Journal of Applied Mathematics and Physics, 2026, 14(9), 3571-3618
https://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

Interference-First Reality Theory: The Variational Principle and Emergent Gravitation

—The IFR Action, Field Equations, and Informational Curvature [IFR Theory Series, Part II of VI]

Michele Bianchi

Independent Researcher, Busto Arsizio, Italy
Email: michele1.bianchi@gsom.polimi.it

How to cite this paper: Bianchi, M. (2026) Interference-First Reality Theory: The Variational Principle and Emergent Gravitation. *Journal of Applied Mathematics and Physics*, **14**, 3571-3618.
https://doi.org/10.4236/jamp.2026.149178

Received: August 11, 2026
Accepted: September 17, 2026
Published: September 20, 2026

Abstract

This is Part II of the six-part series presenting the Interference-First Reality (IFR) Theory. Part I established the kinematic foundations and the definition of objectivity as stable multi-observer contraction; the present part supplies the dynamical principle. We formulate the IFR action, whose kinetic term is shown to be fixed uniquely by unitary invariance on the projective interference-state space (Fubini-Study form), and whose curvature coupling is fixed in sign and dimensional normalisation by semiclassical matching. The action is defined from the outset as a double integral over the ordering parameter and over a comparison domain $\Omega \subset \mathcal{M}$ equipped with its Riemannian volume measure, whose smoothness, dimension, signature, boundary conditions and topology are stated before any variation is performed. Variation with respect to the interference state, the information geometry and the observer maps yields the interference equation, the informational field equation $\mathcal{G}_{ij}^{\Gamma} = \kappa_{\mathrm{IFR}} T_{ij}^{\mathrm{IFR}}$, and the observer condition. This part further establishes the conditions under which effective spacetime curvature, and hence Einstein-type gravitational dynamics, emerge from informational curvature.

Keywords

Interference-First Reality, Information Geometry, Jensen-Shannon Distance, IFR Action, Fubini-Study Metric, Informational Curvature, Informational Stress Tensor, Emergent Gravitation

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 $\mathcal{D}_{\mathrm{red}}$ with operationally fixed weights; and the definition of IFR-objectivity as the existence, uniqueness and perturbation-stability of a Fréchet center $Q^\star$ of observer projections. Those results are kinematic. They specify what an objective structure is, and under what conditions it exists, but they do not specify which interference-geometric configurations are physically realised.

The present paper supplies that missing element. We formulate the IFR variational principle, derive the associated field equations, and develop the gravitational sector in which effective spacetime curvature arises from informational curvature. The central object is the action, defined in Section 2.2 as a double integral over the ordering parameter and over a comparison domain $\Omega\subset\mathcal{M}$ equipped with its Riemannian volume measure, Equation (1), and contracting, on uniform source densities, to the reduced form

$$\mathcal{S}_{\mathrm{IFR}}=\int_I \mathrm{d}\lambda\left[\mathcal{K}_{\mathrm{int}}\left[\Psi,\dot{\Psi};\Gamma\right]-\mathcal{V}_{\mathrm{int}}\left[\Psi;\Gamma\right]-\alpha\mathcal{D}_{\mathrm{red}}\left[\Psi,\Gamma,\Pi\right]+\beta\bar{\mathcal{R}}_\Gamma+\mathcal{L}_\Pi\right],$$

in which $\bar{\mathcal{R}}_\Gamma$ is the mean informational curvature on Ω of Lemma II.1. The reduced form is used for bookkeeping and for the semiclassical matching; the action actually varied in Section 3 is always the double integral. Its four substantive terms encode, respectively, interference propagation, informational self-organisation, multi-observer contraction, and the intrinsic curvature of the comparison geometry, while $\mathcal{L}_\Pi$ is an optional observer-kinematic term, set to zero in the minimal four-term form used in Part I. Two structural points distinguish this action from a conventional field-theoretic one. First, λ is an ordering parameter and not physical time: the resulting interference equation is second-order in λ, and the Schrödinger equation is recovered only conditionally—not as a limit in the high-redundancy regime alone, but as the Hamiltonian flow of the Kähler structure of $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$ on a first-order invariant manifold whose existence is assumed, and not constructed, here (Assumption II.2 and Proposition II.2). Second, the kinetic term is not free to be chosen. Since Postulate I, together with Section 3.1 of Part I, forbids any differentiable or metric structure on $\mathcal{X}$, $\mathcal{K}_{\mathrm{int}}$ must be built from the inner product of $\mathcal{H}_{\mathcal{X}}$ alone, and the requirement of unitary invariance then selects the Fubini-Study metric uniquely [2] [3]. Part I introduced a quadratic velocity functional adequate for the regularity estimates for which it was stated; the present section shows that this is precisely the horizontal-gauge form of the unique unitarily invariant kinetic term, and fixes the latter in manifestly gauge-invariant form (Remark II.4).

We fix here, and use throughout the remainder of the series, the sign and dimensional normalisation of the curvature coupling: $\beta>0$ with $\beta/V_{\mathrm{char}}=1/(2\kappa_{\mathrm{eff}})$, with the curvature term entering the action with a positive sign. This orientation is not conventional: it is forced by the requirement that the semiclassical limit reproduce the Einstein-Hilbert action with attractive gravity. The opposite writing, $-\beta\mathcal{R}_{\Gamma}$, would require a negative coupling and yield a repulsive gravitational sector. The matter is treated in full in Section 2.4.

A further consequence concerns holography. In the applied holographic formulation that preceded the present framework [4], holographic organisation was introduced as a postulate: the physical content of a bulk region was assumed to be encoded on a lower-dimensional screen, in the tradition established by black-hole entropy [5], dimensional reduction in quantum gravity [6] [7], the covariant entropy bound [8], and the bulk-boundary correspondence [9]. In the IFR architecture this assumption becomes unnecessary. What each observer map Π_a returns is, by the finite-accessibility condition of Part I, a representation of strictly lower informational dimension than the underlying interference state; what survives multi-observer contraction is only that part of the structure which is redundantly encoded across the family. Dimensional reduction is therefore not imposed on the theory but produced by it, and holography appears as a consequence of redundant multi-observer projection rather than as an independent principle. The gravitational sector developed in Section 3 is where this consequence acquires dynamical content.

It is worth stating precisely how this differs from established programs. Decoherence [10] explains the suppression of interference for a system coupled to an environment, and quantum Darwinism [11] characterises classicality through the redundant proliferation of records into environmental fragments. Both presuppose a background spacetime, a fixed system/environment split, and an *a priori* tensor structure; IFR assumes none of these, and replaces the multiplicity of records with the sharper criterion of a unique, stable Fréchet center. Thermodynamic and entropic-gravity programs derive gravitational dynamics from coarse-grained degrees of freedom while retaining an underlying spacetime or causal structure; IFR locates gravitation one level deeper, in the curvature of an information geometry over observer projections, with the metric itself emergent. The empirical counterpart of these claims—the cross-domain estimators, null models and contraction indices applied to cosmological, gravitational-wave and physiological ensembles—was developed in [12] [13] and is taken up again in Part IV.

The paper is organised as follows. Section 2 develops the variational principle: the space of admissible histories, the minimal form of the action, the sign and dimensional analysis, the canonical Fubini-Study kinetic term and the resulting interference equation, the variations with respect to the interference state, the information geometry and the observer maps, and the classical stationary limit. Section 3 develops the gravitational sector: informational curvature as a geometric source, the informational field equation $\mathcal{G}_{ij}^{\Gamma} = \kappa_{\mathrm{IFR}} T_{ij}^{\mathrm{IFR}}$, its reduction to Einstein-type dynamics, geodesic motion as informational extremality, the residual correction tensor $C_{\mu\nu}^{\mathrm{IFR}}$, and the gravitational correspondence theorem. The remaining parts of the series treat the emergence of temporal order together with the semiclassical and effective-field limits (Part III), the empirical implementation across cosmological, gravitational-wave and physiological ensembles (Part IV), the Lorentzian sector and the informational Wick mechanism (Part V), and the renormalisation-group flow of the framework (Part VI).

2. The IFR Variational Principle

Part I of this series [1] established the kinematic components of IFR: an interference state Ψ, an information geometry Γ, a family of observer maps Π, and the emergence of objective structures as stable Fréchet centers of observer-dependent projections. We now formulate the dynamical principle of the theory.

The central claim of this section is that physically realized configurations are stationary configurations of an action functional containing four contributions:

interference propagation, *informational self-organization*, *multi-observer contraction*, *informational curvature*.

The variational principle selects those interference-geometric histories for which internal interference dynamics, observer-stability constraints, and curvature of distinguishability are mutually consistent.

2.1. IFR Histories

Let $I \subseteq \mathbb{R}$ be an interval of the ordering parameter λ. An IFR history is a map

$$\lambda \mapsto s_{\text{IFR}}(\lambda) = (\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda)),$$

where

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

Here $\mathfrak{G}$ denotes the admissible class of information geometries, and $\mathfrak{P}$ denotes the admissible class of observer families. The parameter λ is not identified with physical time. It is an ordering parameter on the space of possible interference-geometric configurations. Physical time will be derived later from the ordered sequence of stable objective centers.

The space of admissible histories is denoted

$$\mathscr{C}_{\text{IFR}} = \{\lambda \mapsto (\Psi(\lambda), \Gamma(\lambda), \Pi(\lambda))\}.$$

A physical IFR history is a stationary point of an action functional

$$\mathcal{S}_{\text{IFR}} : \mathscr{C}_{\text{IFR}} \to \mathbb{R}.$$

Thus, $\delta\mathcal{S}_{\text{IFR}} = 0$ is the fundamental dynamical condition.

2.2. Comparison Domain, Action Measure, and Regularity of the Comparison Manifold

The curvature term of the IFR action is evaluated as an integral over the comparison manifold, not as a scalar attached to the ordering parameter. We fix this, together with the regularity class of the manifold on which the metric variation of

Section 3 is performed, *before* writing the action, since that variation presupposes a volume measure, a boundary prescription and a fixed dimensional bookkeeping.

Assumption II.1 (Comparison domain and its regularity). Let $(\mathcal{M}, g_\Gamma)$ be the information-geometric comparison space introduced in Part I of the series. Throughout the variational derivation of this paper we assume the following.

(M1) *Smoothness.* $(\mathcal{M}, g_\Gamma)$ is a C^∞ Riemannian manifold. In the canonical realisation $\mathcal{M}$ is the interior $\mathring{\Delta}_d$ of the simplex of probability vectors over $d+1$ outcomes, or a smooth parametric family of distributions, on which the Fisher-Rao metric is real-analytic.

(M2) *Dimension.* We write

$$d := \dim \mathcal{M} < \infty,$$

fixed along the history, so that $d = (d+1) - 1$ is the dimension of the canonical simplex realisation of (M1). The realisations employed in this series require $d \geq 5$; the value $d = 6$ holds under the additional conditions stated in the gauge-sector analysis of the series. The symbol d is reserved for the dimension of the comparison manifold and is distinguished throughout from the number $d+1$ of measurement outcomes entering the observer maps.

(M3) *Signature.* g_Γ is positive definite. No Lorentzian structure is assumed on $\mathcal{M}$: the indefinite signature belongs exclusively to the emergent manifold $\mathcal{M}_{\text{eff}}$ and arises through the informational Wick mechanism developed in Part V. This is the precise point at which the general information-geometric framework and the smooth Riemannian realisation required by the curvature sector are to be distinguished: the kinematic framework of Part I fixes a comparison geometry $\Gamma = (\mathcal{M}, g, \nabla)$ without imposing the dimensional curvature realisation adopted here, and admits non-smooth comparison structures, whereas everything stated in Sections 2-3 concerning $\mathcal{R}_\Gamma$ presupposes (M1)-(M7); see Remark II.1.

(M4) *Domain and boundary conditions.* The action is evaluated on a relatively compact, connected, geodesically convex open subset $\Omega \subset \mathcal{M}$ with piecewise-smooth boundary $\partial\Omega$. Metric variations obey the Dirichlet condition $\delta g_{ij}^{\Gamma}\big|_{\partial\Omega} = 0$, and the Gibbons-Hawking-York boundary term $\kappa_{\text{IFR}}^{-1} \oint_{\partial\Omega} K \mathrm{d}\sigma$, with K the trace of the second fundamental form of $\partial\Omega$, is understood to be included so that the variational problem for $\mathcal{R}_\Gamma$ is well posed. Where Ω is taken closed without boundary the term is absent.

(M5) *Topology.* Ω is contractible and may be taken to be a Fisher-Rao normal ball. No global topological assumption is placed on $\mathcal{M}$, and all correspondence results of Section 3 are local in Ω.

(M6) *Two levels of the comparison geometry and the informational length scale.* A distinction must be drawn between the dimensionless divergence level, on which the empirical instantiations of the series operate, and the dimensional metric level required by the curvature sector. At the divergence level the comparison distance is the dimensionless distance $\tilde{d}_\Gamma$ induced by $\tilde{g}_\Gamma := \ell_\Gamma^{-2} g_\Gamma$, which is *realised* as the Jensen-Shannon distance in the high-redundancy regime,

$$\tilde{d}_\Gamma \xrightarrow[\mathcal{D}_{\text{red}}\to 0]{} d_{\text{JS}},$$

and is not equal to it off shell. The second-order expansion of d_{JS} at $q = p + \delta$ is, with natural logarithms,

$$d_{\text{JS}}^2(p,q) = \frac{1}{8}\sum_k \frac{\delta_k^2}{p_k} + \mathcal{O}\left(\|\delta\|^3\right) = \frac{1}{8}\|\delta\|_{\text{FR}}^2 + \mathcal{O}\left(\|\delta\|^3\right),$$

so that the dimensionless metric associated with d_{JS} is $\frac{1}{8}g^{\text{FR}}$. The dimensional analysis of Section 2.4 requires $[\mathcal{R}_\Gamma] = L^{-2}$ and hence $[g_\Gamma] = L^2$; the two levels are therefore related, *exactly and off shell*, by a single positive *informational length scale* ℓ_Γ,

$$g_\Gamma = \ell_\Gamma^2 \tilde{g}_\Gamma, \quad \mathcal{R}_\Gamma = \frac{1}{\ell_\Gamma^2}\tilde{\mathcal{R}}_\Gamma, \quad V_\Gamma(\Omega) = \ell_\Gamma^d \tilde{V}_\Gamma(\Omega),$$

where $\tilde{\mathcal{R}}_\Gamma$ and $\tilde{V}_\Gamma(\Omega)$ are the scalar curvature and the Riemannian volume of $\tilde{g}_\Gamma$ and are dimensionless. The Fisher-Rao form appears only in the high-redundancy regime,

$$\tilde{g}_\Gamma \xrightarrow[\mathcal{D}_{\text{red}}\to 0]{} \frac{1}{8}g^{\text{FR}}, \quad g_\Gamma \xrightarrow[\mathcal{D}_{\text{red}}\to 0]{} \frac{\ell_\Gamma^2}{8}g^{\text{FR}},$$

and is not imposed off shell, where $\tilde{g}_\Gamma$ is any metric obeying (M1)-(M5). Distances at the two levels are related exactly by $d_{g_\Gamma} = \ell_\Gamma \tilde{d}_\Gamma$, and only in the high-redundancy regime does this become

$$d_{g_\Gamma} = \ell_\Gamma \tilde{d}_\Gamma \xrightarrow[\mathcal{D}_{\text{red}}\to 0]{} \ell_\Gamma d_{\text{JS}};$$

off shell no relation to d_{JS} is asserted. Wherever a dimensionless norm is required, as in Remark II.2, it is $\tilde{g}_\Gamma$ that is understood. The identification of $\tilde{g}_\Gamma$ with the rescaled Fisher-Rao metric is a matching condition in the high-redundancy regime and not a kinematic constraint on Γ, which off shell is any metric obeying (M1)-(M5); see Remark II.3.

(M7) *Reduction scale and the characteristic volume: a matching ansatz.* The semiclassical matching of Section 2.4 is performed against the four-dimensional Einstein-Hilbert action and therefore involves a three-dimensional characteristic volume, $[V_{\text{char}}] = L^3$, whereas $[V_\Gamma(\Omega)] = L^d$. We adopt as a matching ansatz that the two are related by the same scale,

$$V_{\text{char}} := \frac{V_\Gamma(\Omega)}{\ell_\Gamma^{d-3}} = \ell_\Gamma^3 \tilde{V}_\Gamma(\Omega), \quad \kappa_{\text{red}} := \frac{\kappa_{\text{IFR}}}{\ell_\Gamma^{d-3}},$$

so that κ_{red} is the reduced coupling matched to κ_{eff} and

$$\beta = \frac{V_\Gamma(\Omega)}{2\kappa_{\text{IFR}}} = \frac{V_{\text{char}}}{2\kappa_{\text{red}}},$$

every term of the action then carrying the dimension of energy. We state the epistemic status of this ansatz precisely. The relation $\kappa_{\text{IFR}} = \ell_\Gamma^{d-3}\kappa_{\text{red}}$ does not by itself determine ℓ_Γ: it links two quantities neither of which is derived here. Once either ℓ_Γ or κ_{IFR} is fixed independently, the matching fixes the other. What is *not* supplied in this paper is the interpretation of ℓ_Γ as the scale at which multi-observer redundancy performs the reduction from d to three effective dimensions; that identification belongs to the dimensional-reduction argument of Parts V and VI and is recorded as a limitation in Section 3.17.

Remark II.1 (Compatibility with Part I)**.** Part I of the series defines the comparison geometry as $\Gamma = (\mathcal{M}, g, \nabla)$ with g positive definite, denotes by d_Γ the geodesic distance of g, and writes the redundant dispersion functional as $\mathcal{D}_{\mathrm{red}} = \sum_{a<b} w_{ab} d_\Gamma^2 (\Pi_a[\Psi], \Pi_b[\Psi])$. No dimensional assignment is made there, the treatment of Part I being kinematic. The present paper preserves that content without alteration, under the identification

$$g \text{ of Part I} \equiv \tilde{g}_\Gamma, \quad d_\Gamma \text{ of Part I} \equiv \tilde{d}_\Gamma,$$

so that every formula of Part I, and in particular the dispersion functional and the definition of the stable-center set $\mathcal{Q}$, is unchanged. What is new here is only the dimensional metric $g_\Gamma = \ell_\Gamma^2 \tilde{g}_\Gamma$, introduced because the curvature sector requires $[\mathcal{R}_\Gamma] = L^{-2}$ while a statistical metric is dimensionless; the tilde is therefore a notational refinement made necessary by the gravitational sector of the present paper and not a correction of Part I.

The identification propagates to the curvature, and this must be stated explicitly. Since the scalar curvature of a metric rescaled by a constant c is divided by c, the curvature built from the metric of Part I is the dimensionless one,

$$\mathcal{R}_\Gamma^{(\mathrm{I})} \equiv \tilde{\mathcal{R}}_\Gamma = \ell_\Gamma^2 \mathcal{R}_\Gamma,$$

where $\mathcal{R}_\Gamma$ is the dimensional scalar used here. Preserving the curvature term of the action therefore requires $\beta_{\mathrm{I}} \tilde{\mathcal{R}}_\Gamma = \beta \mathcal{R}_\Gamma$, that is

$$\beta_{\mathrm{I}} = \frac{\beta}{\ell_\Gamma^2}.$$

This is not a correction of Part I, which assigns no dimensions: it is the dimensional refinement introduced here, and without it the identification would preserve g and d_Γ but not the curvature derived from them. The positivity $\alpha, \beta > 0$ asserted in Part I is unchanged, and the curvature entry of the reduced action is here the mean curvature $\bar{\mathcal{R}}_\Gamma$ of Lemma II.1.

