throughout the cycle even though it revisits equivalent conditions.

Exact recurrence of the complete condition at selected realizations is also insufficient to establish complete physical constancy throughout later continuation. The intervals between recurrent stages may contain physically non-equivalent conditions. Periodicity and complete constancy are therefore physically different claims.

25.5 Stable particles and approximate isolation

A stable particle is stable relative to declared decay channels or properties. Approximate isolation means that couplings are weak or controlled relative to a model. Neither expression alone establishes bearer-complete physical equivalence across every physically attributed relation.

These cases remain important candidates for testing the universal postulate. A defensible bearer-complete constancy result would count against sustained change. The theory therefore preserves, rather than excludes, the possibility of adverse stationary cases.

25.6 Modern steady-state caution

A steady state is a claim defined relative to a dynamics and representation. In open quantum systems, a stationary density operator can be the fixed point of a quantum channel or Lindblad generator while relaxation, currents, dissipation, correlations, or perturbation-dependent structure remain physically relevant. Recent work on stable phases of open quantum systems explicitly treats steady-state stability as a dynamical property, not as the absence of all physical processes [17]. Thus a steady-state label is never by itself a bearer-complete demonstration of physical constancy.

25.7 Stationarity-claim discipline

For every apparently stationary class, the analysis must state: the bearer; the full condition; the dynamical law; the exact meaning of stationarity; internal, surface, boundary, and relational channels; the status of isolation; and the evidence that the model is physically realized. A mathematical fixed point remains a serious theoretical challenge, but it is not automatically a physical absence of change. ITOF therefore tests stationary claims at bearer level while retaining the static tail only as an explicitly negated construction.

26. Proof Obligations by Physical Class

The universal postulate cannot be established by repeatedly citing systems that are already visibly changing. Its decisive burden lies in classes whose common representations suggest stationarity, stability, isolation, equilibrium, recurrence, or exceptionally slow change. This section states the bearer, physical routes, evidential access, and adverse condition for the principal classes. It complements the test protocol in Section 27 and prevents one model-specific argument from being generalized beyond its domain.

26.1 Constructed materials and devices

For a polymer, alloy, ceramic, semiconductor, composite, optical element, mechanical structure, electronic component, or other constructed bearer, the complete condition can include composition, microstructure, defects, residual stress, surface chemistry, interfaces, retained charge, phase fractions, damage, and coupling to the environment. Candidate routes of change include thermal fluctuations, diffusion, defect migration, oxidation, photochemistry, creep, fatigue, radiation damage, charge trapping, relaxation, and exchange across boundaries.

Accelerated-weathering standards and long-term aging studies provide controlled evidence for these routes [31, 32, 33, 34, 35, 36]. Such tests establish class-relevant mechanisms and finite-window change. The universal route extends that evidence by testing whether any identity-preserving material realization can make every internal, surface, boundary, and environmental channel permanently neutral.

The adverse model must not be a nominally "stable" product specification. It must be a real bearer whose complete physical condition, including unresolved microstructure and boundaries, remains physically equivalent across all continuing physical engagements compatible with its preserved identity.

26.2 Atomic and molecular systems

Atoms and molecules are systems; energies, orbitals, state vectors, transition frequencies, and spectra are quantities or representations attributed to them. Strong positive witnesses include emission, absorption, scattering, collision, ionization, chemical reaction, decoherence, recoil, and changed correlations. Quantum-jump experiments make individual transitions observable in suitably controlled systems [18, 19].

The hard case is an atom or molecule represented by an exact energy eigenstate of a time-independent Hamiltonian. The formal state can be stationary up to a global phase. This is not yet a bearer-complete counterexample. The analysis must establish the actual bearer, exact Hamiltonian, absence of external coupling, status of quantum fields and boundaries, stability of all relational conditions, and physical equivalence of the complete condition rather than only constancy of selected probabilities or expectation values.

For an atom A, emission supplies a sufficient energy witness only when the ordering, comparison, attribution, and witness-soundness premises of Equation (71) are satisfied. The emitted energy is evidence of a transition in the atom; it is not an independent system governed by the postulate. The lack of emission during a finite observation window does not establish bearer-complete physical equivalence. Metastable and clock states are deliberately selected for long coherence or narrow linewidth; their usefulness depends on controlled transitions and readout, not on becoming systems outside physical change.

26.3 Open quantum systems and steady states

For an open quantum system with density operator ρ_A and generator $\mathcal{L}$, a steady representation can satisfy

$$\mathcal{L}(\rho_{\mathrm{ss}}) = 0. \tag{187}$$

This condition states stationarity under the represented reduced dynamics. It does not automatically assert the absence of microscopic jumps, environmental exchanges, entropy production, currents, correlations, or perturbation-dependent relaxation. The full system–environment bearer and the reduced bearer must not be interchanged.

Research on stable phases of open quantum systems treats steady-state stability in explicitly dynamical terms [17]. For ITOF, the relevant questions are: whether the reduced state is complete for the declared bearer; whether the environment is included or represented only through $\mathcal{L}$; whether individual trajectories differ while the ensemble state is fixed; and whether the physical realization maintains exact stationarity under continuing perturbations.

A class theorem cannot be based on the slogan "steady states still change." It must specify a physically attributable difference or prove the persistence of a non-neutral channel for every identity-preserving member of the class.

26.4 Ground states, vacuum states, and zero-temperature ideals

Ground-state and vacuum descriptions are among the strongest theoretical challenges because they can be stationary under the governing Hamiltonian. The first discipline is type-theoretic: a ket, density operator, vacuum label, or expectation value is not an independent system. A physical field configuration, cavity, material, atom, detector, or bounded identity-coherent arrangement can be a system if it satisfies the bearer criteria.

The second discipline is physical realization. The third law, finite preparation, boundary conditions, coupling to fields, zero-point structure, degeneracy, tunnelling, spontaneous processes, measurement back-action, and residual environments must be examined without presuming that each guarantees an observable transition. The challenge is not defeated by pointing to formal fluctuations if the represented state remains physically equivalent. It is defeated only by a domain-valid difference in the complete bearer condition or a proof that exact physically constant realization cannot persist.

The nuclear-clock programme illustrates the distinction. The ^{229}Th isomer supports exceptionally narrow nuclear transitions and increasingly precise excitation and frequency comparison [24, 25, 26, 27]. The clock transition is a quantity and process of a physical nucleus and apparatus. Long lifetime and narrow linewidth make the system a stringent test of change detection, not a separate temporal substance.

26.5 Classical equilibrium and fixed points

A classical model can possess a fixed point x_* satisfying

$$f(x_*) = 0. \tag{188}$$

Equation (188) alone cannot establish absence of physical change through identity continuation or complete coverage of all internal, relational, and boundary conditions. A fixed mathematical variable is not converted into a positive static-continuation object.

Macroscopic equilibrium usually means stability of selected thermodynamic variables or probability distributions. It can coexist with microscopic motion, exchange, fluctuations, reactions balanced in the mean, or local transitions. These processes count only when they produce physically non-equivalent bearer conditions; their mere mention is not enough. Conversely, equality of temperature, pressure, or density is never a bearer-complete proof of physical constancy.

26.6 Periodic and recurrent systems

Periodic motion can satisfy

$$(o_1, o_3) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_3) \quad \text{with} \quad o_1 \prec_A o_2 \prec_A o_3. \tag{189}$$

The recurrence of content does not erase the physically realized changes through o_2, and the later stage is not the earlier occurrence. A periodic system therefore supplies repeated evidence of change even when an endpoint observable returns to its initial value.

A stronger challenge would be a system represented by a perfectly constant orbit or phase-insensitive state. The bearer and comparison criterion must then be refined. If all purported differences reduce to relabelling, no physical change has been shown. If phase, position, momentum, field configuration, coupling, or another attributable component differs, the recurrence is not bearer-complete physical equivalence.

26.7 Stable particles and long-lived systems

"Stable" commonly means no observed decay channel or a lifetime beyond current bounds, not absence of every physical relation or condition change. A stable particle can propagate, scatter, interact with fields, change momentum, become entangled, or participate in a bound system while preserving particle identity. A free particle in an exact momentum eigenstate is a formal challenge analogous to the stationary quantum case and must be assessed at the level of the physical bearer and complete condition.

Long-lived astrophysical, geological, or material systems similarly require a distinction between category persistence and condition constancy. Stability of identity can coexist with extensive change; indeed, identity criteria are constructed to allow such persistence.

26.8 Geophysical and planetary systems

A glacier, fault, ocean, atmosphere, planetary body, or geophysical region is an open and distributed system. Its boundaries and identity conditions require explicit specification. Evidence can include deformation, mass balance, seismicity, thermal fields, chemical flux, rotation, erosion, accumulation, internal convection, and remote sensing. Long-term glacier monitoring and global mass-loss reconstructions demonstrate the combination of records, models, and uncertainty required for distributed bearers [43, 44, 45].

Planetary seismology and remote missions reveal continuing internal and surface processes even in bodies once treated as inactive [46]. These observations support broad class coverage, but the universal argument must still articulate why an ideally quiescent planetary bearer cannot remain completely physically equivalent across continuation while identity persists.

26.9 Stellar and remote astrophysical systems

Stars and remote objects are known through propagated records rather than direct local access. Asteroseismology, transient surveys, repeated imaging, spectra, and flux records establish many forms of physical change [47, 28, 29, 30]. The source, radiation, detector, and reconstructed record remain different systems, physical carriers, or representations; none is identified with a source stage merely because it carries, propagates, detects, or represents information about that source.

The first received record is not the first stage of source change. A remote source may have undergone extensive prior physical change before detection. Likewise, the cessation of a survey does not end the source's physical continuation. Propagation differences must be separated from emission differences before the record is used as evidence about the source.

26.10 Living, cellular, and genetic systems

Living systems display metabolism, turnover, repair, replication, transport, signalling, adaptation, damage, and interaction. The universal claim must nevertheless avoid vague appeals to "life processes." The bearer can be a molecule, genome, cell, tissue, organism, or population, and the level must remain fixed during inference.

Somatic mutation studies establish continuing localized genomic differences in normal tissues [37, 38, 39, 42]. Comparative vertebrate work shows broad variation in germline mutation rates [40], while persistent lesions demonstrate that a physical trace can remain through multiple cell cycles before generating mutations [41]. These results show that change can be minute, retained, delayed in expression, and detectable only by reconstruction. They do not justify treating DNA sequence, mutation count, or age as the system; the bearer is the declared physical biological system.

26.11 Clocks and measurement systems

A manufactured clock is a constructed physical system designed to convert selected transitions, oscillations, or accumulated phase into a record. A natural astronomical, geological, atomic, or other process functions as a clock only when it is physically registered and a declared protocol converts selected evolution into standardized records. Drift, sensitivity to external physical factors and couplings, relativistic path dependence, control errors, and readout noise are changes in the relevant clock bearer or measurement chain. State-of-the-art optical and nuclear clocks demonstrate both exceptional stability and the continuing physical operations required to produce that stability [23, 20, 21, 22, 27].

A functioning clock must realize distinguishable physical and readout states somewhere within its operative cycle, but two sampled readings may remain equal because both fall within one digital display step or within the device's resolution. Equality of sampled readings therefore does not establish bearer-complete physical equivalence of the clock. The relevant theoretical challenge is an isolated transition system represented as stationary. Its analysis belongs to the atomic and quantum classes, while the instrument as a whole belongs to constructed open systems.

26.12 Geometrically stationary relativistic models

A stationary or static spacetime solution is a mathematical model with specified symmetries. The metric components or curvature invariants are not independent systems. A black hole, star, field configuration, or entire modelled universe can be proposed as the bearer only after the ontology and boundaries are declared.

A stationary solution does not by itself establish a real bearer isolated from accretion, radiation, perturbations, quantum processes, or relational change. Conversely, ITOF cannot dismiss the exact solution merely by citing typical astrophysical environments. The correct test asks whether the physical realization can satisfy the solution's complete constant-condition requirements while preserving identity. This remains one of the most demanding theoretical fronts of the universal proof.

26.13 Class synthesis obligation

Each subsection above supplies a set of candidate routes and adverse conditions. None alone proves the universal postulate. Completion requires showing that every bearer in the full physical-system domain falls into at least one analysed class and that every non-zero identity-preserving interval is covered by a valid class route. Overlapping class descriptions must yield compatible change judgments. The taxonomy must remain open to new physical systems and new levels of description without allowing an unclassified remainder to be ignored.

27. Designing a Domain Test of Sustained Change

A foundational postulate becomes scientifically useful only when it can be translated into domain-specific tests without changing its meaning. This section states the minimum design of such a test. It does not add a new proof route; it organizes the premises that every route must supply. A domain test does not enumerate all ontic realizations or change stages. It selects a physically justified bearer, links a finite set of records or model outputs to realized references, and asks whether at least one sound difference is established or whether a specified bridge fails. The formal domains remain ontological scopes, not completed observational inventories. Investigators, instruments, records, and environments also undergo physical change during the test; their participation must be modelled where relevant, but their changes do not substitute for bearer-attributed evidence about the target system.

