The Ignorant Observer inside Everett

A Finite-Record Quotient Theory

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Abstract

The Ignorant Observer Framework (IOF) reads wavefunction "collapse" and the arrow of time as artifacts of a finite observer tracking a chaotic reference through a finite-rate channel. This paper states the framework as it stands after a sequence of foundational refinements, read as a *finite-record quotient theory hosted by a no-collapse interpretation*, and develops the reading in which that host is Everettian quantum mechanics. The operational core is host-independent: the self-ignorance rate $\kappa = h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2$, the sign-reversal signature, the binary Born form recovered from record geometry, and the production-rate scoping result are unchanged under a change of host. Everett is adopted as the *preferred*, not exclusive, host: among currently viable no-collapse interpretations it is the most developed, requires no new physics, and evades the Bell dilemma by rejecting single outcomes rather than measurement independence, without nonlocality or a fine-tuning defense. Within it, κ supplies the intra-branch epistemic cut. The framework rests on four load-bearing results, stated here and developed in companion papers—the binary-Born and phase-limit results proved in published companions, the record-quotient and inequality results at working-note stage: (i) a record-quotient theorem (conditional on a physically selected accessible record algebra), in which decoherence realizes the modulus map and Fisher–Rao geometry is the host's projective metric restricted to the record base; (ii) a phase-limit theorem, by which relative phase is not generated as an invariant of finite-record geometry and stays host-side; (iii) an exact reference-closure obstruction of Breuer non-factorization type, accompanied by a banked data-rate inequality $\kappa_{\mathrm{op}} \geq h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2$; and (iv) an emergent-reference-rate theorem fixing the production rate h_{KS} as an einselected, semiclassical quantity rather than a closed-quantum invariant, so the framework is a quantum-host plus semiclassical-chaos hybrid by necessity. I separate the Born *form* (which finite-record kinematics reaches) from the existence and multi-outcome content of the Born measure (which stay host-side): Deutsch–Wallace is thereby shifted, for binary records, from source of the amplitude-squared form to rational-use layer for a measure whose calibrated binary form is independently recovered. If the BLQC and Fisher-homogeneity modules survive experiment, the operational reference-channel control law is physically calibrated within standard quantum mechanics; this supports the operational layer but does not discriminate the no-collapse interpretation from standard quantum mechanics. Conditional on the host-side Born and rational-use machinery and the accessible record algebra selected by decoherence and finite capacity, this leaves Everett+IOF a complete no-collapse account. The paper names the residuals: the probability-existence and use problems, the multi-outcome measure, the accessible-record-algebra selection inherited from decoherence, and the unrun confirming experiment.

1 Introduction and Position

The Ignorant Observer Framework treats the measurement basis not as a primitive of the formalism but as a physical reference variable $\theta(t)$ that a finite observer must track through a channel of bounded rate [1, 2]. The keystone quantity is the self-ignorance rate

$$\kappa = h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2,$$

the gap between the information-production rate h_{KS} of the reference dynamics and the useful tracking capacity C_{eff}. Here κ is the structural deficit rate κ_{def}, and its positive sign is the banked converse threshold. When $\kappa_{\mathrm{def}} < 0$ the data-rate obstruction does not bite, so fixed-basis quantum mechanics is operationally available in the sense that this bound supplies no obstruction to holding the reference. When $\kappa_{\mathrm{def}} > 0$, Section 5 establishes that the realized growth rate is bounded below by it, $\kappa_{\mathrm{op}} \geq \kappa_{\mathrm{def}}$, so the observer cannot keep bounded tracking error; before saturation the unresolved basis variance grows at least exponentially, producing a visibility attenuation $V_{\mathrm{IOF}} = \exp(-\sigma_\theta^2/2)$. Equality and positive achievability on the negative side are stronger identity/optimal-coding claims not made here. The signature that distinguishes this mechanism from ordinary thermal decoherence is a sign reversal: increasing the observer's tracking power should *extend* coherence, not shorten it.

This much is operational. It is a control-theoretic statement about a reference loop, fully inside standard quantum mechanics, and it commits to no interpretation of the quantum state. But the framework also carries an ontological reading: that the appearance of a single definite history to a finite embedded observer is the record-level shadow of an underlying deterministic, unitary substrate. That reading needs a host—an interpretation that supplies Hilbert space, composition, unitary dynamics, and the Born measure—on whose finite-record quotient the IOF works. The companion paper on the measurement basis states the relationship plainly: the IOF is "a modifier on an existing interpretation, not a replacement for one," and "swap the host and both the machinery and its exposure to refutation are unchanged" [2].

This paper takes that host to be Everettian quantum mechanics and develops the resulting picture in full. The reframed question is:

> *Why does a deterministic, unitary, no-collapse substrate appear to a finite, embedded observer as a single world of definite classical records governed by Born weights?*

The answer assembled here is that the observer sees the *finite-record quotient* of the host state: the projection that survives decoherence, coarse-graining, and finite tracking. The quotient has its own invariant geometry (Fisher–Rao), its own probability form (the binary Born weight), its own exact closure obstruction (non-factorization of the reference), and its own rate law (κ). The IOF is the theory of that quotient.

The position stated up front. Four commitments fix the standing of everything that follows, and I state them before the development rather than after it.

1. **The operational core is host-independent.** The rate κ, the sign-reversal signature, the binary Born form, and the production-rate scoping result are facts about finite tracking and quantum dynamical entropy. They hold under any no-collapse host. The host supplies vocabulary and an ontology for the records; it does not supply the machinery.
2. **Everett is the preferred host, not the exclusive one.** Among currently viable hosts, Everettian mechanics is the most developed, requires no new fundamental physics, and

sidesteps Bell's hidden-variable dilemma by rejecting the single-outcome premise—not the measurement-independence (setting-independence) premise: with no single global outcome to reconcile with the setting, the nonlocality-or-fine-tuning fork that single-history accounts must face does not arise. Within Everett, κ supplies the intra-branch epistemic cut. I decline the unconditional claims that Everett is *settled* or that the picture is complete before its empirical modules are run. The full Born rule still carries contested measure-sourcing, multi-outcome/contextual-extension, and rational-use questions; the record-based result secures only the binary form and relocates rather than removes the measure question; and the choice among empirically equivalent no-collapse hosts is interpretation, not experiment. A conditional completeness claim is nevertheless available: granting the host's Born and rational-use machinery and the accessible record algebra selected by locality, decoherence, redundancy, and finite capacity, and supposing the IOF modules survive experiment, Everett+IOF becomes a complete hosted account of unitary substrate, emergent branches, branch-local records, binary weighting, and finite-observer recoverability.

3. **Deutsch–Wallace changes role.** Everett no longer has to ask decision theory to generate the calibrated binary amplitude-squared weight from nothing. Theorem 3.1 gives an independent, record-geometric route to the binary Born form, conditional on the stated record and calibration premises. Deutsch–Wallace is therefore shifted, for the binary case, from a derivation of the measure's form to a rational-use theorem for an objective measure whose binary record form is already physically grounded. This is not a complete replacement: the existence of a measure, its multi-outcome/contextual extension, and the use of that measure as credence or caring weight remain host-side.

