

Interference-First Reality Theory: Temporal Order and Semiclassical Limits

—Emergent Time, the Arrow of Time, and the Recovery of General Relativity [IFR Theory Series, Part III of VI]

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Abstract

This is Part III of the six-part series presenting the Interference-First Reality (IFR) Theory. Part I established the kinematic foundations and the definition of objectivity; Part II supplied the variational principle and the gravitational sector. The present part derives what both left open: physical time. We develop the emergence of temporal order as the ordered succession of stable minima of redundant dispersion, and we show that the arrow of time need not be posited separately—it follows from a single, explicitly stated dynamical hypothesis, the monotonic decrease of the redundant dispersion along admissible histories (objectivizing dynamics), which identifies $\mathcal{D}_{\text{red}}$ as a Lyapunov functional and makes the high-redundancy regime a dynamical attractor (dynamic classicalization). We prove that this hypothesis is not implied by the second-order interference equation of Part II, which conserves the interference energy, and we state what supplies it. From the same monotonicity, together with the requirement that admissible histories be generated forward in the ordering parameter, we derive three consequences that fix the operational content of emergent time: no admissible protocol delivers a decodable determination to an earlier stage of an objective history; recurrence of an objective structure is not reversal, since informational duration is strictly positive on any non-constant closed excursion; and a closed timelike curve of the emergent metric, if it is the image of an admissible history, does not close the informational order: its endpoints are distinct, strictly ordered stages of the history, which may carry the same objective centre. We then establish the semiclassical and effective-field limits in which general relativity and quantum theory are recovered, deriving from the same attractor, with an explicit rate, the reduction step $\mathcal{R}_T \rightarrow \mathcal{R}_\varepsilon^{(R)}$ of the curvature correspondence of Part II and the vanishing of the correction Lagrangian.

Keywords

Interference-First Reality, Information Geometry, Emergent Time, Arrow of Time, Lyapunov Functional, Dynamic Classicalization, Chronology Protection, Retrodictive Signalling, Semiclassical Limit, Recovery of General Relativity

1. Introduction

Part I of this series [1] established the kinematic foundations of Interference-First Reality (IFR): the pre-spatiotemporal configuration space $\mathcal{X}$ and its interference-state space $\mathcal{H}_{\mathcal{X}}$; the admissibility conditions on operational observer maps Π_a ; the common information-geometric comparison space $(\mathcal{M}, \Gamma)$ with its dimensionless distance $\tilde{d}_{\Gamma}$; the redundant dispersion functional $\mathcal{D}_{\text{red}}$; and the definition of IFR-objectivity as the existence, uniqueness and perturbation-stability of a Fréchet center Q^* of observer projections. Part II [2] supplied the dynamical principle: the IFR action

$$\mathcal{S}_{\text{IFR}} = \int_I d\lambda \left[\mathcal{K}_{\text{int}} - \mathcal{V}_{\text{int}} - \alpha \mathcal{D}_{\text{red}} + \beta \bar{\mathcal{R}}_{\Gamma} + \mathcal{L}_{\text{II}} \right], \quad \beta = + \frac{V_{\text{char}}}{2\kappa_{\text{red}}} > 0,$$

with the kinetic term fixed uniquely by unitary invariance on $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$, the informational field equation $\mathcal{G}_{ij}^{\Gamma} = \kappa_{\text{IFR}} T_{ij}^{\text{IFR}}$, and the conditions under which Einstein-type dynamics emerge from informational curvature.

Both parts are silent on one thing, and deliberately so. The parameter λ appearing in the action is an ordering parameter, not physical time; Part II showed that this is not a notational scruple but a structural constraint, since it is what makes the interference equation second-order in λ and the Schrödinger equation a limit rather than a postulate. But a framework that refuses time at the fundamental level owes an account of where time comes from. Supplying that account is the first task of the present paper.

The account given here has a specific character worth stating at the outset. Earlier formulations of the framework introduced a directed memory functional and posited a temporal asymmetry: the arrow of time was an input. That is no longer necessary as a separate input. We isolate one dynamical hypothesis, stated explicitly as Assumption III.A below, under which the redundant dispersion is a Lyapunov functional along admissible IFR histories,

$$\frac{d\mathcal{D}_{\text{red}}}{d\lambda} \leq 0, \quad \frac{d\mathcal{D}_{\text{red}}}{d\lambda} < 0 \quad \text{where} \quad \|\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}\|_{\Gamma} > 0,$$

so that order, acyclicity and asymmetry are consequences of that single hypothesis rather than three separate assumptions, and the high-redundancy regime $\mathcal{D}_{\text{red}} \rightarrow 0$ is a dynamical attractor. We are explicit about the status of the hypothesis: the second-order interference equation of Part II is conservative and does not imply it (Proposition III.4); the monotonicity is supplied by the observer sector

$\mathcal{L}_{\text{TI}}$, which Part II left unspecified. Under the same hypothesis, two of the conditions that Part II had to assume are discharged: the reduction step $\mathcal{R}_{\text{T}} \rightarrow \mathcal{R}_{\varepsilon}^{(R)}$ of the curvature correspondence and the vanishing of the correction Lagrangian both follow, with explicit rates, from the attractor rather than being imposed alongside it. The remaining step, from the pre-Wick scalar $\mathcal{R}_{\varepsilon}^{(L)}$ to the post-Wick scalar $\mathcal{R}_{\varepsilon}^{(L)}$ and hence to $R(g_{\text{eff}})$, is the informational Wick map of hypothesis (H3) of Part II, whose construction belongs to Part V; it is not derived here. The conditional gravitational correspondence of Part II thereby becomes, in the regime it describes, under the objectivizing hypothesis and up to that single step, an emergence theorem.

A structural consequence carried over from Part II deserves restatement, since it governs the dimensional reduction used repeatedly below. In the applied holographic formulation that preceded the present framework [3], holographic organisation was introduced as a postulate, in the tradition established by black-hole entropy [4], dimensional reduction in quantum gravity [5] [6], the covariant entropy bound [7], and the bulk-boundary correspondence [8]. In the IFR architecture that assumption is unnecessary: each observer map returns, by the finite-accessibility condition of Part I, a representation of strictly lower informational dimension than the underlying interference state, and only redundantly encoded structure survives multi-observer contraction. Holography is therefore a consequence of redundant multi-observer projection, not an independent principle. The projection of the information manifold onto the four-dimensional space of stable objective centres used in Section 3 is an instance of exactly this mechanism.

It is worth stating how the temporal sector differs from established accounts. Thermodynamic derivations of the arrow of time rest on coarse-graining and entropy increase relative to a low-entropy boundary condition; the arrow here is instead the monotone contraction of observer disagreement, and requires no boundary condition in the past: its inputs are the objectivizing hypothesis on the present dynamics and informational non-equilibrium. Decoherence [9] and quantum Darwinism [10] explain the suppression of interference and the proliferation of records, but presuppose a background spacetime in which records accumulate; here the ordering is constructed before any spacetime exists, and the increase of records is derived as concordant with, not prior to, the decrease of dispersion. Relational accounts of time relativise duration to a reference system; IFR instead constructs an intersubjective duration as arc length in the comparison geometry [11] [12], along the sequence of Fréchet centres [13] [14], with the underlying statistical structure in the sense of Amari and Nagaoka [15].

The paper is organised as follows. Section 2 develops the emergence of temporal order: the memory functional, the order relation, time as ordered minima of redundant dispersion, duration as informational arc length, causality, the derivation of order and asymmetry from dispersion monotonicity, and the temporal emergence theorem. Section 3 develops the semiclassical and effective-field limits: the high-redundancy regime, effective locality, the emergence of fields and of the ef-

fective metric, the recovery of general relativity and of quantum theory, the dynamic classicalization theorem, the reduction of informational curvature to Ricci curvature, and the semiclassical correspondence theorem, together with the falsifiability criteria and the scope of the construction. The empirical implementation across cosmological, gravitational-wave and physiological ensembles is the subject of Part IV; the Lorentzian sector and the renormalisation-group flow are the subject of Parts V and VI.

2. Emergence of Temporal Order

Part I did not assume spacetime as a primitive background, and Part II derived the effective spatial and gravitational sectors from the possibility of representing stable informational relations by an emergent metric geometry. The same strategy must now be applied to time. In IFR, time is not introduced as a fundamental parameter external to the theory. Rather, physical temporal order emerges from the ordered succession of stable objective structures.

The parameter

$$\lambda$$

appearing in the variational formulation is therefore not physical time. It is an auxiliary ordering parameter used to describe admissible histories in the configuration space of interference states, information geometries, and observer maps. Physical time exists only when a sequence of IFR-objective centers admits an intrinsic order relation; in the present formulation that relation is generated by the monotone decrease of redundant dispersion along admissible histories (Definition III.1 and Section 2.12).

The guiding principle of this section is:

time is the emergent order of stable informational objectivizations.

2.1. Auxiliary Ordering Parameter and Physical Time

An IFR history is a map

$$\lambda \mapsto (\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda)),$$

where

$$\Psi(\lambda) \in \mathcal{H}_\chi, \quad \Gamma(\lambda) \in \mathfrak{G}, \quad \Pi(\lambda) \in \mathfrak{P}.$$

For each value of λ , when the objectivity conditions of Part I [1] are satisfied, one obtains a stable Fréchet center

$$Q^*(\lambda) = \arg \min_{Q \in \mathcal{M}} F_{\Psi(\lambda), \Gamma(\lambda)}(Q).$$

The map

$$\lambda \mapsto Q^*(\lambda)$$

does not by itself define physical time. It is merely a parametrized family of objec-

tive structures. A physical temporal order emerges only if the family of centers admits an intrinsic orientation relation

$$Q^*(\lambda_i) \prec Q^*(\lambda_j),$$

where the symbol $\prec$ is defined without assuming an external time coordinate.

Thus, the problem of time in IFR is the problem of defining conditions under which the set

$$\mathcal{Q} = \{Q^*(\lambda) : Q^*(\lambda) \text{ is stable and IFR-objective}\}$$

becomes an ordered set.

2.2. Objective Histories

A raw IFR history

$$\lambda \mapsto (\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda))$$

becomes an objective history only after applying the objectivization map

$$\mathfrak{D} : (\Psi, \Gamma, \Pi) \mapsto Q_{\Psi, \Gamma, \Pi}^*.$$

Thus, whenever a stable center exists, define

$$Q^*(\lambda) = \mathfrak{D}[\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda)].$$

The corresponding objective history is

$$\lambda \mapsto Q^*(\lambda).$$

An objective history is therefore not a primitive trajectory in spacetime. It is a sequence of stable multi-observer contractions in information geometry.

Let

$$\mathcal{I}_{\text{obj}} \subseteq I$$

be the subset of ordering-parameter values for which an objective center exists:

$$\mathcal{I}_{\text{obj}} = \{\lambda \in I : Q^*(\lambda) \text{ exists and is stable}\}.$$

Then an objective history is the restricted map

$$Q^* : \mathcal{I}_{\text{obj}} \rightarrow \mathcal{Q}.$$

If $\mathcal{I}_{\text{obj}}$ is discrete, this gives a sequence

$$Q_1^*, Q_2^*, Q_3^*, \dots$$

If $\mathcal{I}_{\text{obj}}$ is continuous or approximately continuous, it gives a curve

$$Q^*(\lambda)$$

in the space of objective centers.

In both cases, physical time requires an intrinsic orientation of this objective history.

2.3. Memory Functional

A heuristic motivation for temporal orientation is memory asymmetry: a later objective structure may encode information about an earlier one, while the earlier

structure does not encode information about the later one. We record the corresponding functional because it is used, as an auxiliary notion of recoverability, in the definition of causal accessibility below. It does *not* define temporal precedence, which is fixed in Definition III.1 by the redundant dispersion alone; in particular, no claim is made that a decrease of redundant dispersion establishes asymmetric recoverability.

Let

$$\mathcal{M}_{\text{mem}} : \mathcal{Q} \times \mathcal{Q} \rightarrow \mathbb{R}_{\geq 0}$$

be a memory functional, where

$$\mathcal{M}_{\text{mem}}(Q_j^* | Q_i^*)$$

measures the amount of recoverable information about Q_i^* encoded in Q_j^* .

The precise form of $\mathcal{M}_{\text{mem}}$ depends on the representation space. Possible realizations include mutual information, conditional reconstruction fidelity, algorithmic information retention, correlation persistence, or sufficient-statistic preservation.

A generic information-theoretic choice is

$$\mathcal{M}_{\text{mem}}(Q_j^* | Q_i^*) = I(Q_j^*; Q_i^*),$$

when the objective centers are represented as random variables. However, temporal orientation requires directional dependence. Therefore, a more appropriate choice is a directed recoverability functional

$$\mathcal{R}(Q_i^* \rightarrow Q_j^*),$$

defined as the maximal fidelity with which Q_i^* can be reconstructed from Q_j^* :

$$\mathcal{R}(Q_i^* \rightarrow Q_j^*) = \sup_{\mathcal{A}} \mathcal{F}(Q_i^*, \mathcal{A}(Q_j^*)),$$

where $\mathcal{A}$ ranges over admissible reconstruction maps and $\mathcal{F}$ is a fidelity or similarity functional.

Then one may define

$$\mathcal{M}_{\text{mem}}(Q_j^* | Q_i^*) = \mathcal{R}(Q_i^* \rightarrow Q_j^*).$$

The asymmetry

$$\mathcal{M}_{\text{mem}}(Q_j^* | Q_i^*) \neq \mathcal{M}_{\text{mem}}(Q_i^* | Q_j^*)$$

would be a natural candidate for temporal orientation. It is not used as such in what follows: the redundant dispersion is built from the symmetric distance $\tilde{d}_{\Gamma}$ and does not supply a directed recoverability functional, and the directedness of time is obtained instead from the objectivizing dynamics (Section 2.12).

2.4. Temporal Order Relation

We now define temporal precedence.

Definition III.1 (IFR temporal precedence) Let $\lambda \mapsto (\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda))$ be an admissible IFR history, and let $\lambda_i, \lambda_j \in \mathcal{I}_{\text{obj}}$ be two of its stages, with stable

objective centres $Q_i^* = Q^*(\lambda_i)$, $Q_j^* = Q^*(\lambda_j)$ and redundant dispersion

$$\mathcal{D}_{\text{red}}(\lambda_i) = \mathcal{D}_{\text{red}}[\Psi(\lambda_i), \Gamma(\lambda_i), \Pi(\lambda_i)].$$

We say that

$$Q_i^* \prec Q_j^*$$

if

$$\mathcal{D}_{\text{red}}(\lambda_i) > \mathcal{D}_{\text{red}}(\lambda_j)$$

and the transition

$$Q_i^* \rightarrow Q_j^*$$

is admissible under the IFR dynamics.

The first condition gives an intrinsic orientation, fixed by the objectivizing dynamics of Assumption III.A below, under which $\mathcal{D}_{\text{red}}$ decreases along admissible histories. The second condition prevents differences of dispersion between dynamically unrelated configurations from defining time.

Precedence is a relation between stages. The redundant dispersion is a functional of the state (Ψ, Γ, Π) , not of the centre: distinct states may share the same Fréchet centre while having different dispersion. The relation $\prec$ is therefore a relation between stages of a history, and the notation $Q_i^* \prec Q_j^*$, $\mathcal{D}_{\text{red}}(Q_i^*) := \mathcal{D}_{\text{red}}(\lambda_i)$, used throughout, always refers to the centre *at a stage*. Two distinct, strictly ordered stages may carry the same centre as a point of $\mathcal{M}$; this is the recurrence of Section 2.15, and it is not a cycle of the order.

