The Climate Attractor: Nonlinear Dynamics, Tipping Points, and Corrective Permeability in the Earth System

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Abstract

The Earth's climate is a dissipative attractor—a far-from-equilibrium system maintained by a continuous flow of solar energy and entropy export. For 10,000 years, the Holocene basin remained stable due to a network of negative feedbacks that conferred high corrective permeability on the climate system. Since the Industrial Revolution, a sustained, rapid perturbation in atmospheric greenhouse gas concentrations has saturated several of those feedbacks and begun activating positive feedback loops that push the system toward basin transitions. This paper applies the attractor framework to the climate crisis, arguing that linear assumptions about gradual, reversible warming constitute a fantasy attractor, and that tipping points are best understood as ridges between alternative attractor basins. The framework also diagnoses three common social attractors—denial, doom, and techno-utopianism—as low corrective permeability belief systems that reduce the urgency to act. The paper concludes that the principle of corrective permeability (κ) must be

institutionalized in climate policy and individual cognition alike, and that physical systems update whether human belief systems do or not.

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1. Introduction: The Earth as a Dissipative Attractor

The Earth is not a closed system in thermodynamic equilibrium. It is an open, dissipative system maintained far from equilibrium by a continuous influx of solar radiation and the radiative export of entropy to space. Its climate—the long-term statistical pattern of temperature, precipitation, wind, and ocean circulation—is an emergent attractor: a persistent, self-regulating dynamical state.

For approximately 10,000 years, the Earth's climate has occupied a relatively narrow basin known as the Holocene. Within this basin, human civilization emerged and developed agriculture, cities, trade networks, and complex societies. The basin's apparent permanence encouraged a cognitive error that now carries severe consequences: we mistook the walls of the basin for the horizon.

The attractor framework (Galida, 2026) defines reality operationally as *persistence under perturbation*. A stable attractor absorbs perturbations and returns to its basin; an unstable one, when pushed beyond a critical threshold, undergoes a phase transition into a different basin with different structural properties. This paper applies that framework to the climate system, with three objectives:

1. To characterize the Holocene basin's stabilizing feedbacks and the perturbation now overwhelming them.
2. To reframe climate tipping points as ridges between

alternative attractor basins, emphasizing the role of perturbation rate relative to system recovery time.
3. To diagnose the social dynamics of the climate debate using the same principle of corrective permeability (κ) that describes the physical system.

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2. The Holocene Basin: Stabilizing Feedbacks and Corrective Permeability

A stable attractor basin does not persist by accident. It persists because negative feedback loops counteract perturbations, pulling the system back toward equilibrium. The Holocene's stability was maintained by a network of such loops.

Ocean heat absorption. The ocean's thermal inertia acts as a buffer: when atmospheric temperatures rise, the ocean absorbs excess heat, slowing surface warming. This negative feedback dampens short-term fluctuations.

Ice-albedo feedback (negative phase). Polar ice sheets reflect incoming solar radiation back to space. When the climate cooled slightly, ice expanded, increasing albedo and reinforcing cooling. When it warmed, the feedback operated in reverse, but on timescales slow enough to avoid runaway warming.

Forest transpiration. Large forest systems, particularly the Amazon and Congo basins, generate their own rainfall through evapotranspiration. This self-sustaining moisture cycle stabilizes regional climates and prevents desertification.

Silicate weathering thermostat. Atmospheric CO_2 dissolves in

rainwater, forming carbonic acid that weathers silicate rocks. The dissolved carbon is transported by rivers to the ocean, where it precipitates as carbonate minerals and is eventually subducted. This negative feedback operates on timescales of hundreds of thousands of years, but it has regulated atmospheric CO_2 across geological epochs.

These feedbacks collectively conferred high *corrective permeability* (κ) on the Holocene climate. When perturbed—by volcanic eruptions, solar variability, or orbital cycles—the system responded with countervailing adjustments. The basin absorbed the perturbation and returned to its attractor. The basin was deep.

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3. The Perturbation: Magnitude, Rate, and the Saturation of Corrective Capacity

Since the Industrial Revolution, the human enterprise has introduced a sustained, massive perturbation into the climate system through the combustion of fossil fuels, industrial agriculture, and land-use change. Atmospheric CO_2 concentration has risen from approximately 280 parts per million (ppm) to over 420 ppm—a level not seen since the Pliocene, roughly 3 million years ago. Methane and nitrous oxide concentrations have risen sharply as well.

The attractor framework requires that a perturbation be assessed on two dimensions: magnitude and rate. A slow perturbation, even a large one, allows an attractor's corrective mechanisms time to operate. A fast perturbation—one delivered on a timescale shorter than the system's characteristic recovery time—can overwhelm those mechanisms and force a basin exit regardless of absolute magnitude.

The current perturbation is fast by geological standards. The rate of CO_2 increase during the Paleocene-Eocene Thermal Maximum (PETM), a natural warming event approximately 56 million years ago associated with mass extinction, was roughly 0.025 GtC per year. The current rate is estimated at approximately 10 GtC per year—around 400 times faster. The ocean's capacity to absorb heat is approaching saturation. The silicate weathering thermostat operates on timescales two to three orders of magnitude longer than the human perturbation. The system's corrective permeability is being saturated.

The key intellectual error in much public climate discourse is *linear thinking*: the assumption that gradual emissions increases produce gradual, proportional, and reversible temperature increases. This assumption is itself a fantasy attractor. The climate system is nonlinear. It contains tipping points—critical thresholds beyond which the system undergoes a phase transition into a new attractor basin. Once crossed, these transitions are not easily reversed. The perturbation is not merely large. It is arriving at a speed that the system's corrective mechanisms cannot match.

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4. Tipping Points as Ridges Between Basins

A tipping point, in attractor terminology, is a ridge between basins. Below the ridge, the negative feedbacks that define the current basin remain dominant. At the ridge, they are precisely balanced by positive feedbacks. Beyond the ridge, positive feedbacks dominate, and the system cascades into a new basin. The transition is not a smooth slope. It is a phase change.

The following tipping elements are currently under scientific

investigation. In each case, the attractor framework identifies the competing feedbacks and the ridge structure. Where scientific uncertainty exists, it is stated explicitly.

4.1 The Greenland Ice Sheet

The Greenland Ice Sheet is stabilized by its own elevation: the surface is high enough to remain cold, and snowfall replenishes mass. As melt accelerates, the surface elevation decreases, exposing the ice to warmer air—a positive feedback. Current research suggests that Greenland may have a critical threshold between approximately 0.8°C and 3°C of warming above pre-industrial levels, with a central estimate near 1.5°C. However, crossing this threshold does not imply imminent, catastrophic collapse on human political timescales. Full loss of the ice sheet would likely unfold over centuries to millennia, though the process may become irreversible once the threshold is crossed. Sea level rise of up to seven meters is the ultimate consequence, but the timescale is millennial. The ridge is uncertain in both position and temporal gradient.

4.2 The Atlantic Meridional Overturning Circulation (AMOC)

The AMOC is a major ocean current system driven by temperature and salinity gradients. It has at least two stable attractor basins: a strong circulation mode (the current state) and a collapsed or substantially weakened mode. Freshwater input from melting Greenland ice reduces surface water density, weakening the sinking motion that drives the circulation. Multiple climate models show a weakening trend under continued warming, but the proximity to a critical threshold remains debated. Observational evidence indicates that the AMOC is currently at its weakest in over a thousand years (Caesar et al., 2021). Some research suggests a collapse could occur within decades once triggered; other models find the circulation more resilient. The scientific community has not

reached consensus on the threshold's location or the likelihood of near-term crossing. The ridge exists; its distance and height are incompletely characterized.

4.3 The Amazon Rainforest

The Amazon generates a substantial fraction of its own rainfall through evapotranspiration. This is a stabilizing feedback that maintains the forest basin. Deforestation and regional drying weaken this feedback. Beyond a critical level of tree loss (estimated by some studies at 20–25% of original cover), the moisture cycle may break down, triggering a transition to a savanna state. This would release stored carbon and permanently alter regional and global climate. Quantitative modeling suggests that tropical forests exhibit hysteresis, meaning that once a critical threshold is crossed, returning to the original forest state requires a much larger reversal of conditions (Staal et al., 2020). However, the precise threshold remains uncertain, and the interaction of deforestation with global warming complicates prediction. The ridge is plausible but not precisely located.

4.4 Permafrost Carbon Feedback

Northern permafrost soils contain approximately 1,400–1,600 GtC—roughly twice the carbon currently in the atmosphere. As permafrost thaws, microbial decomposition releases CO_2 and methane. This is a positive feedback: warming drives thaw, thaw releases greenhouse gases, which drive further warming. The process is already underway. However, the rate of release is heavily dependent on future emissions trajectories. Lower emissions scenarios substantially reduce the total carbon release over the coming centuries. Permafrost carbon feedback is not a binary, unstoppable runaway process; it is a continuous, trajectory-dependent amplifier of warming. The strength of the amplification is a function of the perturbation magnitude.

4.5 Coupling and Cascade Risk

The individual tipping elements described above do not operate in isolation. They are coupled basins. A perturbation that pushes one across its ridge can propagate through the network, pushing others in turn. This cascade logic is what distinguishes the attractor framework from a list of separate tipping points. The framework's central physical insight is that the climate system's basins are interconnected, and a transition in one alters the boundary conditions—and thus the ridge positions—of its neighbors.

The coupling sequence is structurally clear. Greenland melt injects freshwater into the North Atlantic, reducing surface density and weakening the AMOC. A weakened AMOC shifts tropical rainfall belts southward, drying the Amazon and increasing fire risk. Amazon dieback releases stored carbon into the atmosphere. Permafrost thaw, accelerated by the same warming, releases additional carbon. Each basin exit amplifies the perturbation driving the next. The climate's corrective permeability, once maintained by a web of negative feedbacks, is being progressively replaced by a network of positive couplings that amplify the initial perturbation. This does not imply inevitability. It implies nonlinear risk amplification, in which the probability of cascading transitions increases with continued perturbation. The cascade is not a prediction. It is a structural feature of a coupled nonlinear system. Foundational research on tipping elements first systematically catalogued these components and their interactions over a decade ago (Lenton et al., 2008); subsequent observational and modeling work has strengthened the case that the coupling is real.

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5. Social Attractors: Denial, Doom, and Techno-Utopia

The public debate surrounding climate change is itself a dynamical system of competing attractor basins. Three common configurations exhibit low corrective permeability (κ). In each case, the diagnosis applies not to the *content* of the belief but to its *impermeability to disconfirming evidence*. A high-κ individual may hold any of the positions described below, provided that position is genuinely falsifiable and updated when evidence shifts.

5.1 The Denial Attractor

The denial attractor reframes evidence of anthropogenic warming as natural variability, scientific fraud, or politically motivated exaggeration. Disconfirming data—temperature records, ice core analyses, model projections—are dismissed or attributed to conspiratorial motives. The dopamine reward is social: the denier occupies the role of truth-teller bravely resisting a corrupt consensus. The self-reinforcing loop is tribal belonging: each act of dismissal earns approval from the in-group, deepening the basin. Corrective permeability is near zero.

5.2 The Doom Attractor

The doom attractor asserts that tipping points have already been crossed, that warming is now unstoppable, and that all mitigation efforts are futile. This position is often defended with scientific references, but it shares with denial a structural consequence: the rationalization of inaction. If nothing can be done, nothing need be done. The dopamine reward is moral certainty: despair presents itself as clarity, and the doomer feels superior to the "naive optimist." The self-reinforcing loop operates through despair validating itself by dismissing hope as naivete. Any evidence of

progress—falling renewable costs, policy victories, accelerating deployment—is reframed as “too little, too late.” The basin deepens with each dismissed success.

5.3 The Techno-Utopia Attractor

The techno-utopia attractor defers responsibility to hypothetical future technologies—direct air capture, solar radiation management, fusion energy—that are not yet deployed at scale. This position permits continued present consumption without behavioral or political change. The lever is marked “future fix.” The technology may eventually contribute to mitigation, but reliance on it as a substitute for current emissions reductions is a bet on a lever that has not been wired. The self-reinforcing loop operates through continued consumption: each emission-intensive purchase validates the belief that consumption need not change, because a future technology will compensate. The basin deepens with every unreduced carbon footprint.

These three attractors share a functional outcome: they reduce the perceived urgency of emissions reductions. They are not symmetrical in their relationship to evidence—the denial attractor is the furthest from scientific consensus—but they are symmetrical in their dynamical effect. They are low-κ basins that resist updating.