The reconstruction map requires the same care. Part I writes $\chi_{\mathrm{I}} : \mathcal{Q} \to \mathcal{M}_{\mathrm{eff}}$, whereas the map of Theorem II.1 (H1) is defined on the event manifold. The former is not replaced but recovered as the equal-time restriction of the latter: with $j_t : \mathcal{Q}_3(t) \hookrightarrow \mathcal{E}$ the inclusion of the slice,

$$\chi_{\mathrm{I}}\big|_{\mathcal{Q}_3(t)} = \chi \circ j_t.$$

Part I commits to no dimension for its domain, and the present paper supplies one once the reduction is counted.

With Assumption II.1 in place, the IFR action is defined as the double integral

$$\mathcal{S}_{\mathrm{IFR}} = \int_I \mathrm{d}\lambda \int_\Omega \mathrm{d}\mu_\Gamma \left[\mathfrak{k}_{\mathrm{int}} - \mathfrak{v}_{\mathrm{int}} - \alpha \mathfrak{d}_{\mathrm{red}} + \hat{\beta} \mathcal{R}_\Gamma + \mathfrak{l}_\Pi \right], \quad \mathrm{d}\mu_\Gamma = \sqrt{|g_\Gamma|}\, \mathrm{d}^d q, \tag{1}$$

where the fraktur symbols denote the corresponding densities on Ω and

$$\hat{\beta} = \frac{1}{2\kappa_{\mathrm{IFR}}} > 0.$$

Equation (1) is the definition employed in the metric variation of Section 3; the reduced form used in the next subsection is a consequence of it and not an independent postulate.

Lemma II.1 (Zero-mode reduction)**.** Define the mean informational curvature on the comparison domain,

$$\bar{\mathcal{R}}_{\Gamma}(\lambda) := \frac{1}{V_{\Gamma}(\Omega)} \int_{\Omega} \mathcal{R}_{\Gamma}(q,\lambda)\,\mathrm{d}\mu_{\Gamma}, \; V_{\Gamma}(\Omega) := \int_{\Omega} \mathrm{d}\mu_{\Gamma}.$$

Suppose the source densities are uniform on Ω at the order considered, that is, $\mathfrak{k}_{\mathrm{int}}$, $\mathfrak{v}_{\mathrm{int}}$, $\mathfrak{d}_{\mathrm{red}}$ and $\mathfrak{l}_{\Pi}$ do not depend on $q \in \Omega$. Then (1) reduces to

$$\mathcal{S}_{\mathrm{IFR}} = \int_{I} \mathrm{d}\lambda \left[\mathcal{K}_{\mathrm{int}} - \mathcal{V}_{\mathrm{int}} - \alpha \mathcal{D}_{\mathrm{red}} + \beta \bar{\mathcal{R}}_{\Gamma} + \mathcal{L}_{\Pi} \right],$$

with $\mathcal{K}_{\mathrm{int}} = V_{\Gamma}(\Omega)\mathfrak{k}_{\mathrm{int}}$ and correspondingly for the remaining source terms, and with

$$\beta(\lambda) = \hat{\beta} V_{\Gamma}(\Omega) = \frac{V_{\Gamma}(\Omega)}{2\kappa_{\mathrm{IFR}}} = \frac{V_{\mathrm{char}}}{2\kappa_{\mathrm{red}}}.$$

Proof. The q-integration of a q-independent density multiplies it by $V_{\Gamma}(\Omega)$. For the curvature term no uniformity hypothesis is required: by the definition of $\bar{\mathcal{R}}_{\Gamma}$ one has the identity $\hat{\beta}\int_{\Omega} \mathrm{d}\mu_{\Gamma}\, \mathcal{R}_{\Gamma} = \hat{\beta} V_{\Gamma}(\Omega) \bar{\mathcal{R}}_{\Gamma} = \beta \bar{\mathcal{R}}_{\Gamma}$. The last equality of the statement is (M7). ☐

Three consequences should be noted. First, since Γ is itself varied, $V_{\Gamma}(\Omega)$ is in general λ-dependent and so is $\beta = \hat{\beta} V_{\Gamma}(\Omega)$. The action to be varied is therefore always the double integral (1), in which the constant is $\hat{\beta} = 1/(2\kappa_{\mathrm{IFR}})$; the reduced form of Lemma II.1 is a subsequent contraction, used for bookkeeping and for the semiclassical matching, and is never used to compute $\delta\mathcal{S}/\delta g^{\Gamma}$. Second, the reduced form carries the *mean* curvature $\bar{\mathcal{R}}_{\Gamma}$ and not a pointwise value: the curvature sector is never assumed uniform, and the full q-dependence is retained in the metric variation of Section 3. Third, the characteristic volume of Section 2.4 is identified through (M7) with the reduced volume $V_{\Gamma}(\Omega)/\ell_{\Gamma}^{d-3}$, so that it is a property of the comparison domain and of the informational length scale rather than a free normalisation constant. The zero-mode hypothesis on the source terms is the minimality assumption of the present paper; its relaxation, which promotes those terms to genuine fields on Ω, belongs to the renormalisation-group treatment of Part VI.

2.3. Minimal Form of the IFR Action

The minimal IFR action is defined as

$$\mathcal{S}_{\mathrm{IFR}} = \int_{I} \mathrm{d}\lambda\, \mathcal{L}_{\mathrm{IFR}}\left(\Psi, \dot{\Psi}, \Gamma, \dot{\Gamma}, \Pi, \dot{\Pi}\right),$$

where the dot denotes differentiation with respect to the ordering parameter λ.

The minimal Lagrangian is postulated to have the form

$$\mathcal{L}_{\mathrm{IFR}} = \mathcal{K}_{\mathrm{int}}\left[\Psi,\dot{\Psi};\Gamma\right] - \mathcal{V}_{\mathrm{int}}\left[\Psi;\Gamma\right] - \alpha\mathcal{D}_{\mathrm{red}}\left[\Psi,\Gamma,\Pi\right] + \beta\overline{\mathcal{R}}_{\Gamma} + \mathcal{L}_{\Pi},$$

where the positive sign of the curvature coupling is fixed by the semiclassical matching of Section 2.4 and is used throughout. The curvature entry is the mean curvature $\overline{\mathcal{R}}_{\Gamma}$ of Lemma II.1 and the coupling is $\beta = V_{\Gamma}(\Omega)/(2\kappa_{\mathrm{IFR}})$; this reduced form is used for bookkeeping and for the semiclassical matching only, the action varied in Section 3 being always the double integral (1). Thus,

$$\boxed{\begin{aligned}&\mathcal{S}_{\mathrm{IFR}} = \int_I \mathrm{d}\lambda\left[\mathcal{K}_{\mathrm{int}}\left[\Psi,\dot{\Psi};\Gamma\right] - \mathcal{V}_{\mathrm{int}}\left[\Psi;\Gamma\right] - \alpha\mathcal{D}_{\mathrm{red}}\left[\Psi,\Gamma,\Pi\right] + \beta\overline{\mathcal{R}}_{\Gamma} + \mathcal{L}_{\Pi}\right],\\ &\beta = \frac{V_{\Gamma}(\Omega)}{2\kappa_{\mathrm{IFR}}} = \frac{V_{\mathrm{char}}}{2\kappa_{\mathrm{red}}} > 0.\end{aligned}}$$

(See Section 2.4 for the sign of β and the dimensional normalisation of $\mathcal{K}_{\mathrm{int}}$.)

The terms have the following roles.

$$\mathcal{K}_{\mathrm{int}}\left[\Psi,\dot{\Psi};\Gamma\right]$$

is the kinetic or propagating component of the interference state. It controls how interference configurations change along admissible histories.

$$\mathcal{V}_{\mathrm{int}}\left[\Psi;\Gamma\right]$$

is an informational potential. It encodes selection, instability, symmetry breaking, or self-organization of the interference structure.

$$\mathcal{D}_{\mathrm{red}}\left[\Psi,\Gamma,\Pi\right]$$

is the redundant multi-observer dispersion. It penalizes configurations for which observer projections fail to contract toward a common representation.

$$\mathcal{R}_{\Gamma}$$

is the scalar curvature of the information geometry. It supplies the geometric sector of the theory and is the precursor of effective gravitational curvature.

$$\mathcal{L}_{\Pi}$$

is an optional observer-kinematic or regularization term. It constrains the admissible variation of observer maps and prevents pathological observer families from dominating the variational problem.

The constants $\alpha > 0, \beta > 0$ set the relative strength of objectivizing contraction and informational curvature.

In many formal developments, one may set $\mathcal{L}_{\Pi} = 0$ and treat the observer family Π as an externally fixed admissible class. However, for a fully dynamical theory, Π may also be varied subject to operational constraints.

2.4. Sign Convention and Dimensional Consistency of the Action

Earlier formulations of the framework wrote the curvature term of the action with a negative sign, $-\beta\mathcal{R}_{\Gamma}$. A dimensional and sign analysis fixes both the orientation of this term and the scale of the kinetic term; we record the result here, as it is required for the semiclassical matching carried out in Part III of the series, and it is the convention adopted throughout the present series.

Sign of the curvature coupling. In the semiclassical regime treated in Part III of the series, the curvature term must reproduce the Einstein-Hilbert action

$$S_{\text{grav}} = \frac{1}{2\kappa_{\text{eff}}}\int \mathrm{d}^4x\sqrt{-g_{\text{eff}}}\,R(g_{\text{eff}}), \quad \kappa_{\text{eff}} = \frac{8\pi G}{c^4}.$$

Matching $-\beta\mathcal{R}_\Gamma$ onto $+\frac{1}{2\kappa_{\text{eff}}}R$ would force $\beta<0$, *i.e.* a repulsive (wrong-sign) gravitational sector. The correspondence limit in which this matching is performed is the one established in Theorem II.1 through the Wick correspondence, namely $\mathcal{R}_{\mathcal{E}}^{(L)} \to R(g_{\text{eff}})$ for the post-Wick scalar of the event manifold, and not a direct identification of the comparison scalar $\mathcal{R}_\Gamma$ with $R(g_{\text{eff}})$. The correct matching is obtained by adopting the curvature term with a *positive* sign,

$$\boxed{\begin{aligned}&\mathcal{S}_{\text{IFR}} = \int_I \mathrm{d}\lambda\left[\mathcal{K}_{\text{int}} - \mathcal{V}_{\text{int}} - \alpha\mathcal{D}_{\text{red}} + \beta\bar{\mathcal{R}}_\Gamma + \mathcal{L}_{\text{TI}}\right],\\ &\beta>0, \quad \frac{\beta}{V_{\text{char}}} = \frac{1}{2\kappa_{\text{eff}}} = \frac{c^4}{16\pi G} > 0.\end{aligned}}$$

The qualification is needed because the *reduced* action of Lemma II.1 integrates over the ordering parameter alone, the integration over the comparison domain having already been carried out: the unnormalised coupling is $\beta = V_\Gamma(\Omega)/(2\kappa_{\text{IFR}}) = V_{\text{char}}/(2\kappa_{\text{red}})$, with $V_{\text{char}} = V_\Gamma(\Omega)/\ell_\Gamma^{d-3}$ and $\kappa_{\text{red}} = \kappa_{\text{IFR}}/\ell_\Gamma^{d-3}$ as fixed in Assumption II.1 (M7). The writing above records the ratio β/V_{char} fixed by the semiclassical matching, as detailed in the dimensional analysis that follows. With this convention the emergent gravitational sector is attractive and Newton's constant is recovered with the correct sign. All subsequent variational identities are understood with this orientation; the earlier $-\beta\mathcal{R}_\Gamma$ writing corresponds to the opposite curvature-sign convention and is not used in the semiclassical matching.

Dimensional consistency of the kinetic term. Writing $[\cdot]$ for physical dimension with $[\mathcal{S}] = ML^2T^{-1}$ (action) and $[\lambda]=T$, every term of $\mathcal{L}_{\text{IFR}}$ must carry dimension ML^2T^{-2} (energy). The dispersion term $\alpha\mathcal{D}_{\text{red}}$ with $\alpha = \hbar/\tau_{\text{dec}}$ and dimensionless $\mathcal{D}_{\text{red}}$ gives ML^2T^{-2}; the curvature term with $\beta = \hbar c V_{\text{char}}/(16\pi\ell_P^2)$ and $[\mathcal{R}_\Gamma] = L^{-2}$ likewise gives ML^2T^{-2}. Two remarks are needed on the status of this normalisation. First, the reduced IFR action integrates over the ordering parameter alone, whereas the Einstein-Hilbert action integrates over the four-volume; β therefore carries the characteristic volume V_{char} of the region of the comparison manifold on which $\mathcal{R}_\Gamma$ is evaluated, which by Assumption II.1 (M7) is the reduced volume $V_\Gamma(\Omega)/\ell_\Gamma^{d-3}$ of the comparison domain, of dimension L^3 as the matching requires. Second, the coupling that appears in the informational field equation of Section 3 is κ_{IFR}, defined on the comparison manifold, and not the emergent spacetime coupling κ_{eff}. The defining relation is therefore

$$\beta = \frac{V_\Gamma(\Omega)}{2\kappa_{\text{IFR}}} = \frac{V_{\text{char}}}{2\kappa_{\text{red}}}, \quad \kappa_{\text{red}} \to \kappa_{\text{eff}} \text{ in the correspondence limit,}$$

the limit being the one established in Theorem II.1 through the Wick correspondence, that is $\mathcal{R}_{\mathcal{E}}^{(L)} \to R(g_{\text{eff}})$ for the post-Wick scalar of the event manifold, and not a direct identification of the comparison scalar $\mathcal{R}_{\Gamma}$ with $R(g_{\text{eff}})$, where $\kappa_{\text{red}} = \kappa_{\text{IFR}} / \ell_{\Gamma}^{d-3}$ is the reduced coupling of Assumption II.1 (M7). It is the reduced coupling, and not κ_{IFR} itself, that is matched to κ_{eff}: for $d \neq 3$ the two differ by the reduction factor. So that in the semiclassical regime

$$\beta \to \frac{V_{\text{char}}}{2\kappa_{\text{eff}}} = \frac{\hbar c V_{\text{char}}}{16\pi \ell_P^2}, \quad \ell_P^2 = \frac{\hbar G}{c^3}.$$

The semiclassical matching fixes the ratio $\beta / V_{\text{char}} = 1/(2\kappa_{\text{eff}})$ in that limit; the dimensional argument fixes the overall scale. The identification $\kappa_{\text{red}} \to \kappa_{\text{eff}}$ is imposed by matching and is not derived here (Section 3.17). Throughout the series we write the matching in the form $\beta / V_{\text{char}} = 1/(2\kappa_{\text{eff}})$ and never as $\beta = 1/(2\kappa_{\text{eff}})$: the two are not the same quantity, since $[\beta] = E\,L^2$ whereas $[\kappa_{\text{eff}}^{-1}] = E\,L^{-1}$. What the sign convention fixes is $\beta > 0$; what the semiclassical matching fixes is the ratio. The Fubini-Study kinetic term as written, $\mathcal{K}_{\text{int}} = \frac{\hbar_{\text{IFR}}^2}{2m_\Psi} g^{\text{FS}}(\dot{\Psi}, \dot{\Psi})$, carries dimension ML^4T^{-4}: for a dimensionless normalised state $[g^{\text{FS}}(\dot{\Psi}, \dot{\Psi})] = T^{-2}$, while $[\hbar_{\text{IFR}}^2 / m_\Psi] = ML^4T^{-2}$. Restoring the energy dimension therefore requires division by a squared *velocity*, not by a squared length: division by a length scale L_0^2 alone would leave ML^2T^{-4}. We accordingly adopt the dimensionally corrected form

$$\boxed{\mathcal{K}_{\text{int}} = \frac{\hbar_{\text{IFR}}^2}{2m_\Psi c_{\text{IFR}}^2} g_{[\Psi]}^{\text{FS}}(\dot{\Psi}, \dot{\Psi}) = \frac{1}{2} m_\Psi L_0^2 g_{[\Psi]}^{\text{FS}}(\dot{\Psi}, \dot{\Psi}), \ L_0 := \frac{\hbar_{\text{IFR}}}{m_\Psi c_{\text{IFR}}},}$$

where c_{IFR} is the informational light speed of the Lorentzian sector (Part V of the series) and L_0 is the IFR coherence length, that is the Compton length associated with the interferential inertia m_Ψ. The two writings are identical, and the identification $L_0 \to \ell_P$ in the fundamental regime is no longer an independent stipulation: together with $c_{\text{IFR}} \to c$ and $\hbar_{\text{IFR}} \to \hbar$ it fixes $m_\Psi \to m_P = \sqrt{\hbar c / G}$. Combined with the variance identity (3) below, the kinetic term admits the transparent reading

$$\mathcal{K}_{\text{int}} = \frac{\mathrm{Var}_\Psi(\hat{H})}{2m_\Psi c_{\text{IFR}}^2},$$

that is, the energy variance of the interference state measured in units of its interferential rest energy. The potential term $\mathcal{V}_{\text{int}}$ carries the dimension of energy directly, so that $[\mathcal{K}_{\text{int}}] = [\mathcal{V}_{\text{int}}] = ML^2T^{-2}$. With these assignments the action is dimensionally homogeneous, every term carrying the dimension of energy.

Remark II.2 (Status of the ordering parameter in the dimensional analysis). Assigning $[\lambda] = T$ is a choice of unit, not an identification of λ with physical time, and the two are distinguished by structure rather than by dimension. Writing $\lambda = \tau_\star \varsigma$ with ς dimensionless and $\tau_\star > 0$ a fixed interferential scale, the assignment $[\lambda] = T$ records only that λ is measured in units of $\tau_\star$; solely the ratios $\lambda/\tau_\star$ enter the field equations. Sharing a physical dimension is not sharing an identity: proper time and coordinate time both carry the dimension T and are nonetheless distinct structures, as are arc length along a curve and a spatial coordinate.

What the framework denies is therefore not the dimension but the identification, and the denial is constructive rather than stipulative. Physical time is defined in Part III of the series as the Jensen-Shannon arc length along ordered sequences of stable Fréchet centers. Since $\tilde{d}_\Gamma = d_{\mathrm{JS}}$ is dimensionless at the divergence level of Assumption II.1 (M6), the arc length is converted into a duration by the interferential scale itself,

$$\mathrm{d}t = \tau_\star \left\| \partial_\lambda Q^\star(\lambda) \right\|_{\tilde{g}_\Gamma} \mathrm{d}\lambda, \quad Q^\star(\lambda) \in \mathcal{Q},$$

so that $\lambda \mapsto t$ is a *degenerate*, in general non-invertible reparametrisation. Three structural properties separate the two. First, t is defined only where the variational problem selects a center: for a single observer, $N = 1$, the redundant dispersion vanishes identically, $\mathcal{D}_{\mathrm{red}} \equiv 0$, the minimisation defining $Q^\star$ is completely degenerate—every configuration is a minimiser—and no curve $\lambda \mapsto Q^\star(\lambda)$ is selected, so that the arc length above is not defined and no temporal sector exists while the ordering parameter continues to run. Second, t is oriented by the monotone growth of redundancy along the history, whereas λ carries no arrow. Third, t is observer-relative, being constructed from the projections Π_a, whereas λ is not. A parameter whose associated duration can fail to be defined at all is not the duration it is alleged to be; no contradiction therefore arises from the two statements that λ is not time and that λ is measured in units of time.