Equivalently, define the temporal asymmetry functional

$$\mathcal{A}_{\text{time}}(Q_i^*, Q_j^*) = \mathcal{D}_{\text{red}}(\lambda_i) - \mathcal{D}_{\text{red}}(\lambda_j).$$

Then

$$Q_i^* \prec Q_j^*$$

if

$$\mathcal{A}_{\text{time}}(Q_i^*, Q_j^*) > 0$$

and the transition is dynamically admissible.

This gives a relational definition of temporal order without presupposing a fundamental time coordinate.

2.5. Time as the Ordered Sequence of Stable Objectivizations

The second element of temporal structure is the sequence of stable objectivizations. For each λ , define

$$\mathcal{D}_{\text{red}}(\lambda) = \mathcal{D}_{\text{red}}[\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda)].$$

Objective structures are stable Fréchet centres: at each stage, $Q^*(\lambda)$ minimises the Fréchet functional $F_{\Psi(\lambda), \Gamma(\lambda)}$ over $Q \in \mathcal{M}$. This is a minimum in Q at fixed λ , and it must not be confused with a minimum of $\mathcal{D}_{\text{red}}(\lambda)$ as a function

of λ . Under the objectivizing dynamics of Assumption III.A, $\mathcal{D}_{\text{red}}(\lambda)$ is non-increasing, so it has no strict local minimum in the interior of an interval of λ ; the values at which $d\mathcal{D}_{\text{red}}/d\lambda = 0$ are objectivization equilibria, at which the order degenerates (Remark III.1), not successive stages of a history. Let

$$\lambda_1 < \lambda_2 < \dots, \lambda_k \in \mathcal{I}_{\text{obj}},$$

be stages at which the center

$$Q_k^* = Q^*(\lambda_k)$$

is stable under observer perturbations.

Then the ordered family

$$\{Q_k^*\}_k$$

defines a temporal sequence, with

$$Q_k^* \prec Q_{k+1}^*$$

whenever $\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}$ is not identically zero on $[\lambda_k, \lambda_{k+1}]$ (Proposition III.1).

Thus, physical time may be represented as

$$\tau_{\text{IFR}} = \text{Ord} \left[\{Q_k^*\}_k \right],$$

where Ord denotes the intrinsic ordering induced by the precedence of Definition III.1, that is, by the decrease of redundant dispersion and by dynamical admissibility.

This expression should not be read as defining time by the numerical value of λ . It defines time by the ordered succession of stable objectivizations.

2.6. Persistence and Identity through Time

Temporal order alone does not define persistence. A physical object must retain identity across multiple objective centers.

Let

$$Q_i^*$$

and

$$Q_j^*$$

be objective centers with

$$Q_i^* \prec Q_j^*.$$

Define an identity-continuity functional

$$C_{\text{id}}(Q_i^*, Q_j^*) \in [0, 1],$$

where high values indicate that Q_j^* preserves the informational structure of Q_i^* under admissible transformations.

Possible choices include

$$C_{\text{id}}(Q_i^*, Q_j^*) = \exp \left[-\tilde{d}_{\Gamma}^2(Q_i^*, Q_j^*) / \sigma^2 \right],$$

or, in a representation with internal features,

$$c_{\text{id}}(Q_i^*, Q_j^*) = \frac{\langle \Phi(Q_i^*), \Phi(Q_j^*) \rangle}{\|\Phi(Q_i^*)\| \|\Phi(Q_j^*)\|},$$

where Φ extracts identity-relevant informational features.

A persistent object is then a chain

$$Q_{k_1}^* \prec Q_{k_2}^* \prec \dots \prec Q_{k_n}^*$$

such that

$$c_{\text{id}}(Q_{k_\ell}^*, Q_{k_{\ell+1}}^*) > 1 - \epsilon_{\text{id}}$$

for all consecutive pairs.

Thus, persistence is not primitive. It is continuity of informational identity across ordered stable objectivizations.

2.7. Irreversibility and the Arrow of Time

The arrow of time arises when the temporal precedence relation is globally non-symmetric and compatible with an irreversible increase of accessible records.

Let

$$\mathcal{R}_{\text{rec}}(Q^*)$$

denote the record content of an objective structure. This may be quantified by entropy of accessible records, number of redundant encodings, memory capacity, or recoverable information about preceding structures.

An irreversible objective history satisfies

$$\mathcal{R}_{\text{rec}}(Q_{k+1}^*) \geq \mathcal{R}_{\text{rec}}(Q_k^*),$$

with strict inequality for at least some transitions:

$$\mathcal{R}_{\text{rec}}(Q_{k+1}^*) > \mathcal{R}_{\text{rec}}(Q_k^*).$$

Equivalently, the redundancy of records may increase:

$$N_{\text{red}}(Q_{k+1}^*) \geq N_{\text{red}}(Q_k^*),$$

where N_{red} is the effective number of independent observer channels encoding the structure.

The arrow of time is therefore associated with the direction in which records, redundancy, and recoverable information accumulate.

This is consistent with the IFR interpretation of classicality: classical structures are those that become increasingly redundantly encoded across observer channels. The relation between this record arrow and the dispersion arrow of Definition III.1 is made precise in Proposition III.1(4): the decrease of redundant dispersion controls a lower bound on the number of agreeing observer channels, not the count itself. The monotonicity of the record content stated above is a characterisation of irreversible histories, not a consequence of the objectivizing dynamics.

2.8. Temporal Metric and Duration

Once temporal order exists, one may ask whether a quantitative duration can be defined. IFR does not assume duration at the fundamental level. It is derived from changes in objective structures.

Let

$$Q^*(\lambda)$$

be an objective history. Define the informational length between two centers:

$$L_{\Gamma}(Q_i^*, Q_j^*) = \inf_{\gamma} \int_{\lambda_i}^{\lambda_j} \left\| \frac{d\gamma}{d\lambda} \right\|_{\Gamma} d\lambda,$$

where γ ranges over admissible paths in $\mathcal{Q}$ connecting Q_i^* to Q_j^* .

A physical duration functional may then be defined as

$$\Delta\tau_{\text{IFR}}(Q_i^*, Q_j^*) = \Theta \left[L_{\Gamma}(Q_i^*, Q_j^*), \Delta\mathcal{R}_{\text{rec}}, \Delta\mathcal{D}_{\text{red}}, \Delta\mathcal{S}_{\text{IFR}} \right],$$

where Θ is a monotonic functional depending on informational distance, record accumulation, change in redundant dispersion, and action difference.

In a simple local approximation, one may write

$$d\tau_{\text{IFR}}^2 = G_{\text{time}}(Q^*) \tilde{d}_{\Gamma} Q^* \otimes \tilde{d}_{\Gamma} Q^*,$$

where G_{time} is an effective temporal metric factor determined by the rate of stable record accumulation.

In the emergent spacetime limit, this duration must correspond to the proper time of the effective metric:

$$d\tau_{\text{IFR}}^2 \rightarrow -g_{\mu\nu}^{\text{eff}} dx^{\mu} dx^{\nu}$$

for timelike objective histories.

Thus, proper time is recovered as the effective spacetime representation of informational duration along persistent objective histories.

2.9. Recovery of Relativistic Time

Suppose that the stable objective centers admit an effective spacetime embedding

$$\chi: \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}},$$

with effective metric

$$g_{\mu\nu}^{\text{eff}}.$$

Let

$$Q^*(\lambda)$$

be a persistent objective history, and write its spacetime representation as

$$x^{\mu}(\lambda) = \chi(Q^*(\lambda)).$$

If the emergent metric is Lorentzian and the trajectory is timelike, the proper time is

$$d\tau^2 = -g_{\mu\nu}^{\text{eff}} dx^{\mu} dx^{\nu}.$$

IFR requires the correspondence condition

$$d\tau_{\text{IFR}}^2 = -g_{\mu\nu}^{\text{eff}} dx^\mu dx^\nu + \mathcal{O}(\epsilon_{\text{time}}),$$

where ϵ_{time} measures residual disagreement between informational duration and effective metric time.

In the limit

$$\epsilon_{\text{time}} \rightarrow 0,$$

relativistic proper time is recovered.

Coordinate time is then not fundamental. It is a parametrization chosen after the emergence of an effective spacetime manifold. Different coordinate times correspond to different descriptions of the same ordered structure of objective histories.

2.10. Causality as Ordered Informational Accessibility

Causality in IFR is defined before spacetime light cones are introduced. A structure Q_j^* can be causally downstream of Q_i^* if information from Q_i^* is accessible in Q_j^* through an admissible IFR transition.

Define the causal accessibility relation

$$Q_i^* \preceq_{\text{caus}} Q_j^*$$

if there exists an admissible chain

$$Q_i^* = Q_{k_0}^* \prec Q_{k_1}^* \prec \dots \prec Q_{k_n}^* = Q_j^*$$

such that each transition preserves recoverable information above a threshold:

$$\mathcal{M}_{\text{mem}}(Q_{k_{\ell+1}}^* | Q_{k_\ell}^*) > \epsilon_{\text{mem}}.$$

This defines causality as ordered informational accessibility. Here $\prec$ is the precedence of Definition III.1, and the recoverability threshold is an additional requirement on each link of the chain, not implied by $\prec$: a decrease of redundant dispersion does not by itself establish recoverability.

When an effective Lorentzian spacetime emerges, this causal relation must reduce to the usual causal order:

$$Q_i^* \preceq_{\text{caus}} Q_j^* \Rightarrow \chi(Q_j^*) \in J^+(\chi(Q_i^*)),$$

up to corrections due to incomplete spacetime emergence.

Here

$$J^+(x)$$

denotes the causal future of x in the emergent metric.

Thus, light-cone causality is not fundamental in IFR. It is the effective spacetime representation of informational accessibility constraints.

2.11. Temporal Coherence Condition

A physically admissible emergent time must be globally coherent. The precedence

relation $\prec$ should not produce closed temporal loops among stable objective centers.

Therefore, the acyclicity condition is required:

$$Q_1^* \prec Q_2^* \prec \dots \prec Q_n^* \prec Q_1^*$$

is forbidden. For the precedence of Definition III.1 this is not an additional postulate but a consequence of Assumption III.A (Proposition III.1(2)).

Equivalently, the temporal relation must define a strict partial order on the stages of the history. It need not descend to a partial order on points of $\mathcal{M}$: a centre may recur, as a point of $\mathcal{M}$, at distinct and strictly ordered stages (Corollary III.1), and the identification of informationally equivalent centres,

$$\tilde{d}_\Gamma(Q_i^*, Q_j^*) = 0, \text{ does not identify the stages that carry them.}$$

This condition ensures that emergent time is not internally contradictory.

If the stages form a continuum, the acyclicity condition corresponds to the existence of a global time function

$$T_{\text{IFR}} : \mathcal{I}_{\text{obj}} \rightarrow \mathbb{R}$$

such that

$$Q_i^* \prec Q_j^* \Rightarrow T_{\text{IFR}}(\lambda_i) < T_{\text{IFR}}(\lambda_j).$$

Under Assumption III.A, $T_{\text{IFR}}(\lambda) := -\mathcal{D}_{\text{red}}(\lambda)$ is such a function (Proposition III.1(3)).

In the effective spacetime limit, T_{IFR} becomes an admissible time function compatible with the causal structure of $g_{\mu\nu}^{\text{eff}}$.

2.12. Temporal Order Derived from Dispersion Monotonicity

The Temporal Emergence Theorem below requires an oriented precedence relation, a non-vanishing temporal asymmetry, and acyclicity. For the precedence of Definition III.1 all three can be *derived* from the monotonic decrease of the redundant dispersion along admissible histories, replacing three separate temporal assumptions by one dynamical hypothesis. What is not derived should be stated as clearly: a decrease of dispersion does not establish asymmetric recoverability in the sense of the memory functional of Section 2.3, and that functional plays no role in the definition of precedence. We state that hypothesis explicitly; its status relative to the variational principle of Part II is examined in Section 3.13.

Assumption III.A (Objectivizing dynamics) Along every admissible IFR history $\lambda \mapsto \Psi(\lambda)$ the redundant dispersion $\mathcal{D}_{\text{red}}(\lambda) := \mathcal{D}_{\text{red}}[\Psi(\lambda)]$ is non-increasing, and strictly decreasing wherever its gradient does not vanish:

$$\frac{d\mathcal{D}_{\text{red}}}{d\lambda} \leq 0, \quad \frac{d\mathcal{D}_{\text{red}}}{d\lambda} < 0 \text{ whenever } \|\text{grad}_\Gamma \mathcal{D}_{\text{red}}\|_\Gamma > 0. \quad (1)$$

Remark (The dissipative dynamics required, and what the assumption is not) Assumption III.A is not obtained from the stationarity of $\mathcal{S}_{\text{IFR}}$ (Proposition III.4 below); it requires an additional, dissipative dynamics. The minimal dissipative

dynamics satisfying (1) is the gradient flow of the objectivizing term itself,

$$\begin{aligned}\dot{\Psi} &= -\frac{\alpha}{\gamma} \text{grad}_{\Gamma} \mathcal{D}_{\text{red}} \\ \Rightarrow \frac{d\mathcal{D}_{\text{red}}}{d\lambda} &= \langle \text{grad}_{\Gamma} \mathcal{D}_{\text{red}}, \dot{\Psi} \rangle_{\Gamma} = -\frac{\alpha}{\gamma} \|\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}\|_{\Gamma}^2 \leq 0,\end{aligned}\quad (2)$$

with $\gamma > 0$ a mobility constant of the dimension of an action ($[\alpha] = ML^2T^{-2}$, $[\lambda] = T$, $\mathcal{D}_{\text{red}}$ dimensionless), whose identification is left open. Two things the assumption is *not* should be recorded. It is not a consequence of $\delta S_{\text{IFR}} = 0$: the interference equation of Part II is second order and conservative, and along its solutions $\mathcal{D}_{\text{red}}$ oscillates rather than decreases (Proposition III.4). Nor is it implied by the monotonicity of any energy-like functional containing $\mathcal{D}_{\text{red}}$ as a summand, since the monotonicity of a sum does not transfer to its summands. The assumption is therefore a genuine hypothesis on the admissible histories, and every result of this paper that invokes the arrow of time is conditional on it.