4. **Single-history and pilot-wave hosts are kept as live, scoped alternatives.** In a single-history host (Palmer's invariant-set program, 't Hooft's cellular-automaton interpretation) κ does more work, not less: its concealment result answers the *detectability* form of the superdeterminism conspiracy objection. In a pilot-wave host the IOF is the finite-observer epistemic layer over the hidden variables. Preference directs primary research; it does not close inquiry. Concentrating the framework's exposure on a single contested host would convert host-independence—an asset—into a liability, so I keep the books separate.

The rest of the paper follows the stack layer by layer. Section 2 states the layered architecture and the modulus map. Sections 3 and 4 develop the first bridge—record geometry to the binary Born form—and the phase limit that bounds it, giving the Born *split*. Section 5 develops the second bridge—the exact reference-closure obstruction and the banked κ inequality. Section 6 states the emergent-reference-rate theorem that fixes the production rate as a semiclassical quantity. Section 7 treats decoherence, the two visibility channels, and the movable recoverable cut. Section 8 states the division of labour host by host. Sections 9–10 give the scope and the standing objections, and Section 11 concludes.

2 The Layered Architecture

The host supplies the substrate at the base of the stack; the IOF works the finite-record quotient that decoherence leaves. Figure 1 draws the architecture in the orientation of Figure 1 of [1]—the host substrate at the foot, the finite observer at the top—with the maps that connect the layers as the rungs.

Read upward from the foot, the layers and the maps between them are these. The **host** is the projective state space $\mathbb{CP}^{n-1}$, with its Fubini–Study/Kähler geometry and the full Born measure, evolving unitarily by $U(t)$. Partial trace and dephasing carry it to the **decohered branch**: the reduced state ρ_O, diagonal in the einselected pointer basis (read as branch weights or as one branch's conditioned state, per Remark 2.3). The pointer-diagonal POVM readout $M_\theta : \rho_O \mapsto p_i(\theta)$ then yields the **finite record**, a classical readout algebra whose states are probability vectors on the simplex Δ_n. These records admit finite stochastic recodings $K : \Delta_n \to \Delta_m$—relabel, coarse-grain, forget—and, restricting to those that are *sufficient* Markov morphisms, Chentsov's theorem selects the **Fisher–Rao** manifold $(\Delta_n^\circ, g_{\mathrm{FR}})$ as the unique invariant record geometry, the one on which the binary weight is $\cos^2(\theta/2)$. At the top sits the **constructor**: the finite observer, with its reference dynamics, basis functional Θ, internal model m_t, and tracking rate $\kappa = h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2$. The slogan that organizes the division of labour is: *the host owns* $\mathbb{CP}^{n-1}$*; the IOF owns the* Δ_n *projection.*

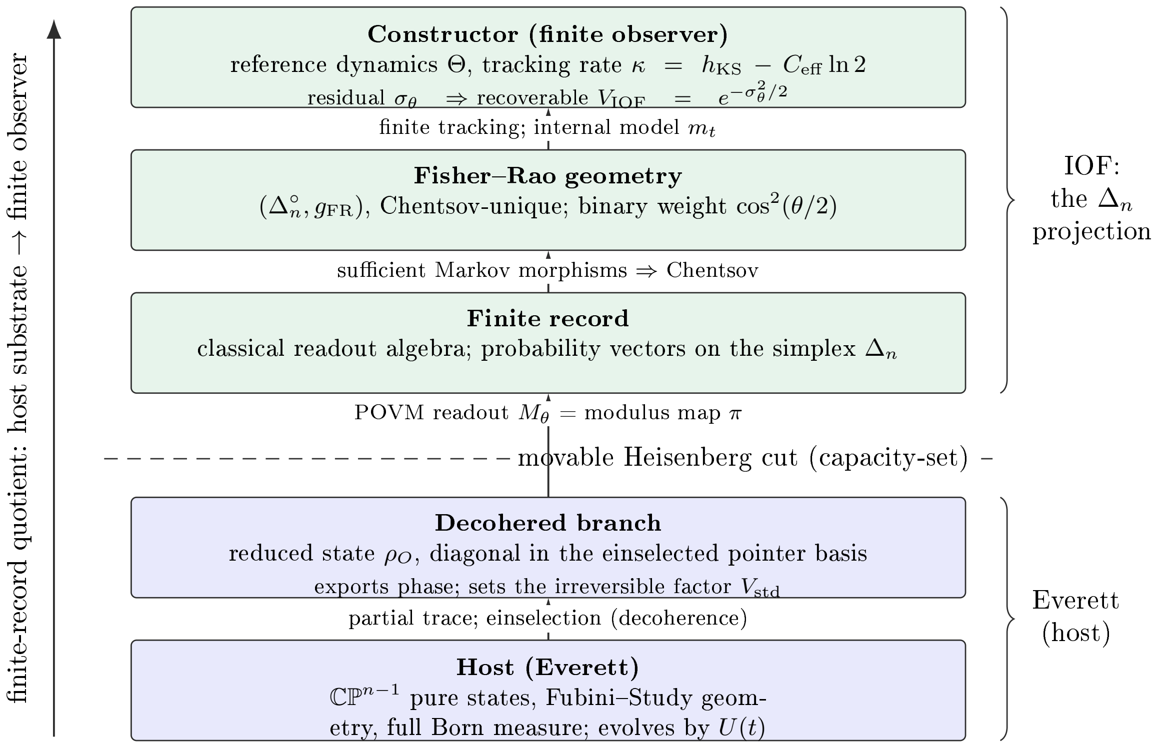

Figure 1: The Everett–IOF stack, read as a finite-record quotient, in the orientation of Figure 1 of [1]: the host substrate at the foot, the finite observer at the top. The labelled maps, read upward, carry the host's projective state space to the finite record the observer reads and the constructor that tracks it. Decoherence (partial trace and einselection) realises the modulus map π on the pointer record; the movable, capacity-set Heisenberg cut marks where the quantum description becomes a classical record; sufficient Markov morphisms select Fisher–Rao geometry by Chentsov's theorem; the finite constructor tracks the reference at rate $\kappa = h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2$. Taking the two smearings to be statistically independent, the observed contrast factors as $V_{\mathrm{obs}} = V_{\mathrm{std}}\, V_{\mathrm{IOF}}$: the irreversible decoherence factor V_{std} at the cut and the recoverable reference-averaging factor $V_{\mathrm{IOF}} = e^{-\sigma_\theta^2/2}$ at the tracking layer. That figure's single classical layer is here resolved into the record geometry the present paper concerns.

The map that carries the host state onto the record base is the modulus map.

Definition 2.1 (Modulus map)**.** In the instantaneous basis $\{|i_\theta\rangle\}_{i=1}^n$, the modulus map is

$$\pi_\theta : \mathbb{CP}^{n-1} \longrightarrow \Delta_n, \qquad [\psi] \longmapsto \big(|\langle i_\theta|\psi\rangle|^2\big)_{i=1}^n.$$

It forgets the relative-phase fibre and keeps the squared-modulus vector—a point of Δ_n that is a probability vector under the host's Born measure or the record kinematics of Section 3.

Three points of discipline attach to this architecture, and they recur throughout.