An equally consistent bookkeeping takes λ dimensionless and assigns the dimension of action to $\mathcal{L}_{\mathrm{IFR}}$; the two conventions differ by the constant factor $\tau_\star$ and lead to the same field equations. We retain $[\lambda] = T$ because it allows the semiclassical matching of Part III to be carried out term by term.

2.5. Canonical Choice of $\mathcal{K}_{\mathrm{int}}$ via the Fubini-Study Metric

The minimal action introduced above contains a kinetic term $\mathcal{K}_{\mathrm{int}}[\Psi, \dot{\Psi}; \Gamma]$ that has not yet been specified. Any concrete realisation of $\mathcal{K}_{\mathrm{int}}$ must respect the foundational constraints of IFR: in particular Postulate I together with Section 3.1 of Part I, which prohibit the use of any differentiable, metric, or locally Euclidean structure on the pre-spatiotemporal configuration space $\mathcal{X}$. A choice such as $\mathcal{K}_{\mathrm{int}} \propto \|\nabla_{\mathcal{X}} \Psi\|^2$ would presuppose a differential structure on $\mathcal{X}$ and is therefore inadmissible at this level. The kinetic term must be built exclusively from objects available on $\mathcal{H}_{\mathcal{X}}$, namely the inner product $\langle \cdot, \cdot \rangle_{\mathcal{X}}$ and the resulting projective structure on $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$.

This requirement selects a unique canonical choice. On the projective Hilbert space $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$, the Fubini-Study metric g^{FS} is the unique (up to a positive multiplicative constant) Riemannian metric invariant under the full unitary group $U(\mathcal{H}_\mathcal{X})$ of the underlying Hilbert space [2] [3]. This uniqueness mirrors Chentsov's theorem on Δ_n [14], established in Part VI of the series (the renormalisation-group flow): just as g^{FR} is the unique monotone metric on the comparison space, g^{FS} is the unique unitarily invariant metric on the primitive interference state space. The two are sibling structures, distinguished by the level at which they act ($\mathbb{P}(\mathcal{H}_\mathcal{X})$ vs. $\mathcal{M}$) and unified by their common information-geometric origin.

Remark II.3 (Chentsov uniqueness and the variability of Γ)**.** An apparent tension must be recorded, since the IFR action varies Γ while Chentsov's theorem asserts that the Fisher-Rao metric is, up to a constant factor, the unique monotone metric on the comparison space. Were Γ constrained to be Fisher-Rao kinematically, the variation $\delta\mathcal{S}/\delta\Gamma = 0$ would be over-determined and, on $\mathring{\Delta}_d$, the curvature $\mathcal{R}_\Gamma$ would be constant, so that the gravitational sector would carry no dynamics. The resolution is that monotonicity under Markov morphisms, the hypothesis of Chentsov's theorem, is a sufficiency requirement, and sufficiency is meaningful in IFR only where multi-observer contraction has already taken place. Accordingly the admissible class $\mathfrak{G}$ consists of Riemannian metrics on Ω satisfying monotonicity only asymptotically, in the limit $\mathcal{D}_{\mathrm{red}} \to 0$; off shell Γ is unconstrained beyond (M1)-(M5), and the Fisher-Rao form recorded in (M6) is the on-shell matching condition recovered as a fixed point of the Γ-dynamics rather than a kinematic constraint imposed on the metric that is to be varied. A testable corollary follows: in the high-redundancy regime the comparison geometry must flow towards the constant-curvature Fisher-Rao geometry, whose sectional curvature on the simplex is constant and positive, so that what the framework predicts is constancy of the informational curvature and not its vanishing. The corresponding flow is analysed in Part VI.

Definition II.1 (Canonical IFR kinetic term)**.** The canonical kinetic term for the interference state is

$$\mathcal{K}_{\mathrm{int}}\left[\Psi,\dot{\Psi}\right] = \frac{\hbar_{\mathrm{IFR}}^2}{2m_\Psi c_{\mathrm{IFR}}^2} g_{[\Psi]}^{\mathrm{FS}}\left(\dot{\Psi},\dot{\Psi}\right) = \frac{\hbar_{\mathrm{IFR}}^2}{2m_\Psi c_{\mathrm{IFR}}^2}\left[\left\langle\dot{\Psi},\dot{\Psi}\right\rangle_\mathcal{X} - \left|\left\langle\Psi,\dot{\Psi}\right\rangle_\mathcal{X}\right|^2\right], \tag{2}$$

where $m_\Psi > 0$ is the IFR *interferential inertia*, $\hbar_{\mathrm{IFR}} > 0$ is the fundamental IFR action quantum, and the prefactor $\hbar_{\mathrm{IFR}}^2/\left(2m_\Psi c_{\mathrm{IFR}}^2\right) = \frac{1}{2} m_\Psi L_0^2$ is fixed by the dimensional analysis of Section 2.4.

Proposition II.1 (Properties of $\mathcal{K}_{\mathrm{int}}^{\mathrm{FS}}$)**.** The kinetic term (2) satisfies:

1) *Gauge invariance*: $\mathcal{K}_{\mathrm{int}}^{\mathrm{FS}}$ is invariant under global and local phase transformations $\Psi(\lambda) \to \mathrm{e}^{i\theta(\lambda)}\Psi(\lambda)$, consistent with the projective nature of the state space (Postulate I and Section 3.2 of Part I of the series).

2) *No structure on* $\mathcal{X}$: the expression uses only the inner product $\langle\cdot,\cdot\rangle_\mathcal{X}$ on $\mathcal{H}_\mathcal{X}$; no manifold, metric, or differential structure on $\mathcal{X}$ is invoked.

3) *Uniqueness*: any positive-definite $U(\mathcal{H}_\mathcal{X})$-invariant quadratic form on tangent vectors to $\mathbb{P}(\mathcal{H}_\mathcal{X})$ is a positive multiple of $g_{[\Psi]}^{\mathrm{FS}}$.

4) *Variance interpretation*: if there exists an emergent self-adjoint operator $\hat{H}$

on $\mathcal{H}_{\mathcal{X}}$ such that $\dot{\Psi} = -(i/\hbar_{\text{IFR}})\hat{H}\Psi$, then

$$g_{[\Psi]}^{\text{FS}}(\dot{\Psi}, \dot{\Psi}) = \frac{1}{\hbar_{\text{IFR}}^2} \text{Var}_{\Psi}(\hat{H}). \tag{3}$$

5) *Speed limit*: the Anandan-Aharonov inequality

$$\frac{\mathrm{d}}{\mathrm{d}\lambda} d_{\text{FS}}([\Psi(\lambda)], [\Psi(0)]) \leq \frac{\Delta E_{\Psi}}{\hbar_{\text{IFR}}} \tag{4}$$

holds along admissible histories, providing an intrinsic IFR quantum speed limit (Mandelstam-Tamm bound in pre-spatiotemporal form).

Proof. (1) Direct computation: $\langle \dot{\Psi} + i\dot{\theta}\Psi, \dot{\Psi} + i\dot{\theta}\Psi \rangle - |\langle \Psi, \dot{\Psi} + i\dot{\theta}\Psi \rangle|^2 = |\langle \dot{\Psi}, \dot{\Psi} \rangle - \langle \Psi, \dot{\Psi} \rangle|^2$, since cross terms cancel due to $\|\Psi\| = 1$. (2) Immediate from the definition. (3) $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$ is a homogeneous space $U(\mathcal{H}_{\mathcal{X}}) / (U(1) \times U(\Psi^{\perp}))$ whose isotropy representation on $T_{[\Psi]}\mathbb{P}(\mathcal{H}_{\mathcal{X}}) \cong \text{Hom}_{\mathbb{C}}(\mathbb{C}\Psi, \Psi^{\perp}) \cong \Psi^{\perp}$ is complex-irreducible with commutant $\mathbb{C}$. By Schur's lemma the space of invariant real symmetric bilinear forms on the tangent space is one-dimensional; hence every positive-definite invariant form is a positive multiple of $g_{[\Psi]}^{\text{FS}}$, which is the Fubini-Study metric underlying the statistical-distance and geometric-phase results of [2] [3]. *(4)* Substituting $\dot{\Psi} = -(i/\hbar_{\text{IFR}})\hat{H}\Psi$,

$$\langle \dot{\Psi}, \dot{\Psi} \rangle = \frac{\langle \Psi | \hat{H}^2 | \Psi \rangle}{\hbar_{\text{IFR}}^2}, \quad |\langle \Psi, \dot{\Psi} \rangle|^2 = \frac{\langle \Psi | \hat{H} | \Psi \rangle^2}{\hbar_{\text{IFR}}^2},$$

whose difference is the variance. *(5)* The function $\lambda \mapsto d_{\text{FS}}([\Psi(\lambda)], [\Psi(0)]) = \arccos|\langle \Psi(\lambda), \Psi(0) \rangle|$ is 1-Lipschitz with respect to Fubini-Study arc length, so its derivative is bounded above by the Fubini-Study speed $\sqrt{g_{[\Psi]}^{\text{FS}}(\dot{\Psi}, \dot{\Psi})}$, which by (4) equals $\Delta E_{\Psi} / \hbar_{\text{IFR}}$ with $\Delta E_{\Psi} = \text{Var}_{\Psi}(\hat{H})^{1/2}$. □

Remark II.4 (Relation to the quadratic velocity functional of Part I)**.** Part I of the series introduced, for the purpose of the regularity conditions (R1)-(R4) that render $\mathcal{S}_{\text{IFR}}$ finite on admissible histories, the quadratic velocity functional $\mathcal{K}_{\text{int}}[\Psi, \partial_{\lambda}\Psi] = \frac{1}{2}\|\partial_{\lambda}\Psi\|_{\mathcal{H}_{\mathcal{X}}}^2$ [1]. That expression and (2) are not competing choices: they coincide exactly in the horizontal gauge. Differentiating the normalisation constraint $\|\Psi\|^2 = 1$ gives $\text{Re}\langle \Psi, \dot{\Psi} \rangle_{\mathcal{X}} = 0$, so that $\langle \Psi, \dot{\Psi} \rangle_{\mathcal{X}} = i\omega(\lambda)$ with ω real — the Berry connection along the history. Hence

$$g_{[\Psi]}^{\text{FS}}(\dot{\Psi}, \dot{\Psi}) = \|\dot{\Psi}\|_{\mathcal{H}_{\mathcal{X}}}^2 - \omega^2 \leq \|\dot{\Psi}\|_{\mathcal{H}_{\mathcal{X}}}^2,$$

and in the horizontal gauge $\omega \equiv 0$ —always attainable by the phase redefinition $\Psi \to \mathrm{e}^{i\theta}\Psi$ with $\dot{\theta} = -\omega$ —the Fubini-Study form reduces to $\|\dot{\Psi}\|^2$. The functional of Part I is therefore the canonical kinetic term written in a particular gauge and in units $\hbar_{\text{IFR}}^2 / (2m_{\Psi}c_{\text{IFR}}^2) = \frac{1}{2}$. Since the inequality above is uniform, the regularity estimates of Part I remain valid verbatim for (2). What the canonical form adds is manifest gauge invariance in *every* gauge, which is what the projective structure of the state space requires and what the variational problem needs in order to be well posed independently of the phase convention.

2.5.1. Resulting Interference Equation

With $\mathcal{K}_{\text{int}}$ specified by (2), the constrained variation of the interference state (Section 2.9) produces an explicit second-order equation in λ for the interference state. Writing $\mathcal{F}(\Psi,\dot{\Psi}) := \langle\Psi,\dot{\Psi}\rangle - |\langle\Psi,\dot{\Psi}\rangle|^2$ and varying with respect to Ψ^* in Wirtinger calculus subject to $\|\Psi\|^2 = 1$:

$$\frac{\hbar_{\text{IFR}}^2}{m_\Psi c_{\text{IFR}}^2}\left[\ddot{\Psi} - \langle\Psi,\ddot{\Psi}\rangle\Psi - 2\langle\Psi,\dot{\Psi}\rangle\dot{\Psi} + |\langle\Psi,\dot{\Psi}\rangle|^2\Psi\right] - \frac{\delta\mathcal{V}_{\text{int}}}{\delta\Psi^*} - \alpha\frac{\delta\mathcal{D}_{\text{red}}}{\delta\Psi^*} = \Lambda\Psi. \quad (5)$$

Equation (5) is the *IFR interference equation in canonical form*. It is second-order in λ (not first-order, as in the Schrödinger equation), consistent with the fact that λ is an ordering parameter rather than physical time: a Schrödinger-type equation would already presuppose temporal evolution, which in IFR is emergent. The structure of (5) is instead Klein-Gordon-like on $\mathbb{P}(\mathcal{H}_\chi)$, with the redundant-dispersion term acting as an objectivizing source.

2.5.2. Conditional Schrödinger Correspondence

Equation (5) is second order in λ, whereas Schrödinger evolution is first order. We state the conditions under which the two are related, and we are explicit about which of them are established here and which are not.

A preliminary observation excludes the reduction that first suggests itself. Since the physical configuration is the ray $[\Psi] \in \mathbb{P}(\mathcal{H}_\chi)$ and the kinetic term is the Fubini-Study form, a λ-dependent global phase $\Psi \mapsto e^{-i\theta(\lambda)}\Psi$ is pure gauge: it leaves $[\Psi]$, $\mathcal{K}_{\text{int}}$ and the whole action invariant. A fast global phase can therefore not be used as a physical carrier from which a term linear in ∂_λ is extracted; any such term produced by substitution is cancelled by the corresponding transformation of the projected terms $\langle\Psi,\ddot{\Psi}\rangle\Psi$, $\langle\Psi,\dot{\Psi}\rangle\dot{\Psi}$ and $|\langle\Psi,\dot{\Psi}\rangle|^2\Psi$ appearing in (5). The reduction must come from geometry, not from a phase.

The relevant geometry is available. The projective space $\mathbb{P}(\mathcal{H}_\chi)$ is Kähler, carrying the compatible triple $(g^{\text{FS}},\omega^{\text{FS}},J)$, and on such a manifold the Hamiltonian flow of the expectation function $h(\Psi) = \langle\Psi,\hat{H}\Psi\rangle$ *is* the Schrödinger equation generated by $\hat{H}$, provided the symplectic form is normalised to carry the interferential quantum of action. Since g^{FS} and hence ω^{FS} are dimensionless, whereas h has the dimension of energy, we fix once and for all the *physical symplectic form*

$$\omega_{\text{IFR}} := 2\hbar_{\text{IFR}}\,\omega^{\text{FS}}, \quad (6)$$

where ω^{FS} is the Kähler form of g^{FS} in the convention $\omega^{\text{FS}}(\cdot,\cdot) = g^{\text{FS}}(J\cdot,\cdot)$, and the Hamiltonian vector field is defined by $\iota_{X_h}\omega_{\text{IFR}} = dh$. The factor 2 is not a convention but is fixed by the normalisation of g^{FS} already adopted for the kinetic term. Indeed, for horizontal v,w one has $g^{\text{FS}}(v,w) = \Re\langle v,w\rangle$ and $\omega^{\text{FS}}(v,w) = \Im\langle v,w\rangle$, while $dh(w) = 2\Re\langle w,(\hat{H}_{\text{eff}} - \langle\hat{H}_{\text{eff}}\rangle)\Psi\rangle$ for $h = \langle\Psi,\hat{H}_{\text{eff}}\Psi\rangle$; the Schrödinger vector field $X_h = -\frac{i}{\hbar_{\text{IFR}}}(\hat{H}_{\text{eff}} - \langle\hat{H}_{\text{eff}}\rangle)\Psi$ then gives $\omega^{\text{FS}}(X_h,w) = \hbar_{\text{IFR}}^{-1}\Re\langle w,(\hat{H}_{\text{eff}} - \langle\hat{H}_{\text{eff}}\rangle)\Psi\rangle$, so that $\iota_{X_h}\omega_{\text{IFR}} = dh$ requires precisely $\omega_{\mathrm{IFR}} = 2\hbar_{\mathrm{IFR}}\omega^{\mathrm{FS}}$. Without this declaration the definition of X_h could not produce $\hbar_{\mathrm{IFR}}$, with the correct coefficient, on the left-hand side of the resulting evolution equation. A first-order quantum evolution is therefore recovered exactly when the second-order interference dynamics restricts, on the stable-state manifold $\tilde{\mathcal{Q}}$ introduced in (S2) below, to such a Hamiltonian flow.

Assumption II.2 (Conditional Schrödinger correspondence).

(S1) *High redundancy, in value and in gradient.* The history is restricted to a neighbourhood of the stable-center manifold $\mathcal{Q}$, on which $\mathcal{D}_{\mathrm{red}} = \mathcal{O}(\epsilon_{\mathrm{red}})$ with $\epsilon_{\mathrm{red}} \ll 1$, *and* on which the associated force term satisfies $\|\delta\mathcal{D}_{\mathrm{red}}/\delta\Psi\| = \mathcal{O}(\epsilon_{\mathrm{red}})$ in the norm of $\mathcal{H}_{\mathcal{Q}}$. The second condition does not follow from the first and is assumed separately: it is the smallness of the gradient, not of the value, that makes the objectivizing term a regular perturbation of the reduced vector field and justifies the residual $\mathcal{O}(\epsilon_{\mathrm{red}})$ in Proposition II.2.

(S2) *Stable-state manifold and Kähler inheritance.* The stable centers $\mathcal{Q}$ live on the comparison manifold, not on the state space, so a distinct object must be introduced: let

$$\tilde{\mathcal{Q}} := \{[\Psi] \in \mathbb{P}(\mathcal{H}_{\mathcal{X}}) : \text{the projections } \Pi_a[\Psi] \text{ admitastable Frechet center in } \mathcal{Q}\}$$

be the *stable-state manifold*, with $\iota : \tilde{\mathcal{Q}} \hookrightarrow \mathbb{P}(\mathcal{H}_{\mathcal{X}})$ the inclusion. We assume $\tilde{\mathcal{Q}}$ is a complex submanifold, so that it inherits the compatible triple $(g^{\mathrm{FS}}, \omega^{\mathrm{FS}}, J)$ by restriction and $\iota^*\omega^{\mathrm{FS}}$ is non-degenerate on it.

(S3) *Existence of a first-order invariant manifold.* The second-order dynamics defined by (5) admits, on $\tilde{\mathcal{Q}}$, an invariant slow manifold on which it reduces to the Hamiltonian flow of the expectation function $h([\Psi]) = \langle\Psi, \hat{H}_{\mathrm{eff}}\Psi\rangle / \langle\Psi,\Psi\rangle$ with respect to $\iota^*\omega_{\mathrm{IFR}}$ as normalised in (6). This is a hypothesis; no construction of such a manifold is supplied in the present paper.

(S4) *Effective generator.* $\hat{H}_{\mathrm{eff}}$, the generator whose expectation function is h, is densely defined and self-adjoint on the reduced Hilbert space $\mathcal{H}_{\mathcal{Q}}$ whose projectivisation contains $\tilde{\mathcal{Q}}$.

(S5) *Branch selection.* Of the two branches admitted by a second-order system the positive-energy branch is retained; this projection is supplied by the informational Wick mechanism of Part V, which also fixes the orientation of the resulting evolution.