27.1 Step 1: fix the bearer and adverse outcome

The bearer specification must be completed before the data are classified. The investigator states the boundary or attribution rule, identity criterion, complete-condition content, full ontological comparison specification, ontic-reference domain, and the conditions under which identity ends. The adverse outcome is also pre-specified: a comparison-complete identity-preserving continuation on which the complete condition remains physically equivalent.

Pre-specification prevents two forms of circularity. A system cannot be redefined after a difference is observed so that the difference enters the bearer, and it cannot be narrowed after a null result so that unmeasured changing content is excluded. Revisions are permitted, but each revision initiates a new analysis whose conclusions are not retrospectively transferred to the old bearer.

27.2 Step 2: identify witnesses and coverage obligations

A local change study needs at least one ordered comparable pair and a sound witness of non-equivalence. A sustained-change study needs a rule that reaches beyond any selected ontic realization while the bearer identity is preserved. A bearer-complete constancy challenge requires ontological comparison completeness throughout the claimed later continuation and, for an empirical claim, protocol-qualified evidential classification of the represented comparisons.

The investigator should therefore state the quantifiers in ordinary language before selecting measurements. Is the claim about one pair, every comparable pair in a window, every later identity-preserving stage reached by the declared continuation rule, or every bearer in a class? Many apparent disagreements arise because evidence adequate for one quantifier pattern is used to support another.

27.3 Step 3: separate physical variables from access variables

The physical variables that belong to X_A need not be identical to the variables directly measured. A detector may estimate a proxy, a remote survey may infer a source property, and a reconstruction may recover an earlier condition through a model. The test must identify the representation map, the instrument or data process, and the bridge from the access variable to the physical component whose difference is claimed.

A good design records which changes would remain invisible to the chosen protocol. This limitation does not invalidate a positive result in a measured component, but it constrains any claim of bearer-complete physical equivalence. The protocol should distinguish a bounded null statement, such as "no difference larger than the declared threshold was resolved," from an ontological statement of equivalence.

27.4 Step 4: state independence and robustness

When several evidential channels are combined, their shared sources, instruments, calibrations, datasets, and models must be represented. Independence is assessed after common dependencies have been merged. Robustness is then tested against admissible changes in calibration, model family, reconstruction assumptions, and realization assignment.

A conclusion that survives these variations carries stronger warrant. A conclusion that depends on one unsupported path remains conditional. This is particularly important for genetic, geological, planetary, and astrophysical reconstructions, where direct access to earlier conditions is limited.

27.5 Step 5: report three possible outcomes

Every test should permit three outcomes:

(i) warranted physical non-equivalence, supporting realized change;

(ii) warranted complete equivalence over the declared scope, supporting constancy within that scope; and

(iii) indeterminacy because order, comparison, attribution, uncertainty, or coverage is insufficient.

A framework that permits only favorable outcomes would not be falsifiable. ITOF therefore treats indeterminacy and adverse evidence as legitimate scientific results.

27.6 Step 6: declare the function of the test

Every study states its primary inferential function before outcome inspection. Five functions are distinguished:

(T1) **sustained-change test**: evaluates one declared bearer continuation or a class-level premise against the identity-preserving interval quantifiers of $\mathrm{SC}(A)$;

(T2) **bridge test**: evaluates whether a law, mechanism, balance, record, projection, or reconstruction soundly warrants full bearer-level equivalence or non-equivalence;

(T3) **compatibility test**: evaluates whether ITOF preserves the operational predictions of an established domain theory, including relativistic clock comparison;

(T4) **type-transfer test**: evaluates whether a conclusion has been moved validly from a quantity, representation, record, or model to the physical bearer; and

(T5) **discriminatory inference test**: compares the ITOF inference rule with a rival rule that identifies constancy of a selected representation or reading with complete bearer constancy.

A study may serve more than one function, but its conclusions are reported separately. Agreement with a domain prediction is a compatibility result; it is not automatically a test of the universal postulate. A successful local bridge is not automatically a class theorem.

27.7 Step 7: grade null results by completeness

A null result receives a declared completeness grade rather than the undifferentiated label "no change":

(C0) **reading stability**: one instrument output or clock reading remains within its registered tolerance;

(C1) **projection stability**: a declared set of measured or represented quantities remains equivalent within the protocol;

(C2) **multi-channel stability**: physically non-redundant channels jointly return bounded null results after shared dependencies are modelled;

(C3) **bearer-model completeness**: the registered model and measurements cover every component and engagement channel claimed to constitute the bearer condition over the tested identity-continuing realization range; and

(C4) **negative no-static-tail standard**: a finite null result never warrants changeless continuation; any adverse claim would require an independently justified bearer-complete physical account of every relevant continuing stage and condition.

Grades C0–C2 warrant bounded operational stability only. C3 can challenge a class bridge when its completeness claim is independently defensible. C4 is retained as the formal adverse standard that defines what would contradict sustained change, not as an ordinary finite-protocol outcome. Failure to reach a higher grade is reported as a limitation or indeterminate status, not converted into physical constancy.

27.8 Step 8: triangulate physically non-redundant channels

For a difficult-class empirical test, the protocol should combine at least two physically non-redundant access routes whenever the bearer permits them. Suitable channels can include spectroscopy, correlation or trajectory measurements, calorimetry, field sensing, surface and boundary diagnostics, structural imaging, compositional analysis, environmental monitoring, and independent replication. Two readouts produced from the same detector, calibration, reconstruction, or model do not count as independent merely because they are numerically different.

The dependency structure is registered before synthesis. Shared instruments, reference standards, priors, simulations, data reductions, and calibration chains are merged into one dependency node. Convergence among genuinely distinct channels strengthens the bridge to full bearer-level non-equivalence; divergence identifies the exact attribution, model, comparison, or completeness assumption requiring revision. A single-channel result remains admissible when no second channel is physically available, but its scope stays conditional on that channel's bridge.

27.9 Step 9: prioritize the most stringent constancy candidates

The validation programme gives first priority to systems for which complete constancy is most plausible rather than to systems already known to vary macroscopically. The priority suite includes exact or candidate energy-eigenstate and ground-state realizations; dark or protected quantum states; stationary reduced open-system descriptions; exact classical fixed points and equilibria; periodic and recurrent systems; stable particles and ideally isolated composites; static relativistic realizations with declared matter and boundary content; and systems whose expected differences lie below the registered resolution or observation window.

Each priority test states the declared bearer, full comparison specification, identity-continuing range, domain equations, independent channels, expected supportive signature, admissible null grade, and the bearer-complete constancy premises that a null result still fails to establish. No priority test is designed to infer an absolute static tail from silence. The difficult-class matrix in Appendix F supplies class-specific starting obligations.

27.10 Step 10: perform a discriminatory inference test

ITOF makes an empirically auditable restriction on ontological inference even when it adopts the same numerical dynamics as the domain theory:

$$\mathrm{Const}_P(R_{A,P}; o_1, o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big]. \tag{190}$$

Here $\mathrm{Const}_P(R_{A,P}; o_1, o_2)$ means protocol-level constancy of the selected record or representation between linked realizations. The implication is licensed only when an independently justified representation-completeness bridge reaches the full comparison specification. A discriminatory protocol therefore registers one primary quantity or representation expected to remain stationary and monitors physically non-redundant bearer channels over the same identity-connected pair. A warranted difference in any declared bearer component refutes the transfer from representational constancy to complete physical constancy while leaving the domain equation governing the primary representation intact.

This is an inference-discrimination test, not a claim that ITOF must alter every numerical prediction of the established domain theory. Its scientific target is the additional ontological conclusion drawn from a stable clock relation, stationary density operator, conserved quantity, or geometric symmetry. If all channels remain null, the result is classified by the C0–C4 ladder rather than promoted directly to bearer-complete physical equivalence.

27.11 From domain result to broader scope

A successful domain test does not automatically establish the postulate for neighbouring classes. Transfer requires an argument that the bearer criteria, comparison structure, and physical premise apply to the broader domain. A multi-domain synthesis additionally requires non-circular coverage: the target cannot be defined by selecting only classes already known to change.

This design discipline connects the foundational ontology to practical research while preserving the distinction between a local witness, a class theorem, an evidential synthesis, and universal completion.

27.12 Compact pre-registration checklist

Before final outcome inspection, a domain test should record:

(P1) the bearer boundary, membership rule, identity criterion, full comparison specification χ_A^{full}, and reason for continued identity;

(P2) the realized or licensed reference segment, coverage window, and rule preventing result-driven truncation;

(P3) the complete-condition content, including internal variables, bearer-attributable relational and coupling states, separately declared interval-operative engagements, and redundancy rules;

(P4) the domain equations or stochastic laws, boundary conditions, and approximation regime;

(P5) the claim projection $X_{A,Q}$, claim-level comparison specification $\chi_{A,Q}$, ideal representation, calibration, provenance, and uncertainty model;

(P6) the realization links, direct-record or reconstruction branch, projection-to-bearer difference bridge, and any representation-completeness claim;

(P7) the primary test function (T1–T5), target quantifiers, registered prediction, direction, magnitude or lower bound where applicable, and realization or record window;

(P8) the evidential-channel dependency map, including which channels are physically non-redundant and which share instruments, calibrations, models, or datasets;

(P9) the apparent-stability control, including tolerance, frame, registration method, anticipated null-result grade (C0–C4), and why that grade is or is not sufficient for complete-constancy testing;

(P10) the adverse outcomes, including model failure, bridge failure, non-identifiability, class-level failure, or independently justified bearer-complete evidence that would contradict sustained change; and

(P11) the permitted conclusion: local change, repeated-window evidence, a class theorem, compatibility, type-transfer failure, cross-domain support, indeterminacy, or countermodel, without upward transfer beyond the warranted scope.

28. Physical Routes to Class-Level Universal Change

A class-level result must match the identity-preserving interval quantifiers in $\mathrm{SC}(A)$. Finding one varying pair somewhere in a class is insufficient.

28.1 Persistent effective route

For a class $\mathcal{C}_k$, suppose the domain theory establishes

$$\forall A \in \mathcal{C}_k\ \forall o_1, o_2 \in \mathcal{O}_A : \quad [o_1 \prec_A o_2 \wedge I_A(o_1, o_2)] \Rightarrow \exists u, v \in \mathcal{O}_A \begin{bmatrix} o_1 \preceq_A u \prec_A v \preceq_A o_2, \\ I_A(u,v),\ (u,v) \in \mathcal{K}_A, \\ \mathcal{C}_A^{\mathrm{eff}}(u,v),\ \mathrm{CauseBridgeSound}_A(u,v) \end{bmatrix}. \tag{191}$$

Because the displayed interval premise supplies an effective, soundly bridged change witness inside every non-zero identity-preserving interval, it yields

$$\forall A \in \mathcal{C}_k : \quad [\mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A)]. \tag{192}$$

28.2 Cumulative route

Some systems admit a cumulative bearer-attributed balance $B_A[o, o']$ whose non-zero value guarantees a difference in complete condition. For a domain-certified witness,

$$(o \prec_A o') \wedge I_A(o, o') \wedge ((o, o') \in \mathcal{K}_A) \tag{193}$$

$$\wedge\ \mathrm{BalanceWitnessSound}_A(o, o') \wedge B_A[o, o'] \neq 0 \Longrightarrow \mathrm{Ch}_A(o, o'), \tag{194}$$

$$\forall o_1, o_2 \in \mathcal{O}_A : \ [o_1 \prec_A o_2 \wedge I_A(o_1, o_2)] \Longrightarrow \exists u, v \in \mathcal{O}_A \tag{195}$$

$$[o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge I_A(u,v) \wedge (u,v) \in \mathcal{K}_A \tag{196}$$

$$\wedge\ \mathrm{BalanceWitnessSound}_A(u,v) \wedge B_A[u,v] \neq 0]. \tag{197}$$

The balance may represent transferred energy, irreversible entropy production, accumulated damage, compositional turnover, phase displacement, flux, mutation burden, or another domain-defined quantity. Its physical sufficiency must be established rather than assumed.

28.3 Exclusion route

A third route excludes every identity-preserving physically constant realization allowed by a bearer-complete class model. Exclusion of a mathematical invariant set is insufficient if the model omits an attributable physical channel, fails to cover actual later realizations, or does not justify comparison completeness.

28.4 Triangulation

The strongest class result combines a physical-cause route, at least one independently controlled observational route, and a theoretical exclusion of bearer-complete physical constancy. Disagreement is scientifically informative and must not be removed by redefining the bearer or condition after the result.