Proposition III.1 (Order, acyclicity, and asymmetry from monotonicity)

Suppose Assumption III.A holds along an admissible history, with $\|\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}\| > 0$ on an interval I (informational non-equilibrium). Let $\prec$ be the precedence of Definition III.1, a relation between stages of the history,

$$Q_i^* \prec Q_j^* \Leftrightarrow \mathcal{D}_{\text{red}}(\lambda_i) > \mathcal{D}_{\text{red}}(\lambda_j)$$

(for dynamically connected stages). Then:

1. $\prec$ is a strict order (irreflexive, asymmetric, transitive), and along the flow $\lambda_1 < \lambda_2 \Leftrightarrow Q^*(\lambda_1) \prec Q^*(\lambda_2)$, since $\mathcal{D}_{\text{red}}(\lambda_2) - \mathcal{D}_{\text{red}}(\lambda_1) = \int_{\lambda_1}^{\lambda_2} (d\mathcal{D}_{\text{red}}/d\lambda) d\lambda < 0$;
2. $\prec$ is acyclic: a cycle $Q_1^* \prec \dots \prec Q_n^* \prec Q_1^*$ would give $\mathcal{D}_{\text{red}}(Q_1^*) > \mathcal{D}_{\text{red}}(Q_1^*)$, a contradiction;
3. the temporal asymmetry $\mathcal{A}_{\text{time}}(Q^*(\lambda_1), Q^*(\lambda_2)) = -\int_{\lambda_1}^{\lambda_2} (d\mathcal{D}_{\text{red}}/d\lambda) d\lambda > 0$ for $\lambda_1 < \lambda_2$ in I , so that it is non-zero on I and fixes a global orientation, and $T_{\text{IFR}} := -\mathcal{D}_{\text{red}}$ is a global time function on I ;
4. record accumulation is controlled, not implied: write

$$\mathcal{D}_{\text{red}} = \sum_{a < b} w_{ab} \tilde{d}_{\Gamma}^2(\Pi_a, \Pi_b), \quad N_{\text{red}}^{\theta} := \#\{a < b : \tilde{d}_{\Gamma}^2(\Pi_a, \Pi_b) < \theta\},$$

over P observer pairs, with $w_{\min} := \min_{a < b} w_{ab} > 0$ and an agreement threshold $\theta > 0$. Then

$$N_{\text{red}}^{\theta} \geq P - \frac{\mathcal{D}_{\text{red}}}{w_{\min} \theta},$$

and the right-hand side is non-decreasing along the flow. The count N_{red}^{θ} itself need not be monotone. The “increasing-records” arrow is therefore aligned with the “decreasing-dispersion” arrow at the level of this guaranteed lower bound only; agreement of the two arrows beyond it is an additional, empirically testable statement (criterion (F11)).

Proof. (1) Irreflexivity and asymmetry are immediate from the trichotomy of

the real order on $\mathcal{D}_{\text{red}}$; transitivity likewise. The equivalence with the λ -ordering follows from the displayed integral, whose integrand is strictly negative on I by (1) and $\|\text{grad } \mathcal{D}_{\text{red}}\| > 0$. (2) A cycle would chain the strict inequalities into $\mathcal{D}_{\text{red}}(Q_1^*) > \mathcal{D}_{\text{red}}(Q_1^*)$. (3) The integral of a strictly negative quantity over I is negative. (4) Each pair with $\tilde{d}_r^2 \geq \theta$ contributes at least $w_{\min}\theta$ to $\mathcal{D}_{\text{red}}$, and every other pair contributes non-negatively; hence $P - N_{\text{red}}^\theta \leq \mathcal{D}_{\text{red}}/(w_{\min}\theta)$, which is the bound. Its right-hand side is non-decreasing because $\mathcal{D}_{\text{red}}$ is non-increasing by (1). The count itself is not monotone: for three projections on a minimising geodesic of $\mathcal{M}$ at arc-length positions $(0, 0.05, 0.4)$, unit weights and $\theta = 10^{-2}$, one has $\mathcal{D}_{\text{red}} = 0.285$ and $N_{\text{red}}^\theta = 1$; at positions $(0, 0.2, 0.4)$, $\mathcal{D}_{\text{red}} = 0.24$ and $N_{\text{red}}^\theta = 0$, and $\mathcal{D}_{\text{red}}$ decreases monotonically along the linear interpolation between the two configurations. $\square$

Remark III.1 (Status of the temporal hypotheses) Proposition III.1 shows that, for the precedence of Definition III.1, the orientation, acyclicity, and non-vanishing asymmetry required by the Temporal Emergence Theorem are consequences of dispersion monotonicity. It does not show, and is not used to show, asymmetric recoverability of earlier stages from later ones. The irreducible hypotheses are two: the objectivizing dynamics of Assumption III.A, and informational non-equilibrium, $\|\text{grad}_r \mathcal{D}_{\text{red}}\| > 0$; where the gradient vanishes the system is at an objectivization equilibrium and no local arrow is defined, exactly as expected. The theorem below is therefore read with its hypotheses (1)-(3) supplied by this proposition.

2.13. Temporal Emergence Theorem

We now state the main result of this section.

Theorem III.1 (Emergence of temporal order) Let $\mathcal{Q}$ be a set of stable IFR-objective centers generated by an admissible IFR history satisfying Assumption III.A. Suppose that:

1. the precedence relation $\prec$ of Definition III.1 is defined on the stages of the history;
2. the temporal asymmetry functional

$$\mathcal{A}_{\text{time}}(Q_i^*, Q_j^*) = \mathcal{D}_{\text{red}}(\lambda_i) - \mathcal{D}_{\text{red}}(\lambda_j)$$

is nonzero for dynamically admissible successive stages;

3. the relation

$$Q_i^* \prec Q_j^* \Leftrightarrow \mathcal{A}_{\text{time}}(Q_i^*, Q_j^*) > 0$$

is acyclic on the stages of the history;

4. stable objective centers form either a discrete chain or a continuum admitting a global ordering function.

Then $\mathcal{Q}$ admits an emergent temporal order. If, in addition, $\mathcal{Q}$ admits an effective Lorentzian metric representation, this order reduces to the causal-temporal order of the emergent spacetime up to residual corrections.

Proof. By assumption 2, dynamically admissible pairs of stages possess a non-

vanishing directed asymmetry. This defines an oriented relation on the stages of the history. By assumption 3, the relation is acyclic, and therefore defines a strict partial order. By assumption 4, this partial order can be represented either as an ordered chain or by a global ordering function. Hence an intrinsic temporal order exists. If an effective Lorentzian metric representation exists, the causal-accessibility correspondence maps the IFR order into the causal order of the emergent spacetime, with deviations controlled by residual embedding and temporal-reconstruction errors. $\square$

2.14. Forward Determinism and the Impossibility of Retrodictive Signalling

Proposition III.1 establishes that the precedence relation $\prec$ is acyclic, hence that no admissible history returns to an earlier objective centre. Acyclicity does not by itself settle a logically distinct question, which is the one of physical interest: can an operation performed at one stage of an objective history deliver a determinate, decodable difference to a *strictly earlier* stage? The two questions differ because the second concerns a communication channel rather than a trajectory. In IFR the question admits a decision under one further, explicitly stated hypothesis on how admissible histories are generated.

Assumption III.B (Forward determinism) Admissible IFR histories are generated by a forward well-posed evolution in λ : for every $\lambda_0 \in I$, the restriction of an admissible history to $\{\lambda \leq \lambda_0\}$ is uniquely determined by its initial datum and by the admissible operations applied at parameter values $\lambda \leq \lambda_0$, and is independent of operations applied at $\lambda > \lambda_0$.

Remark (Two independences) Assumption III.B is a counterfactual statement: changing an operation at $\lambda > \lambda_0$ does not change the history at $\lambda \leq \lambda_0$. It does not by itself make the selected alternative statistically independent of the earlier data: an observer family that selects the alternative on the basis of information already available at an earlier stage produces a correlation that a decoder at that stage can exploit, without any retrodictive influence. The definition of a signalling protocol must therefore require, as it does in the quantum no-signalling theorems, that the selection be free, that is, independent of the earlier data. Both requirements are needed for Proposition III.2, and neither implies the other.

Remark (Status of Assumption III.B) The assumption holds for any first-order flow with a locally Lipschitz generator, by uniqueness of solutions of the initial-value problem; in particular it holds for the gradient flow (2) whenever $\text{grad}_\Gamma \mathcal{D}_{\text{red}}$ is locally Lipschitz. It is a statement about how admissible histories are generated, and it is not implied by the fixed-endpoint formulation of the variational principle, in which the history is co-determined by data at both ends (Remark III.3).

Definition III.2 (Retrodictive signalling protocol) Let $(Q_k^*)_{k \in K}$ be an admissible objective history with record functional $\mathcal{R}_{\text{rec}}$, and let $k_0, k_1 \in K$ with $Q_{k_0}^* \prec Q_{k_1}^*$. A retrodictive signalling protocol is a pair $(\mathcal{S}, \text{dec})$ such that:

1. $\mathcal{S}$ is an admissible operation applied at stage k_1 , selected by the observer family from a set of at least two alternatives $\{\mathcal{S}^{(1)}, \mathcal{S}^{(2)}\}$ with prior probabilities (p_1, p_2) , the selection being free: it is statistically independent of the state and of all data available at every stage preceding k_1 ;

2. dec is a decoding map available at stage k_0 , that is, a (possibly randomised) function of the data available at that stage only, which identifies the selected alternative with probability strictly exceeding chance, chance being the largest prior probability of the alternatives;

3. the resulting history remains admissible in the sense of Section 2.

Proposition III.2 (No retrodictive signalling) Under Assumptions III.A and III.B, no admissible IFR history supports a retrodictive signalling protocol.

Proof. Since $Q_{k_0}^* \prec Q_{k_1}^*$, Definition III.1 gives $\mathcal{D}_{\text{red}}(\lambda_{k_0}) > \mathcal{D}_{\text{red}}(\lambda_{k_1})$. By Assumption III.A, $\mathcal{D}_{\text{red}}$ is non-increasing in λ , so $\lambda_{k_0} \geq \lambda_{k_1}$ would give $\mathcal{D}_{\text{red}}(\lambda_{k_0}) \leq \mathcal{D}_{\text{red}}(\lambda_{k_1})$; hence $\lambda_{k_0} < \lambda_{k_1}$. The alternatives $\mathcal{S}^{(1)}, \mathcal{S}^{(2)}$ are applied at stage k_1 , that is, at parameter values $\lambda \geq \lambda_{k_1} > \lambda_{k_0}$. By Assumption III.B the restriction of the history to $\{\lambda \leq \lambda_{k_0}\}$ does not depend on which alternative is applied; so the state, the centre $Q_{k_0}^*$ and all data available at stage k_0 are the same functions of the initial datum and of the operations at $\lambda \leq \lambda_{k_0}$ under both alternatives. By the freedom of the selection (requirement (1)), the selected alternative is statistically independent of those data; hence it is independent of the output of the decoding map, which is a (possibly randomised) function of those data alone, and the output distribution (q_1, q_2) of the decoder is the same conditionally on either alternative. The probability of correct identification is therefore

$$p_1 q_1 + p_2 q_2 \leq \max(p_1, p_2)(q_1 + q_2) \leq \max(p_1, p_2),$$

which is chance. Requirement (2) therefore cannot be met. $\square$

Remark III.2 (Nature of the exclusion) The exclusion established by Proposition III.2 rests on two dynamical hypotheses, the objectivizing dynamics of Assumption III.A, which aligns the precedence $\prec$ with the order of the generating parameter, and the forward determinism of Assumption III.B, together with the freedom of the selection required by Definition III.2(1) (the remark Two independences in Section 2.14). It is therefore a consequence of how admissible histories are generated and of what counts as a signal, not of the definition of time alone. It differs nonetheless from chronology protection in general relativity, where closed timelike curves are permitted by the field equations in several exact solutions and their exclusion is a conjecture requiring an additional mechanism, typically divergent quantum backreaction on the Cauchy horizon: here no mechanism beyond the two named assumptions is invoked. The heuristic that a delivered message is itself a record, and that records accumulate along $\prec$, is consistent with the result but is not used in its proof: decodability alone does not imply an increase of the record content or of the redundancy count.

Remark III.3 (Ontological status of the future, and a caveat) The successor

centre is defined by $Q_{k+1}^* = \arg \min_{Q \in \mathcal{M}} \sum_a w_a \tilde{d}_\Gamma^2(Q, \Pi_a[\Psi])$ evaluated on the observer family at that stage. It is the solution of a variational problem, not a datum stored elsewhere in a four-dimensional manifold awaiting access. To this extent the framework does not support the eternalist reading on which past and future states enjoy the same mode of existence and differ only in epistemic accessibility.

A caveat must be stated explicitly rather than left implicit. The IFR action is stationary under variations with fixed endpoints, and the objective history from which the order is extracted is determined globally in the auxiliary parameter λ ; in this respect the history is co-determined as a whole, and the framework is not straightforwardly presentist either. What the present section establishes is weaker than a metaphysical thesis, and correspondingly more precise: under Assumption III.B, which is exactly the requirement that admissible histories be generated forward in λ rather than co-determined by data at both ends, no admissible operation renders a later stage available as a channel at an earlier one. Whether that requirement is met by the observer sector $\mathcal{L}_\Pi$ is part of the open problem recorded in Section 3.21. The metaphysical question is left open; the operational one is closed, conditionally on the two named assumptions.

2.15. Recurrence Is Not Reversal

A recurrent history returns to an informationally indistinguishable configuration. It is a persistent source of confusion, in discussions of emergent time, to read such a return as a return to an earlier time. In IFR the two are separated by an elementary inequality, because identity continuity $\mathcal{C}_{\text{id}}$ and informational duration τ_n are independent functionals of the history.

Corollary III.1 (Recurrence is not reversal) Let $(Q_k^*)_{k=0}^n$ be an admissible objective history whose final centre coincides with its initial centre as a point of the comparison manifold, $Q_n^* = Q_0^*$, so that $\mathcal{C}_{\text{id}}(Q_0^*, Q_n^*) = 1$. Then the accumulated informational duration satisfies

$$\tau_n = \sum_{k=1}^n \tilde{d}_\Gamma(Q_{k-1}^*, Q_k^*) \geq 2 \max_{0 \leq m \leq n} \tilde{d}_\Gamma(Q_0^*, Q_m^*) \geq 0,$$

with $\tau_n = 0$ if and only if the history is constant. In particular an exact recurrence of an objective structure carries a strictly positive increment of informational duration whenever the intervening history is non-constant, and never a negative one.

Proof. Fix m with $0 \leq m \leq n$. By the triangle inequality for $\tilde{d}_\Gamma$, the outward segment satisfies $\sum_{k=1}^m \tilde{d}_\Gamma(Q_{k-1}^*, Q_k^*) \geq \tilde{d}_\Gamma(Q_0^*, Q_m^*)$, and the return segment satisfies $\sum_{k=m+1}^n \tilde{d}_\Gamma(Q_{k-1}^*, Q_k^*) \geq \tilde{d}_\Gamma(Q_m^*, Q_n^*) = \tilde{d}_\Gamma(Q_m^*, Q_0^*)$. Adding the two and maximising over m gives the stated bound. Each summand is non-negative, and $\tilde{d}_\Gamma$ vanishes precisely on coincident arguments, so $\tau_n = 0$ forces $Q_{k-1}^* = Q_k^*$ for every k . $\square$

Remark III.4 (Independence of persistence and duration) Corollary III.1

makes precise a separation that is implicit in the identity-continuity construction. Two centres may be informationally indistinguishable, $\mathcal{C}_{\text{id}} \rightarrow 1$, while the duration separating them along the history is arbitrarily large. A system may therefore return to a configuration without there being any sense in which it has returned to an earlier time. Cyclic cosmologies, Poincaré recurrence, and periodic effective dynamics are accordingly compatible with IFR and do not constitute counterexamples to the acyclicity of $\prec$: they are recurrences in $\mathcal{M}$, not cycles in the order. Under Definition III.1, which orders stages, this is exact. The dispersion is a functional of the state and not of the centre, so the initial and final stages may carry the same centre while, along any interval on which $\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}$ does not vanish identically, $\mathcal{D}_{\text{red}}(\lambda_n) < \mathcal{D}_{\text{red}}(\lambda_0)$: then $Q_0^* \prec Q_n^*$ as stages, while $Q_n^* = Q_0^*$ as points of $\mathcal{M}$.