(S6) *Adiabaticity of the reduction data.* The embedding $\iota_\lambda(\tilde{\mathcal{Q}})$ and the generator $\hat{H}_{\mathrm{eff}}(\lambda)$ vary slowly over the scale of the reduction. No adiabaticity of Γ is invoked here: g^{FS} is a fixed structure on $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$ and does not depend on the comparison geometry.

Proposition II.2 (Schrödinger sector). Under Assumption II.2 the reduced motion on $\tilde{\mathcal{Q}}$ is the Hamiltonian flow

$$\frac{\mathrm{d}[\Psi]}{\mathrm{d}\lambda} = X_h([\Psi]) + \mathcal{O}(\epsilon_{\mathrm{red}}), \quad \iota_{X_h}\omega_{\mathrm{IFR}} = dh. \tag{7}$$

In the horizontal lift, characterised by $\langle\Psi, \partial_\lambda\Psi\rangle = 0$, Equation (7) reads

$$i\hbar_{\mathrm{IFR}}\partial_\lambda\Psi=\left(\hat{H}_{\mathrm{eff}}-\left\langle\hat{H}_{\mathrm{eff}}\right\rangle_\Psi\right)\Psi+\mathcal{O}\left(\epsilon_{\mathrm{red}}\right), \tag{8}$$

and the familiar form $i\hbar_{\mathrm{IFR}}\partial_\lambda\Psi=\hat{H}_{\mathrm{eff}}\Psi$ is recovered by the phase lift that reinstates the dynamical phase $\exp\left(-\frac{i}{\hbar_{\mathrm{IFR}}}\int\left\langle\hat{H}_{\mathrm{eff}}\right\rangle_\Psi \mathrm{d}\lambda\right)$. The two lifts describe the same curve in $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$.

Proof. By (S2) the restriction of $\left(g^{\mathrm{FS}},\omega^{\mathrm{FS}},J\right)$ to $\tilde{\mathcal{Q}}$ is a Kähler structure with $\iota^*\omega^{\mathrm{FS}}$, and therefore $\iota^*\omega_{\mathrm{IFR}}$, non-degenerate, so the Hamiltonian vector field X_h of (6) is well defined. By (S3) the reduced motion is X_h, with h the expectation function of the self-adjoint operator supplied by (S4). On a Kähler manifold the ω_{IFR}-Hamiltonian flow, with $\omega_{\mathrm{IFR}}=2\hbar_{\mathrm{IFR}}\omega^{\mathrm{FS}}$ as in (6), of the expectation function of a self-adjoint operator is the flow generated by J applied to its g^{FS}-gradient; computing that flow in a homogeneous representative and imposing the horizontal-gauge condition $\left\langle\Psi,\partial_\lambda\Psi\right\rangle=0$, which is admissible because the global phase is gauge, gives (8), the subtraction of $\left\langle\hat{H}_{\mathrm{eff}}\right\rangle_\Psi$ being exactly the horizontality constraint. The branch is fixed by (S5) and the residual $\mathcal{O}\left(\epsilon_{\mathrm{red}}\right)$ is the contribution of the objectivizing term admitted by (S1). ☐

The flow (7) is a flow in the ordering parameter, not in physical time. Where a temporal sector exists, that is where $\mathrm{d}t/\mathrm{d}\lambda>0$ in the sense of Remark II.2, the chain rule $\mathrm{d}/\mathrm{d}t=\left(\mathrm{d}\lambda/\mathrm{d}t\right)\mathrm{d}/\mathrm{d}\lambda$ converts it into an evolution in t generated by the rescaled operator $\hat{H}_{\mathrm{eff}}^{(t)}=\left(\mathrm{d}\lambda/\mathrm{d}t\right)\hat{H}_{\mathrm{eff}}$. The ordering parameter therefore remains an ordering parameter throughout, and no temporal structure is smuggled into the reduction.

Three points must be stated plainly. First, the imaginary unit in (8) originates in the complex structure J of the Kähler geometry of $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$; it is produced neither by a global phase, which is gauge, nor by an analytic continuation of the ordering parameter. Analytic continuation enters only through (S5), where it selects the branch. Second, the correspondence is conditional on (S3), which asserts the existence of a first-order invariant manifold and is not established here; a construction of that manifold, or a proof that it does not exist, is an open problem of the programme and is recorded in Section 3.17. Third, the correspondence degenerates where $\mathcal{Q}$ does not exist: for a single observer no stable-center manifold is selected, $\hat{H}_{\mathrm{eff}}$ is undefined and no Schrödinger sector is obtained. The quantum-mechanical limit is therefore neither postulated nor obtained by rotating a parameter: it is the Hamiltonian sector of the IFR variational structure on the manifold of stable objective centers, under hypotheses that are here stated rather than proved.

Remark II.5 (Status of $\hbar_{\mathrm{IFR}}$ and m_Ψ)**.** The constants $\hbar_{\mathrm{IFR}}$ and m_Ψ are not free parameters of the framework. Their physical identification follows the same correspondence chain as κ_{eff} in Section 3 and c_{IFR} in the Lorentzian sector of Part V of the series: in the semiclassical limit $\hbar_{\mathrm{IFR}}\to\hbar$ (ordinary Planck constant) and m_Ψ sets the scale of interferential inertia for the underlying objective structures. The matching conditions are stated explicitly in Part III of the series.

This canonical choice closes a structural gap in the original formulation: the IFR action is now specified up to the potential $\mathcal{V}_{\text{int}}$ and the geometric curvature term $\beta\bar{\mathcal{R}}_{\Gamma}$, with all kinetic structure determined by the Fubini-Study geometry of $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$. The variational problem is therefore well-posed at the fundamental level, without smuggling in any pre-existing spacetime structure.

2.6. Structural Restriction of the Informational Potential and a Concrete Parametrised Realisation

The kinetic term having been fixed, the informational potential $\mathcal{V}_{\text{int}}$ remains the principal element of the action that is not determined from first principles. It is not, however, an arbitrary functional: symmetry and regularity restrict it to a low-order family, and the interference states themselves admit a concrete parametrised finite-dimensional realisation. We record both, since without them the variational principle would remain a template rather than a physical model. Neither step is a derivation, and we mark the residue explicitly: the higher-order coefficients of the potential, the dynamics of Γ and the observer-kinematic term remain open.

Admissible potentials. Three requirements act on $\mathcal{V}_{\text{int}}$. It must be invariant under the global phase $\Psi \mapsto e^{i\theta}\Psi$, since the state space is projective. It must be invariant under the IFR gauge group $\mathcal{U}(\mathfrak{A}')$, the unitary group of the commutant of the observer algebra $\mathfrak{A}$ generated by $\{\Pi_a\}$, because transformations in $\mathfrak{A}'$ are by construction unobservable to every member of the observer family. And it must be bounded below and satisfy the regularity conditions (R1)-(R4) inherited from Part I, so that $\mathcal{S}_{\text{IFR}}$ is finite on admissible histories. We accordingly restrict the analysis to the gauge-invariant class

$$\mathcal{V}_{\text{int}} = F(\rho_{\mathfrak{A}}), \quad \rho_{\mathfrak{A}} = \mathbb{E}_{\mathfrak{A}}\left[|\Psi\rangle\langle\Psi|\right],$$

where $\mathbb{E}_{\mathfrak{A}}$ is the conditional expectation onto the observer algebra. We do not claim that gauge invariance *forces* this dependence for every algebra type: for a single block of $\mathfrak{A}$ the orbit of a pure state under $\mathcal{U}(\mathfrak{A}')$ is determined by $\rho_{\mathfrak{A}}$, while relative phases between blocks are further invariants; the class above is a restriction, adopted here, and not a theorem.

Writing $\sigma := \rho_{\mathfrak{A}} - \mathbb{1}/(d+1)$ for the deviation from the maximally mixed state, so that $\operatorname{tr}\sigma^2 = \operatorname{tr}\rho_{\mathfrak{A}}^2 - 1/(d+1) \geq 0$, a smooth, bounded-below and unitarily covariant F admits the Landau-type expansion

$$\mathcal{V}_{\text{int}}[\Psi;\Gamma] = V_0 + \operatorname{tr}\left(\sigma\hat{H}_0\right) + \frac{g}{2}\operatorname{tr}\sigma^2 + \mathcal{O}\left(\|\sigma\|^3\right), \tag{9}$$

with $\hat{H}_0 = \hat{H}_0^{\dagger} \in \mathfrak{A}$ and $g \in \mathbb{R}$. Since the stationarity condition minimises $\mathcal{V}_{\text{int}}$ along the objectivizing directions, the sign of g has a definite meaning: $g > 0$ stabilises the symmetric, maximally mixed configuration and penalises purity of the observer-accessible sector, whereas $g < 0$ destabilises it and drives the symmetry breaking that selects a preferred stable center, the resulting instability being arrested by the higher-order terms. This does not amount to a derivation of $\mathcal{V}_{\text{int}}$, and we do not present it as one; it establishes that the admissible potentials form a low-order gauge-invariant family indexed by $\left(\hat{H}_0, g\right)$ together with the retained higher-order coefficients, rather than an unconstrained choice of functional.

A concrete parametrised finite-dimensional realisation. The interference states of the framework are not left abstract. The minimal realisation used in the empirical instantiations of the series is the following. Here $d = \dim \mathcal{M}$ as in Assumption II.1 (M2), so that the comparison manifold is the interior of the simplex over $d+1$ outcomes:

(I1) $\mathcal{H}_{\mathcal{X}} = \mathbb{C}^{d+1}$ with $d \geq 5$, so that $\Psi \in \mathbb{P}\left(\mathbb{C}^{d+1}\right)$;

(I2) a finite observer family $A = \{1, \cdots, N\}$, $N \geq 2$, each observer a carrying a rank-one positive operator-valued measure $\left\{E_a^{(k)}\right\}_{k=1}^{d+1}$ with $\sum_k E_a^{(k)} = \mathbb{1}$;

(I3) observer maps given by the induced pushforward onto the comparison manifold,

$$\Pi_a[\Psi] = \left(\langle \Psi | E_a^{(k)} | \Psi \rangle\right)_{k=1}^{d+1} \in \mathring{\Delta}_d \subset \mathcal{M};$$

(I4) comparison geometry given by the dimensionless distance $\tilde{d}_\Gamma$ of (M6), realised in the high-redundancy regime as the Jensen-Shannon distance, $\tilde{d}_\Gamma \simeq d_{\mathrm{JS}}$, with natural logarithms;

(I5) potential (9) with $\hat{H}_0$ diagonal in a reference basis.

Given a truncation of the expansion (9) and a choice of $\mathcal{L}_\Pi$, every object entering $\mathcal{S}_{\mathrm{IFR}}$ is then a computable function of the parameters

$$\left(\Psi, \left\{E_a^{(k)}\right\}, \hat{H}_0, g, \alpha, \beta, \ell_\Gamma\right),$$

and the stable Fréchet centers, the redundant dispersion and the embedding diagnostics of Proposition II.3 below are directly evaluable. We do not claim that the realisation is complete: the truncation and the choice of $\mathcal{L}_\Pi$ are inputs, recorded as such in Section 3.17. The estimators, null tests and resampling protocol by which this realisation is confronted with detector, cosmological and physiological ensembles are developed in Part IV of the series and were introduced in [12] [13]; the present paper establishes the variational structure on which they operate.

2.7. Explicit Redundant Dispersion Term

For a finite observer family $A = \{1, \cdots, N\}$, the redundant dispersion term is

$$\mathcal{D}_{\mathrm{red}}[\Psi, \Gamma, \Pi] = \sum_{a<b} w_{ab} \tilde{d}_\Gamma^2\left(\Pi_a[\Psi], \Pi_b[\Psi]\right).$$

The pairwise weights $w_{ab} \geq 0$ are not free parameters of the variational problem. They are fixed operationally, as in Part I [1], by the inverse-uncertainty rule $w_a \propto \sigma_a^{-2}$ combined with an independence factor $\rho_{ab} \in [0,1]$ estimated from the empirical correlation of the observer residuals, so that $w_{ab} \propto w_a w_b (1 - \rho_{ab})$; the uniform choice $w_{ab} = \binom{N}{2}^{-1}$ is the special case of equal reliability and mutual independence. This removes the underdetermination that would otherwise affect $\mathcal{D}_{\mathrm{red}}$ as a term of the action.

Here $\tilde{d}_\Gamma$ is the *dimensionless* distance induced by the rescaled comparison metric $\tilde{g}_\Gamma = \ell_\Gamma^{-2} g_\Gamma$ of Assumption II.1 (M6). Two points must be kept distinct. The dimensionless level is the one that enters $\mathcal{D}_{\text{red}}$, which is thereby dimensionless as required by the dimensional analysis of Section 2.4; were the dimensional distance d_{g_Γ} used instead, $\mathcal{D}_{\text{red}}$ would carry dimension L^2. And $\tilde{d}_\Gamma$ remains a functional of Γ off shell: its identification with the Jensen-Shannon distance [15] [16], with the logarithm base declared explicitly, is the high-redundancy realisation used in the empirical instantiations of the series, not a fixed kinematic structure. This distinction is not cosmetic. If $\tilde{d}_\Gamma$ were frozen to d_{JS} independently of Γ, then $\delta\mathcal{D}_{\text{red}}/\delta\Gamma = 0$ and the redundancy contribution T_{ij}^{red} to the informational stress tensor—the specifically IFR part of the gravitational source—would vanish identically.

For a continuous observer family (A,ν), it becomes

$$\mathcal{D}_{\text{red}}[\Psi,\Gamma,\Pi] = \frac{1}{2}\int_A\int_A w(a,b)\,\tilde{d}_\Gamma^2\left(\Pi_a[\Psi],\Pi_b[\Psi]\right)\mathrm{d}\nu(a)\,\mathrm{d}\nu(b).$$

The appearance of $\mathcal{D}_{\text{red}}$ in the action means that objectivity is not imposed after the dynamics. Instead, the tendency toward multi-observer agreement contributes directly to the selection of physical configurations.

The variational sign convention $-\alpha\mathcal{D}_{\text{red}}$ may be understood as follows. In a stationary-phase formulation, configurations with smaller redundant dispersion contribute coherently to the effective physical sector, whereas configurations with large observer disagreement are suppressed or fail to stabilize as objective structures.

Equivalently, in an Euclideanized or statistical version of the theory, one may write

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

with

$$\mathcal{S}_{\text{IFR}}^E = \int \mathrm{d}\lambda\left[\mathcal{K}_{\text{int}}^E + \mathcal{V}_{\text{int}}^E + \alpha\mathcal{D}_{\text{red}} + \beta\mathcal{R}_\Gamma^E + \mathcal{L}_\Pi^E\right].$$

In this form, high-dispersion configurations are exponentially suppressed. The Lorentzian and Euclidean forms therefore encode the same principle: stable physical reality is associated with low redundant dispersion.

2.8. Generating Functional

The formal generating functional of IFR is

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

This expression is analogous in form to a path integral, but its domain is not the space of fields on a given spacetime. The integration is over Ψ, the primitive interference states; Γ, the information geometries; and Π, the observer projection structures.

Thus the IFR generating functional is not

$$\int \mathcal{D}(\text{fields})\,\mathrm{e}^{iS[\text{fields},g]},$$

but rather

$$\int \mathcal{D}(\text{interference})\,\mathcal{D}(\text{information geometry})\,\mathcal{D}(\text{observerpr ojections})\,e^{iS_{\text{IFR}}}.$$

Conventional field-theoretic path integrals are expected to emerge only in a limiting regime in which Γ admits an effective spacetime representation and the stable objective centers behave as fields or events on that emergent spacetime.

2.9. Variation with Respect to the Interference State

We first consider variations of the interference state, $\Psi \mapsto \Psi + \epsilon\delta\Psi$, with $\delta\Psi \in T_{\Psi}\mathcal{H}_{\mathcal{X}}$, subject to the normalization constraint

$$\langle \Psi, \Psi \rangle_{\mathcal{X}} = 1.$$

The constrained variation can be implemented by introducing a Lagrange multiplier $\Lambda(\lambda)$ and defining

$$\tilde{\mathcal{S}}_{\text{IFR}} = \mathcal{S}_{\text{IFR}} - \int_I \mathrm{d}\lambda\, \Lambda(\lambda)\left(\langle \Psi, \Psi \rangle_{\mathcal{X}} - 1\right).$$

Stationarity with respect to $\bar{\Psi}$ gives

$$\frac{\delta \mathcal{K}_{\text{int}}}{\delta \bar{\Psi}} - \frac{\delta \mathcal{V}_{\text{int}}}{\delta \bar{\Psi}} - \alpha \frac{\delta \mathcal{D}_{\text{red}}}{\delta \bar{\Psi}} - \Lambda\Psi = 0.$$

Equivalently,

$$\boxed{\frac{\delta \mathcal{K}_{\text{int}}}{\delta \bar{\Psi}} - \frac{\delta \mathcal{V}_{\text{int}}}{\delta \bar{\Psi}} - \alpha \frac{\delta \mathcal{D}_{\text{red}}}{\delta \bar{\Psi}} = \Lambda\Psi.}$$

This is the general IFR interference equation.

Its interpretation is direct: physically admissible interference states are not determined solely by internal propagation or self-interaction. They are also constrained by the requirement that their observer projections contract toward stable shared structures.

The variation of the redundant dispersion term is

$$\begin{aligned}\delta_{\Psi}\mathcal{D}_{\text{red}} &= 2\sum_{a<b} w_{ab} \left\langle \log_{\Pi_a[\Psi]}\left(\Pi_b[\Psi]\right), D\Pi_a[\delta\Psi] \right\rangle_{\Gamma} \\ &\quad + 2\sum_{a<b} w_{ab} \left\langle \log_{\Pi_b[\Psi]}\left(\Pi_a[\Psi]\right), D\Pi_b[\delta\Psi] \right\rangle_{\Gamma}.\end{aligned}$$

whenever the information geometry is smooth and the logarithm map is defined.

Here $D\Pi_a$ denotes the Fréchet derivative of the observer map, and $\log_p(q) \in T_p\mathcal{M}$ is the inverse exponential map from p to q.

This expression shows explicitly that the objectivizing force acting on Ψ depends on how changes in the primitive interference state modify the observer projections.

2.10. Variation with Respect to the Information Geometry

We now vary the information geometry:

$$\Gamma \mapsto \Gamma + \epsilon\delta\Gamma.$$

In the smooth Riemannian case, this corresponds to varying the metric tensor

$$g_{ij} \mapsto g_{ij} + \epsilon\, \delta g_{ij}.$$

The variation with respect to the comparison geometry is performed on the fundamental form (1) of the action, not on the reduced form of Lemma II.1, whose coupling $\beta = \hat{\beta} V_\Gamma(\Omega)$ is itself Γ-dependent. The Γ-dependent part of the action is therefore

$$\mathcal{S}_\Gamma = \int_I \mathrm{d}\lambda \int_\Omega \mathrm{d}\mu_\Gamma \left[\mathfrak{k}_{\mathrm{int}} - \mathfrak{v}_{\mathrm{int}} - \alpha\, \mathfrak{d}_{\mathrm{red}} + \hat{\beta} \mathcal{R}_\Gamma + \mathfrak{l}_\Pi \right], \quad \hat{\beta} = \frac{1}{2\kappa_{\mathrm{IFR}}},$$

with the curvature sign fixed as in Section 2.4.