28.5 From classes to universal scope

If $\{\mathcal{C}_k\}_{k\in K}$ is a bearer-complete cover of $\mathbb{S}_{\mathrm{phys}}$ and Eq. (192) holds for every class, then

$$\begin{aligned}\left[\mathbb{S}_{\mathrm{phys}} = \bigcup_{k\in K} \mathcal{C}_k\right] \wedge \left[\forall k\ \forall A \in \mathcal{C}_k :\ (\mathrm{IdExtended}(A) \Rightarrow \mathrm{SC}(A))\right] \\ \Longrightarrow \forall A \in \mathbb{S}_{\mathrm{phys}} :\ (\mathrm{IdExtended}(A) \Rightarrow \mathrm{SC}(A)).\end{aligned} \tag{198}$$

The inference is elementary; proving the class premises is the substantive universal task.

29. Empirical Access and Representative Domains

Representative domains provide direct and instrument-mediated access to realized physical change and to its continuing extension across diverse living and non-living systems. Through successive physical differences and records, the observed progression and extent of change can often be measured operationally and approximately across broad physical categories. Such measurement estimates the represented progression within a declared investigation window; it need not enumerate every physically realized stage and it does not measure time itself. Approximation belongs to the observational and inferential procedure, not to the physical reality of change.

29.1 Materials and constructed systems

Glassy polymers exhibit physical aging in optical, mechanical, and relaxation properties while preserving macroscopic identity for extended periods [31, 32]. Standardized exposure and dynamic-mechanical protocols provide controlled procedures for linking recorded exposure conditions to measured material differences [33, 34, 35].

These systems clarify several ITOF distinctions. A product can remain recognizably the same product while its molecular organization, modulus, optical properties, or failure susceptibility changes. A later fracture can disclose a prior accumulation of fatigue or aging, but the detailed earlier path must be supported by tests and physical models.

Cultured pearls provide an example of localized post-growth modification. Heat and light treatments can alter fluorescence and material properties without requiring replacement of the whole pearl [36]. The case illustrates that small or localized change is sufficient when the difference is physically attributable.

29.2 Geophysical systems

Glaciers and coupled mountain systems are open, distributed bearers. Their boundaries, mass exchange, flow, surface geometry, and environmental couplings must be declared explicitly. Terrestrial photogrammetry, remote sensing, and mass-balance reconstruction document deformation and mass change across ordered observations [43, 44, 45].

The image sequence is not the glacier's physical past itself. Registration, geometry, source attribution, atmospheric correction, uncertainty, and reconstruction create the bridge from records to the physical condition of the glacier. Different choices of bearer – glacier, glacier–mountain system, or regional landscape – support different claims.

Geophysical cases also show why apparent form stability is not bearer-complete physical constancy. A mountain or glacier can preserve a recognizable macroscopic shape while material, stress, temperature, mass distribution, and boundary relations change.

29.3 Planetary systems

In situ planetary missions provide physically linked records of seismic, atmospheric, thermal, and surface processes. The InSight mission, for example, established an ordered measured record of Martian physical activity through a declared instrument suite and operational context [46].

The planet, lander, instrument, local environment, and data products are distinct bearers. A detector record supports a claim about Mars only through source attribution and instrument modeling. Once that bridge is established, the records can warrant physical non-equivalence of planetary conditions without requiring direct human access to the source process.

29.4 Stellar and remote systems

Asteroseismology infers stellar structure and variability from successive optical records. The inference depends on source identity, propagation, detector calibration, mode identification, and stellar models [47]. Survey systems such as TESS and ZTF extend ordered coverage of variable and transient sources [28, 29, 30].

When propagation differences are controlled, differential arrival intervals and reconstructed source successions can preserve successive source information. The evidential burden lies in separating source change from propagation and detection effects.

29.5 Living systems

Living systems contain coupled molecular, cellular, physiological, behavioural, and environmental processes. Their openness and internal organization make bearer specification essential. A cell lineage, tissue, organism, and population can share material and causal relations while supporting different identity criteria and complete conditions.

The macroscopic life course of a human or another living organism, from birth through growth, maturity, and ageing to death, provides a direct manifestation of continuing physical change. Growth, maturity, and ageing encompass many physically realized stages, while birth and death mark biologically described boundary transitions under the declared identity specification; none of these labels is a discrete temporal atom or an exhaustive division of stages. Organisms belonging to the same biological category need not undergo the same physical changes or share equal contents, magnitudes, mechanisms, or rates of change. What they share is the extension and succession of realized change stages while each bearer identity continues, not equality of the physical content of change.

Genetic records are valuable because they can preserve ordered lineage differences beneath outward continuity. Physiological and environmental records can add independent channels. Their convergence strengthens a retrospective account only when shared dependencies are controlled.

29.6 What representative evidence establishes

The cases establish that physically grounded, identity-preserving change occurs in diverse domains and can be accessed through direct records, reconstructed past conditions, and remote signals. They also demonstrate that macroscopic continuity does not imply complete physical constancy. The transition from representative domains to universal synthesis is supplied by the domain-by-domain proof conditions and non-circular class coverage developed in Section 30 and Appendix D.

30. Scientific Status, Falsifiability, and Open Scope

30.1 What has been established

V24/F4 establishes a coherent theoretical architecture with the following components:

(1) a non-metric definition of time as one universal ordered stage extension with direct objective absolute simultaneity;

(2) a bearer-centred, threshold-free definition of physical change;

(3) a strict distinction among systems, quantities, states, representations, records, and measurements;

(4) an identity-conditioned universal-change postulate;

(5) a first proof route through persistent effective physical causes;

(6) a second route through finite observation and measurement;

(7) a difficult-class taxonomy and test design;

(8) a class-cover condition for universal synthesis;

(9) explicit adverse test conditions;

(10) an explicit ontological confrontation with relativistic geometry, spacetime dimensionality, proper time, coordinate simultaneity, and clock synchronization, together with the distinct ITOF postulates of one universal prior–later order and direct objective absolute simultaneity; and

(11) an integrated discipline for derivatives, non-enumerated ontic domains, the negative exclusion of static continuation, and mathematical or representational bridges to material reality.

These components are mutually supporting but do not turn the universal postulate into a theorem by stipulation. The architecture is comprehensive as a formal map of proof obligations, while universal empirical proof remains an explicitly delimited scientific programme.

30.2 What remains open

Universal closure requires at least five achievements. First, the class taxonomy must be bearer-complete. Second, every class must have a domain-valid route from identity-preserving continuation to later physical non-equivalence. Third, claims of neutrality, exact cancellation, isolation, stationary representation, or equilibrium must be tested at the level of the complete bearer condition. Fourth, the resulting class arguments must remain compatible where classes overlap. Fifth, the one universal prior–later order and direct absolute-simultaneity relation must remain mathematically coherent with relativistic causal structure, and an independent empirical or domain-theoretic bridge must be supplied wherever a specific absolute-simultaneity pairing is claimed from coordinate, signal, clock, or other physical data. The ontological relations are postulated as primitive in V24/F4, but a particular assignment is neither created nor established merely by a measurement convention.

The remaining work is therefore finite in structure but extensive in scientific content. It is not solved by adding further universal symbols.

30.3 Falsifiability

The universal postulate is vulnerable to a physically demonstrated system satisfying all of the following:

- the bearer is a real physical system admitted by the declared criteria;
- its identity remains preserved;

- its complete condition is fixed independently of the outcome;
- later continuation is physically grounded rather than merely imagined;
- every attributable internal, local, surface, boundary, relational, and engagement channel is covered, and the comparison domain is complete for the claimed continuation;
- the complete condition remains physically equivalent throughout that continuation;
- the result is not due to finite resolution, coarse graining, model incompleteness, or inaccessible variables.

A purported bearer-complete demonstration of changeless continuation would falsify or restrict the strong postulate if its universal premises were independently established. A finite interval that is quiet only at the protocol or observational level, a repeated equal record, or an unresolved test result remains a bounded epistemic result and cannot establish an absolute static tail. A serious adverse case would require an independently validated bearer-complete physical theory or law, realized identity-preserving applicability, and complete comparison of every physically relevant condition throughout the continuation claimed by that account. A directed physical cycle in the claimed prior–later order would challenge the temporal-order foundation itself and must be treated as a foundational adverse result, not a minor anomaly.

30.4 Outcome classes

Every domain test should report one of three outcomes:

(i) **support**: a sound witness or bridge establishes physical change;

(ii) **adverse**: bearer-complete physical evidence contradicts sustained change or a core order property fails;

(iii) **indeterminate**: the protocol, representation, or class analysis is insufficient.

Indeterminacy is not evidence for either side. It identifies the missing bridge or coverage obligation.

30.5 Universal theory and scientific restraint

ITOF makes a strong universal claim about time and a strong postulate about physical change. The appropriate response is neither rhetorical caution that empties the theory nor premature certainty that closes the research programme. Scientific strength requires stating the claim exactly, exposing its strongest countercases, preserving established physical theories within their domains, and refusing to convert evidential limits into ontological conclusions.

31. Conclusion

ITOF V24/F4 defines time as follows: Time expresses only the one extension and ordering of the realized stages across physical systems in the universe; it does not express the bearer-specific physical differences established between stages, their mechanisms, or their causes. The extension is one and the same for all systems. Stages of different systems are directly related by objective absolute simultaneity, without a universal physical stage or reified temporal layer containing them. Throughout every shared identity extent, stages correspond one-to-one and preserve prior–later order. Their stage conditions may differ, and the bearer-specific changes established across their respective ordered intervals may differ, while their completed identity-bounded stage cardinalities may differ only because bearer identities begin or end at different positions in the one extension. Time does not consist of two stages; two stages are only the minimum analytic distinction required to establish one change.

Physical change belongs to a declared system. It is any actual non-equivalence in the complete condition of that system between ordered, admissibly comparable ontic realizations. Those stages carry the ordered complete conditions between which change is established. The condition realized through change from an earlier condition occupies a later order-position, and that later realization may become earlier relative to a subsequently realized change. No ontological threshold is imposed. A minute, localized, surface, boundary, relational, genetic, or presently unobserved difference can be sufficient. Energy and other quantities can witness change but are not independent systems. The continuation and extension of change stages are attributed to physical systems, not to non-systemic or non-structural physical factors considered only as roles, transfers, operative quantities, boundary conditions, couplings, or constraints; values and representations are not bearers of that extension. A system acting as a factor remains included as a system. Quantum states and geometric quantities are states or representations of bearers. Records and measurements provide access but are not identical with the realized physical past. One sound bearer-attributed difference can establish change without enumerating all stages; observational silence cannot establish their absence or an absolute static tail.

Mathematical, geometrical, derivative, and representational structures are indispensable analytical tools, but their physical meaning depends on explicit realization and attribution bridges. They neither define time nor replace complete bearer change. Researchers, instruments, records, and environments are changing physical systems inside the same universal succession, subject to the governing evidential limits established above.

The universal-change postulate states that physical change in a system does not occur once and then end; it continues and extends while the system's identity is preserved. The postulate and its proof programme concern change itself: why and how it occurs, the internal and external causes and mechanisms through which it is realized, and the grounds for its continuation and extension across physical systems. Where the identity-preserving realization range extends beyond one changed pair, sustained change realizes the extended succession of stages whose extension and order are described by time; the temporal definition neither explains nor proves that physical continuation. When identity fails, attribution to that system ends. Any successor structure or system is analysed under its own specification, and the universal postulate applies to it as a physical system; particular evidential claims are established separately for that bearer. The proof programme begins with physical causes, proceeds through observation and measurement, and confronts the hardest stationary, equilibrium, periodic, quantum, isolated, and geometrically static candidates through class-specific tests and coverage obligations.

ITOF confronts relativistic temporal ontology directly. Lorentz transformations act on coordinates; proper time is a metric functional on a worldline; curvature belongs to the metric and connection;

spacetime is a geometrical representation; dimensionality is a structural property of a model; and clock or redshift differences belong to physical systems, signals, paths, and records. None of those objects is time in the ITOF sense. Relativistic success establishes the relations actually defined and measured, not identity between time and a coordinate, metric functional, manifold, curvature tensor, or formal dimension. ITOF also asserts one objective universal prior–later order and direct objective absolute simultaneity, and rejects the inference from frame-dependent coordinate simultaneity to the nonexistence of objective simultaneity. This is a substantive departure from standard Lorentzian temporal ontology. It does not specify a preferred inertial chart, universal clock, metric spacing, signalling mechanism, reified temporal layer, or dynamical field; particular simultaneity assignments must preserve established causal direction and require an independent physical bridge. Four- or higher-dimensional geometry acquires physical authority only through such bridges and discriminating evidence, not through formal consistency alone.

The present achievement is a disciplined, formally comprehensive architecture for proving universal physical change; its universal empirical closure remains an explicit open scientific programme rather than an assumed conclusion. Closure requires completed class coverage and domain-valid support for sustained change across every admitted bearer class. By keeping this obligation explicit, V24/F4 preserves both the strength of its universal theory of time and the scientific conditions under which its strongest physical postulate can be accepted, restricted, or rejected.