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6. The Physical–Social Symmetry

There is a structural identity between the climate system’s dynamics and the social dynamics of the climate debate. Both are instances of the same phenomenon: a system whose corrective permeability is being eroded by positive feedbacks that amplify perturbation rather than dampening it.

In the physical climate, the Holocene's negative feedbacks—ocean heat absorption, ice albedo, forest transpiration, silicate weathering—conferred high κ. Those feedbacks are now saturating or reversing. Ice melt reduces albedo, accelerating warming. Forest loss breaks the transpiration cycle, accelerating drying. Permafrost thaw releases carbon, accelerating the perturbation. The system's negative feedbacks are becoming positive ones. The climate is becoming a sealed basin, driven by internal amplification rather than external correction.

In the social climate, the same transition is underway. High-κ cognition—the willingness to update beliefs when evidence shifts—is being replaced by low-κ basins that reinforce themselves through tribal belonging, despair-validating narratives, or consumption-maintaining deferral. These social attractors function as positive feedbacks on the physical perturbation: denial blocks mitigation policy, doom dismisses it as futile, techno-utopia delays it indefinitely. The social system, like the physical one, is developing sealed basins that amplify the perturbation rather than correcting it.

The symmetry is not metaphorical. It is dynamical. A sealed belief system and a tipping climate are the same structural phenomenon—a low-κ attractor driven by positive feedback—operating at different scales. The climate system and the human systems embedded within it are coupled. The physical perturbation drives social basin-sealing; social basin-sealing accelerates the physical perturbation. Corrective permeability is the variable that determines whether this coupling is damped or amplified. At present, both systems are trending toward amplification.

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7. Policy as Institutional Corrective Permeability

The attractor framework yields a specific policy principle: any climate strategy must be designed with explicit update mechanisms, because the system is nonlinear, the models carry irreducible uncertainty, and the ridge positions are incompletely known. The question is not only *what to do* but *how to ensure that the strategy corrects as evidence accumulates*.

High-κ climate policy would exhibit the following properties:

- **Adaptive targets.** Emission reduction targets are revised when interim data show deviations from projected pathways. A missed target triggers a stronger response, not a redefinition of the baseline.
- **Technology neutrality with periodic reassessment.** Energy system investments are directed toward the fastest-scaling clean technologies available, with periodic review to incorporate performance data on new options.
- **Feedback-sensitive adaptation.** Adaptation funding (sea walls, drought-resistant agriculture, managed retreat) is allocated based on observed changes in risk, not static projections.
- **Institutionalized error correction.** Policymaking bodies include formal processes for reviewing failed interventions and updating strategy. Truth-telling is built into governance.

Low-κ policy, in contrast, attaches itself to a fixed target, a favored technology, or a politically convenient narrative. When reality diverges, the institution attacks the messenger, rebaselines the accounting, or reframes failure as partial success. The error signal is never allowed to land. The

institution becomes a sealed basin, pressing the lever of its own stated commitments while the physical system moves into a new state.

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8. Individual Corrective Permeability: A Methodological Note

The attractor framework holds that macro-scale social attractors are composed of individual cognitive basins. The corrective permeability of a society is, in part, a function of the corrective permeability of its members. This paper does not prescribe personal behavior; it notes an operational question that operationalizes the framework's diagnostic at the individual level:

Would I update my climate beliefs if the evidence shifted decisively?

If the honest answer is no, corrective permeability is approaching zero, and the individual basin is sealed. The content of the belief—whether denial, doom, techno-optimism, or mainstream concern—is irrelevant to this diagnostic. The diagnostic applies to the structure of belief, not its content.

What, then, characterizes high-κ individual cognition in practice? The framework suggests several structural features. High-κ individuals tend to make small, durable belief adjustments rather than dramatic, identity-threatening reversals; the basin deepens through repeated correction, not emotional intensity. They separate their identity from their beliefs, so that updating a belief does not feel like losing a self. They seek out disconfirming evidence rather than avoiding it, treating error signals as information rather than threats. And they maintain a distinction between what they

know and what they merely find plausible, keeping their confidence calibrated to the strength of the evidence. These features are not personality traits. They are practices. They can be cultivated.

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9. Conclusion

The Holocene basin, which persisted for 10,000 years through a network of stabilizing negative feedbacks, is now being perturbed at a rate that saturates those feedbacks and activates positive ones. Tipping points are not slopes; they are ridges between basins. The location of those ridges is uncertain, but the dynamics that generate them are structurally well-understood. Uncertainty is not a case for complacency; it is a case for corrective permeability.

The social dynamics of the climate debate—denial, doom, techno-utopianism—are low-κ attractors that reduce the urgency of action. They are structurally identical to the physical dynamics they refuse to confront: sealed basins driven by positive feedback. The policy response must be designed with explicit update mechanisms, because the system is nonlinear and the future is incompletely predictable. The principle of corrective permeability applies at every scale: physical, institutional, and individual.

The atmosphere does not negotiate. The ice sheet does not care about ideology. The ocean current does not read manifestos. Physical systems update whether we do or not.

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Persistence Under Perturbation: The Eternal Skeleton and the Transient Dance

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Persistence Under Perturbation: The Eternal Skeleton and the Transient Dance
Robert Galida — June 2026 (Revised Edition)

Note to readers: *This is a revised version of the May 2026*

> *paper. The core insights about the eternal skeleton and transient dance remain, but the treatment of fundamental metronomes has been refined. For the detailed relational account of time, see the companion paper: [Metronome, Memory, and the Threefold Anchor: A Relational Account of Time F.]*

Abstract

This paper presents a unified framework based on a simple idea: **persistence under disturbance is the basic mark of reality.**

We divide all persistent things into two classes:

- **Non-dissipative (conservative) structures** – eternal, time-symmetric, mindless. They form the **eternal skeleton** (Planck scale, quantum fields, the three fundamental metronomes: electron, neutrino mass eigenstates, and proton).
- **Dissipative attractors** – temporary, time-asymmetric, needing energy flow. They form the **transient dance** (life, mind, society, consciousness).

All observed minds are dissipative.

Because the universe as a whole is a conservative system (no outside environment), it cannot have consciousness or intentions.

Therefore, under this framework, a theistic God is extremely unlikely.

No supernatural entities are needed.

The framework gives a naturalistic view of persistence, a

graded idea of mind, and a way to study how people get trapped in **fantasy attractors** (belief systems that ignore reality).

Scope Conditions

This framework is not a finished mathematical theory. It is a cross-domain way of thinking about persistence under disturbance. The word “attractor” is sometimes a metaphor, sometimes a precise term. The framework looks for similar stability patterns across different scales, not a single equation. It is an invitation to explore, not a closed belief system.

Part I: The Nature of Mind

1. The Core Intuition

Your mind feels real, long-lasting, and not just brain tissue. Dualism can’t explain mind-body interaction. Reductive physicalism ignores the feeling of being you. We propose a third way: **the mind is a stable, resilient, persistent pattern — an attractor — of your whole body.**

2. Key Definitions

Term	What it means	How to measure
Attractor	A region in state space that pulls nearby states toward it and holds them	Lyapunov exponents, basin stability
Resilience	Ability to bounce back after a hit	Recovery time, hysteresis

Term	What it means	How to measure
Basin of attraction	The set of states that eventually fall into the attractor	Larger basin = more resilient
Attractor dimensionality	How complex the attractor is	Correlation dimension; proxy for integrated information (Φ)
Fantasy attractor	A belief system cut off from reality checks	Low contact with corrections; deep basin; slow updating
Shared reality attractor	A belief system open to reality checks	High contact with corrections; shallow basin; fast updating

3. Signs of a Resilient Attractor

- Bounces back quickly after stress
- Low hysteresis (forward and return paths nearly the same)
- Stable rhythms (HRV, circadian, breathing lock together)
- Cross-domain coupling (better sleep → better mood, immunity)
- Graceful decline under growing stress (not sudden collapse)
- Critical slowing down (rising variance and autocorrelation before a big change)

4. The Third Ontological Category

View	What it says	Problem
Dualism	Mind is a non-physical substance	How can it interact with the body?

View	What it says	Problem
Reductive physicalism	Mind is just brain activity	It loses the feeling of being you
Attractor framework	Mind is a real, non-substantial pattern (like a whirlpool)	Fully compatible with physics, keeps subjective experience

A whirlpool is real – it depends on water, affects the flow, and isn't just one water molecule. Your mind is like that.

5. Attractor Framework & Consciousness Theories

- **IIT (Integrated Information Theory):** Attractor dimensionality acts like Φ. Awake animals have higher-dimensional attractors than anesthetised ones (Tajima & Kanai, 2017).
- **GWT (Global Workspace Theory):** "Ignition" means settling into a global attractor that spans many brain areas.
- **Testable predictions:** Shallow attractors (unconscious) are easier to disturb; conscious states have deeper basins and higher dimensionality.

6. The Simplest Mind: *C. elegans* (a tiny worm)

The worm has 302 neurons. It shows: integration of senses, minimal self-reference, valence, associative learning, goal-directed behaviour. That's all we need for a minimal mind. Prediction: during learning, its brain should show higher attractor dimensionality than when paralysed.

7. Mind as a Whole-Body Attractor

Your mind is not just in your brain. It includes your body's extracellular matrix (ECM), hormones, immune system, and gut. Alcohol, sleep, and ECM restoration affect the whole body and change your mind. That's why relaxing your belly, getting morning light, or reading a quiet book can improve your sleep and heart rate variability (HRV).

8. Self-Engineering: Reshaping Your Own Attractor

Because your mind is an attractor, you can change it through small, repeated nudges: learning a skill, exposure therapy, forming habits, meditation, physiological hacks (ECM restoration, belly sag, morning cardio). An N=1 experiment (tracking ECM, sleep, HRV) showed that improvements happen in non-linear, threshold-based jumps — exactly as attractor theory predicts.

Part II: The Eternal Skeleton and the Transient Dance

9. Two Fundamental Classes of Persistence

9.1 Non-Dissipative (Conservative) Structures — The Eternal Skeleton

- No energy loss; total energy stays the same (or exchanges only within a closed system)
- Time-reversible at the level of intrinsic persistence (though weak interactions violate CP/T)
- Stable because of conservation laws (charge, baryon

number, energy)
- Do not age, do not die (or are effectively eternal on all observable timescales)

The three fundamental metronomes (see *Threefold Anchor* paper) are the most conservative layer of the eternal skeleton:

Metronome	Role
Electron	Lightest charged lepton; invariant Compton frequency
Neutrino mass eigenstates (ν_1, ν_2, ν_3 collectively)	Effectively stable; theoretically invariant frequencies
Proton	Lightest baryon; stability from baryon number conservation

These three are continuously recycled through all dissipative systems. They are the invariant substrate.

Other conservative structures include: Planck-scale granular spacetime, quantum fields, stable atoms, and the universe as a whole.

These make up the **eternal skeleton** — mindless, timeless, the foundation.

9.2 Dissipative Attractors — The Transient Dance

- Need constant energy and must dump entropy
- Time-irreversible (arrow of time)
- Stay stable through feedback loops, homeostasis, and energy use
- Finite lifetime — they age, decay, and eventually collapse
- **What binds all dissipative systems** (a bacterium, a brain, a galaxy, a society) is the continuous recycling of the three eternal metronomes. Every dissipative

system operates by exchanging electrons, protons, and neutrinos with its environment.

Examples: living cells, metabolic networks, ecosystems, human bodies, conscious minds, societies, economies, fantasy attractors.

These are the **transient dance** — everything that is born, lasts a while, and dies.

10. Why Mind Requires Dissipation

Every known system with integration, self-reference, valence, learning, and goal-directedness is **dissipative**. No non-dissipative mind has ever been seen. So we conclude that, in this framework, the only kind of consciousness we have evidence for is dissipative. This is a best-explanation inference, not an absolute proof.

11. The Universe as a Non-Dissipative System

The universe as a whole has no outside environment. Its total energy is conserved (or at least doesn't exchange with anything else). So it is non-dissipative:

- No metabolism (doesn't eat, breathe, or repair itself)
- No learning (its laws don't change from experience)
- No valence (no likes or dislikes)
- No goal-directedness (it just follows its equations, doesn't aim for a basin)

Therefore, the universe is **not a mind**. Any global attractor (e.g., a de Sitter vacuum state) is a conservative, eternal, mindless pattern.