Remark 2.2 (Decoherence exports phase; it does not destroy it). The host evolves unitarily. Premeasurement plus environmental decoherence sends $|i_\theta\rangle|A_0\rangle|E_0\rangle \mapsto |i_\theta\rangle|A_i\rangle|E_i(\theta)\rangle$ with $|\langle E_i|E_j\rangle| \leq \varepsilon$, so the observer's pointer record becomes diagonal up to ε. The relative phase is not annihilated; it is moved into system–environment correlations and made locally inaccessible. One should say "decoherence realizes π_θ on the observer's pointer-record algebra," never "decoherence destroys phase."

Remark 2.3 (Which state). The reduced state is read two ways and they must not be conflated. The *unconditioned* reduced state $\rho_O \simeq \sum_\alpha |c_\alpha|^2 |O_\alpha\rangle\langle O_\alpha|$ gives branch *weights*. The *branch-conditioned* state $\rho_O^{(\alpha)}$ gives intra-branch future readout within one branch. The mathematics is the same; the reading differs.

Remark 2.4 (The record simplex is a kinematic interface). The IOF does not postulate finite records ex nihilo. In the hosted reading they are produced by decoherence, coarse-graining, and finite tracking capacity. What is used as the record-level interface is this: once the host has produced a stable pointer-record algebra, its mutually exclusive record alternatives may be represented by normalized additive weights, a point of the simplex Δ_n. In Everett those weights are inherited from the host reduced state and its Born-measure machinery; in the binary Born bridge the simplex representation is the conditional input on which Fisher–Rao/Chentsov geometry acts. Thus the bridge derives the calibrated binary *form* given the record simplex; it does not derive the existence of branch weights, nor the emergence of finite records themselves.

Remark 2.5 (Accessible record algebra, not absolute factorization). The framework does not need a unique fundamental tensor-product factorization of the universe into observer and environment. It needs, for each finite observer, a physically selected accessible record algebra: the stable, decohered, redundantly available, finite-capacity part of the host state that the observer can actually record, control, and use. Locality and the interaction Hamiltonian select candidate degrees of freedom; decoherence selects robust pointer records; redundancy selects the records that can function objectively; finite capacity then selects the part available to the indexed observer. The resulting cut is movable and observer-indexed, but not arbitrary. Alternative decompositions are admissible only insofar as they preserve the same accessible record algebra, or a legitimate coarse-graining or refinement of it. Wildly nonlocal factorizations that destroy locality, decoherence stability, or redundant records are formal possibilities, not physically equivalent IOF descriptions.

2.1 What "observer," "branch," and "experience" mean here

The architecture fixes the sense of three words that the host and the framework use differently. Making them precise here keeps the division of labour clear and forecloses a common misreading—that the picture reifies many classical worlds as primitive objects.

Observer. The word "observer" carries a different sense in the host and in the framework. The host defines an observer *extensionally*, by the existence of stable branch records: an observer is wherever decoherence has laid down a redundant, einselected record structure—Wallace's functional patterns [8], the objectivity of Zurek's einselection and quantum Darwinism [11]. The framework defines an observer *operationally*, by the finite resources required to form, maintain, and interpret those records: the extraction capacity C_{eff}, the production rate h_{KS} it must track, and the rate $\kappa = h_{\text{KS}} - C_{\text{eff}} \ln 2$ that decides whether the tracking holds. These are not rival definitions of different things. They are two characterizations of one physical subsystem at two levels of the architecture: the host names the record structure that exists; the framework prices the finite process that forms and sustains it. The binary Born form, the visibility law V_{IOF}, and the movable cut all live at the operational level, on records the host has already certified as stable.

Branch and world. Nothing in the host's mathematics adds countable classical universes to the ontology. There is one global state evolving unitarily; decoherence renders certain of its components dynamically non-interfering for all practical purposes and lays down stable, redundant, quasi-classical records inside them. A branch—a "world"—is one such decohered, redundantly recorded, approximately autonomous record sector: an emergent pattern in the single state, in the functionalist sense of Wallace's emergent multiverse [8], not a primitive classical object. For the framework this is a convenience, not an added commitment: the IOF needs only finite, decohered, locally trackable record algebras, not ontologically primitive worlds.

Experience. Operationally, an observer's experience is the update of its decohered, branch-local memory record; the definite world it reports is the record-consistent, quasi-classical context that its finite resources sustain, not direct access to the global quantum state. The claim is not that consciousness has been reduced to records—it is the weaker and unavoidable one that anything a physical observer can report as experience must be encoded as a finite physical record. A finite observer's reduced state is branch-local and cannot hold the global superposition as an accessible object, so every report is fixed within one decohered record sector; the framework describes the limits and structure of those records.

3 Bridge 1: Record Geometry to the Binary Born Form

The first bridge connects the record base to a probability law. It has two parts: a geometric identity that the record base *is* the host's projective metric quotiented, and a derivation of the binary Born weight from the resulting record geometry. The full development is in the companion papers [3, 4]; here I state the chain and, more importantly, fix exactly what it does and does not claim.

3.1 The geometric spine

Write a pure state in amplitude–phase coordinates, $|\psi\rangle = \sum_i \sqrt{p_i}\, e^{i\phi_i}|i\rangle$. The Fubini–Study line element splits exactly into a modulus part and a phase part,

$$g_{\mathrm{FS}} = \tfrac{1}{4}\, g_{\mathrm{FR}} + g_{\mathrm{phase}}, \qquad \text{equivalently} \qquad g_{\mathrm{QFI}} = g_{\mathrm{FR}} + 4\, g_{\mathrm{phase}},$$

and on the diagonal (decohered) states the Bures/quantum-Fisher metric restricts to $g_{\mathrm{Bures}} = \frac{1}{4}\, g_{\mathrm{FR}}$. So the chain Fubini–Study → Bures → Fisher–Rao is exact differential geometry: *the Fisher–Rao metric is the base/modulus part of the host's projective metric once the relative-phase fibre is quotiented.* The same metric arrives a second way—by Chentsov's theorem, g_{FR} is the unique metric on finite record distributions invariant under sufficient Markov morphisms [13, 14]. Host restriction and record invariance select the same object. That coincidence is the geometric spine of the fit.

This paragraph is not a new theorem of Riemannian geometry. The metric identities are standard. The new use made here is the synthesis: in the Everett–IOF stack, the same Fisher–Rao metric is obtained both by restricting/quotienting the host's quantum geometry and by imposing finite-record invariance. For completeness, the calculation is:

$$ds^2_{\mathrm{FS}} = \langle d\psi|d\psi\rangle - |\langle\psi|d\psi\rangle|^2,$$

with $\sum_i p_i = 1$, hence $\sum_i dp_i = 0$,

$$\langle d\psi|d\psi\rangle = \frac{1}{4}\sum_i \frac{dp_i^2}{p_i} + \sum_i p_i\, d\phi_i^2, \qquad \langle \psi|d\psi\rangle = i\sum_i p_i\, d\phi_i.$$

Therefore

$$ds^2_{\mathrm{FS}} = \frac{1}{4}\sum_i \frac{dp_i^2}{p_i} + \left(\sum_i p_i\, d\phi_i^2 - \Big(\sum_i p_i\, d\phi_i\Big)^2\right),$$

which is $g_{\mathrm{FS}} = \frac{1}{4}g_{\mathrm{FR}} + g_{\mathrm{phase}}$. For mixed states, the Bures metric in an eigenbasis of $\rho = \sum_i p_i|i\rangle\langle i|$ is

$$ds^2_{\mathrm{Bures}} = \frac{1}{2}\sum_{ij} \frac{|\langle i|d\rho|j\rangle|^2}{p_i + p_j}.$$

On diagonal record states $d\rho = \sum_i dp_i|i\rangle\langle i|$, only $i = j$ terms remain, so

$$ds^2_{\mathrm{Bures}} = \frac{1}{4}\sum_i \frac{dp_i^2}{p_i} = \frac{1}{4}\, ds^2_{\mathrm{FR}}.$$

Thus the derivation is standard; the IOF claim is that decoherence makes this standard restriction physically relevant to branch-local records.