A. Formal Type and Comparison Audit

The main text uses compact unindexed physical-equivalence notation for the claim-independent bearer-complete comparison specification χ_A^{full}. This appendix states the minimum structure needed to prevent coordinate choice, gauge, inconsistent transport, changing identity criteria, or a change of experimental question from producing a false ontological difference.

Fix χ_A^{full} with $\mathrm{Spec}(A)$. For each fully comparable pair $(o_1, o_2) \in \mathcal{K}_A$, let $\kappa_{12}^{\mathrm{full}}$ denote the lawful bearer-complete comparison map selected by that specification. When transport is required, the compact ontological judgments used in the main text are evaluated through that map:

$$\begin{aligned}&(o_1, o_2) \in \mathcal{K}_A \Longrightarrow \\ &\begin{cases} X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2) \Longleftrightarrow \kappa_{12}^{\mathrm{full}}(X_A(o_1)) \equiv_{\chi_A^{\mathrm{full}}} X_A(o_2), \\ X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2) \Longleftrightarrow \kappa_{12}^{\mathrm{full}}(X_A(o_1)) \not\equiv_{\chi_A^{\mathrm{full}}} X_A(o_2). \end{cases}\end{aligned} \tag{199}$$

The full comparison domain and its admissible maps close under identity, compatible reversal, and composition only where the component procedures are independently certified as composable for the declared bearer:

$$o \in \mathcal{O}_A \Rightarrow (o, o) \in \mathcal{K}_A \text{ and } \mathrm{id}_o \text{ is admissible,} \tag{200}$$

$$(o_1, o_2) \in \mathcal{K}_A \Rightarrow (o_2, o_1) \in \mathcal{K}_A \text{ and } \kappa_{12}^{\mathrm{full}} \text{ admits a reverse-compatible map } \kappa_{21}^{\mathrm{full}}, \tag{201}$$

$$\left.\begin{array}{c}(o_1, o_2), (o_2, o_3) \in \mathcal{K}_A, \\ \kappa_{12}^{\mathrm{full}}, \kappa_{23}^{\mathrm{full}} \text{ are certified composable for the declared bearer}\end{array}\right\} \Rightarrow \begin{array}{c}(o_1, o_3) \in \mathcal{K}_A, \\ \kappa_{23}^{\mathrm{full}} \circ \kappa_{12}^{\mathrm{full}} \text{ is admissible.}\end{array} \tag{202}$$

The reverse-compatible map need not be a literal set-theoretic inverse. It must preserve the same bearer identity, complete-condition content, gauge conventions, physical redundancies, and attribution rules. Pairwise comparability alone does not license a composed route when the component procedures use incompatible transports or realization-identification conventions.

Whenever a direct map $\kappa_{13}^{\text{full}}$ and a composed path $\kappa_{23}^{\text{full}} \circ \kappa_{12}^{\text{full}}$ are independently certified as physically equivalent full comparison procedures, their transported results must agree modulo complete physical equivalence:

$$\begin{gathered}\left[\kappa_{13}^{\text{full}} \text{ and } \kappa_{23}^{\text{full}} \circ \kappa_{12}^{\text{full}} \text{ are certified physically equivalent}\right] \\ \Longrightarrow \kappa_{13}^{\text{full}}(X_A(o_1)) \equiv_{\chi_A^{\text{full}}} \left(\kappa_{23}^{\text{full}} \circ \kappa_{12}^{\text{full}}\right)(X_A(o_1)) \,.\end{gathered} \tag{203}$$

An admissible closed full-comparison cycle acts trivially under χ_A^{full} only when it is independently certified as physically null for the declared bearer. Genuine path-dependent transport, including non-trivial holonomy, is retained as physical comparison data and may make a pair non-comparable under the full specification; it is not erased as a calibration or gauge artifact.

Claim-level specifications remain distinct. For $\chi_{A,Q}$, the map $\kappa_{12}^{A,Q}$ acts on the declared projection or representation and returns only a claim-level judgment on $\mathcal{K}_{A,Q}$. It may support a full ontological judgment only through Equations (32) or (33). Changing Q changes the evidential question, not the truth conditions of Ch_A.

Within a closed full-comparable component, physical equivalence is reflexive, symmetric, and transitive. These properties are not asserted between ontic references for which no full comparison is defined. Passive coordinate transformations, gauge transformations, and physically null relabelings preserve the full judgment. Active transformations that alter the realized condition are not quotiented out unless independently proved physically null for the bearer.

Observational indistinguishability is weaker than physical equivalence:

$$\widehat{R}_A(o_1) \approx_{P,\alpha} \widehat{R}_A(o_2) \;\not\models\; \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\text{phys}} X_A(o_2)\Big]. \tag{204}$$

The protocol relation $\approx_{P,\alpha}$ states that the selected procedure does not resolve a difference at its declared uncertainty or decision level. It does not certify identity of omitted degrees of freedom or ontological physical equivalence.

B. Past Reconstruction and Cross-Description Consistency

This appendix governs representations of already realized past references without assigning any retrospective description a causal role. A reconstruction procedure must be outcome independent, bearer coherent, restricted to actual physical support, and adequate for the claim evaluated. Arbitrary truncation is not permitted to create or remove change.

Let two protocols produce reconstructions $\widehat{\mathcal{R}}_{A,P}$ and $\widehat{\mathcal{R}}_{A,P'}$. A cross-representation claim is non-vacuous only if both supports contain linked realized references:

$$\begin{gathered}\widehat{O}_{A,P} \neq \varnothing, \qquad \widehat{O}_{A,P'} \neq \varnothing, \\ \exists \widehat{o}_P, o_P \;\; \text{RealizationLinked}_P(\widehat{o}_P, o_P), \\ \exists \widehat{o}_{P'}, o_{P'} \;\; \text{RealizationLinked}_{P'}(\widehat{o}_{P'}, o_{P'}).\end{gathered} \tag{205}$$

When the two representations are claimed to describe an overlapping physical portion, the claim additionally requires non-empty common ontic support:

$$\exists \widehat{o}_P, \widehat{o}_{P'}, o \left[\mathrm{RealizationLinked}_P(\widehat{o}_P, o) \wedge \mathrm{RealizationLinked}_{P'}(\widehat{o}_{P'}, o)\right]. \tag{206}$$

Disjoint represented segments instead require the separately justified continuation link stated below.

For coextensive equal-resolution representations, a correspondence

$$h_{PP'} : \widehat{O}_{A,P} \xrightarrow{\sim} \widehat{O}_{A,P'} \tag{207}$$

must preserve represented order

$$\widehat{o}_1 \widehat{\prec}_{A,P} \widehat{o}_2 \iff h_{PP'}(\widehat{o}_1) \widehat{\prec}_{A,P'} h_{PP'}(\widehat{o}_2), \tag{208}$$

and preserve the intended condition conclusion under declared representation maps:

$$\mathrm{ConclusionPreserved}_{PP'}(\widehat{o}_1, \widehat{o}_2). \tag{209}$$

For partial overlap, the correspondence is restricted to linked sub-supports:

$$h_{PP'} : \widehat{O}^{PP'}_{A,P} \longrightarrow \widehat{O}^{PP'}_{A,P'}. \tag{210}$$

When the overlapping sub-supports also have equal resolution, this restricted map must be bijective and order preserving. Unequal-resolution overlap is governed by the common-refinement construction below. Disjoint represented segments require a separately justified continuation link; no fabricated bijection is permitted.

For unequal resolutions, a represented common refinement $\widehat{\mathcal{R}}_{A,P^\star}$ may admit monotone surjections

$$\pi_P : \widehat{O}_{A,P^\star} \twoheadrightarrow \widehat{O}_{A,P}, \qquad \pi_{P'} : \widehat{O}_{A,P^\star} \twoheadrightarrow \widehat{O}_{A,P'}. \tag{211}$$

They must preserve order

$$\widehat{o}_1 \widehat{\prec}_{A,P^\star} \widehat{o}_2 \Longrightarrow \pi_P(\widehat{o}_1) \widehat{\preceq}_{A,P} \pi_P(\widehat{o}_2), \tag{212}$$

and preserve conclusion-relevant content without merging a changing region into a coarse constant cell:

$$\mathrm{ContentCompatible}_{P^\star \to P}\,. \tag{213}$$

For three or more direct maps, compatibility requires a cocycle condition on common support:

$$h_{PR} = h_{P'R} \circ h_{PP'}. \tag{214}$$

These are relations among representations. Ontic conclusions still require realization linkage, admissible comparison, and a sound evidential bridge. They do not introduce a mathematical retrospective object into the dynamics of change.

C. Evidence and Reconstruction Audit

A record-based inference should state the following chain explicitly:

$$\begin{aligned} &\text{record} \longrightarrow \text{represented quantity} \longrightarrow \text{decision under uncertainty} \\ &\qquad \longrightarrow \text{warrant for physical non-equivalence} \longrightarrow \text{warrant for realized change.} \end{aligned} \tag{215}$$

Each arrow requires independent conditions. A valid record cannot repair an invalid source attribution, and a statistically resolved difference cannot establish change in a physical variable that the representation does not measure. The last two arrows are epistemic warrant relations, not deductive entailments from finite data to infallible ontology.

A direct-record branch requires: bearer attribution, realization attribution, order, calibration, uncertainty control, artifact exclusion, and a sound link to a physically attributable component of X_A.

A reconstruction branch additionally requires: a recorded reconstruction procedure, linkage of the output to the intended earlier ontic realization, identifiability or explicit non-identifiability bounds, an uncertainty-sensitive decision rule, robustness across admissible models, and disclosure of shared data or model dependencies.

For genetic reconstruction, let $G_A(o)$ denote the declared physical genetic component of the complete condition $X_A(o)$, and let g denote the lineage and reconstruction procedure. Let $\widehat{G}_A^{\mathrm{anc}}(o_a; g)$ and $\widehat{G}_A^{\mathrm{desc}}(o_d; g)$ denote the reconstructed or measured represented estimates of that component at the declared ancestral and descendant realizations. The admissible inference has the form

$$\begin{aligned} &\mathrm{AncestorLinked}\big(\widehat{G}_A^{\mathrm{anc}}(o_a; g), o_a, g\big) \wedge \mathrm{DescendantLinked}\big(\widehat{G}_A^{\mathrm{desc}}(o_d; g), o_d, g\big) \\ &\wedge\ (o_a \prec_A o_d) \wedge\ I_A(o_a, o_d) \wedge\ \big((o_a, o_d) \in \mathcal{K}_A\big) \\ &\wedge\ \mathrm{DecisionSound}(g, \alpha) \wedge\ \mathrm{BridgeSound}(A, o_a, o_d; g, \alpha) \\ &\wedge\ \widehat{G}_A^{\mathrm{anc}}(o_a; g) \not\approx_{g,\alpha} \widehat{G}_A^{\mathrm{desc}}(o_d; g) \\ &\qquad\qquad \Vdash_{g,\alpha} \Big[X_A(o_a) \not\equiv_{\mathrm{phys}} X_A(o_d)\Big]. \end{aligned} \tag{216}$$

The physical genetic component is attributed to the declared bearer, and the bridge excludes contamination, sequencing artifacts, unsupported lineage assignment, and unreported model dependence. No separate genetic equivalence relation is introduced. Instead, the registered locus, variant, lineage, and reconstruction criteria determine whether the represented genetic difference is a sound physical difference in the declared component G_A of X_A. Because one warranted physical difference in a declared component is sufficient for non-equivalence of the complete conditions, Equation (216) warrants $X_A(o_a) \not\equiv_{\mathrm{phys}} X_A(o_d)$ directly; together with evidence that the physically grounded order obtains, same-bearer identity continuation, and admissible comparison above, it supports $\mathrm{Ch}_A(o_a, o_d)$. The warrant remains conditional on the recorded uncertainty structure.

Genetic branch discipline. Direct genetic comparison and model-mediated ancestral reconstruction are distinct evidential branches and cannot share one undifferentiated validation. Before inference, the bearer scale and lineage structure are fixed. A reconstruction branch additionally requires a registered mutation or evolutionary model; sequencing-error, contamination, variant-validation, and, where applicable, copy-number and allele-fraction controls; ancestral identifiability or explicit non-identifiability bounds; control of homoplasy and lineage ambiguity; support for the inferred ordering; linkage of each reconstruction output to its declared ontic realization; a pre-specified uncertainty-sensitive decision rule; and sensitivity analysis across admissible reconstruction models. Only after these conditions are satisfied may a reconstructed genetic difference support an ordered physical-change claim. Population evolution across generations must not be conflated with somatic change within one continuing organism, tissue, clone, or cell lineage.

Evidence channels are independent only after shared sources, instruments, calibration chains, datasets, and models have been merged or explicitly represented. Pairwise independence is a minimum diagnostic among the remaining evidential units, but for three or more units it does not by itself establish joint independence. The joint dependence structure must therefore be modeled, bounded, or otherwise controlled; the absence of one cause common to all channels is insufficient.

