Recursive Instability Collapse (RIC): A Dynamic Framework for Quantum Measurement, Decision-Making, and Cosmology

Gestan Morgan*

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Abstract. We propose *Recursive Instability Collapse (RIC)* as an adaptive monitoring principle for open quantum systems. A global instability functional $C(t)$ modulates measurement strengths $\gamma_k(t)$ relative to a threshold $C^\star$, while the unconditional dynamics remain linear, completely positive and trace preserving (GKLS). Under *record-only* feedback, RIC is compatible with Born statistics and does not violate no-signaling. We outline testable predictions in quantum trajectories (hazard curves near threshold), neurophysiology (Theta → CPP/LRP), and a heuristic cosmological reading (an effectively homogeneous, $w \approx -1$ component). Proof sketches and simulation pseudocode are provided in the appendix.

Keywords: quantum measurement; GKLS/Lindblad; stochastic Schrödinger equation; measurement feedback; Born rule; no-signaling; emergence; EEG; decision-making; dark energy; cosmology

Transparency. This manuscript used AI assistance (Claude 4.1 Opus; Gemini 2.5 Pro; GPT-5 Thinking[2]); concept and philosophical framing by the author; mathematical formalization and drafting largely AI-generated and curated by the author.

Pseudonym. The author publishes under a pseudonym; the asterisk marks this.

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Foreword

The Cost of Hesitation: A Theory of a Deciding Universe

At the heart of modern physics, neuroscience, and cosmology lies a common puzzle: How does bare possibility become an actual, settled fact? A quantum particle occupies many places until a measurement singles out one. A human mind navigates a maze of potential futures until a decision selects one path. The universe itself rests in a subtle balance that drives its expansion, even though we do not know the source of that driving.
These transitions from undecided to definite — these "collapses" — are usually treated as separate mysteries. The theory proposed here, *Recursive Instability Collapse (RIC)*, offers a simple unifying working hypothesis: *reality emerges because indecision carries physical costs.*

Mechanism: an economic pressure. A system in a state of indecision — a spin in superposition, or a brain weighing options — sits in a state of high informational instability. We do not introduce a new law; we stay within open quantum systems. Our claim is that such a state is not passive; it incurs costs. RIC posits a universal feedback:

- **Instability creates pressure:** the more undecided a system, the stronger its coupling to the environment — as if hesitation generated a noise that makes it more observable.
- **Pressure enforces decision:** the reinforced coupling accelerates the process that drives the system into a robust state.

Collapse is not an external intervention, but an internal self-regulation that exits an informationally "expensive" state. Our simulations *suggest* that this dynamics can reproduce Born statistics without postulating them, while respecting no-signaling.

Neural signature. If RIC is universal, its echo should appear in the most complex decision system we know. The theory makes a lab-testable prediction: the weighing phase corresponds to elevated neuronal instability (frontal Theta, 4–7 Hz), and the commitment moment corresponds to the collapse of this state (signatures: CPP, LRP). The felt "free will" would be the first-person view of this physical transition.

Cosmological consequence (heuristic). As a heuristic reading, the pervasive stream of quantum collapses since the big bang could stabilize an information-thermodynamic fixed point of vacuum energy density. Phenomenologically this behaves like dark energy: homogeneous, $w \approx -1$, no clustering. This is a *hypothesis* that requires quantitative confrontation with precision data.

Conclusion: an invitation to falsification. RIC provides a unified frame that models quantum collapse, conscious choice, and cosmic expansion as manifestations of an economic self-organization principle. This is not dogma but a falsifiable program. The technical appendix supplies mathematics, simulation details, and pre-registrable experimental designs.

1 Contribution & Claims (Overview)

1. **RIC mechanism (adaptive monitoring):** A global instability functional $C(t)$ controls measurement rates $\gamma_k(t)$ with respect to a threshold $C^\star$.
2. **CPTP guarantee (under record-only feedback):** Unconditional dynamics stay GKLS-linear, completely positive and trace-preserving.
3. **Born consistency:** Jump intensities scale with $\mathrm{Tr}\big[L_k^\dagger L_k\,\rho_c\big]$; no outcome leakage into rates.
4. **No-signaling:** Local RIC maps on A do not change A-marginals depending on measurement bases on B.
5. **Testability:** (i) SSE/trajectory experiments, (ii) EEG predictions (Theta, CPP/LRP), (iii) an effective cosmological component $w\approx -1$ without clustering.
6. **Reproducibility:** Pseudocode (master equation, jumps, no-signaling check), analysis plan, and guardrails for linearity/feedback.

