Why This Unraveling? The Darwinian Selection Principle
A Working Note

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Abstract
The event law made ACT's outcome dynamics precise and left exactly one item carrying the postulate's full weight: a given master equation admits many stochastic unravelings—pointer jumps, phase flips, quantum-state diffusion—all reproducing the same ensemble, so the claim that the *pointer-jump* unraveling represents physical events required justification. This note supplies the selection principle and demonstrates it quantitatively. The principle is operational: **physical events condition only on environmental data that constitutes a record**—data redundantly accessible from small, disjoint environment fragments, the same property that makes a record objective (independently readable by many observers without disturbing the system). In the standard pure-dephasing Darwinism model (system plus N environment qubits), the demonstration is sharp: the pointer observable's conditioning data is massively redundant—a *single* environment qubit yields 75% of the outcome information (0.66 of 0.88 bits), with saturation by three to four fragments and the quantum mutual information plateau $I(S:F)/H(S) \approx 1$ already at $m = 3$—while the conjugate-basis data on which a phase-flip unraveling would condition yields 0.08 bits per fragment and never plateaus short of the global environment. Among PDP unravelings of the same dephasing dynamics, only the pointer-jump law conditions on data satisfying the record condition. The consequence is structural: the pointer basis in the event law becomes an *output* of environmental redundancy rather than an input, einselection and quantum Darwinism close into a single loop with the event law, and the residual postulate weakens from "this unraveling is real" to "events ride on objective records"—a statement nearly definitional given that anchoring *is* record formation. What this note does not claim is also stated: the record condition remains a (now operational) postulate, the demonstration is model-based, and the general theorem, POVM extension, and covariant formulation remain open.

1 The Problem the Event Law Left Open

The event law (working note, *The ACT Event Law*, June 2026) specifies ACT's outcome dynamics as a piecewise-deterministic process: pointer-resolved jumps at hazard $\lambda_k = \Lambda p_k$, with survival probability $e^{-\Phi}$. Its ledger isolated the remaining postulate precisely: a master equation

$$\dot{\rho} = \Lambda\Big(\sum_k P_k \rho P_k - \rho\Big) \tag{1}$$

admits many inequivalent unravelings. Pointer jumps, random phase flips, and continuous quantum-state diffusion all average to Eq. (1); each corresponds to a different scheme for conditioning on the environment. Trajectory theory treats the choice as a matter of which measurement the experimenter performs on the bath. ACT asserts events occur with no experimenter—so it owes an answer to: *which conditioning is nature's?*

2 The Selection Principle

Postulate 1 (Record condition)**.** *A physical event may condition only on environmental data that constitutes a* record*: data whose content is redundantly accessible—obtainable, to within a fixed accuracy, from each of many small, mutually disjoint fragments of the environment, without global measurements and without disturbing the system.*

This is not an arbitrary technical condition; it is the operational definition of objectivity. A record is precisely that which multiple observers can independently consult and agree upon. ACT's own foundational identification—anchoring *is* irreversible record formation—already commits the theory to events that ride on records; the Record Condition merely states what "record" means with enough precision to do mathematical work. The work it does is select the unraveling.

3 The Demonstration

3.1 Model

The standard Darwinism setting: a system qubit prepared in $\sqrt{p}\,|0\rangle + \sqrt{1-p}\,|1\rangle$ with $p = 0.7$, coupled to $N = 8$ environment qubits by controlled rotations (rotation angle 2.4 rad: strong but imperfect copying—the generic case). The pointer basis $\{|0\rangle, |1\rangle\}$ is einselected by the interaction. After the interaction, $H(S) = 0.8813$ bits: decoherence in the pointer basis is essentially complete.

3.2 Redundancy of the pointer record

Quantum mutual information between system and environment fragments F_m of size m, averaged over fragments:

m	1	2	3	4	7
$I(S\!:\!F_m)/H(S)$	0.90	0.99	1.00	1.00	1.10

The classical plateau—the signature of Darwinian redundancy—is reached by $m \approx 3$: nearly complete information about the pointer outcome is available in many disjoint small fragments simultaneously. (The rise above 1 as $m \to N$ is the standard quantum excess, accessible only with the global environment.)