12. Why a Theistic God Is Extremely Unlikely (Probabilistic)

A theistic God is supposed to be: conscious, intentional, personal, eternal, unchanging, and self-sufficient.

- Consciousness (as far as we know) requires **dissipation**.
- Eternal, unchanging, self-sufficient means **non-dissipative** (conservative).

No known entity can be both dissipative (aging, needing energy) and non-dissipative (eternal, self-sufficient). So, under this framework, a theistic God is extremely implausible. The universe itself is already the only non-dissipative system. Adding a separate non-dissipative God is unnecessary and, by definition, cannot interact with anything.

13. The Map of Existence

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            TRANSIENT DANCE (Dissipative Attractors)
              - Societies
              - Minds
              - Cells
              - Ecosystems
              - Human Body (ECM, HRV)
              - Animal Life
              - Metabolism (energy + entropy)
                    ↓ (emergence)
               ETERNAL SKELETON (Conservative Persistence Structures)
              - Atoms
                - Three metronomes: electron, neutrino mass eigenstates, proton
              - Quantum Fields
              - Planck Scale (granular spacetime) ← FLOOR
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Legend: Floor = Planck-scale granularity — the hard, eternal limit. Skeleton = quantum fields, stable particles, atoms — conservative structures. Dance = dissipative attractors —

minds, life, society.

14. Open Questions for Future Work

- **Formal cross-scale unification:** How can we unify conservation-based stability (QFT) and dissipative attractors (nonlinear dynamics) with a single mathematical object?
- **Dissipation-consciousness link:** Is dissipation absolutely necessary for consciousness, or just a fact about life on Earth?
- **ECM mechanism:** What is the exact chain from ECM changes to nervous system regulation to subjective feelings?
- **Persistence vs. selection:** Is persistence a basic feature of reality, or do we only notice stable things because unstable ones vanish?
- **Fantasy attractor measurement:** Can we really measure correction latency, basin depth, and external coupling in real social systems?
- **Coupling equations:** How exactly does the rate of memory inscription depend on metronome frequency? (See the *Threefold Anchor* paper for a working placeholder.)

15. Conclusion

The attractor framework gives a naturalistic picture of reality:

- **Non-dissipative (conservative) structures** – the eternal, mindless skeleton, anchored by the three fundamental metronomes (electron, neutrino mass eigenstates, proton).
- **Dissipative attractors** – temporary, energy-hungry, and mortal. All minds are in this class.
- **What binds all dissipative systems** is the continuous recycling of the same three eternal metronomes.

- The universe as a whole is non-dissipative, therefore not a mind.
- A theistic God is extremely implausible under this framework.

We don’t need religious language. We have the eternal skeleton and the transient dance: persistence without transcendence, structure without the supernatural.

The dance is finite, fragile, and precious. The skeleton is eternal, but mindless.

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This rewrite is ready to replace the old post. It now correctly reflects the threefold metronome framework, includes the recycling insight, and cross-references the newer paper.

Sleep as Attractor Maintenance: Glymphatic Clearance, Synaptic Rescaling, and Dynamical Resilience

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Date: May 2026
Preprint available at: https://fantasyattractor.com/

Abstract

Sleep is often called “hardware maintenance” (deep sleep) and “software maintenance” (REM sleep).
This paper re-interprets sleep using the **attractor framework**, where your mind is a dissipative attractor of your whole body.

We propose that different sleep stages are different **attractor regimes**:

- **Deep (NREM) sleep** – a slow, relaxing state that clears waste and dials down brain connections.
- **REM sleep** – a fast, high-dimensional attractor that updates your brain’s internal model.

We review evidence for:

- Glymphatic clearance (waste removal)
- Synaptic homeostasis (downscaling of connections)
- Slow-oscillation/spindle coupling
- Sleep–immune interactions

We also show how sleep fragmentation, ageing, chronotypes, and sleep disorders can be understood as changes in **attractor depth**, **stability**, and **corrective permeability**.

The framework introduces a **persistence functional** P(x)$P(x)$ – a single number that measures basin depth – which could be estimated from EEG or wearables to predict resilience to sleep loss and guide closed-loop interventions.

1. Introduction

In the attractor framework, your mind is a **dissipative attractor of your whole body** – a pattern that needs constant energy, can be disturbed, and can adapt.
Sleep is a natural, periodic disturbance that lets the system reset, repair, and reorganise. It is **not** passive; it is an **active attractor maintenance process**.

We focus on two major sleep stages:

- **NREM sleep**, especially deep slow-wave sleep (NREM 3) – a **slow constraint relaxation** that brings the brain and body back to a low-energy baseline.
- **REM sleep** – a **fast, high-dimensional attractor** for active reorganisation, memory consolidation, and predictive coding updates.

This paper bridges sleep neuroscience with the attractor framework.
What does the framework add?

- **Integration** – a common language across scales.
- A **unified quantitative biomarker** $P(x)$ from EEG or wearables.
- **Novel predictions** (e.g., wearable early-warning signals, REM-emotional rebound) that are not obvious from the individual component theories.
  This is **generative integration** – a scientific contribution even without claiming new mechanisms.

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2. The Attractor Framework Primer

- **Conservative attractors** (the “six metronomes”) – eternal, time-symmetric, provide steady rhythms. They are the floor, not part of maintenance.
- **Dissipative attractors** (life, mind, society) – need energy flow, have finite lifetimes, can evolve. The brain is a nested stack of dissipative attractors.
- **Persistence under perturbation** – a resilient system returns quickly to its attractor after a disturbance.
- **Self-engineering** – using small, repeated disturbances to reshape your own attractor. Sleep is a natural self-engineering cycle.

Sleep moves you through: **wake → NREM → REM → wake**.

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3. NREM Deep Sleep – Slow Constraint Relaxation

3.1 Glymphatic clearance – flushing out waste

Deep slow-wave sleep (NREM 3) is essential for clearing brain waste.
Studies show that the glymphatic system (which removes waste) works best during deep NREM (Iliff et al., 2012). Norepinephrine drops during sleep, expanding the space around cells and improving fluid flow (Balkrishnan et al., 2023, conference abstract).

In attractor terms: The deep-sleep attractor (high delta power) relaxes the metabolic constraints that build up during the day. Waste clearance rate scales with **attractor**

depth (measured by slow-wave activity, SWA). Shallow or broken sleep leads to waste buildup.

3.2 Synaptic homeostasis – resetting brain connections

The synaptic homeostasis hypothesis (SHY) says:

- Wakefulness strengthens synapses (deepens attractor basins).
- NREM sleep downscales synapses (shallows basins) (Tononi & Cirelli, 2006).

SWA reflects this – it is high after waking and declines across the night.

In attractor terms: The persistence functional P(x)$P(x)$ would be high after waking, then drop during NREM as synapses downscale. The rate is steep early and plateaus later – compatible with critical slowing down near awakening (though direct evidence is mixed).

3.3 Slow-oscillation–spindle coupling – nested rhythms

Memory consolidation during sleep depends on the tight coordination of:

- Cortical slow oscillations (<1 Hz)
- Thalamocortical spindles (12–15 Hz)

This is best described as **nested oscillatory coupling** (Ngo et al., 2013) – the slow oscillation modulates excitability, creating windows for spindles.
We interpret this as **different timescales within a single attractor manifold** (parsimonious). (Two coupled attractors

could also produce phase locking; the question is subtle, but we take the simpler view.)

Stronger phase-locking between spindles and slow oscillations predicts better memory. Closed-loop stimulation (auditory or electrical) timed to the up-phase enhances both slow waves and spindles — showing that the attractor can be externally reinforced.

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4. REM Sleep — Fast, High-Dimensional Attractor

REM sleep has activated EEG (low voltage, fast rhythms) and vivid dreaming.
From a **predictive coding** view (Friston, 2010), REM updates the brain's generative model by resolving prediction errors.

Dynamically, the NREM → REM transition is a **phase bifurcation**:

- NREM is a low-dimensional attractor (regular slow oscillations).
- REM is higher-dimensional (complex, desynchronised EEG).

Indeed, EEG complexity (e.g., Lempel-Ziv complexity) is higher in REM and wake than in NREM.

If REM dreaming implements predictive coding, then nights with stronger REM (longer, more intense periods) should show greater emotional memory consolidation. (The idea of lucid dreaming as a "meta-attractor" is not pursued here.)

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5. Sleep Fragmentation and Attractor Instability

Frequent awakenings (fragmentation) repeatedly disturb the sleep attractor.
Each arousal is a temporary escape from the NREM or REM basin, reducing effective depth and slowing re-entry. This is a state of **reduced attractor stability** with **critical slowing down** (Scheffer et al., 2009): recovery takes longer.

Recent work (de Mooij et al., 2020) found that EEG change-points – transitions between stages – are often preceded by early-warning signals (rising variance and autocorrelation).
Grossman et al. (2025) showed that the wake-to-sleep transition follows a bifurcation dynamic, detectable minutes before sleep onset.

Wearables (HRV, actigraphy) could detect similar signs – rising movement variance, increasing HRV autocorrelation – before a failed sleep transition. Closed-loop auditory tones could then reinforce the desired attractor.

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6. Inter-individual Differences, Aging, Chronotypes, and Immune Coupling

Resilience to sleep loss

People vary widely. The **PER3 clock gene polymorphism** is a paradox:

- PER3$^{5}/^{5}$ individuals have more slow-wave sleep and higher

> delta power, yet they suffer **greater** performance declines under sleep loss (Viola et al., 2011).

This shows that a deeper baseline attractor does **not** guarantee resilience. The framework says resilience requires not only depth but also **corrective permeability** – the ability to re-enter deep sleep after an awakening and to update the attractor under stress (see Section 7).

Aging

Slow-wave sleep drops dramatically with age. In a community study, each 1% annual reduction in SWS was linked to a 27% higher risk of dementia (Himali et al., 2023).
In attractor terms: the deep-sleep basin **erodes** with age, and corrective permeability weakens. Exercise, light therapy, and melatonin may help a little, but only modestly.

Chronotypes

Morning larks and night owls differ mainly in the **phase** of the sleep–wake attractor relative to the light–dark cycle. Both can have similar basin depths, but misalignment may weaken the attractor.

Sleep–immune coupling

Sleep deprivation increases pro-inflammatory cytokines (IL-6, TNF-α) and reduces T-cell activity (Irwin et al., 2016; Besedovsky et al., 2012).
A shallow or fragmented sleep basin destabilises the immune attractor, leading to slower recovery from infection (Cohen et al., 2009) and blunted vaccine responses (Spiegel et al., 2002).

Immune challenge (e.g., infection) also disrupts sleep, increasing SWS – a “sickness behaviour” attractor shift (Krueger et al., 2013). This is **bidirectional coupling** between

two attractor landscapes.

Framework-specific prediction: Corrective permeability κ should be **lower** on nights following an immune challenge, independently of changes in delta power.
(Statistical test: partial correlation or regression of κ on immune challenge, controlling for PEEGPEEG□.) This prediction is not deducible from the cytokine model alone.

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7. Sleep Disorders as Maladaptive Attractors and Corrective Permeability

7.1 Defining corrective permeability κ

κ measures how quickly a system returns to its primary attractor after a disturbance and how easily it updates under chronic stress.$\kappa = 1 \tau_{recovery}$$\kappa = \tau_{recovery}$□1□

where $\tau_{recovery}$$\tau_{recovery}$□ (minutes) is the time from an awakening back to stable deep NREM (stage 3).

- High $\kappa > 0.2$$\kappa > 0.2$ min^{-1} → fast recovery (<5 min).
- Low $\kappa < 0.05$$\kappa < 0.05$ min^{-1} → poor recovery (>20 min).

These thresholds are provisional — for empirical calibration.

Heart-rate recovery slope after awakenings is a candidate wearable proxy (hypothesis, not yet validated).

7.2 Disorder taxonomy

- **Insomnia** — abnormally shallow sleep attractor (low

depth) **and/or** low κ*κ*. Hyperarousal prevents settling into deep sleep.
- **Narcolepsy** – blurred boundary between wake and REM attractors (orexin loss).
- **REM behaviour disorder** – failure of REM attractor to suppress muscle activity; dream movements "leak out".