2.16. Closed Timelike Curves and the Informational Order

The results above concern the informational order. It remains to ask what becomes of them when the order is represented in an emergent Lorentzian manifold, since it is there that closed timelike curves are formulated. The answer separates two levels that are usually conflated: the closure of a curve in the effective representation, and the closure of the order of stages that the curve represents. What the framework establishes concerns the second level only.

Proposition III.3 (Informational order along closed timelike curves) Let $\chi: \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}}$ be an effective spacetime embedding (an injective map) as in the recovery of relativistic time above, and let $\gamma: [0,1] \rightarrow \mathcal{M}_{\text{eff}}$ be a closed timelike curve of $g_{\mu\nu}^{\text{eff}}$, so that $\gamma(0) = \gamma(1)$. Suppose $\gamma = \chi \circ Q^*$ is the image under χ of an admissible objective history $(Q^*(\lambda))_{\lambda \in [0,1]}$ satisfying Assumption III.A and $\|\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}\| > 0$ on a subset of positive measure. Then:

1. $\mathcal{D}_{\text{red}}(\lambda=1) < \mathcal{D}_{\text{red}}(\lambda=0)$, hence the endpoint stages satisfy $Q^*(0) \prec Q^*(1)$;
2. the accumulated informational duration is strictly positive, $\Delta \tau_{\text{IFR}} > 0$;
3. the endpoints are distinct, strictly ordered stages of the history; since χ is injective and $\chi(Q^*(0)) = \gamma(0) = \gamma(1) = \chi(Q^*(1))$, they carry the same objective centre, $Q^*(0) = Q^*(1)$ as points of $\mathcal{M}$. The closure of γ is therefore a recurrence of the centre in the sense of Corollary III.1, not a closure of the order $\prec$: no stage precedes itself.

Proof. (1) By Assumption III.A, $\mathcal{D}_{\text{red}}$ is non-increasing along an admissible history and strictly decreasing where the gradient does not vanish; integrating over $[0,1]$ and using the positive-measure hypothesis gives the strict inequality, and Definition III.1 gives the precedence. (2) A timelike curve has nowhere-vanishing tangent and is therefore non-constant; since $\gamma = \chi \circ Q^*$, the history of centres is non-constant, and its arc length, which is the duration, is strictly positive by the identity property of $\tilde{d}_{\Gamma}$. (3) The stages are distinct and ordered by (1) and the irreflexivity of $\prec$ (Proposition III.1(1)); the coincidence of the centres follows from the displayed equality and the injectivity of χ . The two statements are

compatible because the dispersion is a functional of the state and not of the centre (Definition III.1).

Remark III.5 (Two readings, and what is and is not claimed) Proposition III.3 admits two readings, and they agree on what it establishes. Either an effective metric admitting closed timelike curves is not the image of any admissible objective history, in which case such solutions lie outside the IFR-admissible sector; or it is such an image, in which case the curve closes in the effective representation, and in the space of objective centres, while the sequence of stages it represents remains open and strictly ordered. On either reading there is no closed loop in the order $\prec$, which is the level at which IFR locates physical time.

Consistency paradoxes of grandfather type require that a determination made at a later stage alter what is already fixed at an earlier stage of the same history. Under Assumptions III.A and III.B this is excluded along the loop by Proposition III.2, since the stages traversed are strictly ordered and each is fixed by data preceding it.

The scope of the result is narrower than chronology protection in the sense of general relativity. The proposition does not exclude closed timelike curves from the emergent metric, and it does not assert that the events of $\mathcal{M}_{\text{eff}}$ along such a curve are distinct; it asserts only that the informational order is not closed by any closed timelike curve that is the image of an admissible history.

Remark III.6 (Scope of the result) Two limitations are stated explicitly. First, the proposition is conditional on informational non-equilibrium along the loop; at an objectivization equilibrium the order degenerates and the argument is silent, consistently with the general limitation recorded in Section 3.21. Second, no claim is made here that every effective metric admitting closed timelike curves is excluded from the admissible sector: that would require a classification of the images of admissible histories under χ , which is not attempted in this series. An explicit illustration within a model whose Lorentzian signature is derived rather than assumed is given in Part V, and the general classification is recorded among the open problems of Part VI.

2.17. Relation to Thermodynamic Time

The IFR arrow of time is closely related to, but not identical with, thermodynamic irreversibility. Thermodynamic entropy concerns the number of microscopic states compatible with a macroscopic state. IFR temporal orientation concerns the contraction of observer disagreement, measured by the redundant dispersion, and the redundant encoding of objective structures that it controls.

Nevertheless, the two notions are expected to align in the classical regime. If the number of redundant records increases, then the number of effective degrees of freedom encoding past structures also increases. This may correspond to an increase in coarse-grained entropy:

$$S_{\text{cg}}(Q_{k+1}^*) \geq S_{\text{cg}}(Q_k^*).$$

The thermodynamic arrow is then a macroscopic expression of the deeper infor-

mational arrow:

increasing redundant records $\Rightarrow$ increasing coarse-grained entropy.

However, IFR does not identify time with entropy alone. Entropy increase may be one manifestation of the more general principle that stable objective structures accumulate asymmetric records.

2.18. Relation to Quantum Measurement

In ordinary quantum theory, measurement appears to introduce a transition from superposition to a definite outcome. In IFR, this transition is reformulated as the emergence of a stable objective center from observer-dependent projections.

The pre-objective state is the interference state

$$\Psi.$$

The observer projections are

$$\Pi_a[\Psi].$$

An outcome-like structure appears when these projections contract:

$$\Pi_a[\Psi] \approx Q^*$$

for many independent observers.

Temporal order enters because an outcome-like structure at one stage can be retained as a record at a later stage,

$$Q_i^* \prec Q_j^*,$$

the precedence being fixed by the decrease of redundant dispersion (Definition III.1) and the retention of recoverable information being an additional property of the pair.

Thus, measurement, record formation, and temporal ordering are not separate primitives. They are different aspects of the same objectivization process.

2.19. Interpretive Summary

The temporal sector of IFR may be summarized as follows:

The parameter λ is not time.

Objective centers, not primitive instants, are the carriers of temporal structure.

Temporal precedence is defined by decreasing redundant dispersion and admissible transition.

The arrow of time is the direction of decreasing redundant dispersion.

Relativistic proper time is recovered as the effective metric representation of informational duration.

Thus, IFR treats time as an emergent property of stable informational organization. Just as gravitational geometry arises from informational curvature, temporal

order arises from asymmetric relations among stable objective structures. The next section develops the semiclassical and effective-field limits in which IFR reduces to ordinary spacetime physics.

3. Semiclassical and Effective-Field Limits

Parts I and II defined the fundamental IFR structures, and the preceding section derived temporal order, without assuming spacetime, physical time, classical objects, or gravitational geometry as primitives. We now specify the limiting conditions under which ordinary relativistic field theory is recovered.

The purpose of this section is not to derive the full Standard Model from first principles. Rather, it is to formulate the correspondence requirements that any complete IFR theory must satisfy in order to reproduce the empirically successful semiclassical regime. In this regime, stable objective centers become effectively local fields or events on an emergent spacetime manifold, informational curvature becomes spacetime curvature, and the IFR variational principle reduces to an effective action of general-relativistic field-theoretic form.

The guiding correspondence is

$$(\Psi, \Gamma, \Pi) \rightarrow (\varphi, g_{\mu\nu}^{\text{eff}}),$$

where the left-hand side denotes the pre-spatiotemporal IFR variables, while the right-hand side denotes effective matter fields and an emergent spacetime metric.

3.1. The High-Redundancy Regime

The first condition for a classical or semiclassical limit is high redundant objectivity. Let

$$Q_{\Psi, \Gamma}^*$$

be a stable IFR-objective center associated with an interference state Ψ , an information geometry Γ , and an observer family Π .

The high-redundancy regime is defined by

$$\mathcal{D}_{\text{red}}[\Psi, \Gamma, \Pi] \ll \mathcal{D}_{\text{null}},$$

or equivalently,

$$\Delta_{\text{IFR}} = \frac{\mathcal{D}_{\text{null}} - \mathcal{D}_{\text{red}}}{\mathcal{D}_{\text{null}}} \approx 1.$$

In this limit, observer projections satisfy

$$\Pi_a[\Psi] = Q^* + \epsilon_a,$$

with

$$\tilde{d}_{\Gamma}(\epsilon_a, 0) \ll 1$$

for all admissible observers a in the relevant observer class.

Thus,

$$\Pi_a[\Psi] \approx \Pi_b[\Psi] \approx Q^*.$$

The distinction between different operational projections becomes negligible, and

the stable center Q^* can be treated as an approximately observer-independent structure.

This is the IFR origin of classical objectivity:

classical objects are high-redundancy stable Fréchet centers.

3.2. Effective Locality

A second condition is effective locality. The set of stable objective centers

$$\mathcal{Q} = \{Q^*\}$$

must admit a representation by a low-dimensional manifold

$$\mathcal{M}_{\text{eff}}.$$

Let

$$\chi : \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}}$$

be an embedding or reconstruction map. Effective locality requires that nearby informational centers map to nearby points of the emergent manifold:

$$\tilde{d}_{\Gamma}(Q_i^*, Q_j^*) \ll 1 \Rightarrow d_{g_{\text{eff}}}(\chi(Q_i^*), \chi(Q_j^*)) \ll 1.$$

Conversely, metric neighbourhoods in $\mathcal{M}_{\text{eff}}$ must correspond, up to controlled distortion, to neighbourhoods in information geometry:

$$d_{g_{\text{eff}}}(\chi(Q_i^*), \chi(Q_j^*)) \ll 1 \Rightarrow \tilde{d}_{\Gamma}(Q_i^*, Q_j^*) \ll 1 + \mathcal{O}(\epsilon_{\text{loc}}).$$

The parameter

$$\epsilon_{\text{loc}}$$

measures the failure of exact locality. In the effective-field limit,

$$\epsilon_{\text{loc}} \rightarrow 0.$$

Effective locality allows the assignment

$$Q^* \mapsto x \in \mathcal{M}_{\text{eff}},$$

and hence permits the construction of fields over the emergent manifold.

3.3. Emergence of Effective Fields

In the high-redundancy and effective-locality regime, stable objective centers can be represented by effective fields.

Let

$$\mathcal{F}_{\text{eff}}$$

denote an effective field space over $\mathcal{M}_{\text{eff}}$. A field configuration is a section

$$\varphi : \mathcal{M}_{\text{eff}} \rightarrow \mathcal{E},$$

where $\mathcal{E}$ is an appropriate bundle over $\mathcal{M}_{\text{eff}}$.

IFR requires a reconstruction map

$$\mathfrak{R}_{\text{field}} : \mathcal{Q} \rightarrow \mathcal{F}_{\text{eff}}$$

such that

$$\mathfrak{R}_{\text{field}}(Q^*) = \varphi(x)$$

when

$$x = \chi(Q^*).$$

Thus, in the semiclassical limit,

$$Q_{\Psi, \Gamma}^* \rightarrow \varphi(x).$$

The effective field $\varphi(x)$ is therefore not fundamental. It is the local representation of a stable informational center.

For multiple field species, one obtains

$$Q^* \rightarrow \{\varphi_A(x)\}_{A \in \mathcal{I}},$$

where the index A may label scalar, spinor, gauge, or composite effective degrees of freedom.

The emergence of field multiplicity corresponds to the decomposition of stable objective centers into independent or approximately independent informational modes:

$$Q^* \sim (Q_1^*, Q_2^*, \dots, Q_n^*).$$

3.4. Emergence of the Effective Metric

The information geometry Γ reduces to an effective spacetime metric when the distance between stable centers is represented by geodesic distance on $\mathcal{M}_{\text{eff}}$:

$$d_{\Gamma}(Q_i^*, Q_j^*) = d_{g_{\text{eff}}}(\chi(Q_i^*), \chi(Q_j^*)) + \mathcal{O}(\epsilon_{\text{geo}}).$$

The effective metric tensor is then written as

$$g_{\mu\nu}^{\text{eff}}(x).$$

Along the chain of Section 3.9, the curvature correspondence condition is

$$\mathcal{R}_{\mathcal{E}}^{(L)} = \chi^* R(g_{\text{eff}}) + \mathcal{O}(\epsilon_{\text{geo}}),$$

where

$$R(g_{\text{eff}})$$

is the Ricci scalar of the effective metric.

The Lorentzian signature of spacetime is not assumed at the primitive IFR level. It emerges if the effective metric decomposes into one temporal and three spatial directions:

$$\text{sig}(g_{\mu\nu}^{\text{eff}}) = (-, +, +, +),$$

or equivalently

$$(+, -, -, -),$$

depending on convention.

The emergence of Lorentzian signature is therefore a structural property of the effective information-geometric representation. It is not imposed on $\mathcal{X}$.

3.5. Effective Action

In the semiclassical limit, the IFR action must reduce to an effective action on the emergent manifold:

$$\mathcal{S}_{\text{IFR}} \rightarrow \mathcal{S}_{\text{eff}} [g_{\mu\nu}^{\text{eff}}, \varphi].$$

The general form is

$$\mathcal{S}_{\text{eff}} = \int_{\mathcal{M}_{\text{eff}}} d^4x \sqrt{-g_{\text{eff}}} \left[\frac{1}{2\kappa_{\text{eff}}} R(g_{\text{eff}}) + \mathcal{L}_{\text{matter}}^{\text{eff}}(\varphi, \nabla\varphi, g_{\text{eff}}) + \mathcal{L}_{\text{corr}}^{\text{IFR}} \right].$$

Here

$$\kappa_{\text{eff}} = 8\pi G_{\text{eff}}$$

in units where $c = 1$, and

$$\mathcal{L}_{\text{matter}}^{\text{eff}}$$

is the effective matter Lagrangian.

The correction term

$$\mathcal{L}_{\text{corr}}^{\text{IFR}}$$

contains deviations from the ideal semiclassical limit. It may include contributions from:

- (i) finite redundant dispersion;
- (ii) nonlocal information-geometric structure;
- (iii) imperfect metric embedding;
- (iv) observer-family dependence;
- (v) higher-order informational curvature terms;
- (vi) residual interference effects not captured by local fields.

Thus,

$$\mathcal{L}_{\text{corr}}^{\text{IFR}} = \mathcal{L}_{\text{red}} + \mathcal{L}_{\text{nonloc}} + \mathcal{L}_{\text{embed}} + \mathcal{L}_{\text{obs}} + \mathcal{L}_{\text{curv}}^{(>1)} + \mathcal{L}_{\text{int-res}}.$$

In the ideal high-redundancy local limit,

$$\mathcal{L}_{\text{corr}}^{\text{IFR}} \rightarrow 0,$$

and the effective action becomes

$$\mathcal{S}_{\text{eff}} \rightarrow \int d^4x \sqrt{-g_{\text{eff}}} \left[\frac{1}{2\kappa_{\text{eff}}} R(g_{\text{eff}}) + \mathcal{L}_{\text{matter}}^{\text{eff}} \right].$$

This is the standard form of a generally covariant matter-gravity action.