3.2 The binary weight

On the record simplex, with the useful tracking capacity read as capacity for preserving operational distinguishability of records (the Fisher capacity bridge), the tracking metric is Fisher–Rao. In square-root coordinates $q_i = \sqrt{p_i}$ the simplex is a sphere, and a binary record carries the Fisher-arclength identity $p(s) = \cos^2(s/2)$ with $s = 2\arccos\sqrt{p}$ *by elementary geometry once s is Fisher arclength.* A scalar self-ignorance rate—one threshold κ, not a position-dependent $\kappa(\theta)$—requires equal increments of the physical basis coordinate θ to cost equal Fisher distinguishability, so the Fisher information $I(\theta) = \alpha^2$ is constant and $s = \alpha\theta$. Endpoint calibrations $p(0) = 1$, $p(\pi) = 0$ on the first monotone interval fix $\alpha = 1$:

$$\boxed{p(\theta) = \cos^2(\theta/2).}$$

Theorem 3.1 (Conditional binary Born form, after [3])**.** *Under the Fisher capacity bridge, sufficient-Markov finite-resolution invariance, and scalar-threshold homogeneity of the calibrated basis coordinate, the calibrated two-outcome record carries the Born weight $p(\theta) = \cos^2(\theta/2)$.*

3.3 Form, not existence

The standing of Theorem 3.1 must be stated precisely, because it is easy to overstate.

The result derives the *form* of the binary probability law. It does *not* derive the *existence* of a probability measure. It works at the record-level interface described in Remark 2.4: once decoherence, coarse-graining, and finite capacity have produced a stable record algebra, the mutually exclusive record alternatives are represented by normalized additive weights on Δ_n. *Given* that record kinematics, Markov invariance selects Fisher–Rao, the binary arclength gives the squared cosine, and homogeneity pins the coordinate. So the IOF changes the *form* problem, not the *existence* problem. The deeper question—where the probability measure over branches comes from in a no-collapse ontology—does not disappear; in the Everett-hosted reading it remains with the host's measure-sourcing and rational-use machinery. The IOF supplies an independent binary-form constraint on that measure, not a stand-alone derivation of probability existence.

Two further constraints bound the claim.

1. **The quantitative content is Wootters's.** Once one grants $s \propto \theta$, the squared-cosine form is the two-outcome case of Wootters's statistical-distance identity [15], which therefore carries the quantitative Born content. The contribution here is not the identity. It is the proposed *physical interpretation* of why a laboratory basis coordinate should be Fisher-homogeneous—finite tracking capacity construed as record-distinguishability capacity—a calibration and estimation premise, testable in the falsifying direction by the Fisher-homogeneity module of the BLQC benchmark [5].
2. **"Binary" means two-outcome, not dimension two.** The result is for two-outcome records, which exist in every Hilbert dimension; it is not a statement about $d = 2$. It is therefore an operational two-outcome-record route to the Born form that assumes *less* quantum structure than the POVM-Gleason theorems—Busch [16], and Caves–Fuchs–Manne–Renes [17], recover Born for general effects, including $d = 2$, by assuming the full effect algebra. The records route assumes only classical record kinematics plus the calibration premise. It runs parallel to Gleason/Busch, distinguished by assuming less, not by plugging a dimensional gap.

3.4 Consequence for Deutsch–Wallace

The Everettian probability problem therefore separates into three questions that are often run together:

$$\text{measure existence} \quad + \quad \text{measure form} \quad + \quad \text{rational measure use.}$$

The IOF only touches the middle question, and only in the calibrated binary case. But that is still a material change to the Deutsch–Wallace burden. In the usual decision-theoretic presentation, critics can say that the rationality axioms have been chosen so that the Born weights are already implicit in them. With Theorem 3.1 in place, the binary amplitude-squared form is fixed before any preference axiom enters. The "rigged axioms" objection is then weakened for the binary form: decision theory is no longer being asked to manufacture $\cos^2(\theta/2)$ from an allegedly Born-free normative starting point.

What remains for Deutsch–Wallace is the use problem. Given an objective measure over branch records, why should a rational agent use that measure as credence, caring measure, or decision weight? The IOF does not answer that question by geometry. It makes the binary form less hostage to decision theory, but it leaves the incoherence problem intact. It also leaves the sourcing problem for the full multi-outcome measure: Gleason/Busch-style results still require the relevant non-contextuality or effect-algebra assumptions, and the IOF supplies at most a two-outcome operational route that can agree with those results where both apply.

This makes the relation to Wallace continuous rather than adversarial. Wallace already moves part of the decision-theoretic burden into physical equivalence principles such as branching indifference and state supervenience. The IOF extends that offloading by grounding the binary record form in finite record distinguishability. Deutsch–Wallace then becomes less like "derive the measure" and more like "justify rational use of a measure whose binary record form is physically grounded, and whose full extension must still be supplied by the host."

4 The Phase Limit and the Born Split

The first bridge reaches the modulus and no further. The companion limit theorem [4] shows the boundary is structural, not a gap awaiting more work.

Theorem 4.1 (Phase limit, after [4])**.** *On the finite simplices Δ_n°, the invariant 2-tensors under sufficient Markov morphisms form a one-dimensional space spanned by the symmetric Fisher metric; the antisymmetric part of any invariant 2-tensor vanishes, and the only invariant* $(1,1)$*-tensor is a scalar multiple of the identity. Hence there is no invariant almost-complex structure J (no real scalar satisfies $c^2 = -1$), and therefore no invariant Kähler or symplectic structure on finite-record geometry.*

The reading is that relative phase—the structure that drives interference between non-commuting contexts—is *not generated* as an invariant of finite-record geometry. It must be imported from the host. This is a *generation* statement, not a *reproduction* statement: it does not claim that classical models cannot reproduce quantum statistics (they can, by simplex embeddings); it claims that phase-sensitive context structure is not an invariant tensorial structure of the record geometry. It is silent on whether the imported structure must be complex rather than real or quaternionic; that needs further composition principles.

Theorems 3.1 and 4.1 are one classification read at two parities. The same Markov invariance that *selects* Fisher–Rao (the symmetric part) is what *forbids* phase (the antisymmetric part). Their physical content is a clean split of the Born structure, visible already in the metric decomposition $g_{\mathrm{FS}} = \frac{1}{4} g_{\mathrm{FR}} + g_{\mathrm{phase}}$:

IOF reach (record base)	**Host side (phase fibre)**
the binary modulus weight $\cos^2(\theta/2)$	relative phase and interference
$\frac{1}{4} g_{\mathrm{FR}}$, the modulus metric	g_{phase} (phase-fibre metric) and the antisymmetric Kähler form
finite-record distinguishability	non-commuting context composition
	the multi-outcome Born measure and its existence

The phase fibre is quotiented out the moment one passes to a probability vector, so phase absence is prior to and cheaper than the differential statement: the missing-J theorem is the differential shadow of a quotient already built into the definition of a record. The binary Born weight is the projection the record keeps; quantum phase is the fibre it forgets.