C.1 Protocol-level predicates

For compactness, the main text uses BridgeSound, DecisionSound, and realization-link predicates. Their minimum content is as follows.

BridgeSound$(A, o_1, o_2; P, \alpha)$ requires: correct bearer attribution; correct linkage of data to o_1, o_2; membership of (o_1, o_2) in the declared comparison domain $\mathcal{K}_A$; a calibrated representation map; an uncertainty model adequate for the decision; control of relevant artifacts and confounders; and a physically justified relation between the represented variable and the component of X_A whose difference is claimed.

Within that bridge, *detection-soundness bridge* links a registered finite-data decision to non-equivalence in the ideal representation, and *difference-soundness bridge* links that ideal representational non-equivalence to physical non-equivalence of complete conditions. For equality-based constancy claims, the *representation-completeness bridge* is the stronger, independently justified condition that every physically relevant distinguishing degree of freedom and relation is captured, modulo declared gauge, coordinate, labeling, and redundancy rules.

DecisionSound(g, α) requires: a pre-declared decision or credibility rule; the uncertainty or posterior structure used by that rule; sensitivity analysis over admissible models; disclosure of non-identifiability; and a criterion preventing one unsupported point estimate from carrying the inference.

RealizationLinked$_P(\widehat{o}, o)$ requires a documented attribution from the represented realization-link $\widehat{o} \in \widehat{O}_{A,P}$ to the ontic realization $o \in \mathcal{O}_A$, including bearer identity, source or sampling provenance, ordering information, and uncertainty in the linkage. It is not satisfied by a matching label alone.

The ancestor and descendant link predicates require that the relevant estimates refer to the declared bearer and ontic realizations under the recorded lineage, sampling, and reconstruction procedure. A label in a dataset is not sufficient if sample exchange, contamination, lineage ambiguity, or source mismatch remains unresolved.

These predicates are protocol-relative and can be audited. Their satisfaction supports the warrant relation $\Vdash$; it does not transform finite evidence into strict deductive entailment.

D. Universal Scope and Proof Conditions

This appendix states the scope requirements without treating the future as a completed object or stages as positions in a countable universal set. Membership in $\mathbb{S}_{\text{phys}}$ is ontic: the bearer and its boundary, identity criterion, complete-condition content, full comparison relations, and non-empty realization domain physically obtain whether or not current investigators can implement them. Application readiness is a separate protocol- and claim-relative status. Quantities, equations, states, records, and measured values do not enter as separate systems merely because they occur in a model.

The universal postulate is

Non-vacuous identity-preserving interval postulate

$$\forall A \in \mathbb{S}_{\text{phys}} : \quad [\text{IdExtended}(A) \Longrightarrow \text{SC}(A)], \tag{217}$$

where $\text{SC}(A)$ quantifies over every non-zero identity-preserving interval in $\mathcal{O}_A$. The universal quantifier ranges over all $A \in \mathbb{S}_{\text{phys}}$; $\text{IdExtended}(A)$ is the internal non-vacuity condition for sustained continuation, not a class-level exclusion. Thus every physical-system type remains within the universal claim, while non-systemic or non-structural factors considered only as roles, transfers, operative quantities, boundary conditions, couplings, or constraints remain outside the bearer domain; values and representations are likewise not bearers.

D.1 Class coverage

A physically justified classification must satisfy

$$\mathbb{S}_{\text{phys}} = \bigcup_{k \in K} \mathcal{C}_k, \tag{218}$$

with no bearer type excluded because it is difficult, stationary in one representation, inaccessible to current measurement, or described at an unfamiliar scale. For each class,

$$\forall A \in \mathcal{C}_k : \quad [\text{IdExtended}(A) \Longrightarrow \text{SC}(A)]. \tag{219}$$

The domain theory must supply the bridge from continuing internal operation or effective engagement to later physical non-equivalence.

D.2 Continuation without a completed future object

The theory does not treat future realizations as an observationally available pre-written sequence. The postulate is a physical commitment that every non-zero interval actually realized under one continuing bearer identity contains physical change, without requiring a uniquely identifiable ordered pair or interval for every realized difference. A class route must therefore show

$$\Big[\forall A \in \mathcal{C}_k\ \forall o_1, o_2 \in \mathcal{O}_A : \ (o_1 \prec_A o_2 \wedge I_A(o_1, o_2)) \Rightarrow \exists u, v \in \mathcal{O}_A \\ [o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge I_A(u, v) \wedge (u, v) \in \mathcal{K}_A \\ \wedge\, \mathcal{C}_A^{\mathrm{eff}}(u, v) \wedge \mathrm{CauseBridgeSound}_A(u, v)]\Big] \\ \Longrightarrow \forall A \in \mathcal{C}_k : \quad [\mathrm{IdExtended}(A) \Longrightarrow \mathrm{SC}(A)]. \tag{220}$$

The substantive burden is the physical existence and non-neutrality of the cause, not the notation.

D.3 Evidential coverage and its limit

Empirical studies access finite sets of records and represented references. They can establish particular changes, test bridge laws, constrain stationarity claims, and strengthen class coverage. They cannot identify the first physical change, the final realization, or the complete number of realized stages. Null results remain bounded by sensitivity and representation completeness.

D.4 Negative exclusion and universal closure

No positive static-tail countermodel is admitted. The relevant negative question is whether any bearer-complete physical account could establish continuing identity together with complete-condition equivalence across every later stage. A stationary equation, conserved quantity, density operator, geometric symmetry, practical isolation, or finite null record is insufficient; observational silence cannot establish those universal premises.

Universal closure requires complete class coverage, domain-valid causal or dynamical bridges, bearer-complete testing of difficult candidates, and evidential capacity to challenge those bridges. A genuinely bearer-complete demonstration of changeless continuation would conflict with sustained change, but the present manuscript does not treat finite null tests as capable of establishing such a continuation. It supplies the architecture and substantial evidence while leaving universal empirical closure explicitly open.

E. Application and Synthesis Validation Checklist

Before any domain application or new section is accepted, verify:

Question	**Required answer**
Bearer	A physical system is identified; no quantity, state symbol, coordinate, or equation is treated as the bearer.
Identity	The condition for persistence and the condition for termination are stated.

Continued on next page

Question	Required answer
Complete condition	The condition is fixed independently of the desired outcome and includes relevant internal, surface, boundary, and relational components.
Universal temporal structure	Bearer-attributed stages belong to one extension and are directly related by objective absolute simultaneity and one strict, transitive, non-reversing universal prior–later relation. The local relation $\prec_A$ is the bearer restriction of that order. During every shared identity extent, absolute simultaneity gives a one-to-one order-preserving stage correspondence. No clock equality or coordinate convention is substituted for the ontological relations.
Change	A physical non-equivalence is established; magnitude, visibility, usefulness, and structural depth are not imposed as existence conditions.
Past description	Records are not identified with physical realization, and the protocol window is not identified with the beginning or end of change.
Cause	An internal process or actual external engagement reaches the bearer, and neutrality or cancellation is analysed rather than assumed.
Measurement	Calibration, uncertainty, realization linkage, threshold, and model dependence are stated.
Stationarity	A stationary quantity or representation is not treated as bearer-complete physical constancy without a completeness bridge.
Relativity	Coordinates, metrics, proper time, curvature, spacetime manifolds, formal dimensions, signals, and clock readings are assigned to the objects defined by relativistic theory. ITOF rejects their identification with $\mathsf{T}_{\mathrm{ITOF}}$, rejects the inference from coordinate relativity to the nonexistence of objective simultaneity, and separately postulates one objective universal prior–later order and direct absolute simultaneity between stages. These relations are not coordinate conventions, clock synchronizations, universal physical stages, or reified temporal layers.
Scope	A class result is not promoted to universality without bearer-complete coverage.
Status	The result is labelled support, adverse, or indeterminate; universal closure is not claimed prematurely.

F. Difficult-Class Test Matrix

The following matrix is a design aid rather than a substitute for domain theory. Every row must be converted into a protocol, model, and uncertainty budget appropriate to the bearer.

Class	Declared bearer	Insufficient argument	Required test or bridge
Atomic energy eigenstate	Physical atom or ion in specified apparatus	$\widehat{\mathsf{H}}\lvert E\rangle = E\lvert E\rangle$ alone proves bearer-complete physical constancy	Establish completeness of the Hamiltonian and bearer state; test couplings, emission, absorption, recoil, fields, correlations, and preparation stability.
Ground-state system	Atom, molecule, material, field configuration, or bounded device	Minimum represented energy means no physical change	Distinguish energy minimization from complete-condition equivalence; analyse degeneracy, boundary conditions, tunnelling, fields, and actual isolation.
Vacuum state	Declared physical field configuration or apparatus, not the ket label	Vacuum notation is itself a system	Specify bearer identity and physical observables; separate representation, correlations, boundary realization, detector coupling, and state preparation.
Open-system steady state	Reduced quantum system plus declared environment boundary	$\mathcal{L}(\rho) = 0$ means no processes	Determine whether ρ is bearer-complete; examine trajectories, currents, dissipation, correlations, entropy production, and perturbation response.
Classical fixed point	Real mechanical or field system	$f(x_*) = 0$ in an ideal model proves permanent physical rest	Validate completeness of x, physical realization of exact initial conditions, internal degrees, noise, boundary forces, and stability under actual continuation.

Continued on next page

Class	Declared bearer	Insufficient argument	Required test or bridge
Thermal equilibrium	Declared material system and boundary	Constant temperature and pressure imply bearer-complete physical constancy	Resolve microscopic, compositional, surface, chemical, and transport channels; state whether equilibrium is exact, local, metastable, or statistical.
Periodic system	Oscillator, orbiting body, circuit, field mode, or biological cycle	Return of endpoint values erases intervening change	Record phase-space or bearer-complete trajectory; show that recurrence of content is not identity of occurrence.
Stable particle	Particle, wave packet, or bound state with declared identity	No decay establishes no change	Test propagation, scattering, field coupling, momentum, spin, entanglement, and relational condition; distinguish exact eigenstate representation from localized bearer.
Ideal isolated system	Explicit composite bearer and boundary	"Isolated" is accepted as a physical fact from model declaration	Quantify residual couplings and determine whether the isolation assumption is exact, effective, operational, or counterfactual.
Aged or durable material	Object or material region	Rated service life or stable mean property proves bearer-complete physical constancy	Use microstructural, chemical, surface, mechanical, and spectroscopic witnesses with long-term and accelerated protocols.
Spatially stationary body	Body or material distribution	Zero centre-of-mass velocity means no change	Examine internal, rotational, thermal, chemical, field, boundary, and relational conditions.
Glacier or geophysical region	Explicit distributed region with attribution rule	Sparse remote records exhaust the physical past	Combine photogrammetry, InSAR, mass balance, thermal, seismic, and model evidence; state realization linkage and reconstruction uncertainty.

Continued on next page

Class	Declared bearer	Insufficient argument	Required test or bridge
Planetary body	Planet or declared subsystem	Low visible activity means complete stability	Test seismic, thermal, rotational, atmospheric, surface, magnetic, and tidal channels.
Star or remote source	Source system, not received radiation	First detected light is the first change stage	Separate emission, propagation, detection, and reconstruction; use repeated spectra, flux, oscillation, and transient records.
Genome or cell	Fixed biological bearer level	A sequence difference is attributed ambiguously across levels	Control sampling, mosaicism, contamination, cell lineage, repair, expression, and measurement error; state whether the bearer is DNA, cell, tissue, or organism.
Clock system	Full oscillator, control, comparison standard, and readout chain	Clock ticks are identified with one universal number of stages	Model the physical transition and accumulated readout; apply relativistic, external-factor, boundary, and coupling corrections; keep clock output, bearer stages, and temporal meaning distinct.
Static relativistic solution	Declared physical spacetime system or astrophysical bearer	Metric stationarity alone establishes a physically constant real system	Establish physical realization, boundary and matter content, perturbations, accretion, radiation, quantum effects, and exact symmetry persistence.
Identity failure	Original system and successor bearers	Destruction of the original system stops change	Mark the end of attribution to the original bearer, identify successor systems, and continue analysis under their own specifications.

F.1 Minimum report for every class

A class report is incomplete unless it states:

(1) the physical bearer and identity criterion;

(2) the complete-condition definition fixed before outcome assessment;

(3) the candidate cause or constancy mechanism;

(4) the bridge from model or witness to physical equivalence or non-equivalence;

(5) the observational protocol, realization linkage, uncertainty, and detection threshold;

(6) the status of internal, local, surface, boundary, and relational channels;

(7) the predicted supportive, adverse, and indeterminate outcomes;

(8) the limits on transfer from the tested representative to the entire class;

(9) the compatibility of the result with overlapping class descriptions;

(10) the exact contribution of the result to universal closure.