Definition II.2 (Source densities). For each source term

$$\mathcal{X} \in \left\{ \mathcal{K}_{\mathrm{int}}, \mathcal{V}_{\mathrm{int}}, \mathcal{D}_{\mathrm{red}}, \mathcal{L}_\Pi \right\}$$

the corresponding density $\mathfrak{x}$ on Ω is defined as the localisation of $\mathcal{X}$ over the comparison domain,

$$\mathcal{X} = \int_\Omega \mathrm{d}\mu_\Gamma\, \mathfrak{x}, \quad [\mathfrak{x}] = [\mathcal{X}] \cdot L^{-d}.$$

The calligraphic quantities of Sections 2.5 and 2.6 are thus the integrated forms, and the fraktur quantities the primitive ones; Lemma II.1 is the statement that the two coincide up to the factor $V_\Gamma(\Omega)$ when the densities are uniform. The metric variation below is taken with respect to g_Γ^{ij} at fixed *independent non-metric fields* $(\Psi, \Pi, \cdots)$, retaining the explicit metric dependence of the densities themselves: $\mathfrak{d}_{\mathrm{red}} = \mathfrak{d}_{\mathrm{red}}[g_\Gamma, \Psi, \Pi]$ and likewise for the others, so that both the variation of $\mathrm{d}\mu_\Gamma$ and that of each $\mathfrak{x}$ contribute.

We do not write the stationarity condition as a schematic sum of functional derivatives of the separate densities. Such a writing would be incomplete in two respects: the variation of $\int_\Omega \sqrt{|g_\Gamma|}\, \mathfrak{L}^{\mathrm{src}}\, \mathrm{d}^d q$ contains the variation of the measure $\sqrt{|g_\Gamma|}$ itself, and the observer-kinematic density $\mathfrak{l}_\Pi$ contributes on the same footing as the others. The correct and complete statement is obtained by collecting the source densities into

$$\mathfrak{L}^{\mathrm{src}} := \mathfrak{k}_{\mathrm{int}} - \mathfrak{v}_{\mathrm{int}} - \alpha\, \mathfrak{d}_{\mathrm{red}} + \mathfrak{l}_\Pi$$

and defining the informational stress tensor by the metric variation of the corresponding scalar density, as in Section 2.11. Stationarity of $\mathcal{S}_\Gamma$ with respect to g_Γ^{ij} then gives directly

$$\boxed{\mathcal{G}_{ij}^\Gamma = \kappa_{\mathrm{IFR}}\, T_{ij}^{\mathrm{IFR}},}$$

which is the general IFR geometric equation. It incorporates both the variation of the volume measure and the explicit metric dependence of every density, and no separate schematic identity is needed.

It is the analogue, at the informational level, of a gravitational field equation. The right-hand side acts as an effective source for informational curvature. Crucially, this source includes not only interference dynamics but also the redundant dispersion of observer projections.

In IFR, therefore,

multi-observer objectivity contributes to the geometry that later appears as gravitation.

2.11. Informational Stress Tensor

To make the analogy with gravitational dynamics more explicit, consider a smooth information geometry with metric g_{ij}. Define the informational stress tensor by

$$T_{ij}^{\text{IFR}} = -\frac{2}{\sqrt{|g|}}\frac{\delta}{\delta g^{ij}}\left[\sqrt{|g|}\left(\mathfrak{k}_{\text{int}} - \mathfrak{v}_{\text{int}} - \alpha\mathfrak{d}_{\text{red}} + \mathfrak{l}_{\Pi}\right)\right],$$

the entries being the densities of Definition II.2, as the bracket must be a scalar density for the expression to define a tensor, in agreement with the source density $\mathfrak{L}_{\text{IFR}}^{\text{src}}$ of Section 3; when $\mathcal{L}_{\Pi} = 0$ this reduces to the four-term form.

If the curvature term is chosen in Einstein-Hilbert form on the information manifold,

$$\int_{\mathcal{M}} \mathrm{d}\mu_{\Gamma}\,\mathcal{R}_{\Gamma},$$

then variation with respect to g^{ij} yields a geometric equation of the schematic form

$$\boxed{\mathcal{G}_{ij}^{\Gamma} = \kappa_{\text{IFR}} T_{ij}^{\text{IFR}},}$$

where

$$\mathcal{G}_{ij}^{\Gamma} = \mathcal{R}_{ij}^{\Gamma} - \frac{1}{2} g_{ij}\mathcal{R}_{\Gamma}$$

is the Einstein tensor of the information geometry, and κ_{IFR} is an effective coupling constant determined by β and the normalization of the curvature action.

This equation should not be interpreted as ordinary general relativity on spacetime. It is a field equation on the information-geometric comparison manifold. Ordinary spacetime gravity appears only along the reduction chain of Theorem II.1,

$$(\mathcal{M},\Gamma) \overset{\text{reduction}}{\to} \left(\mathcal{E}, g_{\mathcal{E}}^{(R)}\right) \overset{\mathcal{W}}{\to} \left(\mathcal{E}, g_{\mathcal{E}}^{(L)}\right) \overset{\chi}{\to} \left(\mathcal{M}_{\text{eff}}, g_{\text{eff}}\right)$$

in the emergent manifold limit.

2.12. Variation with Respect to Observer Maps

If observer maps are treated dynamically, one may also vary

$$\Pi_a \mapsto \Pi_a + \epsilon\,\delta\Pi_a.$$

The observer-dependent part of the action is

$$\mathcal{S}_{\Pi} = \int_I \mathrm{d}\lambda\left[-\alpha\mathcal{D}_{\text{red}}[\Psi,\Gamma,\Pi] + \mathcal{L}_{\Pi}\right].$$

Stationarity gives

$$-\alpha\frac{\delta\mathcal{D}_{\text{red}}}{\delta\Pi_a} + \frac{\delta\mathcal{L}_{\Pi}}{\delta\Pi_a} = 0.$$

Thus,

$$\boxed{\frac{\delta \mathcal{L}_{\Pi}}{\delta \Pi_a} = \alpha \frac{\delta \mathcal{D}_{\text{red}}}{\delta \Pi_a}}.$$

If $\mathcal{L}_{\Pi} = 0$, the variational condition reduces formally to

$$\frac{\delta \mathcal{D}_{\text{red}}}{\delta \Pi_a} = 0,$$

meaning that admissible observer maps must be stationary with respect to redundant contraction. In practice, however, Π_a often represents a fixed operational class rather than a fully dynamical variable. In that case, variations with respect to Π_a are not imposed, and objectivity is evaluated relative to the chosen observer family.

This distinction is important. IFR does not claim that arbitrary observer maps are physically realized. Only admissible observers satisfying stability, finite accessibility, and operational reproducibility are allowed.

2.13. Stationary Objective Configurations

A stationary IFR configuration is a triple $\left(\Psi^\star, \Gamma^\star, \Pi^\star\right)$ such that

$$\delta \mathcal{S}_{\text{IFR}}\left[\Psi^\star, \Gamma^\star, \Pi^\star\right] = 0.$$

An objective stationary configuration additionally satisfies the objectivity conditions established in Part I of the series. That is, the projected representations $m_a^\star = \Pi_a^\star\left[\Psi^\star\right]$ must admit a stable Fréchet center [17] [18]

$$Q^\star = \arg\min_{Q \in \mathcal{M}} \sum_a w_a \tilde{d}_{\Gamma^\star}^{\,2}\left(Q, m_a^\star\right),$$

with $F_{\Psi^\star,\Gamma^\star}\left(Q^\star\right) < \varepsilon$. Therefore, IFR distinguishes three levels:

$$\begin{array}{lcl} \text{stationary interference configuration} & : & \delta \mathcal{S}_{\text{IFR}} = 0, \\ \text{objective configuration} & : & F_{\Psi,\Gamma}\left(Q^\star\right) < \varepsilon, \\ \text{physical classical configuration} & : & \begin{array}{l} \text{objective, stable, persistent,} \\ \text{effectively spacetime-localized.} \end{array} \end{array}$$

This hierarchy prevents the theory from identifying every stationary interference pattern with an ordinary physical object. Only those stationary configurations that become redundantly stable across observers enter the objective sector.

2.14. Euclidean and Lorentzian Signatures

The formal generating functional

$$\mathcal{Z}_{\text{IFR}} = \int \mathcal{D}\Psi \mathcal{D}\Gamma \mathcal{D}\Pi \, \mathrm{e}^{i\mathcal{S}_{\text{IFR}}}$$

is Lorentzian in form. Since λ is not physical time, this terminology is formal: it refers to the oscillatory stationary-phase structure rather than to a pre-existing spacetime signature.

For probabilistic, statistical, or numerical applications, it is often preferable to use an Euclideanized functional

$$\mathcal{Z}_{\mathrm{IFR}}^{E}=\int \mathcal{D}\Psi\,\mathcal{D}\Gamma\,\mathcal{D}\Pi\,\mathrm{e}^{-\mathcal{S}_{\mathrm{IFR}}^{E}}.$$

Sign convention (Lorentzian vs. Euclidean). Throughout, the Lorentzian IFR action carries the curvature term with a *positive* sign, $\mathcal{S}_{\mathrm{IFR}}=\int \mathrm{d}\lambda\left[\mathcal{K}_{\mathrm{int}}-\mathcal{V}_{\mathrm{int}}-\alpha\mathcal{D}_{\mathrm{red}}+\beta\bar{\mathcal{R}}_{\Gamma}+\mathcal{L}_{\Pi}\right]$ with $\beta>0$ and $\beta/V_{\mathrm{char}}=1/\left(2\kappa_{\mathrm{eff}}\right)$ (Section 2.4). Under Wick rotation the potential, dispersion and curvature terms enter the Euclidean weight $\mathrm{e}^{-\mathcal{S}^{E}}$ with a uniform $+$ sign, so that all couplings appear as damping factors; this is the convention used in the functional-measure construction below.

A minimal Euclidean action is

$$\mathcal{S}_{\mathrm{IFR}}^{E}=\int_{I}\mathrm{d}\lambda\left[\mathcal{K}_{\mathrm{int}}^{E}+\mathcal{V}_{\mathrm{int}}^{E}+\alpha\mathcal{D}_{\mathrm{red}}+\beta\mathcal{R}_{\Gamma}^{E}+\mathcal{L}_{\Pi}^{E}\right].$$

In this form, the role of redundant dispersion is transparent:

$$\mathcal{D}_{\mathrm{red}}\uparrow\;\Rightarrow\;\mathrm{e}^{-\mathcal{S}_{\mathrm{IFR}}^{E}}\downarrow.$$

Thus, configurations that fail to support observer agreement are suppressed in the Euclidean measure.

The Euclideanized form is particularly useful for empirical inference, where the path integral may be interpreted as a weighted ensemble over interference-geometric hypotheses.

2.15. Classical Stationary Limit

The classical IFR limit is obtained by stationary phase or saddle-point approximation. Suppose the generating functional is dominated by configurations near a stationary point

$$\left(\Psi^{\star},\Gamma^{\star},\Pi^{\star}\right).$$

Then

$$\mathcal{Z}_{\mathrm{IFR}}\approx\mathrm{e}^{i\mathcal{S}_{\mathrm{IFR}}\left[\Psi^{\star},\Gamma^{\star},\Pi^{\star}\right]}\int \mathcal{D}\delta\Psi\,\mathcal{D}\delta\Gamma\,\mathcal{D}\delta\Pi\,\mathrm{e}^{\frac{i}{2}\delta^{2}\mathcal{S}_{\mathrm{IFR}}+\cdots}.$$

The leading-order classical sector is therefore governed by

$$\delta\mathcal{S}_{\mathrm{IFR}}=0.$$

If, in addition, $\mathcal{D}_{\mathrm{red}}\left[\Psi^{\star},\Gamma^{\star},\Pi^{\star}\right]\ll1$ and the corresponding Fréchet center is stable, then the saddle point defines an objective classical structure.

Thus classicality requires both:

stationary action

and

low redundant dispersion.

This is a crucial difference from conventional classical limits. In IFR, a saddle point alone is not sufficient to define a classical object. It must also be redundantly objectivized.

2.16. Noether-Type Considerations

If the IFR action is invariant under a continuous transformation group G acting on (Ψ, Γ, Π), then corresponding conserved quantities or constraints may arise. Let $(\Psi, \Gamma, \Pi) \mapsto (\Psi_\theta, \Gamma_\theta, \Pi_\theta)$ be a one-parameter transformation with $\mathcal{S}_{\text{IFR}}[\Psi_\theta, \Gamma_\theta, \Pi_\theta] = \mathcal{S}_{\text{IFR}}[\Psi, \Gamma, \Pi]$. The associated first variation then vanishes, $(\mathrm{d}/\mathrm{d}\theta)\mathcal{S}_{\text{IFR}}[\Psi_\theta, \Gamma_\theta, \Pi_\theta]\big|_{\theta=0} = 0$.

Depending on the structure of λ and the admissible function spaces, this leads to a conserved current or constraint. In the emergent spacetime limit, such symmetries may reduce to familiar conservation laws associated with effective spacetime translations, rotations, gauge transformations, or diffeomorphisms.

At the fundamental IFR level, however, these symmetries need not be spacetime symmetries. They may instead be symmetries of interference structure, observer alignment, or information geometry.

This provides a possible route by which conventional conservation laws emerge from deeper invariances of the interference-geometric action.

2.17. Correspondence with Ordinary Field-Theoretic Action

The IFR action must satisfy a correspondence requirement. In the high-redundancy, stable-center, effective-manifold regime, there exists an emergent spacetime $(\mathcal{M}_{\text{eff}}, g_{\mu\nu}^{\text{eff}})$ such that the comparison geometry is carried to the effective metric along the reduction chain of Theorem II.1,

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

the curvature correspondence being $\mathcal{R}_{\mathcal{E}}^{(L)} \to R(g_{\text{eff}})$ for the post-Wick scalar of the event manifold and never a direct passage from $\mathcal{R}_\Gamma$ to $R(g_{\text{eff}})$, and objective centers become effective field configurations, $Q^\star \to \varphi(x)$.

In this limit, the IFR action must reduce to

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

where $\mathcal{L}_{\text{corr}}$ contains corrections due to residual redundant dispersion, nonlocal informational effects, or incomplete emergence of spacetime locality.

In the ideal classical limit $\mathcal{D}_{\text{red}} \to 0$ and $\mathcal{L}_{\text{corr}} \to 0$, and the effective action becomes

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

Thus ordinary general-relativistic field theory is recovered as a limiting sector of IFR.

2.18. Interpretation of the Variational Principle

The IFR variational principle may be summarized by the following statement:

Physical configurations are stationary interference-geometric histories that support stable redundant objectivity.

The term $\mathcal{K}_{\text{int}} - \mathcal{V}_{\text{int}}$ governs the internal organization of the primitive interference state; $-\alpha\mathcal{D}_{\text{red}}$ selects configurations whose projections agree across independent observers; $+\beta\mathcal{R}_\Gamma$ makes the geometry of informational distinguishability dynamical and supplies the precursor of gravitational curvature, the positive sign being required so that in the semiclassical limit the curvature term reproduces the Einstein-Hilbert action with attractive gravity (Section 2.4); and the optional $\mathcal{L}_\Pi$ controls the admissibility and stability of observer maps.

This structure gives IFR its defining explanatory order: interference → observer projections → redundant contraction → objective centers → effective spacetime and gravity.

The next section develops the gravitational sector explicitly by showing how informational curvature can generate an effective spacetime metric and gravitational dynamics in the high-redundancy semiclassical limit.

3. Informational Curvature and the Emergence of Gravitation

The preceding section introduced the IFR action and showed that the information geometry Γ is not a passive background structure. It is varied together with the interference state and, in the fully dynamical theory, with the observer maps. This section develops the gravitational sector of IFR.

The central thesis is that gravitation is the effective spacetime expression of curvature in the information geometry of observer-stable structures. In this framework, gravitational geometry does not enter as a primitive metric field on a pre-existing manifold. Instead, it emerges when the geometry of distinguishability among objective informational structures admits a low-dimensional, approximately local, metric representation.

Thus, IFR replaces the standard explanatory order—spacetime metric → curvature → gravitational phenomena—with informational distinguishability → informational curvature → effective spacetime curvature → gravitational phenomena.

3.1. From Information Geometry to Effective Spacetime Geometry

Let $(\mathcal{M},\Gamma)$ be the information-geometric comparison space introduced in Part I of the series. The points of $\mathcal{M}$ represent observer-accessible informational structures, and the geometry Γ determines their distinguishability.

Let $\mathcal{Q}\subset\mathcal{M}$ denote the subset of stable IFR-objective centers:

$$\mathcal{Q}=\left\{Q^\star_{\Psi,\Gamma}\in\mathcal{M}:Q^\star_{\Psi,\Gamma}\text{ is stable and IFR-objective}\right\}.$$

An effective spacetime description exists only if the set $\mathcal{Q}$ admits a low-dimensional metric representation. More precisely, there must exist a differentiable manifold $\mathcal{M}_{\text{eff}}$ and an embedding or reconstruction map $\chi:\mathcal{Q}\to\mathcal{M}_{\text{eff}}$ which, in the precise form given in Theorem II.1 (H1)-(H2), is the equal-time restriction of the reconstruction $\chi:\mathcal{E}\to\mathcal{M}_{\text{eff}}$ defined on the event manifold; we keep the shorter writing here, where only the spatial comparison is at issue, such that, for stable objective centers $Q_i^\star,Q_j^\star\in\mathcal{Q}$ on a common slice,

$$\ell_\Gamma\tilde{d}_\Gamma\left(Q_i^\star,Q_j^\star\right)=d_{g_{\text{eff}}}\left(\chi\left(Q_i^\star\right),\chi\left(Q_j^\star\right)\right)+\mathcal{O}\left(\epsilon_{\text{geo}}\right),$$

where $d_{g_{\text{eff}}}$ is the geodesic distance induced by an effective metric tensor $g_{\mu\nu}^{\text{eff}}$

on $\mathcal{M}_{\text{eff}}$, and ϵ_{geo} measures the residual failure of exact metric representation.

When $\epsilon_{\text{geo}} \ll 1$ over the domain under consideration, the stable objective structures admit an effective spacetime description. In that regime,

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

not by identity at the fundamental level, but by representational reduction along the chain of Theorem II.1.

Thus, spacetime geometry is not fundamental in IFR. It is the metric representation of stable relations among objective informational centers.

3.2. Informational Curvature

In a smooth Riemannian realization of the comparison space, the information geometry is specified by a metric g_{ij}^{Γ} on $\mathcal{M}$. The corresponding Levi-Civita connection is ∇^{Γ}, with Riemann tensor $\mathcal{R}^{i}{}_{jkl}[\Gamma]$, Ricci tensor $\mathcal{R}_{ij}[\Gamma] = \mathcal{R}^{k}{}_{ikj}[\Gamma]$, and scalar curvature

$$\mathcal{R}_{\Gamma} = g_{\Gamma}^{ij}\mathcal{R}_{ij}[\Gamma].$$

The scalar $\mathcal{R}_{\Gamma}$ measures the intrinsic curvature of distinguishability relations among informational structures. It should not be confused with the Ricci scalar of spacetime unless an effective spacetime representation has already emerged.

All statements of this section concerning $\mathcal{R}_{\Gamma}$ presuppose the smooth Riemannian realisation fixed in Assumption II.1, and in particular the positive-definite signature (M3) and the metric normalisation (M6). The indefinite signature required by an effective spacetime does not belong to $(\mathcal{M}, g_{\Gamma})$ at all: it is acquired only by $g_{\mu\nu}^{\text{eff}}$ on $\mathcal{M}_{\text{eff}}$, through the informational Wick mechanism of Part V. The general information-geometric framework of Part I, which does not impose the dimensional curvature realisation adopted here, is correspondingly wider than the curvature sector developed here; see Remark II.1.