5 Bridge 2: Reference Closure and the Banked Inequality

The second bridge concerns the reference itself. A finite observer's measurement basis is a physical variable generated by dynamics that include the observer. Two questions arise: can the observer determine that variable exactly from its own records, and if not, how fast does approximate tracking fail? The answers are an exact obstruction and an inequality.

5.1 The exact obstruction is non-factorization

A tempting slogan—"the model would have to contain its own modeller, hence impossible"—is false in general. By Kleene's recursion theorem, self-reference is routinely consistent; quines and fixed points exist. The correct exact statement is a factorization criterion.

Theorem 5.1 (Exact closure fails by non-factorization, after [18]). *Let $R_{\le t}$ be the observer's own finite record history and Θ_t the basis functional on global histories. Exact self-contained reference closure—a function F_t with $\Theta_t = F_t \circ R_{\le t}$—fails if and only if there exist admissible histories x, y with*

$$R_{\le t}(x) = R_{\le t}(y) \quad \textit{but} \quad \Theta_t(x) \neq \Theta_t(y).$$

Proof. This is the factorization criterion of Lemma A.1, applied with X the admissible global histories, $R = R_{\le t}$, and $\Theta = \Theta_t$. Appendix A gives the set-theoretic proof and a two-qubit Breuer witness. □

Breuer's self-measurement result is the physical instance: an observer is a proper subsystem, the restriction $\rho_U \mapsto \rho_O = \mathrm{Tr}_W\, \rho_U$ is non-injective, so globally distinct states share a local state and identical internal statistics, and a θ depending on self-including degrees of freedom is not internally recoverable. This is a factorization failure, not a bandwidth shortage; it can hold even at zero entropy rate. Quantum-information versions sharpen the same point: the Nielsen–Chuang no-programming theorem [19] forbids exactly programming a continuum of bases with a finite program register, and Wigner–Araki–Yanase constraints [20, 21] give a finite reference frame irreducible orientation uncertainty.

5.2 The approximate bound, and what makes it more than control theory

The exact obstruction forces the observer into approximate tracking. The rate at which approximate tracking fails is a separate, quantitative counting argument. Distinguishable θ-histories of length T grow as $e^{h_{\mathrm{KS}} T}$; the observer's finite channel encodes at most $e^{C_{\mathrm{eff}} \ln 2\, T}$ internal histories; if $C_{\mathrm{eff}} \ln 2 < h_{\mathrm{KS}}$ the reference histories collapse onto shared internal records and bounded tracking fails. This is the data-rate threshold, and it is what couples the exact obstruction to a measurable rate. The exact obstruction explains *why* the observer is forced into approximate tracking at all; the data-rate bound quantifies *when* that forced tracking fails. The data-rate theorem alone never explains why exact closure was off the table; that is the work the Breuer structure does.

The banked result assembles three established theorems—Pesin's identity, the Holevo bound, and the estimation/data-rate converse—on the Breuer structure. Let θ_t be a dynamical phase-space coordinate advected along the unstable manifold of the within-branch map, O a finite observer of fixed dimension d_O whose register is exported each step by decoherence, and define the structural rate $\kappa_{\mathrm{def}} := h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2$ and the operational rate $\kappa_{\mathrm{op}} := \limsup_{t\to\infty} \frac{1}{t} \cdot \frac{1}{2} \ln \sigma_\theta^2(t)$ in the local unstable coordinate, before saturation.

Theorem 5.2 (Inequality form, after [6]). *Assume the within-branch dynamics is, in the semi-classical limit, a smooth uniformly hyperbolic map with an SRB measure, tracked in its basin. Then*

$$\begin{aligned} \text{(structural)} \quad & \kappa_{\mathrm{def}} = h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2 \;\geq\; h_{\mathrm{KS}} - \ln d_O, \\ \text{(operational)} \quad & \kappa_{\mathrm{op}} \;\geq\; h_{\mathrm{KS}} - C_{\mathrm{eff}} \ln 2 = \kappa_{\mathrm{def}}, \end{aligned}$$

the first from the Holevo ceiling $C_{\rm eff}\ln 2 \le \ln d_O$, the second from the estimation/data-rate converse [26–28] applied to the unstable coordinate with the SRB-typical rate $h_{\rm KS}$ (Pesin). Consequently, if the per-step branch entropy production exceeds the per-step extraction capacity, $h_{\rm KS} > \ln d_O$ (both in nats per extraction step), then $\kappa_{\rm def} > 0$ and $\kappa_{\rm op} > 0$: the embedded observer cannot keep bounded tracking error of its own reference, and σ_θ^2 diverges exponentially at rate at least $\kappa_{\rm def}$ until saturation.

So the exact algebraic mismatch (finiteness caps extraction) and the dynamical mismatch (branch chaos drives production) meet in one inequality chain $\kappa_{\rm op} \ge \kappa_{\rm def} \ge h_{\rm KS} - \ln d_O$, governed by the single threshold $h_{\rm KS} > \ln d_O$. What is banked is this common-threshold composition; the stronger reduction—that $h_{\rm KS}$ is literally the entropy rate of the Breuer self-reference process—remains an open toy-model target. Appendix A proves only the exact non-factorization witness, not this reduction. The exponential law $\sigma_\theta^2(t) = \sigma_0^2 e^{2\kappa_{\rm op} t}$ is then a derived lower bound, not an inserted ansatz; on a compact coordinate it is a pre-saturation statement, and saturation is the coherence time. For a single tracked unstable coordinate the bound is on its scalar variance; with several unstable directions the converse bounds the unstable log-volume, and the milestone is chosen so the distinction does not arise.

5.3 What is banked, and what is not claimed

The inequality is banked. The corresponding *equality*—the exact identity $\kappa = h_{\rm KS} - C_{\rm eff}\ln 2$—is *not* claimed here. Equality needs two further things: the data-rate bound to be tight (an optimal estimator saturating the channel), and the observer's pointer partition to be a generating partition for the branch map. On a non-generating partition the observer sees a lower-entropy projection and the inequality stays strict; with extraction efficiency $\eta < 1$ the effective rate is $\eta C_{\rm eff} < C_{\rm eff}$ and $\kappa_{\rm op}$ only grows. Generic conditions give $\eta < 1$, so the identity is non-load-bearing and the framework rests on the inequality. A direct numerical search on a cat-map reference (a particle filter under a static measurement partition) did not exhibit the identity-side transition: the steady-state error pins at the measurement-resolution scale rather than tracking κ, which is consistent with the inequality being the load-bearing form and the identity being a stricter, generically unmet condition.

6 The Production Rate Is Irreducibly Semiclassical

Theorem 5.2 uses $h_{\rm KS}$, a classical entropy rate. A no-collapse host evolves the universal state unitarily, with zero entropy production. So a sharp question stands at the foundation of the framework: what *is* the production rate $h_{\rm KS}$, quantum-mechanically? The answer is a scoping theorem, and it determines the character of the whole framework.