G. Realized-Stage Application and Consistency Audit

This appendix applies the realized-stage architecture across the full theory. Its purpose is not to add a second ontology but to ensure that every use of "stage", every physical witness, and every universal quantifier respects the dependency

$$
\begin{gathered}
\{\mathcal{O}_A\}_{A\in\mathbb{S}_{\text{phys}}} \longrightarrow (\mathcal{O}_{\text{phys}}, \sim_{\text{abs}}, \prec_{\text{U}}),\\
\mathcal{S}_A^{\text{ch}} := \mathcal{O}_A,\\
(\mathcal{O}_A, X_A, I_A, \prec_A, \mathcal{K}_A, \equiv_{\text{phys}}, \not\equiv_{\text{phys}}) \longrightarrow \text{Ch}_A,\\
(\mathcal{S}_{\text{phys}}^{\text{ch}}, \prec_{\text{U}}\restriction_{\mathcal{S}_{\text{phys}}^{\text{ch}}}, \sim_{\text{abs}}\restriction_{\mathcal{S}_{\text{phys}}^{\text{ch}}}) \longrightarrow \mathcal{E}_{\text{U}} \longrightarrow \mathsf{T}_{\text{ITOF}}.
\end{gathered}
$$

The audit also verifies that retrospective description remains downstream and absent from the governing equations.

G.1 Audit rule for ontic references

Every physical condition, quantity, or representation is first attributed to an ontic reference:

$$
\text{Attributed}_A(y, o) \Longrightarrow o \in \mathcal{O}_A. \tag{221}
$$

This attribution identifies a physical stage but does not by itself establish change. A coordinate value, state label, sample identifier, or clock reading cannot substitute for o without a physical linkage bridge.

For every proposed reference the audit asks:

(i) Is the bearer fixed independently of the result?

(ii) Is the reference physically realized rather than merely model allowed?

(iii) Does it carry the complete condition under the declared rule C_A?

(iv) Is its prior–later relation physically grounded?

(v) Is comparison with the proposed partner licensed by $\mathcal{K}_A$?

Failure at any step blocks the change inference or the claimed record-to-stage linkage.

G.2 Audit rule for physical change

Every direct change claim must reduce to the conjunction

$$\begin{aligned}\mathrm{ChangePremises}_A(o_1,o_2) := (o_1 \prec_A o_2) \wedge I_A(o_1,o_2) \wedge ((o_1,o_2) \in \mathcal{K}_A) \\ \wedge\, (X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2)).\end{aligned} \tag{222}$$

Then

$$\mathrm{ChangePremises}_A(o_1,o_2) \iff \mathrm{Ch}_A(o_1,o_2). \tag{223}$$

A witness equation may abbreviate the final non-equivalence premise only when its soundness predicate entails the relevant bearer attribution and physical bridge.

G.3 Audit rule for realized-stage typing

Stage status is not inferred from change. The admissible typing rule is domain membership:

$$\frac{o \in \mathcal{O}_A}{\mathrm{Stage}_A(o)}. \tag{224}$$

Conversely,

$$\mathrm{Stage}_A(o) \Longrightarrow o \in \mathcal{O}_A. \tag{225}$$

It does not follow that every pair of stages changes directly:

$$\mathrm{Stage}_A(o_1) \wedge \mathrm{Stage}_A(o_2) \not\models \mathrm{Ch}_A(o_1,o_2). \tag{226}$$

Direct change requires the full premises of Equation (60). The role of evidence is to warrant source-stage linkage and physical non-equivalence, not to create the stages.

G.4 Local and component change

A local witness must identify a genuine component or relation included by C_A. The part-specific predicate $\mathrm{PartDiff}_{A,P_0}$ must be established without applying bearer-complete equivalence symbols directly to partial content. If $P_0 \subseteq_{C_A} A$, a sound component difference can then lift to bearer non-equivalence:

$$\begin{aligned}& o_1 \prec_A o_2 \wedge I_A(o_1,o_2) \wedge (o_1,o_2) \in \mathcal{K}_A \\ & \wedge\, \mathrm{PartBridgeSound}_{P_0 \to A}(o_1,o_2) \wedge \mathrm{PartDiff}_{A,P_0}(o_1,o_2) \\ & \qquad \Longrightarrow X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2).\end{aligned} \tag{227}$$

The bridge fails if the selected difference is merely a coordinate artifact, lies outside the bearer boundary, or is removed by an admissible gauge identification. When it succeeds, the bearer changes even if most other components remain equivalent.

This audit is particularly important for surface corrosion, boundary flux, local strain, somatic mutation, mosaicism, and regional field change. Small spatial support does not reduce ontological reality.

G.5 Quantity-witness audit

For a physical quantity Q_A, a numerical difference is not sufficient alone:

$$Q_A(o_1) \neq Q_A(o_2) \not\models \mathrm{Ch}_A(o_1, o_2). \tag{228}$$

The valid route is

$$\begin{aligned} &o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \wedge \mathrm{QWitnessSound}_A(o_1, o_2) \\ &\wedge Q_A(o_1) \neq Q_A(o_2) \Longrightarrow \mathrm{Ch}_A(o_1, o_2). \end{aligned} \tag{229}$$

The soundness predicate must state why the quantity difference is physically attributed to the same bearer and why it guarantees non-equivalence of the complete condition.

Equality of a quantity has the asymmetric status

$$Q_A(o_1) = Q_A(o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big], \tag{230}$$

unless a separately proved completeness theorem makes Q_A sufficient for the declared claim.

G.6 Quantum representation audit

A ket, density operator, Hamiltonian, eigenvalue, or vacuum label is not an ontic reference and not a stage. The audit chain is

$$\begin{gathered} \text{quantum formal object} \longrightarrow \text{representation of a declared bearer at } o, \\ \text{representation at } o \longrightarrow \text{physical bridge} \longrightarrow \text{condition claim.} \end{gathered} \tag{231}$$

For example,

$$\rho_A(o_1) = \rho_A(o_2) \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big] \tag{232}$$

unless the representation is bearer complete for the claim and all relevant gauge and relational structure is included. Conversely, when $\mathrm{RepresentationComplete}_A(o_1, o_2)$ is independently validated, equality of ρ_A may warrant both admissible full comparison and complete-condition equivalence for that pair. If this warrant covers every pair required to establish complete equivalence throughout one non-zero identity-preserving interval, the result is adverse evidence against $\mathrm{SC}(A)$.

A stationary-state phase change that is physically global and unobservable does not by itself establish bearer change. Conversely, constancy of one density operator in a reduced description does not prove bearer-complete physical equivalence of an open or relational bearer. The relevant interpretation must identify the actual bearer and its physical stages before a change claim is assessed.

G.7 Classical fixed-point audit

A model equation $\dot{z} = 0$ establishes constancy of the represented variable z under its assumptions. It does not establish that the bearer continues through physically identical stages. Such a transfer would require all of the following:

(a) z is complete for the bearer and claim;

(b) the fixed point is physically realized rather than merely allowed;

(c) identity continues throughout the analysed stage domain;

(d) every relevant later comparison is complete; and

(e) omitted environmental, boundary, quantum, and relational channels are physically excluded.

Thus

$$\begin{aligned} \dot{z} = 0 \not\models \Big[&\mathrm{CmpComplete}_A(o_*) \\ &\wedge \Big(\forall u, v \in \mathcal{O}_A : \ [o_* \preceq_A u \prec_A v \wedge I_A(u,v) \Longrightarrow X_A(u) \equiv_{\mathrm{phys}} X_A(v)]\Big)\Big]. \end{aligned} \tag{233}$$

The distinction prevents mathematical stationarity from being promoted automatically to bearer-complete physical constancy. No finite run of equal represented values can establish complete physical equality throughout continuing stages.

G.8 Equilibrium and steady-state audit

Equilibrium and steady state are typed to selected variables and boundaries. An equilibrium macrostate may contain microscopic activity; a steady state may maintain non-zero flux; a mechanical balance may preserve a mean while internal stress redistributes. The audit therefore requires

$$\mathrm{Steady}_Q(A) \not\models \mathrm{WarrantedCompleteConstancy}(A). \tag{234}$$

A bearer-complete constancy claim must cover internal, local, surface, boundary, compositional, field, and relational content fixed by C_A.

G.9 Periodic and recurrent audit

For a periodic bearer, endpoint equivalence is compatible with intervening change:

$$\begin{aligned} &(o_n, o_{n+p}) \in \mathcal{K}_A \wedge X_A(o_n) \equiv_{\mathrm{phys}} X_A(o_{n+p}) \\ &\quad \not\models \neg\exists u \in \mathcal{O}_A\big[o_n \prec_A u \prec_A o_{n+p} \wedge \mathrm{Ch}_A(o_n, u)\big]. \end{aligned} \tag{235}$$

The later endpoint is not the earlier occurrence, and recurrence does not reverse succession. Both endpoints are stages because they belong to the realized-stage domain; the intervening changes neither confer nor remove that status.

G.10 Identity-preservation audit

The local predicate $\mathrm{IdCont}_A(o)$ performs one function only: it states that later stages can still be attributed to the same bearer beyond o. Identity continuation alone is not a cause or proof of change. For any ordered same-bearer pair,

$$[o_1 \prec_A o_2 \wedge I_A(o_1, o_2)] \not\models \exists u, v \in \mathcal{O}_A \; [o_1 \preceq_A u \prec_A v \preceq_A o_2 \wedge \mathrm{Ch}_A(u, v)]. \tag{236}$$

The right-hand interval claim is the substantive commitment of $\mathrm{SC}(A)$, supported by the proof programme rather than by identity alone.

When identity fails, the audit forbids transfer of the original symbol A to products or fragments without a new specification. Successor systems fall under the universal postulate once physically identified under their own specifications; identity termination alone does not identify their detailed changes, and no post-identity stage is silently included in $\mathcal{O}_A$.

G.11 Cause-route audit

A cause route is valid only when the cause operates over an identity-preserving bearer and the bridge to complete-condition difference is sound:

$$\begin{aligned} &\mathrm{IdCont}_A(o) \wedge o \prec_A o' \wedge I_A(o, o') \wedge (o, o') \in \mathcal{K}_A \\ &\wedge \mathcal{C}_A^{\mathrm{eff}}(o, o') \wedge \mathrm{CauseBridgeSound}_A(o, o') \Longrightarrow \mathrm{Ch}_A(o, o'). \end{aligned} \tag{237}$$

Mere presence of an external system, field, or internal process is insufficient if its effect is exactly neutral for the declared bearer across the pair. Conversely, absence of a newly identified external perturbation does not eliminate internal operation.

G.12 Observation and threshold audit

A protocol threshold belongs to the represented or decision space. It does not enter the ontological definition:

$$\|\widehat{R}_A(o_2) - \widehat{R}_A(o_1)\| \le \varepsilon_P \not\models \Big[(o_1, o_2) \in \mathcal{K}_A \wedge X_A(o_1) \equiv_{\mathrm{phys}} X_A(o_2)\Big]. \tag{238}$$

Positive evidence requires realization linkage, order, comparison, calibration, uncertainty control, and a difference-soundness bridge. A later improvement in sensitivity may warrant a change claim without changing the earlier physical reality.

G.13 Reconstruction audit

A reconstructed ancestral condition is a protocol output, not an ontic reference until linked. The minimum chain is

$$\widehat{R}_A^{\mathrm{anc}} \xrightarrow{\mathrm{RealizationLinked}} o_a \xrightarrow{\text{comparison with } o_d} \text{condition claim} \xrightarrow{\text{definition}} \mathrm{Ch}_A(o_a, o_d). \tag{239}$$

The linkage step warrants that o_a and o_d are the source stages represented by the reconstruction and descendant evidence; the final step warrants change between them. Model uncertainty, lineage ambiguity, contamination, and non-identifiability remain epistemic limitations, not alternative physical stages.

G.14 Clock audit

A clock reading is a protocol-indexed physical output of a declared clock bearer:

$$N_{C,P}(c) = \Phi_{C,P}(X_C(c)), \qquad c \in \mathcal{O}_C. \tag{240}$$

A reading difference can witness a clock-system change when the standard change premises are satisfied, but neither a reading nor a tick is automatically a stage of another system. No equation identifies

$$\Delta N_{C,P}(c_1, c_2), \quad \tau[\gamma], \quad \mathrm{Card}\left(\mathcal{S}_A^{\mathrm{ch}}\right), \quad \mathsf{T}_{\mathrm{ITOF}}. \tag{241}$$

These objects have distinct types and functions. Equation (159) gives the fully typed two-way non-entailment between objective absolute simultaneity and equality of converted clock outputs.