A structural remark on tensorial rank clarifies the relation between IFR and general relativity, and will be used repeatedly in what follows. General relativity operates entirely at rank two: the field equation contains $R_{\mu\nu}$ and R, never the full Riemann tensor, because for that theory the spacetime metric is the fundamental level and the structure has a single layer. IFR also reaches rank two in its effective equation, but that rank-two object descends from an information geometry whose Riemann tensor $\mathcal{R}^{i}{}_{jkl}[\Gamma]$ retains full rank four:

$$\underbrace{\mathcal{R}^{i}{}_{jkl}[\Gamma]}_{\text{rank 4, informational}} \rightarrow \underbrace{\mathcal{G}_{ij}^{\Gamma}}_{\text{rank 2, informational}} \xrightarrow[\mathcal{D}_{\text{red}}\to 0]{} \underbrace{G_{\mu\nu}(g_{\text{eff}})}_{\text{rank 2, spacetime}} + \underbrace{C_{\mu\nu}^{\text{IFR}}}_{\substack{\text{rank 2, retaining}\\ \text{rank-4 information}}}$$

The residual tensor $C_{\mu\nu}^{\text{IFR}}$ of Section 3.9 is precisely the part of the rank-four informational curvature that survives the double contraction. Einstein dynamics cannot contain it, not because the theory is defective, but because the level from which it originates is absent from a formulation in which the metric is primitive. In this sense IFR does not contradict general relativity; it embeds it as the limiting case in which the informational rank collapses without residue.

In the effective spacetime regime, IFR imposes the correspondence condition

$$\mathcal{R}_{\mathcal{E}}^{(L)} \to R\left(g_{\text{eff}}\right),$$

where $R\left(g_{\text{eff}}\right)$ is the Ricci scalar of the emergent metric $g_{\mu\nu}^{\text{eff}}$. Here and throughout, the left-hand side of such a correspondence is understood to be the post-Wick scalar $\mathcal{R}_{\mathcal{E}}^{(L)}$ of the event manifold, reached from $\mathcal{M}$ along the chain of Theorem II.1,

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

and not the comparison scalar $\mathcal{R}_{\Gamma}$ itself; see Theorem II.1 (H1)-(H3).

This correspondence is not assumed globally. It holds only in regimes where objective centers form an approximately local, low-dimensional, metric continuum.

3.3. Persistent Objective Structures as Geometric Sources

In general relativity, stress-energy sources spacetime curvature. In IFR, the more primitive source is not initially stress-energy, but persistent informational objectivity.

A stable objective center $Q^{\star}$ is not merely a point of agreement among observers. It constrains the admissible transitions in the surrounding information geometry. Informally, the presence of a persistent objective structure changes which nearby informational configurations are accessible, distinguishable, or dynamically stable.

This motivates the definition of an informational source functional

$$\mathcal{T}_{\text{IFR}} = \mathcal{T}_{\text{int}} + \mathcal{T}_{\text{red}} + \mathcal{T}_{\text{stab}},$$

where:

$$\mathcal{T}_{\text{int}}$$

is the contribution of interference dynamics;

$$\mathcal{T}_{\text{red}}$$

is the contribution of redundant observer contraction;

$$\mathcal{T}_{\text{stab}}$$

is the contribution of persistence and stability of objective centers.

In a smooth metric realization, this source is represented by an informational stress tensor

$$T_{ij}^{\text{IFR}}.$$

As introduced in Section 2, it may be defined variationally by

$$T_{ij}^{\text{IFR}} = -\frac{2}{\sqrt{|g_{\Gamma}|}} \frac{\delta}{\delta g_{\Gamma}^{ij}} \left[\sqrt{|g_{\Gamma}|}\left(\mathfrak{k}_{\text{int}} - \mathfrak{v}_{\text{int}} - \alpha\, \mathfrak{d}_{\text{red}} + \mathfrak{l}_{\Pi}\right)\right].$$

The redundant dispersion contribution is therefore

$$T_{ij}^{\text{red}} = \frac{2\alpha}{\sqrt{|g_{\Gamma}|}} \frac{\delta}{\delta g_{\Gamma}^{ij}} \left[\sqrt{|g_{\Gamma}|}\, \mathfrak{d}_{\text{red}}\right].$$

The entries are the densities of Definition II.2: only a scalar density integrated against $\mathrm{d}^d q$ yields a tensor under metric variation, so the integrated calligraphic quantities cannot appear inside the bracket.

This term is specific to IFR. It encodes the fact that the degree of multi-observer contraction contributes to the effective geometry of distinguishability.

The gravitational intuition is then:

$$\boxed{\text{persistent objective structures deform the surrounding information geometry}}$$

In the effective spacetime limit, this deformation appears as gravitational curvature.

3.4. The Informational Field Equation

The geometric part of the IFR action is read off directly from the defining form (1), no additional measure being introduced at this stage:

$$\mathcal{S}_\Gamma = \int_I \mathrm{d}\lambda \int_\Omega \mathrm{d}\mu_\Gamma \left[\frac{1}{2\kappa_{\mathrm{IFR}}} \mathcal{R}_\Gamma + \mathfrak{L}_{\mathrm{IFR}}^{\mathrm{src}} \right],$$

where $\Omega \subset \mathcal{M}$ and the boundary conditions are those of Assumption II.1 (M4), so that the Gibbons-Hawking-York term cancels the normal derivative of δg_{ij}^{Γ} on $\partial\Omega$,

$$\mathrm{d}\mu_\Gamma = \sqrt{|g_\Gamma|}\,\mathrm{d}^d q$$

is the volume measure fixed in (1), with $d = \dim \mathcal{M}$ as in (M2), and

$$\mathfrak{L}_{\mathrm{IFR}}^{\mathrm{src}} = \mathfrak{k}_{\mathrm{int}} - \mathfrak{v}_{\mathrm{int}} - \alpha\, \mathfrak{d}_{\mathrm{red}} + \mathfrak{l}_{\Pi}$$

is the source *density* of Definition II.2, not the integrated Lagrangian.

Variation with respect to g_Γ^{ij} gives

$$\mathcal{G}_{ij}^{\Gamma} = \kappa_{\mathrm{IFR}} T_{ij}^{\mathrm{IFR}}$$

where

$$\mathcal{G}_{ij}^{\Gamma} = \mathcal{R}_{ij}^{\Gamma} - \frac{1}{2} g_{ij}^{\Gamma} \mathcal{R}_\Gamma$$

is the Einstein tensor of the information geometry, and

$$T_{ij}^{\mathrm{IFR}} = -\frac{2}{\sqrt{|g_\Gamma|}} \frac{\delta}{\delta g_\Gamma^{ij}} \left(\sqrt{|g_\Gamma|}\, \mathfrak{L}_{\mathrm{IFR}}^{\mathrm{src}} \right).$$

Thus, the gravitational sector of IFR is governed by the informational field equation

$$\boxed{\mathcal{G}_{ij}^{\Gamma} = \kappa_{\mathrm{IFR}} T_{ij}^{\mathrm{IFR}}.}$$

This equation is not yet Einstein's field equation in spacetime. It is a curvature equation on the information-geometric comparison manifold. Its physical meaning is that interference dynamics, redundant objectivization, and stability constraints determine the curvature of informational distinguishability.

3.5. Reduction to Einstein-Type Dynamics

The ordinary gravitational field equation is recovered only after an effective spacetime manifold emerges. Assume that there exists a regime in which:

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

so that, with $\mathscr{R}_g$ and $\mathscr{R}$ the geometric and source reduction maps of Theorem II.1 (H3)-(H4),

$$\mathcal{R}_{\mathcal{E}}^{(L)}\to R\left(g_{\text{eff}}\right),\quad \chi_{*}\mathscr{R}\left[T^{\text{IFR}}\right]\to T_{\mu\nu}^{\text{eff}}.$$

Then the informational field equation reduces to

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

where

$$G_{\mu\nu}\left(g_{\text{eff}}\right)=R_{\mu\nu}\left(g_{\text{eff}}\right)-\frac{1}{2}g_{\mu\nu}^{\text{eff}}R\left(g_{\text{eff}}\right)$$

is the Einstein tensor of the emergent spacetime metric.

The term $\mathcal{C}_{\mu\nu}^{\text{IFR}}$ contains residual corrections arising from incomplete objectivization, nonlocal information-geometric structure, finite observer redundancy, or deviations from exact manifold locality.

In the ideal classical limit,

$$\mathcal{D}_{\text{red}}\to 0,\quad \epsilon_{\text{geo}}\to 0,\quad \mathcal{C}_{\mu\nu}^{\text{IFR}}\to 0,$$

one obtains

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

Thus, general relativity is recovered as the high-redundancy, low-dispersion, effective-manifold limit of IFR.

3.6. Mass-Energy as Persistent Informational Constraint

In the effective spacetime limit, matter is represented by an effective stress-energy tensor

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

Within IFR, this tensor is interpreted as the spacetime representation of persistent informational constraints generated by stable objective structures. A localized mass-energy distribution corresponds to a stable cluster of objective centers that constrains nearby admissible transitions in the information geometry.

Let $\rho_{\text{obj}}(\mathcal{Q})$ denote an objective-structure density on $\mathcal{Q}$. This density may be defined schematically as

$$\rho_{\text{obj}}(\mathcal{Q})=\int\delta_{\Gamma}\left(\mathcal{Q}-\mathcal{Q}_{\Psi,\Gamma}^{\star}\right)W[\Psi,\Gamma,\Pi]\mathcal{D}\Psi\mathcal{D}\Gamma\mathcal{D}\Pi,$$

where $W[\Psi,\Gamma,\Pi]=\exp\left(i\mathcal{S}_{\text{IFR}}\right)$ or its Euclidean analogue, and δ_{Γ} is a geometry-compatible delta distribution on $\mathcal{M}$.

In an effective spacetime representation, this becomes $\rho_{\text{obj}}(\mathcal{Q})\to\rho_{\text{eff}}(x)$, where $\rho_{\text{eff}}(x)$ contributes to the ordinary stress-energy tensor.

Thus, matter is not simply inserted into spacetime. It is the effective representation of stable informational structures whose persistence deforms the geometry of distinguishability.

This interpretation leads to the IFR gravitational principle:

mass-energy is the effective spacetime image of persistent informational constraint.

3.7. Geodesic Motion as Informational Extremality

In general relativity, freely falling bodies follow geodesics of spacetime. IFR provides a pre-spatiotemporal interpretation of this principle.

Let $Q^\star(\lambda)$ be a continuous family of stable objective centers. Its path in the information geometry has length

$$\mathcal{L}_\Gamma\left[Q^\star\right]=\int_{\lambda_1}^{\lambda_2}\left\|\frac{\mathrm{d}Q^\star}{\mathrm{d}\lambda}\right\|_\Gamma \mathrm{d}\lambda.$$

A free objective structure follows an informational geodesic if

$$\delta\mathcal{L}_\Gamma\left[Q^\star\right]=0.$$

When an effective spacetime representation exists, $Q^\star(\lambda)\mapsto x^\mu(\tau)$, and

$$\ell_\Gamma\tilde{d}_\Gamma\to d_{g_{\text{eff}}},$$

the informational geodesic equation reduces to the spacetime geodesic equation

$$\frac{\mathrm{d}^2x^\mu}{\mathrm{d}\tau^2}+\Gamma^\mu_{\alpha\beta}\left(g_{\text{eff}}\right)\frac{\mathrm{d}x^\alpha}{\mathrm{d}\tau}\frac{\mathrm{d}x^\beta}{\mathrm{d}\tau}=0.$$

Thus, free fall is interpreted as extremal motion through the geometry of stable informational distinguishability.

In IFR terms,

geodesic motion is the effective spacetime image of informational extremality

3.8. Informational Curvature and Gravitational Attraction

The appearance of gravitational attraction can be understood through the deformation of admissible informational transitions.

Suppose a persistent objective structure $Q_M^\star$ generates a localized deformation of Γ. The distance between nearby objective centers is then modified:

$$d_{\Gamma_0}\left(Q_i^\star,Q_j^\star\right)\to d_{\Gamma_M}\left(Q_i^\star,Q_j^\star\right),$$

where Γ_0 is the undeformed information geometry and Γ_M is the geometry in the presence of the persistent structure.

If the deformation reduces the informational action for paths approaching $Q_M^\star$, then nearby objective structures follow geodesics that appear, in the effective spacetime representation, as gravitational attraction.

Therefore, attraction is not fundamental force in IFR. It is the emergent consequence of curvature in the admissible transition geometry.

In the weak-field effective limit, write

$$g_{\mu\nu}^{\text{eff}} = \eta_{\mu\nu} + h_{\mu\nu}, \quad \left|h_{\mu\nu}\right| \ll 1.$$

If the dominant component is $g_{00}^{\text{eff}} \approx -(1+2\Phi)$, then the geodesic equation gives the Newtonian limit

$$\frac{\mathrm{d}^2 \boldsymbol{x}}{\mathrm{d}t^2} = -\nabla\Phi.$$

In IFR, the potential Φ is interpreted as the weak-field spacetime representation of informational curvature induced by persistent objective constraints.

3.9. Residual IFR Corrections

Because spacetime geometry is emergent rather than fundamental, IFR generically allows corrections to Einstein dynamics outside the ideal high-redundancy limit.

The effective field equation may be written as

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

where

$$\mathcal{C}_{\mu\nu}^{\text{IFR}} = \mathcal{C}_{\mu\nu}^{\text{red}} + \mathcal{C}_{\mu\nu}^{\text{nonloc}} + \mathcal{C}_{\mu\nu}^{\text{geo}} + \mathcal{C}_{\mu\nu}^{\text{obs}}.$$

The terms represent, respectively:

$$\mathcal{C}_{\mu\nu}^{\text{red}}$$

corrections due to finite redundant dispersion;

$$\mathcal{C}_{\mu\nu}^{\text{nonloc}}$$

corrections due to nonlocal structure in the information geometry;

$$\mathcal{C}_{\mu\nu}^{\text{geo}}$$

corrections due to imperfect embedding into a low-dimensional effective manifold;

$$\mathcal{C}_{\mu\nu}^{\text{obs}}$$

corrections due to observer-family dependence or incomplete objectivization.

In regimes where $\mathcal{D}_{\text{red}} \not\approx 0$ or $\epsilon_{\text{geo}} \not\approx 0$, these correction terms need not vanish.

This provides a possible empirical route for IFR: deviations from standard gravitational behavior should correlate with regimes in which informational redundancy, observer stability, or effective locality fail.

The decomposition above is, at the level of the present part, a classification of the sources of deviation rather than a quantitative prediction: it states which regimes generate corrections, not their magnitude. A closed leading-order expansion of $\mathcal{C}_{\mu\nu}^{\text{IFR}}$ in the dimensionless redundancy parameter $\varepsilon \equiv \mathcal{D}_{\text{red}}/\mathcal{D}_{\text{null}} \in [0,1]$, with coefficients determined by (α,β) and by the effective number of independent observer channels rather than introduced ad hoc, requires the renormalisation-group structure of Part VI and the Lorentzian reduction of Part V of the series. It is therefore developed there, and it is what converts the qualitative criterion (F7) below into a quantitative test against precision gravitational measurements.

3.10. Consistency Conditions

For the gravitational sector to be mathematically and physically consistent, IFR imposes the following conditions.

Metric emergence. There must exist a stable effective metric representation:

$$\left(\mathcal{E},\ell_{\Gamma}\tilde{d}_{\Gamma}\right)\to\left(\mathcal{M}_{\text{eff}},g_{\mu\nu}^{\text{eff}}\right)$$

with residual distortion

$$\epsilon_{\text{geo}}\ll 1.$$

Curvature correspondence. The informational scalar curvature must reduce to the Ricci scalar through the reduction to the event manifold followed by the informational Wick map, and not directly:

$$\mathcal{R}_{\mathcal{E}}^{(L)}:=R\left(\mathcal{W}\left[g_{\mathcal{E}}^{(R)}\right]\right)\to R\left(g_{\text{eff}}\right).$$

No direct reduction of the pre-Wick comparison scalar $\mathcal{R}_{\Gamma}$ on $\mathcal{M}$ to $R\left(g_{\text{eff}}\right)$ is asserted; see Theorem II.1 (H3).

Source correspondence. The informational stress tensor must reduce to the effective stress-energy tensor through the reduction map $\mathscr{R}$ of Theorem II.1 (H4):

$$\mathscr{R}\left[T^{\text{IFR}}\right]\to T_{\mu\nu}^{\text{eff}}.$$

Bianchi compatibility. In the effective limit, the correction tensor must satisfy

$$\nabla^{\mu}\left(\kappa_{\text{eff}}T_{\mu\nu}^{\text{eff}}+\mathcal{C}_{\mu\nu}^{\text{IFR}}\right)=0,$$

so that the effective Einstein tensor obeys the contracted Bianchi identity:

$$\nabla^{\mu}G_{\mu\nu}=0.$$

If $\mathcal{C}_{\mu\nu}^{\text{IFR}}\to 0$, then ordinary local stress-energy conservation follows:

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

Equivalence-principle limit.

In sufficiently small regions of the emergent manifold where the curvature of the effective metric is negligible,

$$R_{\mu\nu\rho\sigma}\left(g_{\text{eff}}\right)\approx 0,$$

in the same formulation as Section 3.13, there must exist local coordinates in which $g_{\mu\nu}^{\text{eff}}\approx\eta_{\mu\nu}$, and freely propagating objective structures follow approximately inertial trajectories.

This gives the IFR version of the equivalence principle.

3.11. Gravitational Correspondence Theorem

We now state the gravitational correspondence result in theorem form.