7.3 Falsification conditions

Falsification of the "shallow basin" explanation
If an insomnia patient shows normal delta power (PEEG>0.7*P*EEG >0.7) **and** normal corrective permeability (κ>0.1*κ*>0.1) but still has non-restorative sleep, the "shallow basin" model is falsified for that patient.
The framework would be incomplete, not wrong. **But** to prevent this clause from making the theory unfalsifiable, we add a provisional bound:

> *If more than 30% of diagnosed insomnia cases need such additional mechanisms, the framework's descriptive utility for insomnia would be in question, and the core hypothesis would be falsified.*

Falsification of the attractor framework itself
If sleep stage transitions show **no** evidence of basin-crossing dynamics (no rise in variance/autocorrelation, no attractor dimensionality difference between NREM and REM, no critical slowing down before awakening), then the attractor framework should be abandoned in favour of a purely stochastic or oscillator-based model.
Specifically, a well-powered study using the methods of de Mooij et al. (2020) that finds null results would constitute strong falsification. (We require convergent null evidence across multiple measures.)

8. The Persistence Functional P(x)$P(x)$

P(x)$P(x)$ measures attractor depth – the ability to resist disturbance and return to stable state.
We base it on the **dominant Lyapunov exponent** λ1$\lambda 1$.

Primary definition (fixed τ=1$\tau=1$ s):Praw=e−λ1·τ$P_{raw}=e^{-\lambda 1\cdot\tau}$

For a stable attractor, λ1<0$\lambda 1<0$, so Praw>1$P_{raw}>1$. Deeper attractors (more negative λ1$\lambda 1$) give larger PrawP_{raw}.

To get a bounded [0,1] measure:Pnorm=11+eλ1τ$P_{norm}=\frac{1}{1+e^{\lambda 1\tau}}$

- Values near 1 → deep basin.
- 0.5 → neutral.
- Near 0 → unstable/chaotic.

EEG-practical approximations:

- **Correlation dimension D2$D2$** – in sleep EEG, deeper stages have lower D2$D2$. This is a **sleep-specific** approximation. Then P∝1/(1+D2)$P\propto 1/(1+D2)$.
- **Delta power ratio** (simplest):

PEEG=⟨δ(t)⟩δwake+⟨δ(t)⟩$P_{EEG}=\frac{\delta_{wake}+\langle\delta(t)\rangle}{\langle\delta(t)\rangle}$

where ⟨δ(t)⟩⟨δ(t)⟩ is mean delta power (0.5–4 Hz) in the epoch, and δwakeδwake is the same during relaxed wakefulness. Deep sleep → value close to 1; shallow sleep → near 0.

We recommend PEEGPEEG for practical sleep research. All three definitions should correlate under the framework's

assumptions, but empirical validation is needed.

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9. Testable Predictions

Prediction	Type	Proposed Test Protocol	Source / Support
Glymphatic clearance correlates with SWA	Retrodiction	–	Iliff et al., 2012
EEG complexity decreases across NREM	Retrodiction	–	Tononi & Cirelli, 2006
SO–spindle coupling predicts memory	Retrodiction	–	Ngo et al., 2013
Sleep fragmentation preceded by rising variance/autocorrelation	Novel	Re-analyse existing sleep EEG datasets	de Mooij et al., 2020; Grossman et al., 2025
Wearable early-warning signals (HRV lag-1 autocorrelation) predict night-to-night sleep quality	**Novel**	Pilot N=1 wearable study (30+ nights); confirm with larger cohort	Proposed here
REM rebound scales with emotional load during wake	Plausible	Daily stress diary (1–10) + actigraphy/PSG for REM%	Proposed here

Prediction	Type	Proposed Test Protocol	Source / Support
Immune challenge reduces next-night κ independently of delta power	**Novel (framework-specific)**	Controlled immune challenge (e.g., vaccine) with wearable/PSG κ; partial correlation controlling for PEEGPEEG	Proposed here

Falsification of core framework: If no evidence of basin-crossing dynamics (rising variance/autocorrelation, difference in attractor dimensionality) is found in a well-powered EEG study using de Mooij et al.'s methods, the attractor framework for sleep should be abandoned.

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10. Conclusion

Sleep is not passive — it is a dynamic, bifurcated process of **attractor maintenance**.

- **Deep NREM sleep** — slow constraint relaxation, clearing waste and downscaling synapses.
- **REM sleep** — fast, high-dimensional attractor, updating the brain's generative model.

Fragmentation, aging, and sleep disorders can be understood as changes in attractor depth, stability, and corrective permeability.

The persistence functional $P(x)$ gives a quantitative language for sleep engineering.

The dance of sleep is the dance of maintenance — and we can learn to engineer it.

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The Sperm and the Dome: An Ancient Pattern

Robert Galida https://fantasyattractor.com/
May 2026

You have seen the diagram.
It appears in biblical studies textbooks, online articles about ancient Near Eastern cosmology, and even on apologetics websites trying to explain away the plain meaning of Genesis.

A flat disc earth.
A solid dome (*rāqīaʿ*) above.
A cosmic ocean below.
The sun, moon, and stars move inside the dome.
Rain enters through literal windows in the sky.

It looks primitive.
Like a child's drawing of a snow globe.

But look again. Squint. Rotate the image ninety degrees.

What do you see?

A sperm.

A single, potent, ordered structure swimming through an infinite ocean.

- The **head** is the dome — the firmament containing the celestial lights.
- The **midpiece** is the flat disc of the earth — the solid ground where life emerges.
- The **tail** is the cosmic ocean below — the chaotic, fertile waters from which everything springs.

And the whole thing is adrift in an infinite, dark, supportive medium — the same infinite ocean that appears in Genesis as the *tehom* (the deep), the primordial waters over which the Spirit of God hovers.

This is not a coincidence.
It is a **pattern**.

The Attractor Framework: A Lens

In my attractor framework, **persistence under perturbation** is the fundamental mark of reality.

Two classes of attractors exist:

- **Conservative attractors** – the eternal skeleton: electrons, protons, neutrinos, photons. They are time-symmetric, unchanging, and provide the invariant rhythms of the universe (the "metronome").
- **Dissipative attractors** – the transient dance: life, mind, society, and everything that requires energy flow, exports entropy, and eventually runs down.

A sperm is a **low-entropy conservative structure** – a packet of highly ordered information (DNA) that is relatively stable and fuel-efficient.
It swims through a **high-entropy dissipative environment** – the chaotic, nutrient-rich ocean of potential.
Its journey is a perturbation.

Fertilisation, when it succeeds, is a **phase transition**: the emergence of a new, more complex attractor (the zygote) from the coupling of two initial basins (sperm and egg).
The subsequent explosion of growth – cell division, differentiation, morphogenesis – is the **transient dance** of life.

The Ancient Mind Saw the Same Pattern

The biblical authors had no microscopes. They could not see a sperm cell.
But they observed the world around them, and they projected the **microcosmic pattern of fertilisation** onto the **macrocosmic canvas of the sky**.

- The **infinite ocean** is the primordial *tehom* – the raw, undifferentiated potential before creation.
- The **sperm** is the *rāqīaʿ* – the solid dome that separates and organises the waters above from the waters below.
- The **fertilised egg** is the cosmos itself – the flat disc of the earth, the lights in the dome, the living creatures on the land.

The ancient author of Genesis was not a scientist.
But he was a **pattern-recogniser**.
He intuited that the universe begins as a single, ordered perturbation in an infinite, chaotic sea.
That is not primitive superstition.
That is **dynamical intuition**.

The Cosmic Conception Hypothesis

Modern science has its own version of this same pattern.
The “cosmic conception hypothesis” (found in some theoretical papers) compares the fertilisation of a galaxy by a supermassive black hole to the fertilisation of an egg by a sperm.
The black hole is the seed; the galaxy is the developing organism.

The same archetype recurs because it is **structurally necessary**: any self-organising system that emerges from a homogeneous background must be born as a localised, ordered perturbation.

The Genesis diagram is not a mistake.
It is a **map**.

The Sperm in the Infinite Ocean

When you look at that ancient Near Eastern cosmology diagram — the flat earth, the solid dome, the cosmic ocean — you are looking at a **sperm in an infinite ocean**.
The author could not have known this consciously.
But the attractor of reality — the deep structure of persistence under perturbation — guided his hand.

- The infinite ocean is the potential.
- The sperm is the first perturbation.
- The fertilised egg (the cosmos) is the new attractor basin.
- And the dance of life — stars, planets, minds, civilisations — is the transient, dissipative dance that follows.

The diagram is not a coincidence.
It is a **necessary projection of a universal dynamic**.
The sperm and the dome are the same pattern, separated by millennia and scale.

You are free to see it or not.
But once you see it, you cannot unsee it.

The mountain does not negotiate.
Neither does the Hebrew text.

Neither does the sperm.

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You are free to see it or not. But once you see it, you cannot unsee it. The mountain does not negotiate. Neither does the Hebrew text. Neither does the sperm.

Author: Robert Galida
Date: May 2026
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Whirling as Attractor Engineering: Chirality, Shared Resonance, and a Minimal-Dose Protocol for Whole-Body Resilience

Author: Robert Galida
Date: May 2026 (Revised June 2026)

 Note (June 2026): This paper's description of conservative attractors has been updated to reflect the refined framework in *Metronome, Memory, and the Threefold Anchor: A Relational Account of Time* [F] (2026). The health and self-engineering

content is unchanged.

Abstract

Whirling – the spinning practice of Mevlevi dervishes – is often seen as a mystical ritual. This paper reinterprets it through the attractor framework, where the mind is a dissipative attractor of the whole body.

Whirling is a controlled, repeated perturbation. It trains your balance, nervous system, and heart to settle into a stable, coherent pattern – a form of attractor engineering.

We discuss two additional ideas:

- **Chirality alignment** – spinning counter-clockwise may symbolically align with the universe's handedness (e.g., left-handed neutrinos), but this is speculative and not needed for health benefits.
- **Shared resonance** – group whirling synchronises heartbeats, creating a collective attractor.

We review scientific evidence showing that whirling improves heart rate variability (HRV), sleep quality, anxiety, brain plasticity, and physical fitness. A minimal effective dose is 5–15 minutes per day, 3–4 times per week. A graduated protocol is provided.

The health benefits are real. The chirality interpretation is optional.

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1. Introduction

In the attractor framework, your mind is a dissipative attractor of your whole body – a pattern that needs energy flow to stay stable, can be disturbed, and can adapt. Self-engineering means using small, repeated disturbances to reshape your own attractor towards greater resilience.

Whirling is a sustained, counter-clockwise spin performed by Mevlevi dervishes for centuries. It is spiritual, but modern science has found clear physical and mental benefits.

This paper argues that whirling is a powerful attractor engineering practice: a rhythmic whole-body disturbance that forces your system to become more stable and coherent. We also explore two extra ideas:

- **Chirality** (spinning with the universe's "handedness" – speculative)
- **Shared resonance** (heartbeat synchronisation in groups – well supported).

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2. The Attractor Framework Primer (Very Brief)

- **Conservative attractors** are eternal, time-symmetric, and require no energy input. They form the *eternal skeleton*. The three most fundamental conservative attractors – the *metronomes* – are the **electron**, **neutrino mass eigenstates** (collectively), and **proton**. (The photon is a signal carrier, not a metronome; see *Metronome, Memory, and the Threefold Anchor* for details.)
- **Dissipative attractors** (life, mind, society) need energy flow, have finite lifetimes, and can change. Your body

is a stack of dissipative attractors.
- **Persistence under disturbance** is the basic mark of reality. A resilient system returns to its attractor after a knock.
- **Self-engineering** uses small, repeated nudges to reshape your own attractor basin.
- **Whirling** is a strong, repeated disturbance. Your body must adapt. That adaptation is the engineering.

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3. Chirality Alignment – A Speculative Interpretation

3.1 What do we know about universal handedness?

- **Weak interactions:** Neutrinos produced in weak decays are always left-handed (Wu experiment, 1956). This is a fact. But electrons and protons do not have a universal spin direction.
- **Astronomical rotations:** From the north pole, Earth, the solar system, and the Milky Way rotate counter-clockwise. From the south pole, they appear clockwise. That’s just a viewpoint – there is no privileged direction in space.
- **Cosmic Microwave Background:** Some studies suggested a preferred axis (“axis of evil”), but these results are contested and likely statistical artifacts. No clear evidence.

3.2 The speculative claim

The dervish’s counter-clockwise spin can be seen as a heuristic alignment with these physical handednesses (neutrino helicity, frame-dependent rotation). In our attractor

framework, we propose that spinning with the majority direction (as seen from the northern hemisphere) may resonate symbolically and phenomenologically with the invariant rhythms of the conservative substrate – the three metronomes.