3.6. Semiclassical Field Equations

Variation of the effective action with respect to the effective metric gives

$$G_{\mu\nu}(g_{\text{eff}}) = \kappa_{\text{eff}} T_{\mu\nu}^{\text{eff}} + \mathcal{C}_{\mu\nu}^{\text{IFR}},$$

where

$$T_{\mu\nu}^{\text{eff}} = -\frac{2}{\sqrt{-g_{\text{eff}}}} \frac{\delta}{\delta g_{\text{eff}}^{\mu\nu}} \left[\sqrt{-g_{\text{eff}}} \mathcal{L}_{\text{matter}}^{\text{eff}} \right],$$

and

$$C_{\mu\nu}^{\text{IFR}} = -\kappa_{\text{eff}} \frac{2}{\sqrt{-g_{\text{eff}}}} \frac{\delta}{\delta g_{\text{eff}}^{\mu\nu}} \left[\sqrt{-g_{\text{eff}}} \mathcal{L}_{\text{corr}}^{\text{IFR}} \right].$$

In the ideal limit,

$$C_{\mu\nu}^{\text{IFR}} \rightarrow 0,$$

so that

$$G_{\mu\nu}(g_{\text{eff}}) = \kappa_{\text{eff}} T_{\mu\nu}^{\text{eff}}.$$

Variation with respect to the effective field φ gives

$$\frac{\delta \mathcal{L}_{\text{matter}}^{\text{eff}}}{\delta \varphi} - \nabla_{\mu} \left(\frac{\delta \mathcal{L}_{\text{matter}}^{\text{eff}}}{\delta (\nabla_{\mu} \varphi)} \right) + \frac{\delta \mathcal{L}_{\text{corr}}^{\text{IFR}}}{\delta \varphi} - \nabla_{\mu} \left(\frac{\delta \mathcal{L}_{\text{corr}}^{\text{IFR}}}{\delta (\nabla_{\mu} \varphi)} \right) = 0.$$

When the IFR correction terms vanish, this reduces to the ordinary field equation:

$$\frac{\delta \mathcal{L}_{\text{matter}}^{\text{eff}}}{\delta \varphi} - \nabla_{\mu} \left(\frac{\delta \mathcal{L}_{\text{matter}}^{\text{eff}}}{\delta (\nabla_{\mu} \varphi)} \right) = 0.$$

Thus, ordinary relativistic field equations arise as effective equations for stable objective centers in the high-redundancy limit.

3.7. Quantum Field-Theoretic Limit

The IFR generating functional is

$$\mathcal{Z}_{\text{IFR}} = \int \mathcal{D}\Psi \mathcal{D}\Gamma \mathcal{D}\Pi \exp \left[i \mathcal{S}_{\text{IFR}} [\Psi, \Gamma, \Pi] \right].$$

In the regime where:

$$\Gamma \rightarrow g_{\mu\nu}^{\text{eff}},$$

$$Q^* \rightarrow \varphi(x),$$

$$\Pi_a[\Psi] \approx Q^*,$$

and observer dependence becomes negligible, the functional measure should reduce formally to

$$\mathcal{D}\Psi \mathcal{D}\Gamma \mathcal{D}\Pi \rightarrow \mathcal{D}\varphi \mathcal{D}g_{\mu\nu}^{\text{eff}},$$

up to gauge fixing, redundancy factors, and Jacobian terms.

The IFR generating functional then becomes

$$\mathcal{Z}_{\text{IFR}} \rightarrow \mathcal{Z}_{\text{eff}} = \int \mathcal{D}\varphi \mathcal{D}g_{\mu\nu}^{\text{eff}} \exp \left[i \mathcal{S}_{\text{eff}} [g_{\mu\nu}^{\text{eff}}, \varphi] \right].$$

If the effective geometry is treated as a fixed semiclassical background, this further reduces to

$$\mathcal{Z}_{\text{QFT}}[g_{\text{eff}}] = \int \mathcal{D}\varphi \exp \left[i \int d^4x \sqrt{-g_{\text{eff}}} \mathcal{L}_{\text{matter}}^{\text{eff}}(\varphi, \nabla \varphi, g_{\text{eff}}) \right].$$

Therefore, quantum field theory on curved spacetime appears as an intermediate limit of IFR:

$$\text{IFR} \rightarrow \text{effective metric geometry} \rightarrow \text{QFT on } g_{\mu\nu}^{\text{eff}}.$$

3.8. Classical Limit

A further limit yields classical field theory. This requires that fluctuations around the dominant effective field configuration be small.

Let

$$\varphi_{\text{cl}}$$

and

$$g_{\mu\nu}^{\text{cl}}$$

be stationary points of the effective action:

$$\frac{\delta \mathcal{S}_{\text{eff}}}{\delta \varphi} = 0, \quad \frac{\delta \mathcal{S}_{\text{eff}}}{\delta g^{\mu\nu}} = 0.$$

The saddle-point approximation gives

$$\mathcal{Z}_{\text{eff}} \approx \exp[i\mathcal{S}_{\text{eff}}[g_{\text{cl}}, \varphi_{\text{cl}}]] \times (\det \delta^2 \mathcal{S}_{\text{eff}})^{-1/2} \times \dots$$

The leading order is classical. In IFR terms, this limit requires:

$$\mathcal{D}_{\text{red}} \rightarrow 0,$$

$$\epsilon_{\text{geo}} \rightarrow 0,$$

$$\epsilon_{\text{time}} \rightarrow 0,$$

$$\delta^2 \mathcal{S}_{\text{IFR}} \text{ suppresses large fluctuations.}$$

Thus, the classical world is not merely a stationary-phase approximation. It is a stationary-phase approximation restricted to stable, redundantly objectivized, effectively local structures.

3.9. Recovery of General Relativity

The recovery of general relativity requires the simultaneous satisfaction of four conditions.

First, informational curvature must reduce to Ricci curvature. Following Part II, the comparison scalar $\mathcal{R}_{\text{T}}$ on $\mathcal{M}$ is not compared with $R(g_{\text{eff}})$ directly: the correspondence passes through the reduction to the pre-Wick event manifold $(\mathcal{E}, g_{\mathcal{E}}^{(R)})$ and the informational Wick map $\mathcal{W}$,

$$\mathcal{R}_{\text{T}} \rightarrow \mathcal{R}_{\mathcal{E}}^{(R)} \xrightarrow{\mathcal{W}} \mathcal{R}_{\mathcal{E}}^{(L)} \rightarrow R(g_{\text{eff}}), \quad \mathcal{R}_{\mathcal{E}}^{(L)} := R(\mathcal{W}[g_{\mathcal{E}}^{(R)}]),$$

and it is the post-Wick scalar $\mathcal{R}_{\mathcal{E}}^{(L)}$ that is required to reduce to $R(g_{\text{eff}})$. The first arrow is established with an explicit rate in Section 3.14; the second is hypothesis (H3) of Part II.

Second, the informational stress tensor must reduce to effective stress-energy:

$$T_{ij}^{\text{IFR}} \rightarrow T_{\mu\nu}^{\text{eff}}.$$

Third, residual IFR corrections must vanish:

$$C_{\mu\nu}^{\text{IFR}} \rightarrow 0.$$

Fourth, the Bianchi compatibility condition must hold:

$$\nabla^\mu T_{\mu\nu}^{\text{eff}} = 0.$$

Under these conditions, the effective equation becomes

$$G_{\mu\nu}(g_{\text{eff}}) = \kappa_{\text{eff}} T_{\mu\nu}^{\text{eff}},$$

which is the Einstein field equation for the emergent metric.

The equivalence principle is recovered when all matter-like objective structures couple to the same effective metric:

$$g_{\mu\nu}^{\text{eff},A} = g_{\mu\nu}^{\text{eff}} + \mathcal{O}(\epsilon_{\text{EP}})$$

for all effective species A , with

$$\epsilon_{\text{EP}} \rightarrow 0.$$

Possible deviations from the equivalence principle correspond to species-dependent informational embeddings or residual observer-geometry couplings.

3.10. Recovery of Quantum Theory

IFR is compatible with ordinary quantum theory when observer-independent objectivity is not yet complete, but the effective background and Hilbert-space structure are stable.

In that regime, the primitive interference state Ψ reduces to an ordinary quantum state

$$|\psi\rangle$$

defined relative to an emergent background structure, and observer maps reduce to measurement operations:

$$\Pi_a \rightarrow \mathcal{E}_a,$$

where $\mathcal{E}_a$ may be a projection-valued measure, positive-operator-valued measure, channel, or coarse-grained measurement map.

The Born-rule probability is then represented as

$$p(k|a) = \langle \psi | E_k^{(a)} | \psi \rangle,$$

where

$$\{E_k^{(a)}\}$$

is the POVM associated with observer context a .

In IFR language, a definite outcome corresponds not merely to a projection in Hilbert space, but to a stable redundant center across observer-accessible records:

$$\Pi_a[\Psi] \approx Q_k^*$$

for many independent observer channels.

Thus, ordinary quantum theory is recovered as the effective theory of interference before full redundant objectivization, while classical measurement outcomes correspond to the stable centers produced by such objectivization.

3.11. Effective Matter Sector

The effective matter Lagrangian

$$\mathcal{L}_{\text{matter}}^{\text{eff}}$$

is not specified uniquely by the minimal IFR framework. Instead, IFR imposes structural constraints on any acceptable effective matter sector.

It must be local in the emergent manifold up to small corrections:

$$\mathcal{L}_{\text{matter}}^{\text{eff}}(x) = \mathcal{L}_{\text{matter}}^{\text{eff}}(\varphi(x), \nabla\varphi(x), g_{\mu\nu}^{\text{eff}}(x)) + \mathcal{O}(\epsilon_{\text{nonloc}}).$$

It must be compatible with the effective metric:

$$\nabla^\mu T_{\mu\nu}^{\text{eff}} = 0$$

in the ideal limit.

It must arise from stable modes of the objective-center structure:

$$\varphi_A(x) = \Re_A(Q_x^*),$$

where Q_x^* is the stable objective center associated with the effective point x .

Gauge structure may emerge from redundancies in the representation of objective centers. If two effective field descriptions correspond to the same IFR-objective structure,

$$\varphi \sim \varphi',$$

then the transformation

$$\varphi \mapsto \varphi'$$

is a gauge redundancy of the effective description.

Thus, IFR interprets gauge symmetry as an invariance of the emergent representation of stable informational structures, not necessarily as a primitive symmetry of $\mathcal{X}$.

3.12. Correspondence Hierarchy

The complete hierarchy of limits may be summarized as:

$$\begin{aligned} (\Psi, \Gamma, \Pi) &\rightarrow (Q^*, \mathcal{Q}, \tilde{d}_\Gamma) \rightarrow (\mathcal{M}_{\text{eff}}, g_{\mu\nu}^{\text{eff}}) \\ &\rightarrow \text{GR} + \text{QFT} \rightarrow \text{classical physics.} \end{aligned}$$

More explicitly:

$$\begin{array}{ll} \text{primitive interference} & \rightarrow \Psi, \\ \text{operational access} & \rightarrow \Pi_a[\Psi], \\ \text{objectivity} & \rightarrow Q^*, \\ \text{information geometry} & \rightarrow \Gamma, \\ \text{spacetime geometry} & \rightarrow g_{\mu\nu}^{\text{eff}}, \\ \text{matter fields} & \rightarrow \varphi(x), \\ \text{gravitation} & \rightarrow R(g_{\text{eff}}), \\ \text{classical objects} & \rightarrow \text{persistent high-redundancy centers.} \end{array}$$

The reversal of explanatory direction is essential. IFR does not begin with fields on spacetime and then ask how observers perceive them. It begins with interfer-

ence and observer-accessible projections, then derives the conditions under which fields, spacetime, and classical observers become meaningful.

3.13. Dynamic Classicalization: $\mathcal{D}_{\text{red}} \rightarrow 0$ under Objectivizing Dynamics

The semiclassical correspondence theorem below requires that the redundant dispersion tends to zero along objective histories. In earlier formulations this was *assumed* as an independent condition. Here we reduce it to the single dynamical hypothesis already stated in Section 2.12: under Assumption III.A the redundant dispersion is a Lyapunov function of the admissible flow, and the high-redundancy regime $\mathcal{D}_{\text{red}} \rightarrow 0$ is reached dynamically. We first record, because it determines the status of that assumption, that the variational principle of Part II does *not* by itself supply the required monotonicity.

Proposition III.4 (Conservation of the interference energy) Let $\lambda \mapsto \Psi(\lambda)$ solve the IFR interference equation of Part II, obtained from $\delta\mathcal{S}_{\text{IFR}} = 0$ by constrained variation with respect to Ψ^* at fixed Γ and Π , with the Fubini-Study kinetic term $\mathcal{K}_{\text{int}} = c \left(\langle \dot{\Psi}, \dot{\Psi} \rangle - \left| \langle \Psi, \dot{\Psi} \rangle \right|^2 \right)$, $c > 0$, and with $\mathcal{L}_{\Pi} \equiv 0$. Then the functional

$$\mathcal{V}(\lambda) := \mathcal{K}_{\text{int}}[\Psi(\lambda)] + \mathcal{V}_{\text{int}}[\Psi(\lambda)] + \alpha \mathcal{D}_{\text{red}}[\Psi(\lambda)]$$

is a first integral, $d\mathcal{V}/d\lambda = 0$. In particular $\mathcal{D}_{\text{red}}$ is not monotone along such solutions: in the one-mode reduction $\mathcal{V}_{\text{int}} = 0$, $\mathcal{D}_{\text{red}} = q^2/2$, $\mathcal{K}_{\text{int}} = \dot{q}^2/2$ one has $q(\lambda) = \cos(\sqrt{\alpha}\lambda)$ for $q(0) = 1$, $\dot{q}(0) = 0$, so that $\mathcal{D}_{\text{red}}(\lambda) = \frac{1}{2} \cos^2(\sqrt{\alpha}\lambda)$ oscillates.

Proof. The Lagrangian $L = \mathcal{K}_{\text{int}} - \mathcal{V}_{\text{int}} - \alpha \mathcal{D}_{\text{red}}$ does not depend explicitly on λ , and the constraint $\|\Psi\|^2 = 1$ is holonomic and λ -independent. The energy integral of an autonomous Lagrangian system is $E = \langle \partial L / \partial \dot{\Psi}, \dot{\Psi} \rangle - L$; since $\mathcal{K}_{\text{int}}$ is a homogeneous quadratic form in $\dot{\Psi}$, Euler's identity gives $\langle \partial \mathcal{K}_{\text{int}} / \partial \dot{\Psi}, \dot{\Psi} \rangle = 2\mathcal{K}_{\text{int}}$, whence $E = \mathcal{K}_{\text{int}} + \mathcal{V}_{\text{int}} + \alpha \mathcal{D}_{\text{red}} = \mathcal{V}$. Explicitly, differentiating $\mathcal{V}$ along a solution and substituting the Euler-Lagrange equation with multiplier $\Lambda(\lambda)$ leaves only the constraint term, $\frac{d\mathcal{V}}{d\lambda} = -\Lambda \frac{d}{d\lambda} \|\Psi\|^2 = 0$, because $\|\Psi\|^2 \equiv 1$ along the solution. The term $-\alpha \mathcal{D}_{\text{red}}$ is a potential, and the force it generates is conservative: the work it does is exactly compensated by the change of $\mathcal{K}_{\text{int}}$. The one-mode example is the harmonic oscillator $\ddot{q} + \alpha q = 0$. $\square$

Remark (Where the monotonicity comes from) Proposition III.4 shows that an argument of the form “the objectivizing term $-\alpha \mathcal{D}_{\text{red}}$ contributes dissipatively to the energy balance” is not available: a potential is not a dissipation. The monotonicity of $\mathcal{D}_{\text{red}}$ must therefore enter through the one term of the action that Part II declared minimal, not complete: the observer sector $\mathcal{L}_{\Pi}$, which couples the interference state to the observer family and is the natural carrier of the irreversibility of objectivization, in the same way that coupling to an environment

is the carrier of irreversibility in decoherence [9] [10]. If, in an overdamped regime of such a coupling, the admissible histories reduce to the gradient flow (2), then Assumption III.A holds identically; that $\mathcal{L}_{\Pi}$ produces this regime is not established here. The derivation of $\mathcal{L}_{\Pi}$ from first principles is not attempted in this series; Assumption III.A is the precise statement of what is required of it.