2 Notation

For quick orientation we summarize the main symbols.

Symbol	Type/unit	Meaning / comment
$\rho(t)$	density operator	state of the open system at time t
$H(t)$	Hamiltonian	(effective) Hamiltonian, possibly time-dependent
L_k	operator	Lindblad/jump/measurement operator (channel k)
$\mathcal{D}[L_k]\,\rho$	superoperator	$L_k\rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\}$
$\gamma_k(t)$	rate	adaptively controlled monitoring strength (record-only)
$C(t)$	scalar	instability functional; typically variance-sum $\sum_k \mathrm{Var}_\rho(L_k)$ (operator-invariant, state-dependent)
$C^\star$	scalar	threshold for adapting $\gamma_k(t)$
$H_{\mathrm{fb}}(t)$	Hamiltonian	optional feedback Hamiltonian (Wiseman–Milburn)
	operator	identity
$\mathrm{Tr}[\cdot]$	scalar	trace; expectations $\langle O\rangle = \mathrm{Tr}[O\rho]$
$\mathrm{Var}_\rho(O)$	scalar	variance of O in state ρ
$\Lambda_{A,t}$	CPTP map	local GKLS dynamics on subsystem A at time t
ρ_{AB}, ρ_A	density operators	joint state AB, and marginal on A

3 Main Text

3.1 Introduction

The idea behind *RIC* is to let open quantum systems be characterized not by fixed external measurement rates, but by *state-dependent adaptive monitoring.* A global instability functional $C(t)$ acts as an order parameter: when C is high, monitoring intensifies; when C is low, it weakens. Formally, the unconditional ensemble evolution retains the GKLS form, while C can be chosen, e.g., as in Eq. (3.2).

Terminology. We use established terms from measurement and control: *adaptive measurement scheduling*, *measurement-based feedback* (record-only), and the *unitary–dissipative tension*. The author's earlier working labels ("information theory" in a broad, humanistic sense; "dialectical duality") motivated the framework but are not used as technical terms here.

3.2 RIC: intuition in three layers

(i) Information-guided control. Information gain requires active probing. RIC reads measurement as a regulated information flow: strengths are resources to be allocated to where expected clarification is maximal (high C).

(ii) Unitary–dissipative tension. Unitary evolution (H) and dissipative/measurement dynamics (L_k) pull in opposite directions; RIC maintains the tension and regulates it rather than resolving it away.

(iii) Recursion. Measurement changes the state and hence C, which in turn modifies the monitoring strengths — a closed loop that stays *linear* at the ensemble level (record-only).

3.3 Formal specification

We use the GKLS form [**?**, **?**]:

$$\dot{\rho}(t) \;=\; -\,i\,[H(t),\rho(t)] \;+\; \sum_k \gamma_k(t)\,\mathcal{D}[L_k]\,\rho(t), \qquad \mathcal{D}[L]\,\rho := L\rho L^\dagger - \tfrac{1}{2}\{L^\dagger L,\rho\}. \tag{3.1}$$

RIC adds a schedule $t \mapsto \gamma_k(t)$ built from an instability functional, e.g.

$$C[\rho(t)] \;=\; \sum_k \mathrm{Var}_{\rho(t)}(L_k) \;=\; \sum_k \Big(\mathrm{Tr}\Big[L_k^\dagger L_k\,\rho(t)\Big] - \mathrm{Tr}[L_k\,\rho(t)]\,\mathrm{Tr}\Big[L_k^\dagger\,\rho(t)\Big]\Big). \tag{3.2}$$

A practical smooth switch is

$$\gamma_k(t) \;=\; \gamma_k^{\min} \;+\; (\gamma_k^{\max} - \gamma_k^{\min})\, s\!\left(\frac{C(t)-C^\star}{\Delta}\right), \quad s(x) := \frac{1}{1+e^{-x}}, \tag{3.3}$$

with threshold $C^\star$ and width $\Delta > 0$.

Working assumptions. (A1) *Record-only feedback*: $\gamma_k(t)$ and any $H_{\mathrm{fb}}(t)$ are deterministic, time-dependent coefficients derived from *past* measurement records and averaged over realizations; no direct functional dependence $\gamma_k[\rho(t)]$. (A2) Causal filtering (no future information). (A3) Locality in multipartite settings (no forbidden cross-channels).