Crucially, there is no known physical mechanism linking a rotating body (~1–2 rpm) to particle spin or photon polarisation. The scale difference is huge. So this alignment is presented as a speculative metaphysical claim within our framework, not as proven physics. It's a way to frame the practice, not a testable hypothesis. The health benefits of whirling do not depend on this speculation.

3.3 Clockwise vs. counter-clockwise

No study has compared clockwise and counter-clockwise whirling for health effects. The idea that clockwise spinning "needs more energy" or "opposes the Tao" is unsupported – we label it as speculation. You can try both directions, but the traditional counter-clockwise spin is recommended for alignment with our framework's interpretive preferences.

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4. Shared Resonance: Heartbeat Synchronisation

A published study measured heart rates during a group Sufi whirling ritual. It found that participants' heartbeats became synchronised – the biological data matched the spiritual goal of unity.

In attractor terms: the shared rhythm creates a common basin of attraction across people. Each body locks onto the same external rhythm (the group spin), and through mutual coupling, their cardiac oscillators fall into step.

This is like metronomes placed on a movable platform – they

eventually synchronise (a classic demonstration from Huygens, 1665). Here, the “platform” is the shared sound and feel of the group whirling. The result is a collective attractor – a stable shared state where heart rates align, possibly amplifying resilience.

Note: The term “collective attractor” simply means a stable pattern in a coupled system. The 2019 study showed cardiac synchronisation, but the idea that whirling together increases resilience beyond what you can do alone is still a plausible hypothesis that needs testing.

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5. Evidence for Health Benefits

5.1 Heart Rate Variability (Autonomic Resilience)

A 2012 study on “Whirling-Kung” (5–15 minutes, three times per week) found the practice prevented a decline in key HRV measures (SDNN, total power) seen in a control group. Higher HRV means a wider attractor basin, faster recovery, and greater resilience.

5.2 Sleep Quality and Stress Markers

A 2022 study on whirling dervishes found significantly better sleep quality and much lower anxiety ($p < 0.001$) compared to non-whirling controls. The dervishes also had lower levels of VEGF, BDNF, and GDNF – markers often elevated by chronic stress.

Note on BDNF: Lower BDNF is usually linked to depression, not less stress. The authors of the study interpreted this as a possible protective effect, but the relationship is complex. We simply report the finding without endorsing a specific interpretation.

5.3 Neuroplasticity — Reshaping the Brain's Attractor Landscape

An MRI study found that long-term dervishes have cortical thinning in the default mode network (DMN) and motion-perception areas (right DLPFC, lingual gyrus, visual area V5). This thinning is experience-dependent neuroplasticity: the brain prunes inefficient connections to become more specialised.

5.4 Physical Fitness and VO_2max

A 12-week whirling training programme improved body composition, leg strength, flexibility, grip strength, and both anaerobic and aerobic power (VO_2max). Whirling is effective whole-body cardiovascular exercise.

5.5 Mental Health — Less Anxiety, Better Self-Regulation

Multiple studies confirm lower anxiety. Participants report better mind-body focus, self-regulation, positive feelings, and a "quietness in the centre of the vortex" — the subjective experience of a stable core attractor.

Finding the original studies: The papers cited here (2012 HRV, 2022 sleep/anxiety, MRI, 12-week fitness, and the 2019 heartbeat study) can be found by searching terms like "whirling dervish heart rate variability," "whirling kung HRV," "Dursun whirling MRI," "Karakaya whirling sleep," or "Genc whirling VO2max."

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6. The Minimal Effective Dose

Based on the 2012 study and traditional practice:

- 5–15 minutes per session

- 3–4 times per week
- Counter-clockwise rotation (traditional; clockwise not harmful but lacks evidence)
- Gradual progression

Phase	Duration	Frequency	Goal
Adaptation (weeks 1–2)	5 min	3–4x/week	Get used to the spin
Consolidation (weeks 3–4)	10–15 min	3–4x/week	Find the rhythm, notice calm
Expansion (week 5+)	20–30 min	3–4x/week	Explore deeper states

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7. Practical Instructions

- **Space:** A large, empty room. Bare feet.
- **Posture:** Start with arms crossed on your chest. Begin turning counter-clockwise. After a few revolutions, open your arms: right hand up (palm to sky), left hand down (palm to earth).
- **Gaze:** Soft, unfocused — don’t fixate on a single point.
- **Safety:** Stop if you feel severe nausea. Use a wall for support if needed.
- **Afterward:** Rest lying down for 5–10 minutes to let your balance system settle.

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8. Conclusion

Whirling produces real, measurable benefits: better HRV, sleep, anxiety, brain plasticity, and fitness. A minimal dose of 5–15 minutes a day, three to four times a week, is enough.

The shared resonance (heartbeat synchronisation in groups) is empirically supported.
The chirality alignment (spinning counter-clockwise to align with the universe) is a speculative interpretation – not required for the health benefits.

The dervish's spin is a dance of persistence under perturbation – a transient dancer humming along with the eternal skeleton. The dance has a new step.

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The Cosmology of Genesis: Flat Earth, Solid Dome, and Cosmic Ocean

A Plain-Language Guide to What the Bible Actually Says

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May 2026

Note on genre: *This is an open letter and*

historical-philological analysis, not a peer-reviewed journal article. It draws on mainstream biblical scholarship, standard Hebrew lexicons, and ancient Near Eastern comparative materials. The primary evidence comes from narrative and descriptive passages (Genesis 1, Job 37–38, Ezekiel 1, etc.). The analysis is addressed to scholars who have dismissed the flat-earth reading as "silly."

Abstract

This paper examines the physical description of the universe in the Hebrew Bible. Using standard Hebrew dictionaries (BDB, HALOT, Holladay), ancient Near Eastern texts, and the plain meaning of the biblical passages, we show that the biblical authors believed:

- The earth is a **flat disc**.
- A **solid dome** (*rāqīaʿ*, "firmament") covers it, separating the waters below from a **cosmic ocean above**.
- The sun, moon, and stars move inside this dome.
- Rain enters through literal **windows** or **sluices** in the dome.
- The earth rests on **pillars** and **foundations**, and has **ends** and **corners**.

We provide a representative list of verses, address common apologetic reinterpretations, and reference standard scholarly reconstructions of ancient Hebrew cosmology. The Bible's cosmology closely matches those of Mesopotamia and Egypt. This poses no problem for a non-inerrancy reading, but it is a severe challenge for any claim of divine scientific inerrancy.

Introduction: What Did the Biblical Authors Actually Believe?

The question is not whether the Bible is "true" in a theological or moral sense. The question is: **what did its human authors believe about the physical structure of the world?**

Modern readers often project a post-Copernican, spherical, heliocentric universe onto the ancient text. But a straightforward reading – using standard Hebrew lexicons and the context of the ancient Near East – shows that the Hebrew Bible shares the common model of a flat earth under a solid sky-dome, with a cosmic ocean above and below.

For standard scholarly reconstructions (with diagrams), see:

- Bible Odyssey (Society of Biblical Literature) – includes a clear diagram of the flat earth, solid dome, and cosmic waters.
- Wikimedia Commons – a modern, clearly labelled reconstruction.
- Biblical Archaeology Society – comparative diagrams of Israelite, Babylonian, and Egyptian models.

For print references, see Smith (1998) and Keel (1997).

The Solid Dome: *Rāqīaʿ* (□□□□□□□)

The word *rāqīaʿ* occurs 17 times in the Hebrew Bible. Its verbal root *rāqaʿ* (□□□□□) means "to beat, stamp, or spread out

by hammering" – the same word used for beating metal into thin plates (Exodus 39:3). The noun denotes a **solid, hammered-out dome**.

Lexical Evidence

Lexicon	Definition
Brown-Driver-Briggs (BDB)	"Extended surface, (solid) expanse (as if beaten out)"
Holladay	"Beaten metal 'plate', firmament (i.e. vault of heaven, understood as a solid dome)"
Koehler-Baumgartner (HALOT)	"Firmament, vault of heaven, understood as a solid dome"

Key Verses by Genre

Narrative (primary evidence)

- **Genesis 1:6–8** – God says, "Let there be a *rāqīaʿ* in the midst of the waters, and let it separate the waters from the waters." He calls the *rāqīaʿ shamayim* (sky/heaven). The dome is placed inside a cosmic ocean, dividing "waters below" from "waters above."
- **Genesis 1:14–18** – The sun, moon, and stars are placed **inside** the *rāqīaʿ*. They are not above the dome; they are embedded in its inner surface.

Wisdom poetry (corroborative)

- **Job 37:18** – "Can you, like Him, spread out the skies, hard as a mirror of cast metal?" This unambiguously describes solidity.

Apocalyptic vision (structural)

- **Ezekiel 1:22–26** – Above the living creatures is "something like a *rāqīaʿ*, sparkling like ice (or crystal)." Above this *rāqīaʿ* is the throne of God. This is a solid platform, not empty space. Even though Ezekiel's vision is symbolic, it describes physical properties (solid, crystalline) as part of the visionary architecture.

Hymnic (doxological, not load-bearing)

- **Psalm 19:1** – "The heavens declare the glory of God; the skies (*rāqīaʿ*) proclaim the work of His hands."
- **Psalm 150:1** – "Praise God in His sanctuary; praise Him in His mighty *rāqīaʿ*."
- **Daniel 12:3** – "Those who are wise will shine like the brightness of the *rāqīaʿ*."

These do not prove solidity on their own, but they assume the same conceptual framework. No text contradicts the solid-dome interpretation.

Ancient Translations

- **Septuagint** (3rd century BCE, Jewish translation): *stereōma* (στερέωμα) – a solid or firm structure.
- **Latin Vulgate**: *firmamentum* – something firm, a support.

Scholarly Confirmation (Including Believing Scholars)

- **Seely (1991–1992)** – Demonstrates that *rāqīaʿ* in context refers to a solid dome.
- **Walton (2011)** – Affirms that the ancient Israelites

believed in a solid *rāqīaʿ*, even though his main argument is that Genesis 1 assigns functions rather than making material claims.
- **Greenwood (2015)** – "A vaulted dome above the earth, a 'firmament,' like the ceiling of a planetarium."
- **Parry (2014)** – "A flat earth at the centre of the cosmos, with a vast ocean in the sky."

The Waters Above – A Cosmic Ocean

If the dome is solid and separates "waters above" from "waters below", those waters must be literal.

- **Genesis 1:6–7** (as above).
- **Psalm 148:4** – "Praise Him, highest heavens, and you waters above the heavens."
- **Genesis 7:11** – "All the fountains of the great deep burst forth, and the windows of the heavens were opened." The word *arubbah* means "lattice window" or "sluice." Rain comes through openings in the solid dome.
- **Genesis 8:2** – "The fountains of the deep and the windows of heaven were closed."
- **2 Kings 7:2, 19** – "The Lord will open the windows of heaven."
- **Isaiah 24:18** – "The windows of heaven are opened, the foundations of the earth tremble."
- **Malachi 3:10** – "See if I will not open the windows of heaven and pour out blessing."

The Flat Earth: Pillars, Foundations, Ends, and Corners

A spherical earth does not have pillars, foundations, ends, or four corners. The Bible uses all these terms repeatedly.

Pillars of the Earth

- **1 Samuel 2:8** – “For the pillars of the earth are the Lord’s, and on them He has set the world.”
- **Job 9:6** – “He shakes the earth out of its place, and its pillars tremble.”
- **Psalm 75:3** – “When the earth and all its dwellers quake, it is I who bear its pillars firmly.”
- **Job 26:11** – “The pillars of heaven tremble and are stunned at His rebuke.”

Foundations of the Earth

- **Psalm 104:5** – “He set the earth on its foundations, so that it should never be moved.”
- **Job 38:4–6** – “Where were you when I laid the foundations of the earth? … On what were its bases sunk?”
- **2 Samuel 22:8** – “The foundations of the heavens shook.”

Ends of the Earth (assumes a bounded earth)

- **Deuteronomy 28:49** – “A nation from afar, from the end of the earth.”
- **Isaiah 45:22** – “Turn to Me and be saved, all you ends of the earth.”
- **Psalm 67:7** – “All the ends of the earth will fear Him.”

- **Psalm 72:8** – “He shall have dominion from sea to sea… to the ends of the earth.”

Four Corners of the Earth

- **Isaiah 11:12** – “He will assemble the scattered of Judah from the four corners of the earth.” The word *kanpôt* (wings/edges) is a directional idiom whose origin in a flat-earth, bounded-space worldview is widely recognised.