Theorem III.2 (Dynamic classicalization under objectivizing dynamics)

Let (Γ, g_{Γ}) be a complete information geometry and let $\mathcal{M}_{\text{class}} \subset \Gamma$ be the closed set of configurations of perfect observer agreement ($\mathcal{D}_{\text{red}} = 0$). Define

$$\mathcal{D}_{\text{red}}[\Psi] = \sum_{a < b} w_{ab} \tilde{d}_{\Gamma}^2(\Pi_a[\Psi], \Pi_b[\Psi]) \geq 0,$$

and suppose that the admissible IFR histories $\lambda \mapsto \Psi(\lambda)$ are the trajectories of an autonomous flow satisfying Assumption III.A. Then:

1. $\mathcal{D}_{\text{red}}$ is a Lyapunov function of the flow: it is non-increasing along every admissible history, and $d\mathcal{D}_{\text{red}}/d\lambda = 0$ only where $\text{grad}_{\Gamma}\mathcal{D}_{\text{red}} = 0$;
2. every bounded admissible history converges, as $\lambda \rightarrow \infty$, to the largest invariant set contained in $\{\text{grad}_{\Gamma}\mathcal{D}_{\text{red}} = 0\}$;
3. if the only invariant configurations are the agreement configurations $\mathcal{M}_{\text{class}}$, then

$$\lim_{\lambda \rightarrow \infty} \mathcal{D}_{\text{red}}[\Psi(\lambda)] = 0$$

for almost every initial datum.

Proof. (1) is the content of (1): the inequality gives monotonicity, and the strict inequality where the gradient does not vanish gives the identification of the stationary set. (2) $\mathcal{D}_{\text{red}} \geq 0$ is bounded below and non-increasing, hence converges along every history. By the LaSalle invariance principle for an autonomous flow with a Lyapunov function, the ω -limit set of any bounded history is contained in the largest invariant subset of $\{d\mathcal{D}_{\text{red}}/d\lambda = 0\} = \{\text{grad}_{\Gamma}\mathcal{D}_{\text{red}} = 0\}$, the equality being (1). (3) On that invariant set $\mathcal{D}_{\text{red}}$ is stationary; if the stationary configurations are exactly the agreement set $\mathcal{M}_{\text{class}}$ (no spurious critical points, e.g. $\mathcal{D}_{\text{red}}$ a Morse-Bott function with minimum set $\mathcal{M}_{\text{class}}$), then $\mathcal{D}_{\text{red}} \rightarrow \min = 0$. For the gradient flow (2) with $\mathcal{D}_{\text{red}}$ Morse-Bott, the convergence is exponential in λ : in a normal coordinate ξ to $\mathcal{M}_{\text{class}}$ with $\mathcal{D}_{\text{red}} = \frac{1}{2}h\xi^2 + O(\xi^3)$, $h > 0$, the linearised flow is $\dot{\xi} = -(\alpha h/\gamma)\xi$, so $\mathcal{D}_{\text{red}}(\lambda) \propto e^{-2(\alpha h/\gamma)\lambda}$. $\square$

Remark III.7 (Status of the high-redundancy hypothesis) Theorem III.2 converts the hypothesis “ $\mathcal{D}_{\text{red}} \rightarrow 0$ ” of the semiclassical correspondence theorem from an independent assumption into a consequence of two named hypotheses: the objectivizing dynamics of Assumption III.A, and informational non-equilibrium, $\|\text{grad}_{\Gamma}\mathcal{D}_{\text{red}}\| > 0$, away from the agreement set, which is the condition under which a non-trivial arrow of objectivization exists (Section 2.12). The gain is not that the hypothesis disappears but that it is the same hypothesis that generates the arrow of time: time and classicality are consequences of one assumption, not of two.

3.14. Reduction of Informational Curvature to Ricci Curvature

We now show that, in the high-redundancy regime reached under Assumption III.A by Theorem III.2, the informational curvature scalar $\mathcal{R}_\Gamma$ reduces to the scalar curvature of the pre-Wick event metric, up to terms controlled by $\mathcal{D}_{\text{red}}$. This derives the reduction step of hypothesis (4) of the semiclassical correspondence theorem.

Remark III.8 (Placement in the correspondence chain of Part II) The gravitational correspondence theorem of Part II relates the comparison manifold to the emergent spacetime along the chain

$$(\mathcal{M}, \Gamma) \xrightarrow{\mathcal{R}_g} (\mathcal{E}, g_\mathcal{E}^{(R)}) \xrightarrow{\mathcal{W}} (\mathcal{E}, g_\mathcal{E}^{(L)}) \xrightarrow{\chi} (\mathcal{M}_{\text{eff}}, g_{\text{eff}}),$$

where $\mathcal{R}_g: \mathcal{G}^\Gamma(\mathcal{M}) \rightarrow \mathcal{G}_\mathcal{E}^{(R)}$ is the geometric reduction map, $\mathcal{W}$ the informational Wick map, with $g_\mathcal{E}^{(L)} := \mathcal{W}[g_\mathcal{E}^{(R)}]$, and $\chi: \mathcal{E} \rightarrow \mathcal{M}_{\text{eff}}$ the manifold representation of the event manifold, whose equal-time restriction is the map

$\chi: \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}}$ of hypothesis (2) of the theorem below (hypotheses (H1)-(H3) of Part II). The event manifold $\mathcal{E} = \{(Q, t)\}$ carries the Riemannian pre-Wick metric $g_\mathcal{E}^{(R)}$ and its Wick image $g_\mathcal{E}^{(L)}$, which is Lorentzian. Lemma III.1 below is a statement about the first arrow only: it exhibits the reduction $\mathcal{R}_g$ at the level of scalar curvature, as a Riemannian submersion onto $(\mathcal{E}, g_\mathcal{E}^{(R)})$, and supplies its rate. It says nothing about $\mathcal{W}$: a Riemannian submersion cannot produce a Lorentzian base, since the signature of a non-degenerate metric is locally stable, and the passage from $\mathcal{R}_\mathcal{E}^{(R)}$ to $\mathcal{R}_\mathcal{E}^{(L)} := R(\mathcal{W}[g_\mathcal{E}^{(R)}])$ is exactly the content of (H3) of Part II, constructed in Part V (equivalently, the Wick map cannot be omitted, as Part II states). The tensor-level construction of $\mathcal{R}_g$ likewise belongs to Part V; what is established here is the scalar rate.

Lemma III.1 (Curvature reduction via Riemannian submersion) Let $\pi: (M, \gamma) \rightarrow (\mathcal{E}, g_\mathcal{E}^{(R)})$ be the projection that quotients the information manifold M by the directions along which $\mathcal{D}_{\text{red}}$ is non-decreasing (the “non-physical” fibres), with $\mathcal{E}$ the four-dimensional event manifold of stable objective centres of Part II, endowed with its Riemannian pre-Wick metric $g_\mathcal{E}^{(R)}$, and let $k := n - 4 \geq 1$ be the fibre dimension. Assume, on the compact comparison domain $\Omega \subset M$:

(B1) (*warped-product / horizontal integrability*) the metric γ has warped-product structure with respect to the fibration, $\gamma = g_\mathcal{E}^{(R)} \oplus \phi^2 g_F$, with warping function ϕ constant along the fibres, so that the O’Neill integrability tensor A vanishes;

(B2) (*flat fibres at the reduction scale*) the fibre (F, g_F) is a compact flat manifold, $\text{Scal}_F \equiv 0$, and the warping function is set by the informational scale ℓ_Γ of Part II (M6)-(M7) up to a factor depending only on the dispersion,

$$\phi = \ell_\Gamma e^{\sigma(\mathcal{D}_{\text{red}})}, \quad \sigma \in C^2([0, \mathcal{D}_{\text{max}}]),$$

where $\mathcal{D}_{\text{red}} \in C^2(\Omega)$ is constant along the fibres (a basic function, $\mathcal{D}_{\text{red}} = \bar{\mathcal{D}} \circ \pi$

with $\bar{\mathcal{D}} \in C^2(\Omega_{\mathcal{E}})$, and the comparison domain is saturated, $\Omega = \pi^{-1}(\Omega_{\mathcal{E}})$ with $\Omega_{\mathcal{E}} \subset \mathcal{E}$ compact; all constants below are uniform on Ω , the suprema of $|\sigma'|$, $|\sigma''|$ and $|\Delta_{\mathcal{E}} \bar{\mathcal{D}}|$ being finite. Here $\Delta_{\mathcal{E}}$ is the Laplacian of the base metric $g_{\mathcal{E}}^{(R)}$; for a basic function it is related to the Laplacian Δ_{Γ} of (M, γ) by

$$\Delta_{\Gamma} \mathcal{D}_{\text{red}} = \Delta_{\mathcal{E}} \bar{\mathcal{D}} \circ \pi + k \sigma'(\mathcal{D}_{\text{red}}) \|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2, \text{ while the gradients agree,}$$

$$\|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\| = \|\nabla_{\mathcal{E}} \bar{\mathcal{D}}\| \circ \pi.$$

Then, with $\mathcal{R}_{\mathcal{E}}^{(R)} := R(g_{\mathcal{E}}^{(R)})$, the scalar curvature of the warped product satisfies the exact identity

$$\begin{aligned} \mathcal{R}_{\Gamma} &= \mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi - 2k \sigma'(\mathcal{D}_{\text{red}}) (\Delta_{\mathcal{E}} \bar{\mathcal{D}}) \circ \pi \\ &\quad - \left[2k \sigma''(\mathcal{D}_{\text{red}}) + k(k+1) \sigma'(\mathcal{D}_{\text{red}})^2 \right] \|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2, \end{aligned} \quad (3)$$

equivalently, in terms of the Laplacian of the total space,

$\mathcal{R}_{\Gamma} = \mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi - 2k \sigma' \Delta_{\Gamma} \mathcal{D}_{\text{red}} - \left[2k \sigma'' + k(1-k) \sigma'^2 \right] \|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2$; every term on the right is basic, so $\mathcal{R}_{\Gamma}$ is constant along the fibres. Hence

$$\left\| \mathcal{R}_{\Gamma} - \mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi \right\|_{L^{\infty}(\Omega)} \leq C_1 \left\| \sigma'(\mathcal{D}_{\text{red}}) \right\|_{L^{\infty}(\Omega)} + C_2 \left\| \nabla_{\Gamma} \mathcal{D}_{\text{red}} \right\|_{L^{\infty}(\Omega)}^2, \quad (4)$$

with $C_1 = 2k \left\| \Delta_{\mathcal{E}} \bar{\mathcal{D}} \right\|_{L^{\infty}(\Omega_{\mathcal{E}})}$ and $C_2 = 2k \left\| \sigma'' \right\|_{\infty} + k(k+1) \left\| \sigma' \right\|_{\infty}^2$. In particular, if the

fibre size is stationary at the attractor, $\sigma'(0) = 0$, and $\mathcal{D}_{\text{red}}$ is Morse-Bott with minimum set $\mathcal{M}_{\text{class}}$ (hypothesis (3) of Theorem III.2), then

$\left\| \nabla_{\Gamma} \mathcal{D}_{\text{red}} \right\|^2 = O(\mathcal{D}_{\text{red}})$ and $\left| \sigma'(\mathcal{D}_{\text{red}}) \right| = O(\mathcal{D}_{\text{red}})$, so that

$$\mathcal{R}_{\Gamma} - \mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi = O\left(\left\| \nabla_{\Gamma} \mathcal{D}_{\text{red}} \right\|^2\right) = O(\mathcal{D}_{\text{red}}) \quad (\mathcal{D}_{\text{red}} \rightarrow 0), \quad (5)$$

and $\mathcal{R}_{\Gamma} \rightarrow \mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi$ uniformly on Ω . Since the mean over Ω is linear and positive, the same bounds hold, with the same L^{∞} norms on the right-hand side, for the mean curvature $\bar{\mathcal{R}}_{\Gamma}$ entering the reduced action of Part II, with $\mathcal{R}_{\mathcal{E}}^{(R)} \circ \pi$ replaced by its mean over Ω ; on the saturated domain, with $d\mu_{\Gamma} = \phi^k d\mu_{\mathcal{E}} d\mu_F$, that mean is the ϕ^k -weighted mean of $\mathcal{R}_{\mathcal{E}}^{(R)}$ over $\Omega_{\mathcal{E}}$.

Proof. For a warped product $B \times_{\phi} F$ with $\dim F = k$ the scalar curvature is [16] [17]

$$\text{Scal}_M = \text{Scal}_B \circ \pi + \phi^{-2} \text{Scal}_F - 2k \phi^{-1} \Delta_B \phi - k(k-1) \phi^{-2} |\nabla_B \phi|^2,$$

the warped product being a Riemannian submersion with $A \equiv 0$ and second fundamental form of the fibres determined by $\nabla \phi$ [18]. The base is Riemannian because π is a Riemannian submersion from the positive-definite information metric γ of (M3); the Lorentzian signature arises only under the subsequent Wick map $\mathcal{W}$ of Remark III.8. Under (B2) the term $\phi^{-2} \text{Scal}_F$ vanishes identically, and substituting $\phi = \ell_{\Gamma} e^{\sigma(\mathcal{D}_{\text{red}})}$, for which $\phi^{-1} \nabla \phi = \sigma \nabla \mathcal{D}_{\text{red}}$ and $\phi^{-1} \Delta_{\mathcal{E}} \phi = \sigma'' \|\nabla \bar{\mathcal{D}}\|^2 + \sigma' \Delta_{\mathcal{E}} \bar{\mathcal{D}} + \sigma'^2 \|\nabla \bar{\mathcal{D}}\|^2$, all derivatives being those of the base since ϕ is basic, gives (3) by direct computation, the coefficient of $\sigma'^2 \|\nabla \mathcal{D}_{\text{red}}\|^2$ being $2k + k(k-1) = k(k+1)$; the scale ℓ_{Γ} drops out, as it must, since only

$\nabla \ln \phi$ enters. The form with Δ_Γ follows from the identity $\Delta_\Gamma f = \Delta_\varepsilon f + k \langle \nabla \ln \phi, \nabla f \rangle$ for basic f on a warped product with $d\mu_\Gamma = \phi^k d\mu_\varepsilon d\mu_F$. The bound (4) follows by taking suprema on Ω with the constants of (B2). If $\sigma'(0) = 0$ then $|\sigma'(\mathcal{D})| \leq \|\sigma''\|_\infty \mathcal{D}$; if $\mathcal{D}_{\text{red}}$ is Morse–Bott at its minimum set, then near $\mathcal{M}_{\text{class}}$ one has $\mathcal{D}_{\text{red}} \asymp \text{dist}^2$ and $\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2 \asymp \text{dist}^2$, whence (5). The statement for $\bar{\mathcal{R}}_\Gamma$ follows by averaging (3) over Ω with respect to $d\mu_\Gamma$: the right-hand side is bounded pointwise by the L^∞ norms in (4), which are uniform on Ω by (B2), and a pointwise bound integrates against the positive finite measure $d\mu_\Gamma$ on the compact saturated domain; Fubini on $\Omega = \pi^{-1}(\Omega_\varepsilon)$ gives the weighted-mean statement. $\square$

Remark III.9 (Reduction scale and the gradient invariant) Hypothesis (B2) is a Kaluza–Klein reduction: the non-physical directions form a flat compact fibre of size ℓ_Γ , the scale at which, in Part II (M7), the characteristic volume and the reduced coupling $\kappa_{\text{red}} = \kappa_{\text{IFR}} / \ell_\Gamma^{d-3}$ are defined; this is the interpretation of ℓ_Γ that Part II records as belonging to the dimensional-reduction argument. A collapsing fibre would not do: for a non-flat fibre the term $\phi^{-2} \text{Scal}_F$ diverges as $\phi \rightarrow 0$, and the warping terms grow like $\|\nabla \mathcal{D}_{\text{red}}\|^2 / \mathcal{D}_{\text{red}}^2$, so that curvature reduction requires fibres of fixed size and vanishing intrinsic curvature, not small fibres. The residual of the reduction is then governed by the gradient invariant $\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2$, the same quantity f that fixes the informational light speed c_{IFR} in Part V through $m_\Psi c_{\text{IFR}}^2 = \alpha f$, and by $\sigma'(\mathcal{D}_{\text{red}})$, the sensitivity of the fibre size to the dispersion, which vanishes at the attractor when ℓ_Γ is the size actually attained there.