Theorem 6.1 (Emergent reference rate)**.** *A closed physical system with bounded energy and finite volume has strictly zero intrinsic asymptotic quantum dynamical entropy: the Connes–Narnhofer–Thirring [24] and Alicki–Fannes [25] entropies vanish for finite-dimensional automorphisms, and bounded energy with finite volume gives a discrete spectrum by Weyl's law, hence quasi-periodic, non-mixing dynamics. For such a finite closed system, a sustained, strictly positive production rate $h_{\rm ref}$ is unavailable; it becomes well-defined only when the system is subjected to a spectrum-continuing limit: the semiclassical limit $\hbar \to 0$, the open-system continuous-measurement limit (Zurek–Paz decoherence), or the thermodynamic limit $N, V \to \infty$. In that case $h_{\rm ref} = \sum_i \lambda_i^+$, the Pesin sum of positive Lyapunov exponents, is uniquely and maximally defined on the einselected, semiclassical branch domain.*

Every attempted escape from this conclusion fails in the same way. The CNT/ALF entropy of a quantized cat map is zero at fixed dimension; a positive rate needs $d \to \infty$ before $t \to \infty$. Genuinely positive-entropy quantum dynamics (quantum K-systems) require infinite-dimensional type-III algebras and continuous spectrum, unreachable for a finite apparatus. An open-system Lindblad rate is sustained but breaks "closed," and in the chaotic regime the Zurek–Paz rate *equals* the classical Kolmogorov–Sinai entropy $\sum_i \lambda_i^+$ precisely because the environment monitors the expanding manifolds—it enforces the semiclassical rate, it does not replace it. The out-of-time-order correlator measures the largest Lyapunov exponent, not the Pesin sum, and saturates at the Ehrenfest time, so it cannot be a sustained capacity.

The recurring tension between Lyapunov and Kolmogorov–Sinai quantities across the framework's development is exactly this bridge made visible. A Lyapunov exponent λ is a geometric tangent-space divergence rate, quantum-accessible through the out-of-time-order correlator. The Kolmogorov–Sinai entropy h_{KS} is an informational production rate, the Pesin sum the framework needs. They coincide only through Pesin's identity, which requires smooth dynamics with an SRB measure—the semiclassical, continuous-spectrum regime; off SRB only Ruelle's inequality $h_\mu \leq \sum_i \lambda_i^+$ holds [22, 23]. A finite closed quantum system has no SRB measure. They are two different rates, and the bridge between them is semiclassical.

Remark 6.2 (Hybrid by necessity). The consequence is structural, and I state it as content rather than caveat. The IOF is a quantum-host plus semiclassical-chaos-module hybrid *by necessity*, not by temporary limitation. The Pesin/Zurek–Paz bridge that joins the unitary substrate to the classical information channel is load-bearing and permanent given current dynamical-entropy theory; it is the pillar, not scaffolding awaiting a quantum replacement. The semiclassical, einselected domain on which h_{ref} exists is the *maximal* domain on which the production rate is defined at all—and it is exactly where the IOF natively lives, because a continuous record-extraction process *is* an open, monitored system. The framework never sat in the closed finite-dimensional regime the no-go excludes. "Closing the seam"—deriving h_{KS} as a closed-quantum invariant with the semiclassical form as a mere limit—was the wrong goal; the inequality of Section 5 is intrinsically restricted to the einselected domain by the same theorem, and that restriction is where the rate is well-posed.

7 Decoherence, Two Channels, and the Movable Cut

In the host, branching is the emergent structure decoherence produces: einselection picks the pointer basis and correlates it with the environment, and this is host-side physics, not something the IOF causes. The observer's visibility therefore carries two factors of different kinds,

$$V_{\mathrm{obs}} = V_{\mathrm{std}} \cdot V_{\mathrm{IOF}},$$

the product of two angular smearings taken to be statistically independent (a factorization that fails if environmental decoherence correlates with the reference uncertainty). The standard factor V_{std} is environmental decoherence: phase exported into system–environment correlations, irreversible in the operational sense (recoverable only by recohering the environment, which is for-all-practical-purposes impossible). The IOF factor $V_{\mathrm{IOF}} = \exp(-\sigma_\theta^2/2)$ is observer-relative phase averaging over an unresolved reference: it is recoverable in post-processing whenever the realized reference is logged, the hallmark of reference-frame physics within quantum mechanics [29].

Recoverability is a host-conditional prediction. Under a unitary host, both channels are recoverable in principle—V_{obs} because global unitarity preserves the information, V_{IOF} because it is mere phase averaging. This "both recoverable in principle" is not a free interpretive choice; it is a prediction conditional on the host being unitary, and it is exactly what an objective-reduction theory denies. The empirical handle is the recoverability classifier R_{rec} of the BLQC benchmark [5]: it asks whether a coherence index, once apparently lost, can be restored, or whether it has genuinely dropped. A genuine, unrestorable drop in the regime where the host predicts recoverability would favour objective reduction (Penrose-type [32]) over the no-collapse substrate. The classifier tests substrate-determinism against objective collapse; it does not, and cannot, separate one no-collapse host from another (Section 8).

κ is the movable, observer-set cut. The Heisenberg cut—the boundary between the part of the world treated as quantum and the part treated as a definite classical record—is in this framework not fixed by fiat; it is set by the capacity-to-chaos balance. Where $\kappa_{\text{def}} > 0$ the banked converse supplies an obstruction to bounded tracking; where $\kappa_{\text{def}} < 0$ that obstruction is absent and more of the world can remain coherently tracked, subject to estimator efficiency. An observer with more capacity pushes the cut outward, one with less pulls it in. The cut is therefore epistemic, observer-set, and movable, and the visibility it controls is recoverable. This is the indexed-objectivity reading developed in the companion paper on the measurement basis [2]: there is no observer-independent location for the cut, only an observer-relative one set by the capacity-to-chaos balance.

This role of κ is the part of the framework that is most thoroughly host-independent, and it must be stated because the Everett reading can make it look smaller than it is. In *every* host, κ marks the same epistemic border: the rate-limited boundary across which an underlying substrate becomes, for a finite observer, a definite, reportable classical record. Everett supplies a particularly clean ontology for what lies on the far side of that border (other branches), but it does not diminish the border's role. The cut, and the substrate-to-record transition it marks, is the framework's central and universal object.

8 Hosts and the Division of Labour

The framework is host-pluralist by construction, and the role κ plays differs—tellingly, often growing—as the host changes. I state the division of labour host by host, then what stays open on each side.

Everett (the preferred host). Branching sidesteps Bell's dilemma by rejecting the single-outcome premise, not the measurement-independence premise: with no single global outcome to reconcile with the setting, the conspiracy worry that drives single-history measurement-dependence does not arise. The IOF is then a modifier: the intra-branch recoverable-visibility overlay V_{IOF}, the binary Born form, and the movable cut. Everett does the heavy lifting on ontology, but the modifier is not decorative: it supplies a finite-record account of why each successor report is single-branch, gives a record-geometric route to the calibrated binary amplitude-squared form, and turns the Heisenberg cut into a capacity-dependent boundary. Its role is narrower than in single-history hosts, where κ carries concealment, but it materially lowers the load carried by Deutsch–Wallace in Everett. The virtue is that there is no superdeterminism stigma and the reading is the most defensible. The cost is that the host inherits Everett's own contested elements, stated below.