The Vaulted Dome Over a Flat Disc

- **Amos 9:6** – “The One who builds His upper chambers in the heavens and has founded His vaulted dome over the earth.”
- **Isaiah 40:22** – “He sits enthroned above the circle of the earth.”

On *chûg* (“circle”)

The word *chûg* occurs in three places: Job 26:10 (“He has inscribed a circle on the face of the waters” – a flat circular boundary), Proverbs 8:27 (same), and Isaiah 40:22. The Akkadian cognate *khâqu* means “to draw a circle.” The Septuagint translates *chûg* as *gyros* (circle), not *sphaira* (sphere). The same verse also says God “stretches out the heavens like a curtain” – a flat surface, not a spherical shell.

Therefore, *chûg* denotes a **disc**, not a ball.

The Cosmic Ocean Below

- **Genesis 7:11** – "The fountains of the great deep burst forth." (Subterranean ocean)
- **Psalm 24:2** – "For He has founded it upon the seas and established it upon the rivers."
- **Exodus 20:4** – "You shall not make an idol… of anything that is in the waters under the earth."
- **Psalm 136:6** – "He spread out the earth upon the waters."

Comparison with Ancient Near Eastern Cosmologies

The Hebrew cosmology is closely analogous to those of Israel's neighbours.

- **Mesopotamia:** The *Enuma Elish* describes Marduk fixing a solid sky-barrier to hold back the cosmic waters. This is the functional equivalent of the Hebrew *rāqīaʿ*.
- **Egypt:** The sky goddess Nut arches her body over the earth god Geb, forming a solid vault with stars attached. The Pyramid Texts describe the sky as "a metal vault" or "iron" – directly parallel to Job 37:18 ("hard as a mirror of cast metal").

The Hebrew *rāqīaʿ* fits comfortably within this regional intellectual context. The Bible is not scientifically unique; it reflects the common ancient Near Eastern worldview.

Geocentric Passages (Consistent with the Model)

These verses are not flat-earth proof on their own, but they presuppose a geocentric, non-rotating, bounded cosmos — fully consistent with the flat-earth, solid-dome model.

- **Joshua 10:12–13** — The sun and moon stand still at Joshua's command. This implies a moving sun and a non-rotating earth.
- **2 Kings 20:11 / Isaiah 38:8** — The shadow on the sundial moves backward. Again implies a geocentric system.
- **Ecclesiastes 1:5** — "The sun rises and the sun sets, and hurries to its place where it rises." Phenomenological geocentrism.
- **Psalm 19:4–6** — The sun runs its circuit from one end of the heavens to the other.

These passages are not necessary to demonstrate flat-earth cosmology, but they are part of the broader biblical cosmic picture.

The Verse Often Misused by Apologists: Job 26:7

Job 26:7 — "He stretches out the north over the void and hangs the earth on nothing (*belî-māh*)."

This is the only verse that might suggest a free-floating earth. However:

- *Belî-māh* is a rare construction; it may mean "**without any visible support**," not "without any support at all." Clines (1989) notes that the phrase indicates "no visible means of support" rather than absolute suspension.

One ambiguous verse does not overturn the dozens that describe pillars, foundations, and a solid dome. The majority witness of the Hebrew Bible is flat-earth, solid-dome cosmology. If Job 26:7 is taken as a late, more abstract cosmological statement, it represents a minority view and does not negate the consistent picture in Genesis, Psalms, and other prophets.

The Inerrancy Dilemma (and the Phenomenological Language Defence)

If one affirms that the Bible is a human document, the presence of ancient cosmology presents no crisis. But if one claims divine inerrancy — that the Bible is without error in all that it affirms — one faces a dilemma:

- **Admit** that God described His creation in terms that are scientifically false (a flat earth, a solid dome).
- **or Reinterpret** the plain meaning as metaphor or accommodation — but then the words lose stable meaning, and any verse can be explained away.

A common inerrantist response is the "phenomenological language" defence: the Bible describes things as they appear to human observers (e.g., "sunrise") without making scientific claims. This defence works for atmospheric or observational descriptions (sunrise, sunset, the shadow on a sundial). However, it **fails** for the structural, material claims of

Genesis 1: a solid dome, a cosmic ocean, and windows in the sky. These are **not appearances**; they are physical mechanisms. No one "observes" a solid dome or waters above the sky.

Therefore, the phenomenological defence cannot rescue the inerrancy of Genesis 1 without effectively admitting that the text is making false scientific statements.

This paper does not require any particular theological conclusion. It simply presents the evidence.

Conclusion

The evidence is consistent and extensive. The Hebrew Bible presents the universe as:

- a **flat disc**,
- covered by a **solid dome** (the *rāqīaʿ*),
- with a **cosmic ocean above** and a **cosmic ocean below**.
- The sun, moon, and stars move inside the dome; rain enters through literal windows.
- The earth rests on pillars and foundations and has ends and corners.

This cosmology is closely analogous to that of Israel's ancient Near Eastern neighbours. It is the plain meaning of the text, confirmed by every standard Hebrew lexicon and by believing scholars such as Walton, Greenwood, Parry, and Seely.

The mountain does not negotiate. Neither does the Hebrew text.

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Free Will as Attractor Autonomy: A Dynamical Account of Agency

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Date: May 2026

Abstract

Free will is often seen as either a magical mystery (libertarianism) or an illusion (hard determinism). This paper offers a third view using the attractor framework.

In this framework, your mind is a **dissipative, self-referential attractor** of your whole body.

Free will is redefined as **attractor autonomy**:

- The ability to generate behaviour from your own internal dynamics.
- To keep yourself stable over time.
- To model yourself.
- And to reshape your own attractor landscape over time.

Agency comes in degrees — it is not a simple yes/no.
We give a mathematical formula for an **agency index** A*A* that combines three factors:

- **Attractor dimensionality** D*D* (complexity of your brain's activity)
- **Recursive self-modification** R*R* (your ability to change your own habits)
- **Self-reference strength** S*S* (how well you have a persistent self-model)

The paper makes a **falsifiable prediction**: an **inverted-U** relationship between attractor dimensionality and sense of agency — too low or too high reduces agency.
We describe how to test this with EEG, intentional binding tasks, and statistical methods. We also engage with classic compatibilist philosophers (Frankfurt, Dennett) and address Pereboom's manipulation argument.
We even provide an explicit rule to avoid the "liver problem" (a false positive for self-reference).

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1. Introduction

The attractor framework says that **persistence under disturbance** is the basic mark of reality.

Minds are **dissipative attractors** – patterns that need constant energy flow, integrating the whole body.
In this view, free will cannot be a supernatural break from cause and effect. Instead, it must be a **dynamical property** of certain attractors.

We do not claim to solve the ancient free will debate. We offer a **naturalistic, testable redefinition** that adds new empirical content to compatibilism.

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2. What Free Will Is Not – And What It Is

2.1 Rejecting supernatural libertarianism

Libertarian free will requires an uncaused choice – a break in the chain of cause and effect.
The attractor framework rejects this: there is no evidence for it, and it contradicts physical laws.

2.2 The error of hard determinism

Hard determinism says freedom is an illusion because everything is determined. But it confuses "determined" with "externally coerced".
A system can be **internally determined** – by its own attractor – yet still be free. That is the core of **compatibilism**.

2.3 Free will as attractor autonomy

We define **free will** (or agency) as the degree to which a system has four properties:

1. **Dissipative persistence** – it stays alive by using energy

and exporting waste (measured by energy use and recovery speed).
2. **Self-reference** – it has an internal subsystem (an "indexical locus") that models the whole system and is stable.
3. **Trajectory selection** – it can choose among different possible futures (measured by **policy entropy** H(π)$H(\pi)$).
4. **Recursive self-engineering** – it can change its own attractor shape (measured by learning-to-learn or metacognitive accuracy).

These four are **jointly necessary**. If any is missing, agency is at best primitive.

Because they are necessary, we combine them with a **multiplicative** formula (if any factor is zero, agency is zero).A=(D−Dmin⁡Dmax⁡−Dmin⁡)α(RRmax⁡)β(S−Smin⁡Smax⁡−Smin⁡)γ$A=(\frac{D-D_{\min}}{D_{\max}-D_{\min}})^{\alpha}(\frac{R}{R_{\max}})^{\beta}(\frac{S-S_{\min}}{S_{\max}-S_{\min}})^{\gamma}$

Where:

- DD = attractor dimensionality (e.g., from EEG)
- RR = recursive modification capacity (e.g., improvement in a meta-learning task)
- SS = self-reference strength (normalised mutual information)

The constants (Dmin⁡,Dmax⁡$D_{\min}, D_{\max}$, etc.) are set from a reference population.
The exponents α,β,γα, β, γ are estimated from data (e.g., comparing healthy people with patients).
A threshold AcritA_{crit} (e.g., the 5th percentile of healthy humans) decides where agency begins.

Agency is **graded**:

- Rock: A≈0$A \approx 0$

- Thermostat: $A \approx 0$
- Worm: $A \approx 0.1$ (some learning, little self-model)
- Human: $A \approx 0.8$

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3. The Indexical Locus: Defining the "Self" and Avoiding the "Liver Problem"

The **indexical locus** L is the part of the system that acts as a persistent self-model.
To avoid trivial cases (like a liver having high mutual information with the rest of the body), we add three extra conditions:

- **Top-down causal influence** — L can change the rest of the body in ways that serve the body's goals (measured by variance explained beyond bottom-up effects).
- **Informational closure** — L's own dynamics are relatively independent of the rest over short timescales (conditional mutual information > 0).
- **Self-referential loop** — L influences the body, and the body influences L back (bidirectional Granger causality).

These criteria rule out livers, pacemakers, and simple homeostats. The indexical locus is a **recursive self-model**, not just a predictive subsystem.

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4. Active Inference and Policy Entropy

In active inference (Friston), agents try to minimise “free energy” — they pick **policies** (sequences of actions).
Each policy is a trajectory through the agent’s attractor landscape.

Policy entropy $H(\pi) = -\sum p(\pi) \log p(\pi)$ measures how many different policies are available.

- Low entropy → rigid, one-track mind.
- High entropy → flexible, but possibly noisy.

Free will is the ability to access many low-energy policies. The agent’s choices are not random; they are constrained by the attractor geometry. But if several attractor basins are open, the agent can choose among them — that is what we feel as free choice.

Policy entropy can be measured in behavioural tasks where multiple choices are equally good (e.g., probabilistic reversal learning, two-armed bandit tasks).

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5. The Inverted-U Prediction and Falsification

5.1 Core prediction

We predict an **inverted-U** relationship between attractor dimensionality D and the subjective sense of agency (e.g., from intentional binding experiments).

- Very low DD → chaotic, unstable (like schizophrenia) → low agency.
- Very high DD → rigid, stuck (like OCD) → low agency.
- In the middle → flexible but stable → high agency.

The agency index AA also includes RR and SS, which we think increase agency across the board. So to test the inverted-U for DD alone, you need to **control for** RR and SS (e.g., study people matched on those, or use partial correlation).

5.2 How to measure and test

- **Attractor dimensionality DD** – use the Grassberger-Procaccia algorithm on 5-min resting-state EEG/MEG.
- **Sense of agency** – use the **intentional binding** paradigm: press a key, then a tone sounds; participants estimate the time between action and tone. Stronger binding means higher agency.
- **Statistical test** – fit a quadratic regression: agency = $\beta 0 + \beta 1 D + \beta 2 D^2$ $\beta 0 + \beta 1 D + \beta 2 D 2$.
  If $\beta 2 < 0$ $\beta 2 < 0$ and the vertex lies inside the observed range of DD, the inverted-U is supported. Use bootstrap (1000 resamples) to check confidence intervals.

5.3 Falsification condition

The framework is **falsified** if:

- The quadratic coefficient $\beta 2$ $\beta 2$ is not negative (no inverted-U).
- Or, in a clinical experiment (e.g., increasing DD in OCD patients with NMDA drugs), agency does **not** decrease but keeps increasing.

6. Experimental Proxies — Summary Table

Construct	Measure	How to record	Expected relation to agency
Attractor dimensionality DD	Correlation dimension (Grassberger-Procaccia)	Resting-state EEG/MEG (5 min)	Inverted-U
Policy entropy H(π)$H(\pi)$	Entropy of choice distribution	Probabilistic reversal learning (200 trials)	Inverted-U
Sense of agency	Intentional binding magnitude	Action-outcome interval compression (50 trials)	Max at intermediate DD
Recursive self-modification RR	Learning-to-learn improvement	Meta-learning task (pre-post difference)	Positive (more is better)
Self-reference strength SS	Normalised mutual info In(L;S)$In(L;S)$	Resting-state fMRI or MEG	Threshold > θ

7. Hierarchical Constraints and Social Attractors

Free will is **nested** inside larger attractors — society, culture, laws, economy. Your range of choices is partly set by these.