Theorem II.1 (Conditional gravitational correspondence). Let $(\mathcal{M},\Gamma)$ be a smooth information-geometric comparison manifold with scalar curvature $\mathcal{R}_\Gamma$. Let $\mathcal{Q}\subset\mathcal{M}$ be the set of stable IFR-objective centers generated by a stationary solution $(\Psi^\star,\Gamma^\star,\Pi^\star)$ of the IFR variational principle, with $(\mathcal{M},\Gamma)$ satisfying Assumption II.1 and with the reduced coupling $\kappa_{\text{red}}=\kappa_{\text{IFR}}/\ell_\Gamma^{d-3}$ of (M7) matched to κ_{eff}. Suppose that:

(H1) the dimensional reduction of Assumption II.1 (M7) has as image a *three*-dimensional submanifold $\mathcal{Q}_3(\lambda)\subseteq\mathcal{Q}$ of the stable centers, consistently with $[V_{\text{char}}]=L^3$; the fourth dimension is not a further coordinate on $\mathcal{M}$ but the emergent temporal order of Part III. The object carrying the effective representation is accordingly the four-dimensional *event manifold*

$$\mathcal{E}:=\{(Q,t):Q\in\mathcal{Q}_3(\lambda),t=t(\lambda)\},\quad \dim\mathcal{E}=3+1=\dim\mathcal{M}_{\text{eff}},$$

built from $\mathcal{Q}_3$ together with the arc-length parameter of Remark II.2, and we assume that $\mathcal{E}$ admits an effective differentiable manifold representation

$$\chi:\mathcal{E}\to\mathcal{M}_{\text{eff}},\quad e_i:=(Q_i^\star,t_i)\in\mathcal{E},$$

and carries a Riemannian pre-Wick metric $g_{\mathcal{E}}^{(R)}$ whose spatial sector is induced by the reduced comparison geometry on $\mathcal{Q}_3$ and whose remaining sector is induced by the construction of t. All statements below are made on $\mathcal{E}$, not on $\mathcal{M}$: the comparison metric g_Γ lives on $\mathcal{M}$ and enters only through the reduction;

(H2) the information-geometric distance is approximated by the geodesic distance of the Riemannian, pre-Wick effective metric $g_{\mathcal{E}}^{(R)}$, at the dimensional level of Assumption II.1 (M6), that is with the dimensionless comparison distance rescaled by ℓ_Γ. The statement is made at *equal time*, comparing only the spatial sector $g_{\mathcal{E},t}^{(R)}$ of the event metric on the slice $\mathcal{Q}_3(t)$: the left-hand side contains the separation of $Q_i^\star$ and $Q_j^\star$ alone and carries no information about t_i-t_j, so it cannot be equated with a four-dimensional distance. The temporal sector of $g_{\mathcal{E}}^{(R)}$ is supplied instead by the construction of dt in (H1):

$$\ell_\Gamma\tilde{d}_\Gamma(Q_i^\star,Q_j^\star)=d_{g_{\mathcal{E},t}^{(R)}}\left((Q_i^\star,t),(Q_j^\star,t)\right)+\mathcal{O}(\epsilon_{\text{geo}}),\quad t_i=t_j=t;$$

(H3) writing $g_{\mathcal{E}}^{(L)}:=\mathcal{W}\left[g_{\mathcal{E}}^{(R)}\right]$ for the image of the pre-Wick event metric of (H1) under the informational Wick map $\mathcal{W}$ of Part V, and assuming a *geometric reduction map*

$$\mathscr{R}_g:\mathcal{G}^\Gamma(\mathcal{M})\to\mathcal{G}_{\mathcal{E}}^{(R)},$$

the counterpart for the geometric side of the source reduction $\mathscr{R}$ of (H4), which carries the Einstein tensor of the comparison manifold to that of the pre-Wick event metric and whose construction, like that of $\mathscr{R}$, belongs to Part V; the pull-back of the effective metric then approximates $g_{\mathcal{E}}^{(L)}$ in the C^2 sense,

$$\chi^* g_{\text{eff}}=g_{\mathcal{E}}^{(L)}+\mathcal{O}_{C^2}(\epsilon_{\text{geo}}),$$

which yields the correspondence of the curvature *tensors*, and in particular, *for* *the post-Wick scalar of the event manifold*

$$\mathcal{R}_{\mathcal{E}}^{(L)} := R\left(\mathcal{W}\left[g_{\mathcal{E}}^{(R)}\right]\right), \quad \mathcal{R}_{\mathcal{E}}^{(L)} = R\left(g_{\text{eff}}\right) + \mathcal{O}\left(\epsilon_{\text{geo}}\right).$$

No such relation is asserted between $R\left(g_{\text{eff}}\right)$ and the comparison scalar $\mathcal{R}_\Gamma$ on $\mathcal{M}$: the two are related only through the reduction followed by $\mathcal{W}$, and the correspondence of Einstein tensors used below requires in addition that $\mathcal{W}$ intertwine the curvature construction, which is assumed here and established in Part V. Agreement of the scalar curvatures alone would not suffice, since the conclusion below is an identity between tensors. The Wick map cannot be omitted here: g_Γ is positive definite by (M3) while g_{eff} is Lorentzian, and since the signature of a non-degenerate metric is locally stable, no C^2-small perturbation can connect the two. The pre-Wick statement of (H2) is to be read on $g_{\text{eff}}^{(R)}$, and (H3) on its Wick image;

(H4) the informational stress tensor admits an effective spacetime representation. Since T_{ij}^{IFR} is a rank-two tensor field on the d-dimensional comparison manifold $\mathcal{M}$, obtained in Section 2.11 from the metric variation of a scalar density, while χ is defined on $\mathcal{E}$, the push-forward cannot be applied directly: a reduction map

$$\mathscr{R} : T^{\text{IFR}}\left(\mathcal{M}\right) \to T_{\mathcal{E}}^{\text{IFR}},$$

which integrates over the $d-3$ reduced directions and thereby carries the factor ℓ_Γ^{d-3} of (M7), must be applied first. The correspondence then reads

$$T_{\mu\nu}^{\text{eff}} = \chi_* \mathscr{R}\left[T^{\text{IFR}}\right] + \mathcal{O}\left(\epsilon_{\text{src}}\right);$$

the construction of $\mathscr{R}$ from the push-forward and the integration over the reduced directions belongs to Part V and is assumed here;

(H5) redundant dispersion is small, and the residual nonlocal structure of the comparison geometry is controlled:

$$\mathcal{D}_{\text{red}} = \mathcal{O}\left(\epsilon_{\text{red}}\right), \quad \epsilon_{\text{red}} \ll 1,$$
$$\left\|\mathcal{C}_{\mu\nu}^{\text{nonloc}}\right\| = \mathcal{O}\left(\epsilon_{\text{nonloc}}\right), \quad \epsilon_{\text{nonloc}} \ll 1,$$

where $\mathcal{C}_{\mu\nu}^{\text{nonloc}}$ is the nonlocal contribution isolated in Section 3.9.

Then the informational field equation

$$\mathcal{G}_{ij}^{\Gamma} = \kappa_{\text{IFR}} T_{ij}^{\text{IFR}}$$

induces an effective spacetime equation of the form

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

where

$$\mathcal{C}_{\mu\nu}^{\text{IFR}} = \mathcal{O}\left(\epsilon_{\text{geo}}\right) + \mathcal{O}\left(\epsilon_{\text{red}}\right) + \mathcal{O}\left(\epsilon_{\text{nonloc}}\right) + \mathcal{O}\left(\epsilon_{\text{src}}\right).$$

In the limit

$$\epsilon_{\text{geo}}, \epsilon_{\text{red}}, \epsilon_{\text{nonloc}}, \epsilon_{\text{src}} \to 0,$$

the effective dynamics reduce to Einstein-type gravitational dynamics:

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

Proof. By (H1) and (H2) the event manifold built from the stable objective centers admits an effective metric representation at the dimensional level of (M6), its spatial sector being fixed at equal time. The informational field equation $\mathcal{G}_{ij}^{\Gamma}=\kappa_{\mathrm{IFR}}T_{ij}^{\mathrm{IFR}}$ holds on $\mathcal{M}$, and the two sides are carried to $\mathcal{E}$ by the reduction maps of (H3) and (H4) respectively, so that the chain is

$$\mathcal{G}^{\Gamma}\xrightarrow{\mathscr{R}_g}\mathcal{G}_{\mathcal{E}}^{(R)}\xrightarrow{\mathcal{W}}\mathcal{G}_{\mathcal{E}}^{(L)}\xrightarrow{\chi}G\left(g_{\mathrm{eff}}\right),\quad T^{\mathrm{IFR}}\xrightarrow{\mathscr{R}}T_{\mathcal{E}}^{\mathrm{IFR}}\xrightarrow{\chi_*}T^{\mathrm{eff}}.$$

(H3) then identifies the pull-back of the effective metric with $g_{\mathcal{E}}^{(L)}$ in the C^2 sense, from which the correspondence of the curvature *tensors*, and hence of the Einstein tensors, follows; the scalar relation $\mathcal{R}_{\mathcal{E}}^{(L)}=R\left(g_{\mathrm{eff}}\right)+\mathcal{O}\left(\epsilon_{\mathrm{geo}}\right)$ is a consequence and not the hypothesis. Substituting these correspondences into the informational field equation yields the stated effective spacetime equation, with residual terms arising from the finite errors in metric representation, curvature correspondence, nonlocality, and redundant dispersion. Taking all residual errors to zero, including ϵ_{src}, gives the Einstein-type limit. □

This theorem does not assert that the full structure of general relativity is fundamental. It states the precise conditions under which general-relativistic dynamics emerge from IFR.

We stress that Theorem II.1 is a correspondence statement and not an existence statement. It asserts that *if* (H1)-(H5) hold on Ω, *then* Einstein-type dynamics follow with the stated residuals; it does not establish that any IFR realisation satisfies them, and in particular no mechanism is supplied here guaranteeing $\epsilon_{\mathrm{geo}}\ll 1$ (Section 3.17). The construction of such a mechanism remains open. What can be supplied, and is supplied in Section 3.12 below, is a set of finite-data diagnostics for the spatial and source components of (H1)-(H4), computable on any given finite family of stable centers, so that those components of the theorem's hypotheses are testable rather than merely stipulated. The geometric-reduction and Wick assumptions of (H3) are not decided by them.

3.12. Operational Diagnostics for the Correspondence Hypotheses

The hypotheses (H1)-(H4) of Theorem II.1 are stated as approximations controlled by ϵ_{geo} and ϵ_{src}. They are not thereby beyond empirical control: on a finite family of stable centers, the *spatial reconstruction* and *source correspondence* components of (H1)-(H4) reduce to computations on the matrix of comparison distances and on the reconstructed tensors, which are precisely the objects produced by the estimators of the series. We are explicit about the scope of what follows: the criteria below are finite-data diagnostics for those components, and they do not by themselves verify the full content of (H3), which further assumes the existence of the geometric reduction map $\mathscr{R}_g$, the informational Wick map $\mathcal{W}$, the intertwining of $\mathcal{W}$ with the curvature construction, and the four-dimensional structure of the event manifold. Those assumptions belong to Part V and are not decided here.

Proposition II.3 (Finite-data diagnostics for the spatial and source components of (H1)-(H4)). Let $\{Q_i^\star\}_{i=1}^m \subset \mathcal{Q}$ be a finite family of stable objective centers, let $D_{ij} = \tilde{d}_\Gamma(Q_i^\star, Q_j^\star)$, and let

$$B = -\frac{1}{2} J D^{(2)} J,\ D_{ij}^{(2)} = D_{ij}^2,\ J = I_m - \frac{1}{m}\mathbf{1}\mathbf{1}^\top,$$

with eigenvalues $\mu_1 \geq \mu_2 \geq \cdots \geq \mu_m$ and let $\hat{B}_k^+$ be the matrix obtained by retaining the k largest *positive* eigenvalues of B and discarding the remainder. Then:

(V1) *Reconstruction map and metric representability.* By Schoenberg's theorem the family admits an exact isometric representation in a k-dimensional Euclidean space if and only if $B \succeq 0$ and $\operatorname{rank} B \leq k$. Setting

$$\epsilon_{\mathrm{MDS}} := \frac{\sum_{j>k} |\mu_j|}{\sum_{j\geq 1} |\mu_j|},$$

the classical multidimensional-scaling reconstruction χ onto the leading k positive eigendirections satisfies, in nuclear norm, the exact identity

$$\left\| B - \hat{B}_k^+ \right\|_* = \sum_{\substack{j>k \\ \mu_j>0}} \mu_j + \sum_{\mu_j<0} |\mu_j|,$$

which reduces to $\sum_{j>k} |\mu_j|$ when the k retained eigenvalues are the k largest and are non-negative, and which controls the discrepancy between $D^{(2)}$ and the squared-distance matrix of the reconstruction. The quantity ϵ_{MDS} is a diagnostic for (H1)-(H2) and is to be distinguished from the embedding error ϵ_{geo} appearing in the theorem, which is a C^2 quantity; the negative eigenvalue mass of B is the obstruction to metric representability, and its vanishing is necessary, not sufficient, for (H3).

(V2) *Curvature correspondence.* Let κ_{OR} denote the Ollivier curvature of the δ-neighbourhood graph of $\{Q_i^\star\}$ with transport cost $\tilde{d}_\Gamma$, built from the centers alone and therefore carrying no temporal sector, so that the comparison below concerns the spatial slice and not the full four-dimensional Ricci curvature. The Ollivier curvature is dimensionless, and it is the *rescaled* quantity

$$\kappa_{\mathrm{OR}}^{\mathrm{resc}} := \frac{c_k}{r^2} \kappa_{\mathrm{OR}},\quad r := \ell_\Gamma \delta,$$

with δ the *dimensionless* neighbourhood radius measured in $\tilde{d}_\Gamma$, r the corresponding physical radius, and c_k the dimension-dependent constant of the discrete-to-continuum convergence results, that approximates the *Ricci* curvature under the stated sampling and scale conditions. The factor ℓ_Γ^{-2} implicit in r^{-2} cannot be omitted: κ_{OR} and δ are both dimensionless, whereas the Ricci curvature of $g_{\mathcal{E},t}^{(R)}$ has dimension L^{-2}. Hypothesis (H3) is accepted at level $1-\gamma$ when the averaged discrepancy between $\kappa_{\mathrm{OR}}^{\mathrm{resc}}$ and the Ricci curvature of the reconstructed *spatial* slice metric $g_{\mathcal{E},t}^{(R)}$ lies within the confidence interval obtained under the resampling protocol of the reproducibility appendix. No sectional-curvature comparison is implied, and no comparison with the unrescaled Ollivier curvature is meaningful.

(V3) *Source correspondence.* (H4) is tested by direct comparison of the two tensors through χ, with the reduction factor that (H4) itself carries,

$$\frac{\left\| \chi_* \mathscr{R}\left[T^{\mathrm{IFR}}\right] - T^{\mathrm{eff}} \right\|}{\left\| T^{\mathrm{eff}} \right\|} \le \epsilon_{\mathrm{src}},$$

both tensors living on $\mathcal{M}_{\mathrm{eff}}$ and the norm being taken with respect to the transported Riemannian pre-Wick metric $g_{\mathrm{eff}}^{(R)} := \chi_* g_{\mathcal{E}}^{(R)}$ there: a Lorentzian metric induces no positive-definite norm, so g_{eff} cannot be used, and $g_{\mathcal{E}}^{(R)}$ itself lives on a different manifold. The contracted Bianchi identity, $\left\| \nabla^{\mu} T_{\mu\nu}^{\mathrm{eff}} \right\| / \left\| T^{\mathrm{eff}} \right\| \le \epsilon_{\mathrm{Bianchi}}$, is retained as an auxiliary consistency check on the reconstruction: it verifies conservation, not correspondence, and it renders falsifiability criterion (F8) operational rather than declarative.

Criteria (V1)-(V3) do not prove that (H1)-(H4) hold. They convert the spatial-reconstruction and source-correspondence components of those hypotheses into quantities that can be estimated, with uncertainty, from a finite ensemble of objective centers, so that the conditional statement of Theorem II.1 acquires a definite empirical content in any given realisation. They do not by themselves verify the geometric-reduction and Wick assumptions of (H3). The corresponding computations are carried out on detector, cosmological and physiological ensembles in Part IV of the series.

3.13. Relation to the Equivalence Principle

The equivalence principle is recovered as a local property of the emergent metric representation. If, in a neighbourhood $\mathcal{U} \subset \mathcal{M}_{\mathrm{eff}}$ one has $R_{\mu\nu\rho\sigma}\left(g_{\mathrm{eff}}\right) \approx 0$, then there exist local coordinates in which $g_{\mu\nu}^{\mathrm{eff}} = \eta_{\mu\nu} + \mathcal{O}\left(|x|^2\right)$.

In such a neighbourhood, the informational geodesic equation reduces locally to inertial motion. Therefore, all freely propagating objective structures follow the same local inertial geometry, independent of their internal composition, provided they are coupled to the same emergent metric.

In IFR, the equivalence principle is therefore not primitive. It is a consequence of the universality of the effective metric representation of informational curvature.

The condition for its validity is not a direct passage from the comparison geometry to the effective metric, which Theorem II.1 (H1)-(H3) excludes, but the universality of the reconstruction chain itself:

$$\chi^* g_{\mathrm{eff}} = g_{\mathcal{E}}^{(L)} + \mathcal{O}_{C^2}\left(\epsilon_{\mathrm{geo}}\right)$$

with the *same* effective metric, reached through the same reduction and Wick maps, for every freely propagating objective structure in the relevant class.

Violations may occur only if different classes of objective structures couple to inequivalent effective geometries or if residual nonlocal informational corrections remain significant.

3.14. Interpretive Summary

The gravitational sector of IFR may be summarized by four statements:

1. Information geometry precedes spacetime geometry.
2. Persistent objective structures curve information geometry.
3. Effective spacetime curvature is the metric representation of informational curvature.
4. General relativity is recovered in the high-redundancy, low-dispersion, local-manifoldlimit.

Thus, gravity is not appended to IFR. It is one of the central consequences of the theory. The same mathematical mechanism that produces objectivity through multi-observer contraction also supplies the geometric structure that, in the effective limit, appears as gravitation.

The next section develops the complementary emergence of temporal order. Just as space and gravitation arise from stable information geometry, time arises from the ordered succession of stable objective centers.

3.15. Conceptual Novelty Relative to Existing Programs

The gravitational sector developed above shares vocabulary with several established programs, and it is therefore useful to state precisely where its specific content lies. Part I distinguished IFR from decoherence, quantum Darwinism and relational interpretations at the level of objectivity [1]; the distinctions relevant here concern dynamics.

The observer sector is dynamical, not diagnostic. In holographic and emergent-gravity programs [5]-[9], coarse-graining is a method of analysis applied to a theory whose action is already given. In IFR the redundant dispersion $\mathcal{D}_{\text{red}}$ appears *inside* the action, with coupling $\alpha > 0$: multi-observer agreement participates in selecting which configurations are realised and contributes to the source of informational curvature through T_{ij}^{red}, a term with no counterpart in those programs.

The kinetic term is forced. Because Postulate I denies $\mathcal{X}$ any differentiable or metric structure, the propagating term cannot be a gradient energy; unitary invariance on $\mathbb{P}(\mathcal{H}_{\mathcal{X}})$ then determines $\mathcal{K}_{\text{int}}$ uniquely up to normalisation [2] [3]. The resulting interference equation is second-order in λ rather than of Schrödinger type—a structural consequence of the fact that λ orders configurations without measuring duration.

Gravitation is not derived from spacetime notions. Thermodynamic and entropic derivations of the field equations begin from horizons, causal diamonds, or entanglement entropies defined on an existing manifold. The informational field equation $\mathcal{G}_{ij}^{\Gamma} = \kappa_{\text{IFR}} T_{ij}^{\text{IFR}}$ is written on the comparison manifold $\mathcal{M}$, whose points are observer-accessible informational structures, and is meaningful before any effective metric exists; Einstein dynamics appear only once the embedding conditions of Theorem II.1 are satisfied.

Deviations are structured, not free. The residual tensor $C_{\mu\nu}^{\mathrm{IFR}}$ is not a phenomenological addition. Its four components are tied to identifiable failures—finite redundancy, non-locality, imperfect embedding, observer-family dependence—and each is expected to vanish in a regime that can be characterised independently. This is what makes the framework discriminating rather than merely reinterpretive.

3.16. Falsifiability Criteria

Part I stated criteria (F1)-(F5) for the objectivity sector [1]. The dynamical and gravitational content of Part II adds the following, with the outcomes that would count as failure.

(F6) *Orientation of the gravitational sector.* The semiclassical matching of Section 2.4 fixes $\beta > 0$ with $\beta / V_{\mathrm{char}} = +1/(2\kappa_{\mathrm{eff}})$ and therefore an attractive emergent gravitational sector. This is not adjustable: the framework cannot accommodate a repulsive sign without abandoning the correspondence condition. *Failure*: any consistent derivation within the framework yielding $\beta < 0$ in the semiclassical limit.