G.15 Relativity audit

The relativity audit begins from an independent ITOF ontology. Relativistic causal structure, transport, proper time, curvature, spacetime geometry, dimensional structure, and clock-comparison rules govern the quantities they define; they do not make coordinates, manifolds, formal dimensions, or proper-time values into stages or into $\mathsf{T}_{\mathrm{ITOF}}$. Standard Lorentzian relativity does not define the ITOF absolute-simultaneity relation, and frame dependence of coordinate simultaneity does not by itself prove the nonexistence of objective simultaneity. The valid typed separation is

$$\mathrm{RelativisticBridge} \longrightarrow (\text{operational order evidence}, \mathcal{K}_A, \text{predictions}), \tag{242}$$

while

$$\tau[\gamma] \not\equiv_{\mathrm{type}} \mathsf{T}_{\mathrm{ITOF}}, \qquad x^0 \not\equiv_{\mathrm{type}} \mathsf{T}_{\mathrm{ITOF}}, \qquad \mathcal{M} \not\equiv_{\mathrm{type}} \mathsf{T}_{\mathrm{ITOF}}, \qquad \dim(\mathcal{M}) \not\equiv_{\mathrm{type}} \mathsf{T}_{\mathrm{ITOF}}. \tag{243}$$

Einstein clock synchronization is an operational convention and is not identical with the objective absolute-simultaneity relation $\sim_{\mathrm{abs}}$. ITOF postulates direct objective absolute simultaneity and one strict, transitive, non-reversing universal prior–later order within one extension. No universal physical stage is introduced, and no equivalence class is reified as a temporal layer. Any claim that relativistic observations warrant a particular absolute-simultaneity pairing requires an explicit coordinate-independent, causally compatible bridge and cannot be obtained from coordinate equality alone. The disagreement is ontological and explicit, while the relativistic equations remain typed to coordinates, metrics, worldlines, signals, and clock systems.

G.16 Remote-record audit

For an emitting source, emission references, propagation, arrival, and detection are distinct. A received record is linked to a source realization only through a source and propagation model. The arrival relation

$$\Delta t_{\mathrm{arr}} = \Delta t_{\mathrm{emit}} + \Delta\Pi \tag{244}$$

concerns measured or modeled intervals. It does not define source stages. The source stages exist independently of the record; a soundly warranted physical difference establishes source change between the linked stages.

G.17 Genetic-change audit

A genetic difference must be assigned to a declared bearer level: molecule, genome, cell, tissue, organism, or lineage-defined system. If $G_A(o)$ denotes attributed genetic content, then

$$\begin{gathered} o_1 \prec_A o_2 \wedge I_A(o_1, o_2) \wedge (o_1, o_2) \in \mathcal{K}_A \\ \wedge\, G_A(o_1) \neq G_A(o_2) \wedge \mathrm{GeneticBridgeSound}_A(o_1, o_2) \\ \Longrightarrow X_A(o_1) \not\equiv_{\mathrm{phys}} X_A(o_2). \end{gathered} \tag{245}$$

Mosaicism, sampling, repair, sequencing error, and level mismatch must be controlled. Phenotypic visibility is not required for the genetic difference to establish bearer change.

G.18 No-static-tail audit

The audit admits no positive static-continuation object. It checks only that the negative exclusion in Equation (123) is not weakened by finite null evidence. In particular,

$$\begin{aligned} &\neg\,\mathrm{Warranted}[\mathrm{SC}(A)] \\ &\not\models \mathrm{Warranted}\left[\begin{aligned} &\mathrm{CmpComplete}_A(o_*) \\ &\wedge \forall u, v \in \mathcal{O}_A :\ [o_* \preceq_A u \prec_A v \wedge I_A(u,v) \Rightarrow X_A(u) \equiv_{\mathrm{phys}} X_A(v)] \end{aligned}\right]. \end{aligned} \tag{246}$$

Failure to prove sustained change is an epistemic limitation; it is not evidence for a physically real static tail.

G.19 Class-cover audit

A universal synthesis is valid only if every bearer belongs to at least one analysed class and overlap does not generate inconsistent bearer specifications. Let

$$\mathrm{CoverSound}(\{\mathcal{C}_k\}) \tag{247}$$

include exhaustive bearer coverage, compatibility on overlaps, and absence of outcome-driven reclassification. Then

$$\begin{aligned} &\mathrm{CoverSound}(\{\mathcal{C}_k\}) \wedge \forall k\ \forall A \in \mathcal{C}_k :\ (\mathrm{IdExtended}(A) \Rightarrow \mathrm{SC}(A)) \\ &\qquad \Longrightarrow \forall A \in \mathbb{S}_{\mathrm{phys}} :\ (\mathrm{IdExtended}(A) \Rightarrow \mathrm{SC}(A)). \end{aligned} \tag{248}$$

The realized-stage formalism does not reduce this substantive burden; it makes the burden explicit.

G.20 Retrospective-description independence audit

No retrospective symbol appears in the governing dependency, in the sustained-change definition, or in the cause routes. No description of the past is treated as a physical cause, state variable, or premise of sustained change. Protocol reconstruction uses $\widehat{\mathcal{R}}_{A,P}$, which denotes a representation assembled from records, not a dynamical object.

Descriptions of changes and stages that have already occurred may be used in ordinary retrospective prose. Their exclusion from the equations does not deny the physical reality of the past; it denies that a description of the past acts on the system.

G.21 Final consistency conditions

The realized-stage architecture is internally consistent only if all of the following remain true:

(1) every X_A is evaluated on the physically realized stage domain $\mathcal{O}_A = \mathcal{S}_A^{\mathrm{ch}}$, and each $\mathcal{O}_A$ is formed as one connected, uninterrupted bearer-identity domain;

(2) every $\equiv_{\mathrm{phys}}$ or $\not\equiv_{\mathrm{phys}}$ judgment is asserted only for bearer-complete conditions on a pair in $\mathcal{K}_A$, or under a predicate or theorem that warrants such comparability; partial content uses a part-specific predicate and a sound part-to-bearer bridge; every Ch_A equation additionally displays or inherits order, same-bearer identity continuation, and physical non-equivalence;

(3) every $\mathrm{Stage}_A(o)$ claim is a realized-stage membership claim $o \in \mathcal{O}_A$, never a consequence manufactured by observation or change;

(4) the one extension, $\prec_{\mathrm{U}}$, and $\sim_{\mathrm{abs}}$ act directly on bearer-attributed stages without a reified temporal layer or universal physical stage; a stage may have spatially distributed support but occupies one position in the universal succession, while a temporally extended history segment is a range of stages;

(5) every bearer-identity span is an interval in the universal order, and stages correspond one-to-one and order-preservingly throughout every shared bearer-identity extent; equal cardinality follows only as a set-theoretic consequence and is not a duration, rate, magnitude, or metric, while unequal completed identity-bounded cardinalities arise only because bearer identities begin or end at different positions in the one extension;

(6) absolute simultaneity is never defined by equal clock readings, equal coordinate values, signal exchange, or equality of physical conditions;

(7) $\mathrm{SC}(A)$ uses local identity continuation and does not depend on a retrospective variable;

(8) an identity-preserving static tail is mentioned only in the negative as physically excluded and is never inferred from finite null readings or observational silence;

(9) measurements and reconstructions link records to source stages or stage ranges; they do not create the stages or identify a unique ordered pair or interval of physical change without an independent physical bridge;

(10) the realized-stage domain is an ontological scope, not an observational inventory, and one sound change witness does not require enumeration of all stages;

(11) no finite window or first resolved record is identified with the first or final physical stage or with a unique ordered pair or interval over which continuing change was realized;

(12) derivatives remain model-relative statements about differentiated objects and do not define time, physical change, or stages without a sound physical bridge;

(13) no quantity, state representation, geometric value, or record is promoted to an independent bearer without satisfying Spec(A), and formal consistency alone is not treated as physical instantiation;

(14) investigators, instruments, records, and environments remain physical systems within the change domain rather than an external changeless standpoint; and

(15) no descriptive account of the past appears as a cause or dynamical input.

These conditions form the final formal audit for all applications of V24/F4.

H. Canonical Definitions, Symbols, and Dependency Map

H.1 Canonical definitions

Term	Canonical definition
Physical system	A physically instantiated bearer with declared boundaries or attribution conditions, an identity criterion, and physically attributable conditions and relations.
Realized stage	An actual bearer-attributable physical realization in the one extension, capable of carrying the complete condition. It is not created by an index, observation, record, or reconstruction.
Complete physical condition	The bearer-relative physical content fixed independently by C_A, with $X_A(o)$ assigning its realized values at reference o.
Physical change	A physically actual non-equivalence between the complete conditions of one system at ordered, identity-connected ontic realizations comparable under the full specification χ_A^{full}.
Change stage	A realized physical stage of a bearer within its identity-bounded domain. Change is judged between stages; stage status is not derived from the change judgment.
Universal prior–later order	One strict, transitive, non-reversing relation $\prec_{\mathrm{U}}$ acting directly on bearer-attributed realizations and stages in the one extension. Its fixed non-reversal is the invariance named by ITOF.

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Term	Canonical definition
Invariant succession	The fixed prior–later succession of extended change stages: once one stage is prior to another, the relation cannot reverse. This does not mean physical immobility and is not defined as invariance under an observer, coordinate system, redescription, or transformation group.
Absolute simultaneity	The direct objective equivalence relation $\sim_{\mathrm{abs}}$ between stages of different systems in the one extension. It is not equality of clock readings, coordinate times, physical conditions, or a containing universal stage. Its equivalence classes admit a derived quotient representation but are not reified as physical layers or stages.
Time	The descriptive meaning of the one extension and ordering of realized stages across physical systems. During every shared identity extent, stages correspond one-to-one under absolute simultaneity; physical contents and changes can differ, and final identity-bounded cardinalities can differ only through different identity beginnings or endings. Cardinality is not a temporal amount.
Sustained change	Change does not occur once and end: every non-zero identity-preserving interval of the bearer's realized stage succession contains an ordered comparable pair with non-equivalent complete conditions.
Factor-role	The relational role of a physical system or non-systemic factor in affecting another bearer; the role does not erase the influencing system's identity.
Non-structural physical factor	A physically operative role, transfer, quantity, boundary condition, coupling, or constraint that is not independently specified as a system with its own identity and stage domain. It can condition or witness system change but is not assigned an independent extension of change stages; values and representations remain type-distinct from bearers.
Record	A physical trace, signal, sample, inscription, or device state of a recording system, evidentially linked to one source stage or a range of source stages; not the source stage itself.
Measurement	A physical and inferential procedure mapping bearer-dependent processes and records into calibrated results with uncertainty.
Representation	A declared mathematical, geometrical, observational, or record-producing map associated with a physical bearer under specified conditions; not the bearer, its complete condition, realized change, a stage, or time.

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Term	Canonical definition
No static tail	The negative principle that preserved identity and continuing stages cannot form a changeless continuation. A finite interval that is quiet only at the protocol or observational level, a repeated equal record, or observational silence does not establish otherwise.
Detection threshold	A protocol-relative sensitivity or decision boundary; not a threshold for the existence of physical change.
Proper time	A relativistic metric functional associated with a timelike worldline; operationally valid within relativity but type-distinct from ITOF temporal meaning.

H.2 Canonical symbols

Symbol	Meaning
$\mathbb{S}_{\text{phys}}$	Domain $\{A \mid \text{OnticallyAdmissible}(A)\}$ of ontically admissible physical bearers.
$\text{OnticallyAdmissible}(A)$	A genuine physical bearer whose boundary, identity criterion, condition content, and full comparison relations physically obtain and whose ontic-realization domain is non-empty; this does not require current application readiness.
$\text{ApplicationReady}(A; P, Q)$	Present protocol- and claim-relative ability to issue a warranted judgment; it is epistemic and is not a condition for physical existence.
A, B, C	Arbitrary physical systems; expository placeholders, not a census of the universe.
$o \in \mathcal{O}_A$	Physically realized stage of bearer A.
$\mathcal{O}_A$	Non-enumerated and non-exhaustively represented connected domain of actual physical stages attributable to one bearer A throughout one uninterrupted identity; successor identities receive their own domains.
$\mathcal{O}_{\text{phys}}$	Bearer-attributed disjoint union $\bigsqcup_A(\{A\} \times \mathcal{O}_A)$ of ontic realizations across physical systems.
$\jmath_A(o) = (A, o)$	Canonical injection that places an ontic realization of bearer A in the bearer-attributed universal domain.
$\sim_{\text{abs}}$	Direct objective absolute-simultaneity equivalence relation on $\mathcal{O}_{\text{phys}}$; on the stage-bearing restriction it relates stages of different systems without introducing a universal physical stage or reifying an equivalence class as a layer.