Single-history hosts (Palmer, 't Hooft). Here κ is load-bearing. The setting and system share causal ancestry, but the correlation is epistemically bounded: unreconstructable by the finite observer at rate κ. The concealment result—no-signalling preserved exactly, the setting–system dependence unreadable and unexploitable from within—is the framework's distinctive contribution to the superdeterminist program, making "non-conspiratorial measurement dependence" [30, 31] operational through finite tracking. This is the detectability form of the conspiracy objection, and it is where the framework's central quantity does the most work. The cost is the superdeterminism stigma the concealment is designed to dissolve. This host is kept as a scoped hedge, not headlined as a co-equal: κ defends detectability there, not the host's dynamics or its fine-tuning.

Pilot-wave (Bohm). The IOF is the finite-observer epistemic layer over the hidden variables: the ontic state is definite, and finite access makes it read as probability. The virtue is single outcomes with a clear ontology; the cost is nonlocality and a less natural fit with the shared-ancestry move.

Making Everett *exclusive* would relegate the IOF to its least distinctive role and discard the host where its central quantity is most load-bearing. Preference is the right posture; exclusivity is not.

The residual debts. Three things stay open under Everett—the first two on the host's side, the third the framework's own. The first is the *measure-sourcing* residual. This is not the claim that Everett lacks a full Born story: Gleason/Busch-style representation theorems and decision-theoretic programmes do supply routes to the full measure. The point is that those routes carry contested assumptions—non-contextuality or effect-algebra structure on the sourcing side, and rational-use principles on the Deutsch–Wallace side. The binary record result secures an important but restricted corner of the measure-form problem; it strengthens Everett's probability story without generating the whole measure. The second is the *measure-use* residual—the incoherence problem: even granting a mathematically unique, physically sourced objective measure, why must a rational agent adopt it as decision-relevant credence or caring weight? Wallace's decision-theoretic answer [8, 9] is contested [10], and no measure-sourcing settles it. The strongest positive claim is narrower and sharper: because the IOF fixes the binary *form* before decision theory enters, it weakens one Deutsch–Wallace vulnerability—the charge that the decision axioms were rigged to yield Born, for the binary form—and turns Deutsch–Wallace into a rational-use argument for a measure whose binary record form is independently grounded. The third is the framework's own. The IOF's record-quotient is realized *by* decoherence, and einselection fixes the pointer basis only after a physically stable observer–record–environment decomposition has been selected. Remark 2.5 weakens the debt: the framework need not derive a unique absolute tensor factorization, but it does need an observer-indexed accessible record algebra selected by locality, decoherence, redundancy, and finite capacity. Read as debts, these fall on two sides: the host owes the Born measure—its sourcing and rational use—and the framework owes the selection and invariance of the accessible record algebra. The IOF reshapes them; it does not close them.

9 What This Does and Does Not Prove

It is structurally closed within its scope, conditional on its host. The framework is an internally consistent intra-branch effective theory: the record-quotient theorem, the phase limit, the exact Breuer obstruction, the banked inequality, and the emergent-reference-rate scoping are mutually consistent, conditional on the Everettian host and restricted to the einselected semiclassical domain where h_{KS}—and hence the inequality—is well-defined. "Closed within scope, conditional on the host" is the exact claim; it is not unconditionally complete and not self-standing. If the host falls, the division of labour falls with it.

It locates probability at the record boundary, and derives only the binary form. The IOF does not need primitive objective chance. The substrate is deterministic/unitary, and probability is the record-level epistemic form taken by that substrate for finite embedded observers. In that sense the experience and use of probability are observer-side: a finite observer does not access the global state, but only branch-local records, coarse-grained histories, and limited reference information. What remains host-side is not the experience of probability, but the full Born measure: why amplitude-squared weighting extends uniquely across all multi-outcome and contextual measurements. Theorem 3.1 supplies the binary Born *form* from record geometry, once the host has supplied a stable record algebra represented on Δ_n. It does not derive that a probability measure over branches exists, nor the multi-outcome rule (forbidden by Theorem 4.1 from this route), nor a rational-credence theorem. The full Born measure remains a boundary problem between the Everett host and the finite-record quotient.

It does not derive the production rate as a closed-quantum invariant. By Theorem 6.1, h_{KS} is a semiclassical, einselected quantity. The framework is a hybrid by necessity. No claim is made that κ's production rate has been obtained fully quantum-mechanically with the semiclassical form as a mere limit; that goal is provably unreachable for a finite closed system, and that impossibility is the structural conclusion, not a deferred task.

It does not claim the exact identity. The banked result is the inequality $\kappa_{\text{op}} \geq h_{\text{KS}} - C_{\text{eff}} \ln 2$. The exact identity is not claimed; it requires a generating partition and a saturating estimator, generically unmet.

Its confirming experiment is unrun, and the gap is host-bound. The sign-reversal signature—increasing tracking power extends coherence—is the framework's discriminating prediction against thermal decoherence, and it has not been run. The Fisher-homogeneity and recoverability modules of the BLQC benchmark [5] carry force only in the falsifying direction, because constant $I(\theta)$ and κ-scaled visibility loss are also standard-quantum-mechanics predictions. The empirical confirmation gap is itself conditional on the contested status of the host.

What confirmation would establish. If the BLQC control-law benchmark, the recoverability classifier, and the Fisher-homogeneity module survive their staged tests, the result would not be evidence for a new Schrödinger dynamics. That is the point: the IOF layer pays its way without requiring new physics. Confirmation would instead establish that finite reference tracking is a calibrated component of observer-relative quantum visibility, that the Fisher-homogeneity premise behind the binary Born bridge has survived its direct falsification exposure, and that the single-branch report of an embedded observer is correctly described as a finite branch-local record update. Conditional on accepting the Everett host's full measure and rational-use machinery, and granting the physically selected accessible record algebra that decoherence and finite capacity presuppose, this would make Everett+IOF a complete no-collapse picture. It still would not make the picture logically forced, metaphysically unique, or independent of its host.

10 Objections and Replies

Remark 1 (Is this just decoherence relabelled?). No. Decoherence is the host-side process that realizes the modulus map and exports phase; the framework uses it, and says so (Remark 2.2). The added content is the second channel: the reference-tracking rate κ, its sign-reversal signature, and the recoverable observer-relative visibility V_{IOF} that factorizes off the irreversible decoherence factor V_{std}. Decoherence sets the stage; κ is the actor.

Remark 2 (Is the Born result circular—you assumed probability to derive it?). The result derives the *form*, not the *existence*, and it says so. It does not postulate finite records from nowhere: the host supplies stable pointer records by decoherence and coarse-graining. The bridge then works on the record simplex Δ_n and derives $\cos^2(\theta/2)$ as the calibrated binary form. The existence of the full branch measure remains host-side; it is not eliminated and not derived by the IOF alone (Section 3). The quantitative content is Wootters's statistical-distance identity; the contribution is the physical interpretation of Fisher-homogeneity as a testable calibration premise. The claim is a change to the form problem.

Remark 3 (Does committing to Everett over-reach?). The commitment is to Everett as the *preferred* host, not the exclusive or unconditionally complete one (Sections 2, 8). The operational core is host-independent; single-history and pilot-wave hosts are kept as scoped alternatives; the choice among empirically equivalent no-collapse hosts is interpretation, not experiment. "Preferred" is a revisable ranking that directs research, not a closure that ends it.