(F7) *Correlation of deviations with redundancy.* IFR predicts that departures from Einstein dynamics are controlled by
$C_{\mu\nu}^{\mathrm{IFR}} = O(\epsilon_{\mathrm{geo}}) + O(\epsilon_{\mathrm{red}}) + O(\epsilon_{\mathrm{nonloc}}) + O(\epsilon_{\mathrm{src}})$ and therefore appear only where redundancy, metric embedding, or locality degrade. *Failure*: systematic deviations from general relativity in regimes of demonstrably high observer redundancy and small ϵ_{geo}, or the absence of any deviation in regimes where these quantities are independently shown to be large.

(F8) *Bianchi compatibility.* The contracted Bianchi identity requires
$\nabla^{\mu}\left(\kappa_{\mathrm{eff}} T_{\mu\nu}^{\mathrm{eff}} + C_{\mu\nu}^{\mathrm{IFR}}\right) = 0$. This is a non-trivial constraint on the correction tensor, not a definition of it. *Failure*: a correction tensor required by the informational dynamics that cannot be made compatible with the identity without introducing additional free structure.

(F9) *Universality of the effective metric.* The equivalence principle is recovered only if all classes of objective structures couple to the same emergent metric. *Failure*: a composition-dependent coupling, that is, distinct classes of stable centers following geodesics of inequivalent effective geometries in the same region, beyond the bound set by ϵ_{geo}.

Criteria (F6) and (F8) are internal consistency tests, decidable within the formalism. Criteria (F7) and (F9) are empirical and become operational once the correspondence chain of Part III is completed and the estimators of Part IV are applied.

3.17. Scope and Limitations

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

The action is minimal, not complete. Only $\mathcal{K}_{\text{int}}$ is determined from first principles. The informational potential $\mathcal{V}_{\text{int}}$ is restricted, in Section 2.6, to the gauge-invariant class $F\left(\rho_{\mathfrak{A}}\right)$ and to the low-order form (9), but neither the coefficients $\left(\hat{H}_0, g\right)$ nor the retained higher-order terms $\mathcal{O}\left(\|\sigma\|^3\right)$ are fixed here; the restriction is adopted and not derived. The observer-kinematic term $\mathcal{L}_\Pi$ is left unspecified and is frequently set to zero, and the dynamics of Γ itself is determined only implicitly, through the stationarity condition. A predictive dynamics requires all of these to be fixed, and none is fixed here.

The gravitational correspondence is conditional. Theorem II.1 does not derive general relativity from IFR. It states the conditions—the existence of an effective manifold representation, the approximation of $\ell_\Gamma \tilde{d}_\Gamma$ by a geodesic distance, the curvature and source correspondences, and small redundant dispersion—under which Einstein-type dynamics follow. That these conditions are attainable for physically realised configurations is assumed, not proven. In particular no mechanism is given here that would guarantee $\epsilon_{\text{geo}} \ll 1$.

The couplings are not derived. The relation between κ_{IFR} on the comparison manifold and κ_{eff} in the emergent spacetime is imposed by matching, not computed. The dimensional normalisation of β involves a characteristic volume V_{char} of the region of $\mathcal{M}$ on which $\mathcal{R}_\Gamma$ is evaluated, which is likewise not derived. The same holds for $\hbar_{\text{IFR}}$ and m_Ψ, whose identification is deferred to Part III.

The generating functional is formal. Z_{IFR} is written as an integral over interference states, comparison geometries and observer projections. No measure has been constructed on any of these spaces, and no renormalisation programme is carried out; that is the subject of Part VI. The saddle-point statements of Section 2 should be read accordingly.

Smoothness is assumed where it is convenient. The informational field equation is derived in a smooth Riemannian realisation of $(\mathcal{M}, \Gamma)$. Part I already noted that non-smooth comparison geometries require generalised curvature notions; the variational derivation given here does not extend to those cases without further work. The regularity actually used is now stated in full as Assumption II.1: smoothness (M1), finite dimension $d = \dim \mathcal{M}$ (M2), positive-definite signature (M3), a relatively compact geodesically convex domain with Dirichlet data and a Gibbons-Hawking-York term (M4), contractible topology (M5), and the metric normalisation (M6). Nothing outside this class is claimed.

The interpretation of the informational length scale is deferred. The dimensional bookkeeping is closed by the single scale ℓ_Γ of (M6)-(M7). We do not claim that ℓ_Γ is thereby determined: the matching relation links it to κ_{IFR} without fixing either, so ℓ_Γ is not independent once the coupling ratio is independently fixed, and conversely. What is not supplied here is its physical interpretation as the scale at which multi-observer redundancy performs the reduction from d to three effective dimensions. That identification is the content of the dimensional-reduction argument of Parts V and VI, where holography appears as a consequence of redundancy rather than as a postulate; until it is established, the matching $\beta/V_{\mathrm{char}} = 1/(2\kappa_{\mathrm{eff}})$ should be read as conditional on that reduction.

The potential is restricted, not derived. Section 2.6 restricts $\mathcal{V}_{\mathrm{int}}$ to the gauge-invariant class $F(\rho_{\mathfrak{A}})$ and to the low-order form (9), and specifies a concrete parametrised finite-dimensional realisation (I1)-(I5). We are careful about what this buys: every observer-side and statistical quantity entering the chosen *truncated* realisation is computable once the truncation of $\mathcal{V}_{\mathrm{int}}$, the observer-kinematic term $\mathcal{L}_{\Pi}$ and the off-shell dynamics of Γ are specified. None of those three is specified here, the restriction to the gauge-invariant class is adopted rather than proved, and the coefficients $(\hat{H}_0, g)$ remain to be fixed empirically.

The Schrödinger sector is conditional. Proposition II.2 recovers first-order quantum evolution from the Kähler structure of $\mathbb{P}(\mathcal{H}_{\chi})$, but only under hypothesis (S3), the existence of a first-order invariant manifold on which the second-order interference dynamics reduces to a Hamiltonian flow. No construction of that manifold is given here, and its existence, or a proof of its non-existence, is an open problem of the programme. The global phase of Ψ is gauge on projective space and cannot substitute for it.

The status of Chentsov uniqueness is a resolved but non-trivial point. As recorded in Remark II.3, the variability of Γ is compatible with Chentsov's theorem only because monotonicity is imposed asymptotically, in the limit $\mathcal{D}_{\mathrm{red}} \to 0$, rather than kinematically. The consequence—that the comparison geometry is predicted to flow towards the constant-curvature Fisher-Rao geometry in the high-redundancy regime—is a testable claim whose analysis belongs to Part VI and is not carried out here.

These are not defects concealed by the construction but the precise boundary of what Part II establishes: a well-posed variational principle with a determined kinetic sector, and a gravitational correspondence whose hypotheses are stated in full.

Observational consequences. The observable consequences of the gravitational sector developed above are tested empirically in Part IV of the series, through the multi-observer contraction of detector, cosmological, and physiological ensembles; the corresponding cross-domain estimators and null tests were introduced in [12] [13].

Continuation of the series. Part III develops the emergence of temporal order and the semiclassical and effective-field limits.

4. Conclusions

This paper has presented Part II of the Interference-First Reality (IFR) series, supplying the dynamical principle on which the kinematic foundations of Part I [1] were silent.

We have, first, formulated the IFR variational principle (Section 2). The defining action (1) integrates over the ordering parameter *and* over a comparison domain $\Omega \subset \mathcal{M}$ carrying the Riemannian volume measure $\mathrm{d}\mu_{\Gamma}$, whose regularity, dimension, signature, boundary data, topology and metric normalisation are fixed in Assumption II.1; its reduced form, $\mathcal{S}_{\text{IFR}} = \int_I \mathrm{d}\lambda \left[\mathcal{K}_{\text{int}} - \mathcal{V}_{\text{int}} - \alpha \mathcal{D}_{\text{red}} + \beta \bar{\mathcal{R}}_\Gamma + \mathcal{L}_{\Gamma\Pi} \right]$, follows by Lemma II.1 and carries the mean curvature $\bar{\mathcal{R}}_\Gamma$ with characteristic volume $V_\Gamma(\Omega)/\ell_\Gamma^{d-3}$. It combines interference propagation, informational self-organisation, multi-observer contraction and informational curvature in a single stationarity condition $\delta \mathcal{S}_{\text{IFR}} = 0$. We fixed the orientation and dimensional normalisation of the curvature coupling, $\beta > 0$ with $\beta / V_{\text{char}} = +1/(2\kappa_{\text{eff}})$, as required by the semiclassical matching to the Einstein-Hilbert action, and showed that the kinetic term is not a free choice: the prohibition on differentiable structure over $\mathcal{X}$, together with unitary invariance, selects the Fubini-Study form uniquely [2] [3]. The resulting interference equation is second-order in the ordering parameter, with the Schrödinger equation recovered only conditionally, as the Hamiltonian sector of the Kähler structure of $\mathbb{P}(\mathcal{H}_\mathcal{X})$ on the stable-state manifold (Proposition II.2), under the hypotheses of Assumption II.2. Variation with respect to Ψ, Γ and Π yields the interference equation, the geometric equation and the observer condition respectively, and the classical limit requires both stationarity and low redundant dispersion—a saddle point alone does not define a classical object.

Second, we have developed the gravitational sector (Section 3). Persistent objective structures deform the geometry of distinguishability, and this deformation is encoded in an informational stress tensor T_{ij}^{IFR} containing a contribution T_{ij}^{red} specific to multi-observer contraction. The resulting informational field equation $\mathcal{G}_{ij}^\Gamma = \kappa_{\text{IFR}} T_{ij}^{\text{IFR}}$ is a curvature equation on the comparison manifold, meaningful before any spacetime exists. Theorem II.1, a conditional correspondence result and not an existence result, states the conditions—effective manifold representation, metric approximation of $\ell_\Gamma \tilde{d}_\Gamma$, curvature and source correspondence, small dispersion—under which it induces $G_{\mu\nu}(g_{\text{eff}}) = \kappa_{\text{eff}} T_{\mu\nu}^{\text{eff}} + C_{\mu\nu}^{\text{IFR}}$, reducing to Einstein dynamics as the residual errors vanish. Geodesic motion appears as informational extremality, mass-energy as persistent informational constraint, and the equivalence principle as the universality of the effective metric representation rather than as a primitive assumption.

Third, we have stated where the construction is discriminating and where it is conditional. Criteria (F6)-(F9) extend the falsifiability list of Part I to the dynamical sector, and the scope statement makes explicit that $\mathcal{V}_{\text{int}}$ and $\mathcal{L}_{\Gamma\Pi}$ remain unspecified, that the gravitational correspondence is conditional on hypotheses assumed rather than derived, that the couplings are matched rather than computed, and that the generating functional remains formal.

A structural consequence deserves emphasis. Holographic organisation, which in the applied formulation preceding this work [4] was introduced as a postulate in the tradition of [5]-[9], is not assumed anywhere in Part II: dimensional reduction follows from the finite-accessibility condition on observer maps together with the requirement that only redundantly encoded structure survives contraction. Holography is thus a consequence of the IFR architecture rather than an independent principle—a result of the dynamics, not an input to it.

The central conclusion of Part II is that gravitation need not be added to an information-theoretic theory from outside. The same variational structure that selects interference configurations compatible with stable multi-observer contraction also renders the geometry of distinguishability dynamical, and it is the curvature of that geometry which, in the high-redundancy limit, is seen as gravitation. The emergence of temporal order from ordered sequences of stable Fréchet centers, the semiclassical and Lorentzian limits, the empirical implementation across cosmological, gravitational-wave and physiological ensembles, and the renormalisation-group flow of the framework are developed in the subsequent parts of the series.

Acknowledgements

The author thanks the editorial team of JAMP for their professional handling of previous submissions, and acknowledges managing editor *Nancy Ho* for her commitment to high publication standards. The author also thanks the Planck Legacy Archive, GWOSC, JWST/JADES and PhysioNet teams for maintaining the open-access repositories on which the empirical parts of the series rely.

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.

Data Availability

Part II is variational and geometric and contains no new empirical analysis. The datasets underlying the empirical program of the series are all publicly available: CMB spectra (TT, TE, EE) from the Planck 2018 legacy release [19], with theoretical background in [20] [21]; gravitational-wave strain data (GW150914-v2, GW170817-v2) from GWOSC; ECG/HRV records from PhysioNet [22] (*Fantasia* and *MIT-BIH Arrhythmia*), with PSD estimated by the Welch method [23] and band definitions following [24]; and JWST spectroscopy from the public JADES release [25]. No raw ECG signals are redistributed. All datasets, Python scripts and LaTeX materials are openly available on Zenodo, https://doi.org/10.5281/zenodo.17672528; the complete theoretical formulation of the IFR framework, of which this paper is Part II of VI, is available as a preprint at 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 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 II is a variational and geometric paper: it contains no new empirical results, data tables, numerical analyses or figures, and there is therefore no data pipeline to reproduce within Part II itself. For continuity with the series we note that the full empirical program of IFR—heart-rate variability, the cosmic microwave background, gravitational-wave open data, JWST spectroscopy, large-scale structure and their cross-domain synthesis—is documented in the data-oriented publications [12] [13] and in the supplementary file *Reproducibility_sequence.txt*, which lists the commands, input specifications, execution order and outputs for every figure and table of those works, including both computational pathways used for the CMB analysis. All information-geometric quantities used across that 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; property-based and on-data equivalence tests confirm that this consolidation leaves all previously reported results numerically unchanged, with a maximum discrepancy below 10^{-13}. All datasets, analysis scripts and LaTeX materials are openly available at https://doi.org/10.5281/zenodo.17672528; the module ifr_core, its verification routines and the ready-to-run launcher packages for macOS and Windows are archived at https://doi.org/10.5281/zenodo.20528552.

Conflicts of Interest

The author declares no conflict of interest.

References

[1] Bianchi, M. (2026) Interference-First Reality Theory: Foundations and Objectivity—Postulates, Mathematical Structure, and Emergent Objectivity [IFR Theory Series, Part I of VI]. *Journal of Applied Mathematics and Physics*, **14**, 2735-2772. https://doi.org/10.4236/jamp.2026.147137

[2] Wootters, W.K. (1981) Statistical Distance and Hilbert Space. *Physical Review D*, **23**, 357-362. https://doi.org/10.1103/physrevd.23.357

[3] Anandan, J. and Aharonov, Y. (1990) Geometry of Quantum Evolution. *Physical Review Letters*, **65**, 1697-1700. https://doi.org/10.1103/physrevlett.65.1697

[4] Bianchi, M. (2025) Quantum Holographic Consciousness Theory (QHCT): A Lagrangian Formulation of an Interference-First Holographic Framework and Planck-Oriented Validation. *Neuroquantology*, **23**, 166-187.

[5] Bekenstein, J.D. (1973) Black Holes and Entropy. *Physical Review D*, **7**, 2333-2346. https://doi.org/10.1103/physrevd.7.2333

[6] 't Hooft, G. (1993) Dimensional Reduction in Quantum Gravity, Salamfestschrift: A Collection of Talks. World Scientific. arXiv:gr-qc/9310026.

[7] Susskind, L. (1995) The World as a Hologram. *Journal of Mathematical Physics*, **36**, 6377-6396. https://doi.org/10.1063/1.531249

[8] Bousso, R. (2002) The Holographic Principle. *Reviews of Modern Physics*, **74**, 825-

874. https://doi.org/10.1103/revmodphys.74.825

[9] Maldacena, J. (1998) The Large-N Limit of Superconformal Field Theories and Supergravity. *Advances in Theoretical and Mathematical Physics*, **2**, 231-252. https://doi.org/10.4310/atmp.1998.v2.n2.a1

[10] Zeh, H.D. (1970) On the Interpretation of Measurement in Quantum Theory. *Foundations of Physics*, **1**, 69-76. https://doi.org/10.1007/bf00708656

[11] Zurek, W.H. (2009) Quantum Darwinism. *Nature Physics*, **5**, 181-188. https://doi.org/10.1038/nphys1202

[12] Bianchi, M. (2025) Information Geometry, Coherence, and the Emergence of Time: A Cross-Domain Analysis from Cosmology to Physiology. *Journal of Applied Mathematics and Physics*, **13**, 4355-4378. https://doi.org/10.4236/jamp.2025.1312240

[13] Bianchi, M. (2026) Interference-First Reality: Multi-Observer Emergence of Objectivity and Time from Information Geometry. *Journal of Applied Mathematics and Physics*, **14**, 1627-1674. https://doi.org/10.4236/jamp.2026.144077

[14] Amari, S. and Nagaoka, H. (2000) Methods of Information Geometry. American Mathematical Society.

[15] Shannon, C.E. (1948) A Mathematical Theory of Communication. *Bell System Technical Journal*, **27**, 623-656. https://doi.org/10.1002/j.1538-7305.1948.tb00917.x

[16] Lin, J. (1991) Divergence Measures Based on the Shannon Entropy. *IEEE Transactions on Information Theory*, **37**, 145-151. https://doi.org/10.1109/18.61115

[17] Fréchet, M. (1948) Les Éléments Aléatoires de Nature Quelconque dans un Espace Distancié. *Annales de l'Institut Henri Poincaré*, **10**, 215-310.

[18] Sturm, K.T. (2003) Probability Measures on Metric Spaces of Nonpositive Curvature. In: Auscher, P., *et al*, *Heat Kernels and Analysis on Manifolds*, *Graphs*, *and Metric Spaces*, American Mathematical Society, 357-390.

[19] Planck Collaboration (2020) Planck 2018 Results. I. Overview and the Cosmological Legacy of Planck. *Astronomy & Astrophysics*, **641**, A1. https://doi.org/10.1051/0004-6361/201833880

[20] Hu, W. and Sugiyama, N. (1996) Small-Scale Cosmological Perturbations: An Analytic Approach. *The Astrophysical Journal*, **471**, 542-570. https://doi.org/10.1086/177989

[21] Hu, W. and Dodelson, S. (2002) Cosmic Microwave Background Anisotropies. *Annual Review of Astronomy and Astrophysics*, **40**, 171-216. https://doi.org/10.1146/annurev.astro.40.060401.093926

[22] Goldberger, A.L., Amaral, L.A.N., Glass, L., Hausdorff, J.M., Ivanov, P.C., Mark, R.G., *et al*. (2000) PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. *Circulation*, **101**, e215-e220. https://doi.org/10.1161/01.cir.101.23.e215

[23] Welch, P.D. (1967) The Use of Fast Fourier Transform for the Estimation of Power Spectra. *IEEE Transactions on Audio and Electroacoustics*, **15**, 70-73. https://doi.org/10.1109/tau.1967.1161901

[24] Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) Heart Rate Variability: Standards of Measurement, Physiological Interpretation and Clinical Use. *European Heart Journal*, **17**, 354-381.

[25] Eisenstein, D.J., Willott, C., Alberts, S., *et al*. (2026) Overview of the JWST Advanced Deep Extragalactic Survey (JADES). *The Astrophysical Journal Supplement Series*, **283**, Article 6.

Abbreviations

CMB	Cosmic Microwave Background
GWOSC	Gravitational Wave Open Science Center
HRV	Heart Rate Variability
IFR	Interference-First Reality
JS/JSD	Jensen-Shannon Divergence/Distance
JWST	James Webb Space Telescope
PSD	Power Spectral Density