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Symbol	Meaning
$\prec_{\mathrm{U}}$	Strict universal prior–later relation acting directly on bearer-attributed realizations and stages in the one extension.
$\mathcal{Q}_{\mathrm{U}} = \mathcal{O}_{\mathrm{phys}} / \sim_{\mathrm{abs}}$	Derived quotient representation of absolute-simultaneity equivalence classes; neither the quotient nor its classes are primitive physical domains, universal physical stages, temporal layers, containers, or physical objects.
I_A^{sp}	Local reflexive extension $S_- = S_+ \vee I_A(S_-, S_+)$ used only in identity-span construction; it does not alter the directed continuation relation used in the change definition.
$\preceq_{\mathrm{U}}$	Non-strict universal relation: prior or absolutely simultaneous.
$\prec_A$	Same-bearer restriction of $\prec_{\mathrm{U}}$ to $\mathcal{O}_A$.
$\prec_{\mathrm{caus}}$	Domain-valid strict physical causal precedence established independently and required to be preserved by the temporal relations.
$X_A(o)$	Complete physical condition of A at realization o.
$X_A^{P_0}(o)$	Content attributed to genuine part or region P_0 within $X_A(o)$; not a separately typed bearer condition and not an admissible direct argument of $\equiv_{\mathrm{phys}}$ or $\not\equiv_{\mathrm{phys}}$.
$\mathrm{PartDiff}_{A,P_0}(o_1, o_2)$	Part-specific predicate for a physically attributed and admissibly compared difference in P_0; it reaches bearer-complete non-equivalence only through a sound part-to-bearer bridge.
χ_A^{full}	Claim-independent bearer-complete comparison specification fixed within $\mathrm{Spec}(A)$.
$\mathcal{K}_A = \mathcal{K}_A^{\mathrm{full}}$	Domain of pairs on which full ontological comparison is admissibly defined.
$\mathrm{CmpStatus}_A^{\mathrm{full}}$	Three-valued full comparison status: equivalent, non-equivalent, or undefined.
$\equiv_{\mathrm{phys}}, \not\equiv_{\mathrm{phys}}$	Mutually exclusive and jointly exhaustive complete-condition judgments inside $\mathcal{K}_A$.
$\mathcal{P}_{A,Q}$	Pre-declared projection from the complete bearer condition to the content selected for claim Q.
$\chi_{A,Q}, \mathcal{K}_{A,Q}$	Claim-level comparison specification and projected comparison domain; neither defines ontological change without a bridge to the full relation.
$\mathrm{ProjDiffSound}_{A,Q}$	Bridge warrant that a projected difference supplies full comparability and complete-condition non-equivalence.

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Symbol	Meaning
$\mathrm{ProjComplete}_{A,Q}$	Bearer-completeness bridge required before projected equivalence can warrant complete-condition equivalence.
ι_A	Bearer-identity criterion fixed in Spec(A).
$I_A := I_A^{\iota_A} \subseteq \mathcal{O}_A \times \mathcal{O}_A$	Directed same-bearer continuation relation induced by ι_A; formation of $\mathcal{O}_A$ requires every ordered pair in that domain to belong to one uninterrupted bearer identity.
$\mathrm{Ch}_A(o_1, o_2)$	Realized physical change of A between ordered, identity-connected references comparable under χ_A^{full}.
$\mathrm{Stage}_A(o)$	Realized-stage type predicate, equivalent to $o \in \mathcal{O}_A$.
$\mathcal{S}_A^{\mathrm{ch}}$	Stage-domain notation, defined as $\mathcal{O}_A$; the superscript is mnemonic and neither requires a prior change proof nor analytically implies SC(A).
$\mathrm{Card}(\mathcal{S}_A^{\mathrm{ch}})$	Identity-bounded cardinality of realized change stages; final only after bearer identity terminates, and not a stage, order position, clock reading, or universal temporal quantity.
$\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}$	Bearer-attributed domain of realized change stages across physical systems in the one extension; equal to $\mathcal{O}_{\mathrm{phys}}$ under the realized-stage typing adopted here.
$\mathcal{S}_A^{AB}, \mathcal{S}_B^{AB}$	Stage domains of bearers A and B restricted to their shared identity extent.
f_{AB}	Unique order-preserving absolute-simultaneity bijection $\mathcal{S}_A^{AB} \to \mathcal{S}_B^{AB}$, coherent under composition on triple shared overlaps.
$\mathrm{ExtStruct}[D, \prec, \sim]$	Structure constructor returning the relational structure $(D, \prec, \sim)$; it is not a truth-valued predicate.
$\mathrm{IsUniversalExtSucc}[D, \prec, \sim]$	Truth-valued predicate requiring a strict universal order, an absolute-simultaneity equivalence relation compatible with that order, and at least one realized three-stage chain; it adds no metric, count, adjacency, equal spacing, or universal rate.
$\mathcal{E}_{\mathrm{U}}$	One-extension structure $\mathrm{ExtStruct}[\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}, \prec_{\mathrm{U}} \restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}, \sim_{\mathrm{abs}} \restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}]$.
DescriptiveMeaning	Meta-level map from the declared universal extension-and-order structure to the temporal meaning $\mathsf{T}_{\mathrm{ITOF}}$; it does not reproduce physical stage content or causes.
ExtSucc	Meta-level notation for a realized non-reversing extension beyond one changed pair, without a count or metric.
ContinuedExtSucc	Identity-bounded total order of all realized stages, retaining every stage within the single identity-bounded succession.

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Symbol	Meaning
$\mathrm{IdBoundedGenOrd}_{\iota_A}$	Meta-predicate stating that the prior–later relation on realized stages is bounded by the actual bearer-identity range under criterion ι_A.
InvCosmicSucc	Invariance of succession only: the fixed non-reversal of the universal prior–later relation among extended change stages. It does not denote physical constancy or invariance under redescription or a transformation group.
$\mathrm{IdCont}_A(o)$	The identity criterion for A remains physically applicable to at least one actually realized later reference.
$\mathrm{IdExtended}(A)$	Internal non-vacuity condition for sustained continuation: at least one ordered same-bearer stage pair is physically realized.
$\mathrm{SC}(A)$	Identity-preserving interval form of sustained change: every non-zero realized stage interval contains a pair satisfying Ch_A; the universal claim ranges over all $A \in \mathbb{S}_{\mathrm{phys}}$ conditionally on $\mathrm{IdExtended}(A)$.
$\mathrm{CmpComplete}_A(o_*)$	Every later same-bearer comparison relevant to a constancy claim from o_* is admissibly defined under χ_A^{full}.
$\mathcal{R}_{A,P}$	Declared map from bearer-complete condition space to protocol-relative representation space $\mathcal{Y}_{A,P}$; P includes relevant linkage, apparatus, calibration, environmental, and processing conditions.
$Y_{A,P}(o)$	Representation $\mathcal{R}_{A,P}(X_A(o))$ of the complete physical condition at ontic realization o; not the condition or bearer itself.
$\mathrm{Rec}_{A,P}(o)$	Single-stage record notation when a one-stage source link is independently warranted; no record is identical with its source stage.
$\mathrm{StageSupport}_{A,P}(r)$	Non-empty subset of $\mathcal{O}_A$ physically warranted as the source-stage support of record r; it may be a singleton or a stage range and is never identical with the record.
$\mathcal{I}_{A,P}(r_1, r_2)$	Order-convex stage range generated by the warranted source supports of records r_1, r_2; positive observation can warrant change within it without selecting a unique ordered pair or interval over which every realized difference occurred.
$\mathcal{G}$	Coarse-graining or reduced-representation map used only to illustrate that representational equality need not imply complete physical equivalence.

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Symbol	Meaning
$\Xi_A[o_1, o_2]$	Interval-operative physical engagements relevant to bearer A between two ontic realizations, excluding endpoint content already included in $X_A(o_1)$ and $X_A(o_2)$.
$\mathcal{C}_A^{\mathrm{eff}}$	Domain-specified effective internal process or external engagement sufficient for change under a sound bridge.
$\widehat{\mathcal{R}}_{A,P}$	Finite or access-limited protocol reconstruction.
$\mathcal{E}_{P,\alpha}$	Registered evidential premises for a claim under protocol P and declared error or credibility control α.
$\Vdash_{P,\alpha}$	Defeasible epistemic warrant relation; it is not ordinary logical implication.
$\lambda_{A,P}$	Partial map linking represented support to physically realized source stages; records may additionally have non-singleton stage support.
P	Measurement or observation protocol.
$\widehat{X}_{A,P}$	Protocol-level estimate or representation of bearer condition.
ε_P	Protocol-relative detection threshold or uncertainty scale.
$\Phi_{C,P}$	Protocol-indexed readout map that converts the complete physical condition of clock bearer C into its numerical reading.
$N_{C,P}(c)$	Numerical reading produced from clock realization $c \in \mathcal{O}_C$ under readout protocol P.
$\Lambda_{A,C,P}$	Protocol-level linkage pairing realizations of measured bearer A with realizations of clock bearer C; it is not bearer identity and is not itself the objective absolute-simultaneity relation.
$\Gamma_{i,P_{12}}$	Conversion map placing a native clock output into the common numerical codomain fixed by two-clock comparison protocol P_{12}.
$\mathcal{G}_F$	General target of relativistic or covariant representation F, admitting point events and domain-appropriate represented regions, sections, or hypersurface assignments.
$\mathcal{M}_F$	Point-event sector of $\mathcal{G}_F$, on which the coordinate function t_F is defined.
$\mathcal{O}_{\mathrm{pt}}^F$	Ontic realizations whose images under ρ_F lie in the point-event sector $\mathcal{M}_F$.
$J_F^+(p)$	Relativistic causal future of represented point event p in the Lorentzian structure used by F.

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Symbol	Meaning
ρ_F	Partial representation map from bearer-attributed ontic realizations into the general representation target $\mathcal{G}_F$; it does not define absolute-simultaneity assignment.
$\mathbb{R}_{P_{12}}$	Common numerical codomain, including the unit and scale conventions fixed by clock-comparison protocol P_{12}.
$\tau[\gamma]$	Relativistic proper-time functional for timelike worldline γ; not ITOF temporal meaning.
$g_{\mu\nu}$	Relativistic metric field; not a bearer or the ontology of time.
$\mathsf{T}_{\mathrm{ITOF}}$	The descriptive meaning of the one universal extension and ordering of realized stages, including direct objective absolute simultaneity between stages; not the physical content of change or its causes.

H.3 Dependency map

$$\begin{gathered}
\mathrm{OnticallyAdmissible}(A) \longrightarrow \mathrm{Spec}(A) \longrightarrow (\mathcal{O}_A, X_A, \iota_A, I_A, \chi_A^{\mathrm{full}}, \mathcal{K}_A), \\
\{\mathcal{O}_A\}_{A\in\mathbb{S}_{\mathrm{phys}}} \longrightarrow \mathcal{O}_{\mathrm{phys}} \longrightarrow (\sim_{\mathrm{abs}}, \prec_{\mathrm{U}}, \prec_{\mathrm{caus}}) \longrightarrow \{\prec_A\}_{A\in\mathbb{S}_{\mathrm{phys}}}, \\
(\mathrm{Spec}(A), \mathcal{O}_A, X_A, I_A, \prec_A, \chi_A^{\mathrm{full}}, \mathcal{K}_A, \equiv_{\mathrm{phys}}, \not\equiv_{\mathrm{phys}}) \longrightarrow (\mathrm{Stage}_A, \mathcal{S}_A^{\mathrm{ch}}, \mathrm{Ch}_A), \\
(\mathrm{Stage}_A, \mathcal{S}_A^{\mathrm{ch}}) \longrightarrow \mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}, \\
(\mathcal{S}_A^{AB}, \mathcal{S}_B^{AB}, \sim_{\mathrm{abs}}, \prec_{\mathrm{U}}) \longrightarrow \underset{\text{and triple-overlap coherent}}{f_{AB} \text{ order-preserving}} \longrightarrow \mathrm{Card}(\mathcal{S}_A^{AB}) = \mathrm{Card}(\mathcal{S}_B^{AB}), \\
(\mathcal{P}_{A,Q}, \chi_{A,Q}, \mathcal{K}_{A,Q}, P) \longrightarrow \text{claim-level evidence and bridge warrants}, \\
\underset{\mathrm{ContinuedExtSucc}[\mathcal{S}_A^{\mathrm{ch}}, \prec_A],\ \mathrm{SC}(A)}{A\in\mathbb{S}_{\mathrm{phys}},\ \mathrm{IdExtended}(A),} \longrightarrow \underset{\text{the identity-bounded stage succession}}{\text{sustained change throughout}}, \\
\mathcal{E}_{\mathrm{U}} := \mathrm{ExtStruct}\left[\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}, \prec_{\mathrm{U}}\restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}, \sim_{\mathrm{abs}}\restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}\right], \\
\mathrm{IsUniversalExtSucc}\left[\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}, \prec_{\mathrm{U}}\restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}, \sim_{\mathrm{abs}}\restriction_{\mathcal{S}_{\mathrm{phys}}^{\mathrm{ch}}}\right] \wedge \mathcal{E}_{\mathrm{U}} \longrightarrow \mathsf{T}_{\mathrm{ITOF}}.
\end{gathered} \tag{249}$$

The claim-level branch can warrant premises of the ontological branch through explicit bridges, but it does not redefine Ch_A. Likewise, $\sim_{\mathrm{abs}}$ is ontologically primitive while any evidential claim assigning particular stages to absolute simultaneity requires an independent coordinate-independent and causally compatible bridge. Retrospective description is intentionally absent from the dependency map: it neither generates nor conditions change.

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