Remark 4 (Would experimental success make Everett+IOF complete?). Only in the hosted sense. If the BLQC/Fisher modules survive experiment, the operational layer becomes physically supported: finite reference tracking is not merely an interpretive gloss, and the binary record form has passed its direct calibration exposure. If, in addition, one accepts Everett's host-side Born-measure and rational-use machinery and grants the accessible record algebra selected by locality, decoherence, redundancy, and finite capacity, the combined picture is complete in the relevant explanatory sense: unitary substrate, emergent branches, branch-local records, binary amplitude-squared weighting, finite-observer recoverability, and no new collapse dynamics. This is not a proof that no other host can do the job, nor a derivation of the full measure from IOF alone.

Remark 5 (Is the semiclassical seam an unsolved gap?). No. The production rate cannot be a closed-quantum invariant for a finite closed system (Theorem 6.1); a sustained positive rate exists only on the einselected semiclassical domain. The semiclassical character is therefore not a gap to be closed but the shape of the answer, and it coincides with the domain in which the framework natively operates (Remark 6.2).

Remark 6 (Does the IOF fill the $d = 2$ gap in Gleason's theorem?). No, and the claim should not be made. "Binary" here means two-outcome records, which exist in every dimension, not Hilbert dimension two; and the POVM-Gleason theorems of Busch and of Caves–Fuchs–Manne–Renes already reach $d = 2$ via the full effect algebra. The records route is a parallel derivation that assumes *less* quantum structure, not a patch for a surviving dimensional hole (Section 3).

Remark 7 (Is κ self-reference made impossible, contradicting Kleene?). No. The exact obstruction is non-factorization (Theorem 5.1), a non-injectivity of the observer's restricted record map, not the false slogan that a model cannot contain itself. Kleene's recursion theorem is respected: self-reference per se is consistent; what fails is the specific factorization of a self-including reference functional through finite local records.

11 Conclusion

Read inside a no-collapse host, the Ignorant Observer Framework is the invariant information geometry and reference-tracking theory of finite branch-local records. The host owns the projective state space, the phase structure, and the full Born measure; the framework owns the finite-record quotient that decoherence leaves—its Fisher geometry, its binary Born form, its exact closure obstruction, and its rate law κ. Four results carry the structure: the record-quotient theorem, the phase limit, the Breuer non-factorization obstruction with the banked data-rate inequality, and the emergent-reference-rate scoping that fixes the production rate as semiclassical. Everett is the cleanest host for this reading because it evades the Bell dilemma by rejecting single outcomes rather than measurement independence, and it is adopted as the preferred host on those grounds, without crowning it the only one.

The additional Everett payoff is that Deutsch–Wallace no longer has to generate the calibrated binary amplitude-squared form from nothing: for binary records, decision theory is demoted from source of form to rational-use layer. The full Born measure is not absent from the host; it is supplied by the usual Everettian machinery, with the known contested assumptions. The IOF strengthens that machinery where it is most exposed, gives the observer a finite-record definition, and turns the cut into a capacity-dependent recoverability boundary, all without asking for new fundamental dynamics.

The resulting claim is conditional. If the BLQC sign-reversal/recoverability tests and the Fisher-homogeneity module survive experiment, the operational reference-channel control law is physically calibrated within standard quantum mechanics; this supports the operational layer but does not discriminate the no-collapse interpretation from standard quantum mechanics. Conditional on accepting the Everett host's full measure and rational-use account, and granting the physically selected accessible record algebra that decoherence and finite capacity presuppose, Everett+IOF then becomes a complete no-collapse picture: one unitary substrate, emergent quasi-classical branches, branch-local records as the worlds observers report, hosted Born weights, an independently grounded binary form, and a finite-observer law for recoverability. What remains open is named and bounded: the measure and use residuals inherited from Everett, the multi-outcome/contextual extension of Born, the accessible-record-algebra selection inherited from decoherence, and the experiments whose verdict the framework is waiting for. It is not a metaphysical proof of uniqueness; it is a physically exposed and explicitly bounded hosted account.

A Branch-Record Witness for Exact Non-Factorization

This appendix supplies the minimal proof behind Theorem 5.1. It proves only the exact closure obstruction. It does not prove the later rate claim, nor the stronger conjecture that the same self-referential process literally supplies the entropy rate h_{KS}.

Lemma A.1 (Factorization criterion)**.** *Let X be a set of admissible histories, $R : X \to Y$ a record map, and $\Theta : X \to Z$ a target functional. There exists a function $F : R(X) \to Z$ such that*

$$\Theta = F \circ R$$

if and only if Θ is constant on the fibres of R:

$$R(x) = R(y) \implies \Theta(x) = \Theta(y).$$

Equivalently, exact factorization fails if and only if there exist $x, y \in X$ with $R(x) = R(y)$ but $\Theta(x) \neq \Theta(y)$.

Proof. If $\Theta = F \circ R$ and $R(x) = R(y)$, then $\Theta(x) = F(R(x)) = F(R(y)) = \Theta(y)$, so Θ is constant on each fibre. Conversely, suppose Θ is constant on each fibre. Define F on the image $R(X)$ by choosing any x with $R(x) = r$ and setting $F(r) := \Theta(x)$. This is well-defined because any two choices lie in the same fibre and therefore have the same Θ value. Then $F(R(x)) = \Theta(x)$ for every $x \in X$. The negation of the fibre-constancy condition is exactly the existence of x, y with equal records and different Θ values. □

Proposition A.2 (Two-qubit Breuer witness). *Let $\mathcal{H} = \mathcal{H}_O \otimes \mathcal{H}_W$ and define*

$$|\Phi(\theta)\rangle = \frac{1}{\sqrt{2}}\big(|0\rangle_O|0\rangle_W + e^{i\theta}|1\rangle_O|1\rangle_W\big).$$

For every θ,

$$\rho_O(\theta) := \mathrm{Tr}_W\, |\Phi(\theta)\rangle\langle\Phi(\theta)| = \frac{1}{2}I_O.$$

Hence every record map depending only on the observer's local state, or equivalently on the statistics of local observer measurements, gives the same record for all θ. But the global functional $\Theta(\Phi(\theta)) = \theta$ can take different values. Therefore Θ does not factor through the observer's local records.

Proof. Expanding the projector gives

$$\begin{aligned}|\Phi(\theta)\rangle\langle\Phi(\theta)| = \frac{1}{2}(&|00\rangle\langle 00| + e^{-i\theta}|00\rangle\langle 11| \\ &+ e^{i\theta}|11\rangle\langle 00| + |11\rangle\langle 11|).\end{aligned}$$

The partial trace over W kills the cross terms because $\langle 0|1\rangle = 0$, leaving

$$\rho_O(\theta) = \frac{1}{2}(|0\rangle\langle 0| + |1\rangle\langle 1|) = \frac{1}{2}I_O.$$

Choose, for example, $\theta = 0$ and $\theta' = \pi/2$. The observer's local state and all local measurement statistics coincide, while Θ differs. By Lemma A.1, no exact self-contained function of the observer's own records can recover this global relative phase. □

The witness is deliberately static: the obstruction does not rely on entropy production or bandwidth shortage. It is a non-injectivity of the restriction from global state to local record. The κ inequality enters only after one asks how accurately a finite observer can track a branch-effective reference once exact recovery is unavailable.

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