3.3 The two unravelings, compared at the data they condition on

Every unraveling of Eq. (1) corresponds to conditioning on some environmental observable. The pointer-jump law conditions on fragment observables in the *record basis*; the phase-flip unraveling conditions on the *conjugate basis*. Classical mutual information about the outcome k obtained by measuring m-qubit fragments in each basis:

m	record basis	conjugate basis
1	0.659	0.078
2	0.837	0.149
3	0.874	0.213
4	0.880	0.271

($H(K) = 0.881$ bits.) The contrast is the entire argument. Record-basis data is redundant: one fragment yields 75% of the available information; four yield 99.9%. Conjugate-basis data is not a record by any standard: a fragment yields 9%, accumulation is slow, and the information the phase-flip unraveling actually requires—the global phase-kick pattern—lives only in correlations spanning the entire environment. Quantum-state diffusion conditions on bath field quadratures and fails the condition the same way.

Claim 1 (Selection)**.** *Among piecewise-deterministic unravelings of the pure-dephasing dynamics Eq.* (1) *in this model, the pointer-jump unraveling is the unique one whose conditioning data satisfies the Record Condition.*

The claim's scope deserves emphasis. The Record Condition selects the recorded *basis*: it excludes conjugate-conditioned unravelings of every type (jump, phase-flip, diffusive), because their conditioning data is never redundant. It does not by itself exclude record-conditioned *continuous* localization within the pointer manifold—a diffusive process conditioned on the same redundant records would pass the condition. Within the piecewise-deterministic class the selection is unique; the discrete-jump form, as against record-conditioned pointer-manifold diffusion, remains part of the event postulate. A natural refinement integrates the condition into the hazard itself: $\lambda_k = \dot{\Phi}\, p_k\, g(R_k)$, with R_k the redundancy of the k-record and g saturating from 0 to 1—which simultaneously formalizes the irreversibility gating and, since redundancy does not retreat under non-Markovian recoherence, supplies the monotone hazard the survival formula requires.

4 Consequences

The pointer basis becomes an output. In the event law as first stated, the projectors $\{P_k\}$ were supplied by einselection—an input. Under the Record Condition they are derived twice over: the interaction selects which observable decoheres (einselection), and redundancy selects which observable is *recorded*, and these coincide. Einselection, quantum Darwinism, and the event law now close into one loop: the interaction writes redundant records of exactly one observable, and events are jumps resolved in exactly that observable because events ride on records.

The postulate weakens to near-definition. "The pointer-jump unraveling is physically real" becomes "physical events condition on objective records"—which, for a theory whose core identification is *anchoring = record formation*, is close to analytic. What remains genuinely postulated is that record-conditioned jumps are *ontic* events rather than bookkeeping; that residue is ACT's irreducible claim about reality, and no smaller one seems possible for any single-world theory.

Wigner's friend, completed. The friend's measurement record is redundant across the laboratory environment—thousands of fragments carry it. By the Record Condition it is objective *before* Wigner asks; the event fired when redundancy formed. Wigner's superposed description fails not by decree but because an objective record existed that his description omitted.

5 The Ledger

Derived (in the model): the uniqueness of the pointer-jump unraveling under the Record Condition; the coincidence of einselected and redundantly recorded observables; the redundancy and conjugate-basis-fragility numbers above.

Postulated: the Record Condition itself (operational, and arguably definitional for "record," but a postulate); the ontic status of record-conditioned jumps; and the discrete-jump form as against record-conditioned continuous localization within the pointer manifold.

Model assumptions, stated: pure dephasing; good fragmentation (no intra-environment interactions scrambling records); independent fragments; a finite toy environment. Real baths with mixing dynamics degrade redundancy over time—the principle then predicts events ride on records *while they are redundant*, which is physically sensible but needs the general treatment.

Open: a general theorem beyond the toy model (arbitrary spectral densities, partial einselection); the POVM/continuous-outcome extension, where redundancy of *coarse-grained* position records should select the smeared Kraus operators M_x already anticipated in the event-law note; per-event energy accounting (untouched here); the covariant formulation, where fragment accessibility may supply exactly the frame-independent structure the ordering problem needs—redundant records on a hypersurface are a natural covariant object. That last possibility is flagged as the most promising direction this note opens.