Remark III.10 (The warped-product hypothesis) Hypotheses (B1) and (B2) are the irreducible technical assumptions of the curvature reduction: (B1) makes the quotient a Riemannian submersion with vanishing integrability tensor, (B2) fixes the fibre geometry at the reduction scale. The codimension-one foliation argument (the level sets of $\mathcal{D}_{\text{red}}$) gives $A \equiv 0$ automatically for one-dimensional fibres, but the four-dimensional quotient $\mathcal{E}$ requires fibres of dimension $n-4$; for $n > 5$ the integrability of the horizontal distribution is not automatic, and the warped-product structure (or an equivalent G -symmetry of the fibres, or direct horizontal Frobenius integrability) must be assumed. This is a named, local structural hypothesis on the information geometry—not a restatement of the conclusion—and is the honest replacement for the previously implicit assumption.

3.15. Vanishing of the Correction Lagrangian

Lemma III.2 (Controlled corrections) Under the hypotheses of Lemma III.1, and under hypothesis (H3) of Part II together with the identification $\kappa_{\text{red}} \rightarrow \kappa_{\text{eff}}$ of Part II (M7), let $\chi: \mathcal{E} \rightarrow \mathcal{M}_{\text{eff}}$ be the representation map of Remark III.8 and write $\epsilon_{\mathcal{W}} := \|\mathcal{R}_{\mathcal{E}}^{(R)} - \mathcal{R}_{\mathcal{E}}^{(L)}\|_{L^\infty(\mathcal{E})}$ for the scalar residual of the intertwining of the curvature construction by the Wick map, which (H3) assumes and Part V estab-

lishes ($\epsilon_{\mathcal{W}} = 0$ under exact intertwining). Then the curvature part of the IFR correction Lagrangian, pulled back to the event manifold, satisfies

$$\begin{aligned}\chi^* \mathcal{L}_{\text{corr}}^{\text{IFR}}|_{\text{curv}} &= \frac{1}{2\kappa_{\text{eff}}} (\mathcal{R}_{\Gamma}|_{\mathcal{E}} - \chi^* R(g_{\text{eff}})) \\ &= O(\|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2) + O(|\sigma'(\mathcal{D}_{\text{red}})|) + O(\epsilon_{\mathcal{W}}) + O(\epsilon_{\text{geo}}),\end{aligned}\quad (6)$$

where $\mathcal{R}_{\Gamma}|_{\mathcal{E}}$ denotes the fibre mean of $\mathcal{R}_{\Gamma}$ over $\pi^{-1}(e)$, $e \in \mathcal{E}$, a function on $\mathcal{E}$. Under $\sigma'(0) = 0$ and the Morse–Bott hypothesis the first two terms are $O(\mathcal{D}_{\text{red}})$, and the curvature part vanishes in the joint limit $\mathcal{D}_{\text{red}} \rightarrow 0$, $\epsilon_{\mathcal{W}} \rightarrow 0$, $\epsilon_{\text{geo}} \rightarrow 0$. No statement is made here about the non-curvature contributions to $\mathcal{L}_{\text{corr}}^{\text{IFR}}$ enumerated in Section 3.5.

Proof. The curvature part of $\mathcal{L}_{\text{corr}}^{\text{IFR}}$ is the deviation of the informational curvature term of the reduced action of Part II, $\beta \bar{\mathcal{R}}_{\Gamma}$ with $\beta = V_{\text{char}}/(2\kappa_{\text{red}})$, from the Einstein–Hilbert term $\frac{1}{2\kappa_{\text{eff}}} R(g_{\text{eff}})$; after the matching $\kappa_{\text{red}} \rightarrow \kappa_{\text{eff}}$ of (M7)

the coefficient is the emergent one. To compare the two scalars they are brought to the same manifold: $R(g_{\text{eff}})$ is pulled back to $\mathcal{E}$ along χ , and $\mathcal{R}_{\Gamma}$ is pushed down to $\mathcal{E}$ as its fibre mean, which by (3) is exact: every term of (3) is basic, so $\mathcal{R}_{\Gamma}$ is constant along each compact fibre and $\mathcal{R}_{\Gamma}|_{\mathcal{E}} \circ \pi = \mathcal{R}_{\Gamma}$. The difference telescopes along the chain of Remark III.8:

$$\mathcal{R}_{\Gamma}|_{\mathcal{E}} - \chi^* R(g_{\text{eff}}) = (\mathcal{R}_{\Gamma}|_{\mathcal{E}} - \mathcal{R}_{\mathcal{E}}^{(R)}) + (\mathcal{R}_{\mathcal{E}}^{(R)} - \mathcal{R}_{\mathcal{E}}^{(L)}) + (\mathcal{R}_{\mathcal{E}}^{(L)} - \chi^* R(g_{\text{eff}})).$$

The first term is bounded by (4) of Lemma III.1; the second is $\epsilon_{\mathcal{W}}$ by definition; the third is $O(\epsilon_{\text{geo}})$ by (H3) of Part II, which asserts $\mathcal{R}_{\mathcal{E}}^{(L)} = \chi^* R(g_{\text{eff}}) + O(\epsilon_{\text{geo}})$. No rate in $\mathcal{D}_{\text{red}}$ is claimed for the second term: its control is the content of (H3), not of the present lemma. The linear rate under $\sigma'(0) = 0$ and Morse–Bott is (5), and the limit $\mathcal{D}_{\text{red}} \rightarrow 0$ is reached dynamically, under Assumption III.A, by Theorem III.2. $\square$

Remark III.11 This derives hypothesis (6) of the semiclassical correspondence theorem in its curvature part and in its reduction step only: the vanishing of the curvature correction is a consequence of the dynamical attractor $\mathcal{D}_{\text{red}} \rightarrow 0$, with the explicit rate $O(\|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2) = O(\mathcal{D}_{\text{red}})$ under the stationarity and Morse–Bott conditions, conditionally on (H3) of Part II supplying $\epsilon_{\mathcal{W}} \rightarrow 0$ and $\epsilon_{\text{geo}} \rightarrow 0$. The non-curvature contributions to $\mathcal{L}_{\text{corr}}^{\text{IFR}}$ are not bounded here and remain part of hypothesis (6).

3.16. From Conditional Statement to Emergence Theorem

The semiclassical correspondence theorem as originally stated lists six hypotheses and concludes that the IFR action reduces to the Einstein–matter action. Several of those hypotheses—specifically the reduction of the information geometry to a Lorentzian metric (3), the reduction of informational curvature to Ricci curvature (4), and the vanishing of the correction Lagrangian (6)—coincide with parts of the conclusion, so that the theorem, read literally, is a conditional restatement

rather than a derivation. The results established above reduce this circularity by deriving those hypotheses from the IFR dynamics supplemented by one explicit dynamical hypothesis:

- Hypothesis (1), $\mathcal{D}_{\text{red}} \rightarrow 0$, is derived as a dynamical attractor by the Dynamic Classicalization Theorem (Theorem III.2), under the objectivizing dynamics of Assumption III.A and informational non-equilibrium; the variational principle of Part II alone does not supply it (Proposition III.4).
- Hypothesis (4), $\mathcal{R}_{\mathcal{E}}^{(L)} \rightarrow R(g_{\text{eff}})$, is derived in its reduction step $\mathcal{R}_{\Gamma} \rightarrow \mathcal{R}_{\mathcal{E}}^{(R)}$ by the curvature-reduction Lemma III.1, under the named warped-product structural hypothesis (B1); the passage through the informational Wick map, $\mathcal{R}_{\mathcal{E}}^{(R)} \rightarrow \mathcal{R}_{\mathcal{E}}^{(L)}$, is hypothesis (3) below (Part II, (H3); Part V) and is not derived here.
- Hypothesis (6), $\mathcal{L}_{\text{corr}}^{\text{IFR}} \rightarrow 0$, is derived by Lemma III.2 in its curvature part, with explicit rate $O(\|\nabla_{\Gamma} \mathcal{D}_{\text{red}}\|^2) = O(\mathcal{D}_{\text{red}})$ under the stationarity and Morse-Bott conditions of Lemma III.1, conditionally on (H3) of Part II for the Wick and embedding residuals; its non-curvature part is retained as a hypothesis.
- Hypothesis (3), the emergence of the Lorentzian signature $(-, +, +, +)$, is derived in Part V (*the Emergence of Lorentzian Signature*) from the memory-gradient decomposition, with the temporal sign fixed by the irreversibility of $\mathcal{D}_{\text{red}}$ rather than postulated.

The remaining hypotheses (2) (existence of a differentiable manifold representation $\chi: \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}}$) and (5) (field representation $Q^* \rightarrow \varphi(x)$) are legitimate technical regularity assumptions and are retained as such. With this understanding, the theorem below is read as a genuine *emergence* theorem: given the objectivizing dynamics of Assumption III.A, informational non-equilibrium and the warped-product structural hypothesis, the IFR dynamics drive the system to a high-redundancy attractor on which the Einstein-matter action is recovered. The constant β is fixed to $+V_{\text{char}}/(2\kappa_{\text{red}})$, with the reduced coupling κ_{red} matched to κ_{eff} , as established in Part II (M7).

The original statement is preserved below for reference, with its hypotheses now understood as the derived consequences listed above.

3.17. Semiclassical Correspondence Theorem

We now state the main result of this section.

Theorem III.3 (Semiclassical correspondence) Let

$$(\Psi^*, \Gamma^*, \Pi^*)$$

be an admissible configuration of the IFR dynamics, that is, of the variational principle of Part II supplemented by an observer sector $\mathcal{L}_{\text{TI}}$ satisfying Assumption III.A; stationarity of $\mathcal{S}_{\text{IFR}}$ with $\mathcal{L}_{\text{TI}} \equiv 0$ does not by itself supply hypothesis 1 (Proposition III.4). Suppose that:

1. the observer projections admit stable Fréchet centers with

$$\mathcal{D}_{\text{red}} \rightarrow 0;$$

2. the set of stable centers $\mathcal{Q}$ admits an effective differentiable manifold representation

$$\chi : \mathcal{Q} \rightarrow \mathcal{M}_{\text{eff}};$$

3. the information geometry reduces to an effective Lorentzian metric:

$$\Gamma^* \rightarrow g_{\mu\nu}^{\text{eff}};$$

4. informational curvature reduces to Ricci curvature, through the reduction to the event manifold and the informational Wick map:

$$\mathcal{R}_{\mathcal{T}} \rightarrow \mathcal{R}_{\mathcal{E}}^{(R)} \xrightarrow{\mathcal{W}} \mathcal{R}_{\mathcal{E}}^{(L)} \rightarrow R(g_{\text{eff}});$$

5. stable objective centers admit field representations:

$$Q^* \rightarrow \varphi(x);$$

6. residual nonlocal, observer-dependent, and finite-redundancy corrections vanish:

$$\mathcal{L}_{\text{corr}}^{\text{IFR}} \rightarrow 0.$$

Then the IFR action reduces to an effective generally covariant field action,

$$\mathcal{S}_{\text{IFR}} \rightarrow \int d^4x \sqrt{-g_{\text{eff}}} \left[\frac{1}{2\kappa_{\text{eff}}} R(g_{\text{eff}}) + \mathcal{L}_{\text{matter}}^{\text{eff}} \right],$$

and the corresponding field equations reduce to the Einstein equation coupled to effective matter fields:

$$G_{\mu\nu}(g_{\text{eff}}) = \kappa_{\text{eff}} T_{\mu\nu}^{\text{eff}},$$

together with the Euler-Lagrange equations for φ .

Proof. By assumption 1, stable observer-independent objective centers exist. By assumption 2, these centers admit a differentiable manifold representation. By assumption 3, the information geometry becomes an effective Lorentzian metric on this manifold. By assumption 4, the curvature term in the IFR action becomes the Einstein-Hilbert curvature scalar. By assumption 5, the stable centers become effective matter fields. By assumption 6, the residual IFR corrections vanish. Substituting these correspondences into the IFR action gives the stated effective action. Variation with respect to $g_{\mu\nu}^{\text{eff}}$ and φ gives the corresponding Einstein and matter field equations. $\square$

This theorem states the precise conditions under which IFR reproduces ordinary semiclassical spacetime physics.

3.18. Interpretive Summary

The semiclassical limit of IFR can be summarized by the following statements:

Observer-independent objects are stable high-redundancy Fréchet centers.

Fields are local representations of objective centers on an emergent manifold.

The spacetime metric is the effective representation of information geometry.

General relativity is recovered when informational curvature becomes Ricci curvature.

Quantum field theory is recovered when interference persists on an emergent spacetime background.

Part IV turns from correspondence to empirical implementation. It specifies how the theoretical quantities of IFR can be estimated in concrete observational settings and how previous applications involving gravitational-wave detectors, cosmological maps, physiological epochs, smoothing scales, and catalog partitions fit into the present formalism.

3.19. Conceptual Novelty Relative to Existing Programs

Part I distinguished IFR from decoherence, quantum Darwinism, relational interpretations and emergent-gravity programs at the level of objectivity, and Part II did so at the level of dynamics. The distinctions relevant here concern time and the classical limit.

The arrow is derived from one hypothesis, not posited as three. Thermodynamic accounts obtain temporal asymmetry from entropy increase relative to a low-entropy past, which is an initial condition imported from outside the dynamics. Proposition III.1 obtains order, acyclicity and asymmetry from the monotonicity of $\mathcal{D}_{\text{red}}$ along admissible histories. The irreducible hypotheses are the objectivizing dynamics of Assumption III.A, which is a condition on the present dynamics, and informational non-equilibrium, $\|\text{grad}_{\Gamma} \mathcal{D}_{\text{red}}\| > 0$, which is a condition on the present state; neither is a boundary condition in the past.

Duration is intersubjective, not relational. Relational approaches relativise duration to a chosen reference system and decline to assign an observer-independent temporal interval. Here duration is the arc length of the trajectory of Fréchet centres in the comparison geometry: it is built from observer-dependent projections, but the object it measures is the observer-invariant centre, so the resulting interval is intersubjective in the same sense in which objectivity was intersubjective in Part I.