This is not an objection; it is just the fact that freedom is always **constrained autonomy**.

We predict that societies with more cultural diversity (higher "cultural entropy") allow more individual agency, other things

being equal. This can be tested by cross-cultural comparisons of policy entropy in decision tasks.

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8. Engagement with Compatibilist Literature

8.1 Standard compatibilists (Frankfurt, Dennett)

- **Frankfurt (1971)**: freedom is about your will aligning with your own desires. Our framework adds that those desires must be encoded in a persistent self-referential attractor. The recursive self-engineering component R*R* maps directly to Frankfurt's "second-order volitions".
- **Dennett (1984)**: freedom is about being able to respond to reasons. Our framework adds that this requires a certain basin geometry and recursive plasticity.

8.2 Addressing Pereboom's manipulation argument

Pereboom argues: if a neuroscientist engineers your brain, you are not free – even if your behaviour comes from internal dynamics.
Our reply: agency requires **recursive self-modification** (R>0*R*>0) at some point in your history.

- A perfectly manipulated agent that never changed its own attractor would have R≈0*R*≈0 and thus A≈0*A*≈0.
- A healthy human who learned and adapted has R>0*R*>0 and genuine agency.

The origin of the initial attractor does not matter – only the presence of self-modification over time.

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9. Open Questions and Limitations

- **Calibrating exponents** – α, β, γ and the threshold θ need to be estimated from large-scale data (e.g., Human Connectome Project) using maximum likelihood.
- **The liver problem** – our exclusion criteria need empirical validation; we must show that organs like the liver do **not** satisfy them.
- **Inverted-U for policy entropy** – the same shape is predicted but may be hidden by decision noise.
- **Moral responsibility** – the framework gives a basis for responsibility (if $A > A_{crit}$), but it does not settle all normative questions – it only gives a scientific starting point.

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10. Conclusion

Free will is **not** a supernatural escape from physics. It is a **dynamical property** of certain dissipative, self-referential attractors:

- The ability to act from your own internal dynamics.
- To keep a stable self-model over time.
- And to reshape your own attractor landscape.

This account is compatibilist, testable, and graded.

The inverted-U prediction, with a specified statistical test, gives a clear falsification criterion.
The dance of free will is the dance of a self that persists under perturbation.

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Attractor Dynamics in Belief Formation, Correction, and Mental Health: A Research Programme

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Abstract

This paper applies the attractor framework (persistence under disturbance) to **belief systems** and **mental health**.

We introduce three measurable concepts:

- **Attractor depth** – how rigid or unstable a belief is.
- **Error half-life** – how long it takes for a false belief to fade after correction.
- **Coupling strength to error signals** – how open a belief is to reality checks.

We contrast two disorders:

- **OCD** (obsessive-compulsive disorder) may involve *overly deep* (rigid) attractors.
- **Schizophrenia** may involve *too shallow* (unstable) attractors – with appropriate caution.

We propose experiments to measure error half-life, detect early warning signs of belief shifts (while managing false alarms), and find the optimal pace for correction ("critical damping").

We also outline:

- **N=1 attractor engineering** (self-experimentation)
- **Wearable early-warning systems** for relapse prevention (discussing lag time and false positives)
- **Cross-coupling** as a measure of resilience (distinguishing healthy from brittle coupling)

This paper is a **research roadmap**, not a finished theory.

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1. Introduction

In the attractor framework, your mind is a **dissipative attractor of your whole body** – a pattern that needs energy, can be disturbed, and can adapt (Galida, 2026, *Persistence*

Under Perturbation).
Beliefs are smaller attractors inside that landscape. Their stability determines how easily you update when faced with contradictory evidence.

This paper turns attractor concepts into testable ideas about how beliefs form, stick, and change — and how to help them change. It is a roadmap, not the final word.

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2. Attractor Depth and Mental Disorders

Neurocomputational models suggest a contrast between OCD and schizophrenia, but we must be careful.

Disorder	Attractor Property	Behavioural Sign	Example Task
OCD	Too deep (rigid)	Stuck, hard to switch	Reversal learning (changing rules)
Schizophrenia	Too shallow (unstable)	Jumpy, over-sensitive to noise	Delayed match-to-sample with distractions

Evidence:

- Unmedicated OCD patients make many perseverative errors on reversal-learning tasks; this correlates with symptom severity (Remijnse et al., 2006).
- Reduced NMDA/GABA function in schizophrenia makes attractor networks unstable, leading to cognitive slips and delusions (Rolls, 2021).

Caveats:

- Mental disorders are complex, with multiple attractors. We are talking about symptom clusters, not whole-disorder diagnoses.
- Disorders like anxiety, depression, and personality disorders lie in the middle — their attractors are **domain-specific** (e.g., depression has deep negative-belief basins but shallow positive ones).

Prediction: Attractor depth could be measured from behaviour (switching rates, reaction time variability) by fitting a two-state hidden Markov model to reversal-learning data — a hypothesis for future work.

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3. Error Half-Life: A New Measure of Belief Rigidity

Error half-life T1/2$T_{1/2}$ is the time it takes for a false belief's confidence to drop by half after you present corrective evidence.

How to measure it

1. Give people a false belief (e.g., a made-up fact).
2. Give them correct information (text, video) every day for a while.
3. Ask them to rate their belief confidence (0–100) at intervals.
4. Assume a simple **exponential decay** model C(t)=C0e−t/τ$C(t) = C_0 e^{-t/\tau}$ as a starting point (real decay could be sigmoidal or power-law).
5. Then T1/2=τln⁡2$T_{1/2} = \tau \ln 2$.

What we expect in different conditions

- **Delusional disorders** → very long half-life (deep attractor).
- **Depression** → long half-life for negative self-beliefs, but normal for positive ones (asymmetric updating).
- **Anxiety** → short half-life, but possible overshoot (shallow basin → oscillation).

Therapeutic application

The goal is to **shorten error half-life**. Methods like **spaced repetition** and **active recall** (quizzing) could help – they strengthen corrective memory traces, similar to memory reconsolidation.

Relationship to attractor depth

Attractor depth is a **static** measure (inertia). Error half-life is a **dynamic** measure (recovery speed). They are related but not the same: depth gives initial resistance, half-life gives the time course. We need both.

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4. Critical Slowing Down Before Belief Shifts

Before a sudden change of belief (e.g., leaving a cult, political conversion, therapy breakthrough), you may see **early warning signals** – rising variance, higher autocorrelation, slower recovery from small disturbances. This is called **critical slowing down** (Scheffer et al., 2009).

How to detect it

- Collect daily belief ratings, mood scores, or social media sentiment.
- Compute rolling variance and autocorrelation with a moving window.
- If they exceed a baseline threshold, a shift may be coming.

False positive problem

Rising variance can be caused by other things (seasonal mood, life events). To reduce false alarms:

- Use control periods (compare with a stable trait belief).
- Combine multiple signals (HRV, sleep, activity) with self-report.
- Use a conservative threshold (e.g., 3 standard deviations above baseline).

This is a research tool, not a clinical diagnostic yet.

Prediction: You can detect these signals in diaries before a person deconverts, changes politics, or relapses into depression. A well-timed prompt might help, but false positives must be managed.

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5. Optimal Correction Dosing (Critical Damping)

From control theory, there is an **optimal pace** for delivering corrections: not too slow (oscillates), not too fast

(overshoot/backfire). This is called **critical damping**.

N=1 protocol

- Vary the gap between corrections (massed vs. spaced).
- Track belief confidence over time.
- Measure how quickly and smoothly it changes.

Hypothesis: Spaced correction (e.g., daily micro-doses) works better than one big confrontation — a well-known finding in memory research (Ebbinghaus, spaced repetition). The twist is applying it to **beliefs**, which are more emotional and identity-linked. The mechanism may be similar, but emotional valence may change the optimal schedule.

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6. Fantasy vs. Shared Reality Attractors — Operational Metrics

Metric	Low Corrective Permeability (Fantasy)	High Corrective Permeability (Shared Reality)
Coupling to error signals	Low (few fact-checks, no update)	High (active correction)
Basin depth	Deep (needs large evidence)	Shallow (small anomalies work)
Error-correction latency	Long (days/weeks)	Short (hours/days)
Information diversity tolerated	Low (echo chamber)	High (multiple sources)

Double-bind computational model

In conspiracy cultures, contradictory evidence gets reinterpreted as confirmation (“cover-up”). We can model this as an **asymmetric Bayesian update**:P(belief∣contrary evidence)≥P(belief∣supporting evidence)*P*(belief∣contrary evidence)≥*P*(belief∣supporting evidence)

Example: Start with belief probability 0.9. A contrary piece of evidence that would normally lower it to 0.3 is instead interpreted as evidence of suppression, so the new probability stays at 0.85. The belief drifts only slowly.

Breaking the loop: Indirect interventions work better than direct refutation:

- Point out internal inconsistencies.
- Seed doubt through trusted messengers.
- Use graduated reality-testing.

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7. Wearable Early Warning of Attractor Shifts

Protocol: Use consumer wearables (HRV, skin conductance, actigraphy, sleep) plus daily self-reports (mood, belief rigidity). Compute rolling variance and autocorrelation in real time.

Evidence: Drops in nocturnal HRV preceded a depressive relapse in a case study (Tonge et al., 2024).
Prediction: Rising variance/autocorrelation in HRV, plus mood volatility, can predict an imminent crisis.

Latency and false alarms

- Useful lead time is **days**, not hours. HRV changes can appear 1–2 weeks before relapse.
- False positives are a concern. Use a **two-stage alert**: first detect statistical anomaly, then confirm with a brief self-report (EMA).
- Specificity needs to be established in longitudinal N=1 studies.

Intervention: When thresholds are crossed, trigger a micro-intervention (mindfulness, therapist call) – a closed-loop prevention system.

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8. N=1 Attractor Engineering – Minimal Perturbation Protocol

Goal: Find the smallest intervention that shifts a maladaptive attractor (phobia, obsessive thought) without causing oscillation or backfire.

Procedure:

1. Define the target (e.g., fear rating 0–10).
2. Start with very low-intensity perturbations (e.g., brief exposure, mild counter-evidence).
3. Measure change after each step.
4. When a threshold shift is detected (say, 30% reduction – a provisional starting point; adjust based on baseline variability), record the dose.
5. Back off slightly and check stability.

Principle: Never collapse an attractor faster than reality can

correct. Use fine steps (5–10% increments) and frequent monitoring. This is **precision self-regulation**. Generalisability from N=1 to populations is an open question (see Section 12).

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9. Cross-Coupling as a Resilience Metric

Hypothesis: High cross-domain coupling (e.g., HRV ↔ mood ↔ sleep) indicates **adaptive resilience** – the system is coordinated and self-correcting. Low coupling or unidirectional cascades indicate **brittle coupling** (a disturbance in one area spreads uncontrollably).

Measurement: Collect simultaneous time series (HRV, sleep, activity, mood). Compute cross-correlation or Granger causality.

- **Adaptive** = bidirectional, with negative feedback (e.g., poor sleep → lower HRV → mood drop → social support → sleep improves).
- **Brittle** = unidirectional, amplifying (e.g., sleep loss → stress → more sleep loss).

Prediction: Good recovery from stress shows strong bidirectional influences. Low coupling or unidirectional cascades will precede breakdowns.

Intervention: Improve adaptive coupling with synchrony exercises (e.g., daily breathing with light exposure, yoga, social rhythm therapy). Testable in an N=1 self-tracking experiment.

10. Philosophical Extensions (Brief)

- **Are attractors real?** Yes, as structural patterns (process metaphysics). They have causal power – like the path of a river.
- **Free will as attractor autonomy** – acting according to your own attractor is compatibilist freedom. Our framework adds that freedom is about basin width and flexibility, not a binary.
- **Cosmic attractor** – speculative. The universe might have a global attractor (e.g., heat death), but it's untestable now.
- **Darwinian problem of evil** – animal suffering is a strong challenge to theism; the "deep harmonies" hypothesis is hard to falsify.