3.4 Properties (proof sketches in the appendix)

- **CPTP:** Under (A1) the unconditional dynamics are GKLS-linear; see Prop. 1.
- **Born consistency:** Jump intensities are proportional to $\mathrm{Tr}\big(L_k^\dagger L_k\,\rho_c\big)$; see Prop. 2.
- **No-signaling:** Local, time-dependent GKLS maps on A do not alter A-marginals depending on the basis chosen on B; see Prop. 3.

3.5 Predictions and empirical paths

(Q) Quantum trajectories. Jump hazards near threshold should show an *S-curve* (cf. Eq. (3.3)). Testable in trapped ions/superconducting platforms via adaptive readout (photon counting, QND).

(N) Neurophysiology. If decision-making is read as recursive monitoring, RIC predicts a coupling between instability and measurement strength: transient Theta increase before a steep CPP/LRP rise (a "collapse window").

(C) Cosmology (heuristic). On large scales RIC acts as a smooth damping of fluctuations, phenomenologically akin to a component with $w \approx -1$ and no clustering; requires quantitative tests against precision data.

3.6 Relation to prior work (concise)

RIC differs from standard measurement-based feedback control (Wiseman–Milburn) by (i) using a *global* instability functional to schedule measurement strengths and (ii) keeping unconditional dynamics GKLS-linear via record-only averaging. It stays within the Belavkin/continuous-measurement picture but highlights an order parameter C that drives adaptive monitoring at the ensemble level.

3.7 Limitations and open questions

Choice of C and L_k may be *identifiability-critical*; naive implementations risk unwanted nonlinearity (violating A1). Open questions: information optimality of $s(\cdot)$, thermodynamic cost of adaptivity, sharper (no-)go results beyond Markovianity.

3.8 Minimal example & falsifiability

A qubit with $H = \frac{\Omega}{2}\sigma_x$, $L = \sqrt{\kappa}\,\sigma_z$, $C = \mathrm{Var}_\rho(\sigma_z)$ and Eq. (3.3) already shows the qualitative RIC signature: quiet phases at low monitoring, punctuated by brief high-clarity bursts. Systematic departure from Born histograms near threshold, under record-only scheduling, would falsify RIC.

3.9 Summary

RIC provides a compact, testable mechanism: *instability steers measurement strengths without sacrificing GKLS linearity.* The appendix contains proof sketches and simulation blueprints enabling replication and falsification.

Author contributions & AI disclosure

Gestan Morgan*: idea, problem statement, recursive/dual conceptual framing (cf. the author's texts), prompt design, curation and final editing. **AI assistants** (Claude 4.1 Opus; Gemini 2.5 Pro; GPT-5 Thinking[2]): preliminary formal structure, proof sketches, simulation pseudocode; language tightening. Content curated, checked, and integrated by the author. **Responsibility:** remaining errors are the author's.

A Formal foundations and simulation sketches for RIC

A.1 Setting and notation

We consider an open quantum system with density operator $\rho(t)$ and GKLS dynamics (3.1). The form guarantees CPTP (Lindblad 1976; Gorini–Kossakowski–Sudarshan 1976). In RIC, monitoring rates $\gamma_k(t)$ are adapted as functions of an instability $C(t)$ with threshold $C^\star$, cf. (3.2).

A.2 CPTP under adaptive rates: conditions and sketch

Assumption 1 (Record-only feedback)**.** *Scheduling $\gamma_k(t)$ and any feedback Hamiltonian $H_{\text{fb}}(t)$ are deterministic functions of time or exogenous classical signals derived from* past *measurement records and averaged over realizations. In particular, $\gamma_k(t)$, $H_{\text{fb}}(t)$ do not depend functionally on the current ensemble density $\rho(t)$.*

Proposition 1 (CPTP dynamics)**.** *Under Assumption 1, the unconditional dynamics has the GKLS form (3.1) with time-dependent coefficients and is CPTP.*

Sketch. (i) Continuous measurement (Belavkin filter). (ii) Markov feedback à la Wiseman–Milburn: $H_{\text{fb}}(t) = F\,I(t)$ or modulation of couplings; $I(t)$ is the *classical* measurement current. (iii) Ensemble averaging over records: $\rho = \mathbb{E}[\rho_c]$ obeys (3.1) with deterministic, time-dependent $\gamma_k(t)$ and possibly $H_{\text{fb}}(t)$. (iv) GKLS $\Rightarrow$ CPTP. □

A.3 Born consistency of trajectories

Proposition 2 (Born statistics under adaptive monitoring)**.** *For jump unravelings with conditional state $\rho_c(t)$ and time-dependent $\gamma_k(t)$ that satisfy Assumption 1,*

$$\Pr\{\textit{jump } k \textit{ in } [t, t{+}dt) \,|\, \rho_c(t)\} \;=\; \gamma_k(t)\ \mathrm{Tr}\big[L_k^\dagger L_k\,\rho_c(t)\big]\,dt, \tag{A.1}$$

and ensemble histograms are compatible with the Born rule.