The classical limit is an attractor, not a regime of validity. In conventional treatments the semiclassical limit is a regime one enters by assumption, characterised by large quantum numbers, large actions, or strong environmental coupling. Theorem III.2 shows that in IFR, under Assumption III.A, the high-redundancy regime is dynamically selected: it is where admissible histories go, with a rate controlled by a single parameter, $\mathcal{D}_{\text{red}}$ itself.

The correspondence hypotheses are discharged, not assumed. The gravitational correspondence theorem of Part II required, among its hypotheses, that $\mathcal{R}_{\mathcal{E}}^{(L)} \rightarrow R(g_{\text{eff}})$ and that the correction terms vanish. Lemma III.1 and Lemma

III.2 derive the reduction step of both, $\mathcal{R}_T \rightarrow \mathcal{R}_\varepsilon^{(R)}$, from the attractor, with an explicit rate $O(\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2)$, linear in $\mathcal{D}_{\text{red}}$ at a Morse-Bott attractor, at the cost of two named and local geometric hypotheses (the warped-product structure and the flat fibre at the reduction scale ℓ_Γ of Remarks III.10 and III.9) which are stated rather than concealed. The remaining step, the informational Wick map of (H3), is left to Part V and is declared as such.

3.20. Falsifiability Criteria

Part I stated criteria (F1)-(F5) for the objectivity sector and Part II criteria (F6)-(F9) for the dynamical and gravitational sectors. The temporal and semiclassical content of Part III adds the following, with the outcomes that would count as failure.

(F10) Monotonicity of redundant dispersion. Along a sequence of observational reconstructions that is not subject to independent loss of redundancy (removal of channels, degradation of resolution, injection of uncorrelated noise), IFR predicts that the redundant dispersion is non-increasing. This is the empirical counterpart of Assumption III.A, and the criterion is where that assumption is exposed to data. *Failure:* systematic, reproducible growth of $\mathcal{D}_{\text{red}}$ in sequences where the observer family is stable or enriched.

(F11) Concordance of the two arrows. The decreasing-dispersion arrow controls the increasing-records arrow through the bound $N_{\text{red}}^\theta \geq P - \mathcal{D}_{\text{red}} / (w_{\min} \theta)$ of Proposition III.1(4); the count itself is not derived to be monotone. IFR predicts, as an additional empirical statement, that the two arrows agree in the high-redundancy regime. *Failure:* domains in which records proliferate while dispersion increases, or the converse, beyond the resolution of the estimators.

(F12) Additivity and reparametrisation-invariance of informational duration. Emergent time is the cumulative arc length $\tau_n = \sum_k \tilde{d}_\Gamma(Q_{k-1}^*, Q_k^*)$. It must be additive under concatenation of sequences and invariant under admissible refinement of the sampling, and in the semiclassical regime it must reduce to proper time up to a single global normalisation. *Failure:* a duration that depends on the sampling resolution after refinement, or that cannot be matched to proper time with a single constant across a domain.

(F13) Rate of the curvature correspondence. The reduction of informational curvature to the scalar curvature of the pre-Wick event metric is predicted to occur with a residual controlled by the gradient invariant,

$\mathcal{R}_T - \mathcal{R}_\varepsilon^{(R)} = O(\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2)$, hence linear in $\mathcal{D}_{\text{red}}$ at a Morse-Bott attractor (Lemma III.1); the same invariant fixes c_{IFR} in Part V. *Failure:* an empirically or model-theoretically established residual that does not vanish with $\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2$, or that scales with a different exponent in $\mathcal{D}_{\text{red}}$ at the attractor, which would indicate that the flat-fibre reduction at the scale ℓ_Γ is not the correct mechanism of dimensional reduction.

(F14) Absence of retrodictive signalling. Proposition III.2 forbids any protocol in which an alternative selected at one stage of an objective history is decoded,

at above-chance rate, at a strictly earlier stage of that history, the ordering being fixed independently of the protocol. This is asserted not only for quantum correlations, where it coincides with the standard no-signalling theorems, but for classical objective structures as well, and it is asserted as a consequence of the objectivizing dynamics and of forward determinism (Assumptions III.A and III.B) rather than as a property of particular models. *Failure*: a reproducible protocol exhibiting above-chance retrodictive decoding, with the temporal ordering established by an independent clock and the record content of the decoding stage controlled against leakage from the preparation.

(F15) Non-degeneracy of informational duration. Emergent duration is identified with proper time only in the high-redundancy limit. Writing $\varepsilon = \mathcal{D}_{\text{red}}/\mathcal{D}_{\text{null}} = 1 - \Delta_{\text{IFR}}$ for the residual fraction of unobjectivized dispersion, IFR therefore predicts a controlled deviation at finite ε ,

$$\frac{d\tau_{\text{IFR}}}{d\tau_{\text{proper}}} = 1 + c_1\varepsilon + \mathcal{O}(\varepsilon^2), \quad c_1 \neq 0,$$

with c_1 fixed by the same expansion that generates the correction tensor of Part V. The prediction has content only if the two clocks are distinguishable somewhere in the accessible range of ε . *Failure*: a ratio indistinguishable from unity across the accessible range, with the marginal spectral content of the individual observer channels held fixed so that the comparison is not confounded by a trivial dependence of the arc length on channel noise. In that event τ_{IFR} would carry no information beyond a relabelling of proper time, and the central construction of this part would be empty rather than merely unconfirmed. A dedicated experimental design for this criterion is proposed in Part IV.

Criteria (F10), (F11) and (F14) are directly testable with the estimators applied in Part IV; (F12) and (F15) are testable wherever an independent clock is available; (F13) is at present a model-theoretic criterion and becomes operational once explicit comparison geometries are constructed.

3.21. Scope and Limitations

The results of this paper are conditional, and we state the conditions explicitly rather than leaving them implicit.

The objectivizing dynamics is assumed, not derived. The monotone decrease of $\mathcal{D}_{\text{red}}$ along admissible histories (Assumption III.A) is the hypothesis on which the arrow of time, the classicalization theorem, the exclusion of retrodictive signalling and the chronology result all rest. It is not a consequence of the variational principle of Part II: the interference equation is conservative and preserves $\mathcal{K}_{\text{int}} + \mathcal{V}_{\text{int}} + \alpha\mathcal{D}_{\text{red}}$ (Proposition III.4), so that along its solutions $\mathcal{D}_{\text{red}}$ oscillates. The monotonicity must be supplied by the observer sector $\mathcal{L}_{\text{TI}}$, which Part II left unspecified and which is here characterised only by what is required of it. Whether an explicit $\mathcal{L}_{\text{TI}}$ satisfying Assumption III.A can be derived rather than postulated is an open problem of the framework, recorded in Part VI.

Forward determinism is assumed. The exclusion of retrodictive signalling and

its application to closed timelike curves rest, in addition, on Assumption III.B: admissible histories are generated forward in λ . It holds for the gradient-flow realisation of Assumption III.A, but it is not implied by the fixed-endpoint variational formulation.

Non-equilibrium is assumed, not derived. The monotonicity argument yields a strict order only where $\|\text{grad}_{\Gamma}\mathcal{D}_{\text{red}}\| > 0$. At the agreement set the order degenerates and no temporal direction is defined. IFR therefore predicts the absence of time in exactly objectivized configurations, but it does not explain why the actual universe is in informational non-equilibrium.

The geometric hypothesis of the curvature reduction is irreducible. The warped-product structure of Remark III.10 is required for the O'Neill integrability tensor to vanish when the fibres have dimension greater than one. It is a local structural hypothesis on the information geometry, not a consequence of the axioms, and no mechanism is given here that would guarantee it.

Time is constructed on the manifold of stable centres. The construction presupposes that a sequence of stable Fréchet centres exists. In regimes where objectivity fails—where no stable centre exists or the centre is non-unique—the temporal order is not defined by the present construction, and nothing here determines what replaces it.

The matter sector is not derived. The recovery of effective fields identifies the conditions under which stable centres behave as local field configurations. It does not derive the field content, the gauge structure, or the interactions; that remains an open problem of the framework.

The chronology result is conditional and non-exhaustive. Proposition III.3 shows that a closed timelike curve of the emergent metric, when it is the image of an admissible objective history, does not close the informational order. It does not show that every effective metric admitting such curves is excluded from the admissible sector: that would require a classification of the images of admissible histories under χ , which is not attempted here and is recorded among the open problems of Part VI. The result is also conditional on informational non-equilibrium along the loop, and degenerates with the order itself at an objectivization equilibrium.

The Lorentzian signature is used before it is derived. The recovery of relativistic time below is stated in an effective Lorentzian manifold whose signature is here assumed. Its derivation from informational structure is the subject of Part V of the series, and the present results should be read as conditional on it.

4. Conclusions

This paper has presented Part III of the Interference-First Reality (IFR) series, supplying the temporal and semiclassical content on which Parts I and II were silent.

We have, first, derived the emergence of temporal order (Section 2). The ordering parameter λ of the variational principle is not physical time; physical time

is the intrinsic order of a sequence of stable Fréchet centres, generated by asymmetric informational dependence and realised concretely as the cumulative arc length $\tau_n = \sum_k \tilde{d}_\Gamma(Q_{k-1}^*, Q_k^*)$ in the comparison geometry. The central structural result is that the arrow of time need not be posited as such: Proposition III.1 derives strict order, acyclicity and global asymmetry, together with a monotone lower bound on the number of agreeing observer pairs, from the single monotonicity hypothesis of Assumption III.A, whose status relative to the variational principle is settled by Proposition III.4. Causality follows as ordered informational accessibility, and relativistic time is recovered in the semiclassical regime.

Second, we have established the semiclassical and effective-field limits (Section 3). The Dynamic Classicalization Theorem (Theorem III.2) shows that, under the same objectivizing hypothesis, $\mathcal{D}_{\text{red}} \rightarrow 0$ is a dynamical attractor rather than an independent assumption, so that classicality is selected by the dynamics. Building on it, Lemma III.1 reduces informational curvature to the scalar curvature of the pre-Wick event metric with residual $O(\|\nabla_\Gamma \mathcal{D}_{\text{red}}\|^2)$, linear in $\mathcal{D}_{\text{red}}$ at the attractor, and Lemma III.2 shows that the curvature part of the correction Lagrangian vanishes at the same rate, up to the Wick and embedding residuals of Part II (H3). Together these discharge two of the hypotheses that the gravitational correspondence theorem of Part II had to assume, converting a conditional statement into an emergence theorem within the regime it describes. General relativity and quantum theory are recovered as the high-redundancy, low-dispersion, effective-manifold limits of a single variational structure.

Third, we have shown what emergent time permits. Under the same monotonicity and the forward determinism of Assumption III.B, Proposition III.2 excludes retrodictive signalling; Corollary III.1 separates recurrence from reversal; and Proposition III.3 shows that a closed timelike curve of the emergent metric that is the image of an admissible history does not close the informational order, its closure being a recurrence of the objective centre at a strictly later stage rather than a return to an earlier one.

Fourth, we have stated where the construction is discriminating and where it is conditional. Criteria (F10)-(F15) extend the falsifiability list of Parts I and II to the temporal and semiclassical sectors, and the scope statement makes explicit that the objectivizing dynamics is assumed rather than derived from the interference equation, that forward determinism is assumed, that informational non-equilibrium is assumed rather than derived, that the warped-product hypothesis of the curvature reduction is irreducible and local, that the construction of time presupposes the existence of stable centres, that the matter sector is not derived, and that the Lorentzian signature is used here and derived only in Part V.

The central conclusion of Part III is that time and classicality are not two separate emergences but one. The same monotone contraction of observer disagreement that orders the sequence of objective structures also drives the system into the regime in which those structures behave as classical objects on an emergent spacetime. That contraction is one hypothesis, stated once and exposed to data through criterion (F10); the temporal order and the classical limit of this part fol-

low from it, and the exclusion of retrodictive signalling requires in addition only that admissible histories be generated forward in λ . Time is the order of objectivization, and the classical world is its limit.

Continuation of the series. Part IV develops the empirical implementation across five physical domains and the discussion of the framework.

Declarations

Data Availability

All datasets used in this study are publicly available. CMB spectra (TT, TE, EE) are from the Planck 2018 legacy release (Planck Legacy Archive) [19]; for theoretical background on CMB anisotropies see [20] [21]. Scripts associated with the legacy CMB and HRV analyses are archived separately in the Zenodo repository accompanying the previous article. <https://doi.org/10.5281/zenodo.17672528>.

Gravitational-wave strain data (GW150914-v2 and GW170817-v2) are from the Gravitational Wave Open Science Center (GWOSC). ECG/HRV records are from PhysioNet (*Fantasia* and *MIT-BIH Arrhythmia* databases); PSD was estimated using the Welch method [22] and frequency-band definitions follow established HRV standards [23]. No raw ECG signals are redistributed. JWST spectroscopic data are from the public JADES release [24]. All datasets, Python scripts, and LaTeX materials are openly available on Zenodo at

<https://doi.org/10.5281/zenodo.17672528>. The complete theoretical formulation of the IFR framework, of which this paper constitutes Part III of VI, is available as a preprint on Zenodo: <https://doi.org/10.5281/zenodo.20528552>.

Generative AI Tools

Generative AI tools (Claude by Anthropic, and GPT-based assistants) were used for manuscript revision, LaTeX formatting, code refactoring, and minor stylistic editing. All analyses, parameter choices, and numerical results were obtained by executing the released Python code on public datasets. This paper contains no figures. No data, numerical results, or scientific conclusions were generated by AI tools; all scientific analyses, interpretations, and conclusions are the author's own.

Reproducibility and Computational Transparency

Part III is a mathematical paper: it contains no new empirical results, data tables, or numerical analyses, and no figures. There is therefore no data pipeline to reproduce within Part III itself.

For completeness and continuity with the series, we note that the full empirical program of IFR—spanning heart-rate variability (HRV), the cosmic microwave background (CMB), gravitational-wave open data (GWOSC), JWST spectroscopy, large-scale structure (LSS), and their cross-domain synthesis—is developed in Part IV and documented in the data-oriented publications of the series [25] [26] and in the accompanying supplementary file *Reproducibility_sequence.txt*, which lists the complete commands, input specifications, execution order, and output descriptions for every figure and table in those works, including both computational pathways used for the CMB analysis (the binned-direct and bootstrap

+ sweep procedures).

All information-geometric quantities used across the empirical program (the Jensen-Shannon divergence and distance, the geometric and arithmetic barycenters, and the redundant-dispersion functional) are computed by a single audited module, `ifr_core`, imported by every analysis script. This consolidation guarantees that the information geometry is implemented identically across all domains; property-based and on-data equivalence tests confirm that it leaves all previously reported results numerically unchanged, with a maximum discrepancy below 10^{-13} .

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Author Contributions

Conceptualization, M.B.; methodology, M.B.; software, M.B.; validation, M.B.; formal analysis, M.B.; visualization, M.B.; writing—original draft preparation, M.B.; writing—review and editing, M.B.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Abbreviations

CMB	Cosmic Microwave Background
GWOSC	Gravitational Wave Open Science Center
HRV	Heart Rate Variability
IFR	Interference-First Reality
JS	Jensen-Shannon divergence
JSD	Jensen-Shannon distance
JWST	James Webb Space Telescope
KL	Kullback-Leibler divergence
LSS	Large-Scale Structure
PSD	Power Spectral Density
VLF/LF/HF	Very-Low/Low/High Frequency bands