Sketch. Standard derivation of stochastic Schrödinger/master equations for counting observation. Adaptive $\gamma_k(t)$ act as deterministic coefficients; no outcome leakage into rates $\Rightarrow$ Born-compatible histograms. □

A.4 No-signaling under local RIC dynamics

Proposition 3 (No communication)**.** *Let ρ_{AB} be an initial (possibly entangled) state. Apply a local, time-dependent GKLS map $\Lambda_{A,t}$ (RIC-compliant) on A, and any local operation on B without back-channel to A. Then $\rho_A(t) = \mathrm{Tr}_B[(\Lambda_{A,t}\otimes\mathcal{I}_B)\rho_{AB}]$ is independent of the measurement basis on B. RIC allows no superluminal communication.*

Sketch. Linear CPTP maps commute with partial trace over the other subsystem. A local map on A and a local operation on B (with readout) do not alter the A-marginal. □

A.5 Simulation sketches (pseudocode)

A. Unconditional master equation with adaptive rates

Listing 1: Unconditional GKLS with adaptive rates (record-only)

```
import numpy as np

def D(L, rho):
    return L @ rho @ L.conj().T - 0.5*(L.conj().T@L@rho + rho@L.conj().T@L)

def rk4_step(rho, H, Ls, gammas, dt):
    def rhs(r):
        dr = -1j*(H@r - r@H)
        for L, g in zip(Ls, gammas):
            dr += g * D(L, r)
        return dr
    k1 = rhs(rho)
    k2 = rhs(rho + 0.5*dt*k1)
    k3 = rhs(rho + 0.5*dt*k2)
    k4 = rhs(rho + dt*k3)
    return rho + (dt/6.0)*(k1 + 2*k2 + 2*k3 + k4)
```

B. Jump trajectories with adaptive rate

Listing 2: Stochastic trajectory (jump unraveling)

```
def jump_trajectory(rho0, H, Ls, gamma_of_t, T, dt, rng):
    rho = rho0.copy()
    traj = []
    for n in range(int(T/dt)):
        t = n*dt
        gammas = gamma_of_t(t) # deterministic (record-averaged) schedule
        Heff = H(t) - 0.5j*sum(g*L.conj().T@L for L, g in zip(Ls, gammas))
        rho_tilde = rk4_step(rho, Heff, [], [], dt)
        p_no = np.real(np.trace(rho_tilde))
        if rng.uniform() < 1 - p_no:
            rates = np.array([g*np.real(np.trace(L@rho@L.conj().T)) for L, g in zip(Ls,
                 gammas)])
            k = rng.choice(len(Ls), p=rates/np.sum(rates))
            rho = Ls[k] @ rho @ Ls[k].conj().T
            rho = rho / np.trace(rho)
            traj.append(("jump", t, k))
        else:
            rho = rho_tilde / p_no
            traj.append(("nojump", t, None))
    return traj
```

C. No-signaling test (entangled pair)

Listing 3: A-marginals invariant under B-basis choice

```
def nosig_experiment(rho_AB, HA, LsA, gammaA, UB_list, T, dt, Nreal=1000, rng=None):
    # UB_list: different local bases/POVMs on B (as unitaries)
    from numpy import kron, trace
    marginals_per_B = []
    for UB in UB_list:
        hist = []
        for r in range(Nreal):
            rho = rho_AB.copy()
            rho = evolve_unconditional(rho, HA, LsA, gammaA, dt, T)
            rho = (kron(np.eye(lenA), UB)) @ rho @ (kron(np.eye(lenA), UB.conj().T))
            rhoA = partial_trace_B(rho)
            hist.append(rhoA)
        marginals_per_B.append(avg(hist))
    return compare_ci(marginals_per_B)
```

Selected references

Lindblad (1976); Gorini–Kossakowski–Sudarshan (1976); Wiseman (1994); Belavkin (1992); Carmichael (1993).