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11. Open Questions and Next Steps

- Can error half-life be measured reliably from smartphone-based belief tracking? What decay model fits best?
- What is the dose-response curve for corrective interventions? Linear, exponential, or threshold? How does it vary with attractor depth?
- Can wearables detect early warning signs before a psychiatric relapse? What are the false-positive rates and lead times?
- Does adaptive cross-coupling improve after

synchrony-based therapies?

- How are error half-life and attractor depth related? Same thing at different timescales, or different constructs?
- How can N=1 findings be aggregated into population-level knowledge? One approach: meta-analysis of single-subject time series using hierarchical Bayesian models.

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12. Conclusion

This research programme puts attractor dynamics to work on beliefs and mental health.

We have proposed **testable metrics** (attractor depth, error half-life, coupling strength) and **experimental protocols** for N=1 self-engineering and early warning.

The framework provides a naturalistic language for understanding why some beliefs resist correction and how to intervene optimally.

We acknowledge our limitations — the exponential decay assumption, false positives in early warning, and the generalisability of N=1 results — and treat them as open questions for future work.

This extends the attractor trilogy into **actionable health and epistemology**.

Suggested citation: Galida, R. S. (2026). *Attractor Dynamics in Belief Formation, Correction, and Mental Health: A Research Programme (Reader-Friendly Version).* Fantasy Attractor.

The Persistence Functional: A Mathematical Measure of Attractor Resilience

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Date: May 2026

Abstract

The attractor framework says that **persistence under disturbance** is the basic mark of reality.
To turn this idea into a formal science, we introduce the **persistence functional** P(x)$P(x)$.

P(x)$P(x)$ is a single number that measures:

- How deep a state is inside an attractor basin.
- How quickly it returns after a knock.

We define P(x)$P(x)$ for three different kinds of systems:

1. **Deterministic dissipative systems** – here PP is linked to Lyapunov exponents and basin stability.
2. **Stochastic systems** – here PP is linked to escape time and quasipotential.
3. **Information-theoretic systems** – here PP is linked to negative free energy or mutual information.

The **recovery rate** $-\dot{P}/P$–$\dot{P}/P$ is a universal sign of **critical slowing down** – a warning that a system is about to tip.

We also discuss limitations: resilience may depend on direction ("anisotropic"), and multiple timescales may need **vector** or **tensor** persistence. We list open mathematical problems.
This paper is a **roadmap**, not a finished theory.

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1. Introduction

In the attractor framework, **persistence under disturbance** is central. But we have not had a single number to say *how persistent* a state is.
The **persistence functional** $P(x)$ aims to fill that gap.

What $P(x)$ should do:

- $P(x)>0$ for states inside an attractor basin.
- For a **conservative attractor** (like a free electron), P is maximal (normalised to 1).
- For a **dissipative attractor**, P drops after a disturbance and then recovers.
  The recovery rate $-\dot{P}/P$–$\dot{P}/P$ equals:
  - the negative of the largest Lyapunov exponent (for deterministic systems)
  - the inverse return time (for stochastic systems)
  - the rate of information loss (for informational systems)

- P falls as the system approaches a **bifurcation**, giving early warning.

We do **not** give one universal formula. Instead, we give

a **family** of definitions, each suited to a different type of system, all united by the same purpose — measuring resilience.

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2. Deterministic Dissipative Systems

Consider a smooth system $\dot{x}=f(x)$ with a stable attractor A and its basin $B(A)$.

A natural candidate for $P(x)$ uses a **Lyapunov function** $V(x)$ — a kind of energy that always decreases inside the basin ($\dot{V}<0$).

We define:$P(x)=1-V(x)-V_A V_{max}-V_A$

This gives $P=1$ on the attractor and $P\to 0$ at the basin boundary.
Near the attractor, the recovery rate is related to the **largest Lyapunov exponent** λ_1:$-\dot{P}/P\approx-\lambda_1$

When the system approaches a tipping point, $\lambda_1\to 0-$, so the recovery rate slows down — this is **critical slowing down**.

Conclusion: For deterministic systems, P can be built from a Lyapunov function. The recovery rate equals the negative of the largest Lyapunov exponent.

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3. Stochastic Systems

When noise is present, persistence is about how long it takes to escape from the basin.
The **mean first passage time** $\tau(x)$ — the average time to leave — is a natural measure.

We define:P(x)=τ(x)τmaxP(x)=τmaxτ(x)

where τmaxτmax is the value at the attractor.

For weak noise, τ(x)τ(x) grows exponentially with the **quasipotential** U(x)U(x) (Freidlin–Wentzell theory):τ(x)~eU(x)/ϵτ(x)~eU(x)/ϵ

So:P(x)∝e−(Umax−U(x))/ϵP(x)∝e−(Umax−U(x))/ϵ

The recovery rate is the inverse of the return time. As a tipping point is approached, the return time diverges, and the recovery rate goes to zero. This again gives **critical slowing down** — rising variance and autocorrelation.

Conclusion: For stochastic systems, PP is proportional to the mean exit time (or the exponential of the quasipotential). This connects persistence to large deviation theory.

---

4. Information-Theoretic Systems

For systems where information matters (neural, cognitive, social), we can define persistence using **mutual information** between past and future.

Let Ipast,futureIpast,future be the **predictive information**. Then:P(t)=I(past;future at time t)orP=e−surprisalP(t)=I(past;future at time t)orP=e−surprisal

The decay of P(t)P(t) over time measures **memory loss**.
Landauer's principle connects information loss to entropy production:P˙/P≤−S˙kBln2P˙/P≤−kBln2S˙

Alternatively, in the **free energy principle** (Friston), the negative free energy −F−F acts like a Lyapunov function. We can set:P=e−F/kTorP=−FP=e−F/kTorP=−F

Then $-\dot{P}/P$–$\dot{P}/P$ is the rate of free energy minimisation, which slows near bifurcations.

Conclusion: For information-theoretic systems, P*P* can be defined via mutual information decay or negative free energy, linking persistence to entropy production and predictive coding.

---

5. Unifying Recovery Rate and Critical Slowing Down

Across all types of systems, the **recovery rate** $\lambda_{rec} = -\dot{P}/P$ $\lambda_{rec} = -\dot{P}/P$ (just after a small disturbance) is a universal indicator:

- **Deterministic dissipative:** $\lambda_{rec} = |\lambda_1|$ $\lambda_{rec} = |\lambda_1|$ (absolute value of the largest Lyapunov exponent)
- **Stochastic:** λ_{rec} λ_{rec} = inverse of the return time, related to the quasipotential's curvature
- **Information-theoretic:** λ_{rec} λ_{rec} = rate of free energy minimisation or information loss

As the system approaches a bifurcation, $\lambda_{rec} \to 0$ $\lambda_{rec} \to 0$. This is **critical slowing down**.
It shows up as rising lag-1 autocorrelation and variance (Scheffer et al., 2009).
So P*P* and its recovery rate give early warnings.

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6. Normalisation for Conservative

Attractors

For a perfect **conservative attractor** (e.g., an electron in its ground state, no decay), the persistence functional should be constant and maximal:Pcons=1for all times$P_{\text{cons}}=1$for all times

No recovery rate is defined (or it is zero). This anchors the scale.

For **emergent approximate conservative systems** (like atomic clocks), PP is very close to 1 and decays extremely slowly.

---

7. Limitations – Scalar Collapse and Anisotropic Resilience

A single scalar P(x)$P(x)$ may not be enough for systems where resilience is **anisotropic** – that is, recovery speed depends on the direction of the perturbation.
High-dimensional systems can have **multiple timescales** (fast and slow modes). A scalar average can miss important structure.

Future work may need:

- **Vector persistence** – a list of recovery rates along different directions.
- **Tensor persistence** – a metric that captures the full shape of the basin.
- **Persistence manifold** – the geometry of the basin in state space.

We accept this limitation. The scalar PP is a useful first approximation for systems with isotropic resilience or for early-warning applications where a single number is enough.

For complex systems, a multidimensional generalisation is an open research problem.

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8. Open Mathematical Problems

1. **Derive P(x)$P(x)$ from first principles** for a given class of systems (e.g., from a variational principle).
2. **Prove that $-\dot{P}/P=\lambda_1$ $-\dot{P}/P=\lambda_1$** for a wide class of dissipative systems.
3. **Extend the definition to systems with multiple attractors and chaotic basins** (where basin stability is fractal).
4. **Establish a rigorous relationship between PP and the mutual information decay rate** for non-equilibrium processes.
5. **Formulate a universal persistence functional** that works across all regimes — or prove it's impossible.
6. **Test the predictive power of PP** in controlled experiments (e.g., ecological microcosms, neural cultures, social media sentiment).
7. **Develop vector/tensor persistence** for anisotropic resilience.

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9. Conclusion

The persistence functional P(x)$P(x)$ gives a mathematical language for attractor resilience.

We have given **operational definitions** for three regimes:

- **Deterministic dissipative** → Lyapunov / basin stability

- **Stochastic** → escape time / quasipotential
- **Information-theoretic** → mutual information / free energy

The **recovery rate** $-\dot{P}/P$–$\dot{P}/P$ unifies critical slowing down across all these domains.

We have explicitly noted **limitations** (scalar collapse, anisotropy) as open problems.

This paper is a **roadmap**, not a final theory. The framework now has a quantitative step.

Suggested citation: Galida, R. S. (2026). *The Persistence Functional: Towards a Mathematical Measure of Attractor Resilience (Reader-Friendly Version).* Fantasy Attractor.

Metronome, Memory, and the Threefold Anchor: A Relational Account of Time [F] (2026)

Abstract

This paper presents a relational view of time based on the attractor framework.

We argue that two very different kinds of attractors work together to create what we call time:

- **Conservative attractors** (electrons, neutrinos, protons)

act as metronomes. They provide a steady, repeatable rhythm – a ruler for measuring duration.
- **Dissipative attractors** (living cells, minds, societies) act as memory. They accumulate irreversible changes, giving time its direction.

Time is not a mysterious substance. It is the coupling between these three fundamental metronomes and the irreversible flow of memory. What binds all dissipative systems – from a bacterium to a brain to a galaxy – is the continuous recycling of the same three eternal metronomes.

This view offers a conceptual account of how clocks work, why time has an arrow, and how aging, entropy, and history fit together.

The dance of time has three metronomes and a memory.

---

1. Two Classes of Persistence, Two Roles for Time

In the attractor framework, everything that persists does so by resisting disturbance. We identify two distinct types of persistent structures, each giving rise to a different aspect of time.

1.1 Conservative Attractors – The Metronome

Conservative attractors are protected by physical conservation laws (charge, baryon number, energy). They are:

- **Eternal** – they do not age or decay (or are effectively stable on all observable timescales).
- **Time-symmetric at the level of intrinsic persistence** – their existence as attractors is symmetric under time

reversal, though some interactions (weak force) violate CP and thus T.
- **Type-identical** – every electron has the same Compton frequency; every neutrino mass eigenstate has an invariant (though not yet precisely measured) frequency.

Because of these properties, conservative attractors serve as reference standards for duration – metronomes. The international definition of the second is literally a fixed number of such ticks.

1.2 Dissipative Attractors – Memory

Dissipative attractors (cells, minds, ecosystems, societies) are different:

- They require a continuous flow of energy and must export entropy.
- Their dynamics are irreversible – you cannot return to a past microstate without enormous cost.
- This irreversibility creates a directional arrow: before and after, past and future.
- They accumulate memory – irreversible state changes that persist and affect future behaviour.

Memory = irreversible accumulated state change (inscription). Examples: synaptic plasticity, scars, fossil records, cultural archives, radioactive decay (the daughter nucleus retains a record of the parent's disintegration).

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2. The Three Metronomes: Our Most Fundamental Clocks

The Standard Model contains many particles, but only three

classes are absolutely or effectively stable and serve as fundamental metronomes. The photon is not a metronome — it has zero rest mass, hence no rest-frame Compton frequency. It is a mode of propagation, not a standalone persistent entity.

Class / Particle	Symbol	Key Property	Role as Metronome
Electron	e^-	lightest charged lepton	Compton frequency ~1.24 × 10^{20} Hz
Neutrino mass eigenstates (collectively)	ν_1, ν_2, ν_3	neutral, tiny masses	Compton frequencies (mass-dependent); effectively stable
Proton	p	lightest baryon	Compton frequency ~2.27 × 10^{23} Hz; no observed decay

These three classes form what the framework calls the *eternal skeleton* — the collection of conservative structures that persist without decay and provide the stable background against which dissipative change occurs.

Stability notes

- Proton decay has never been observed; lower limit on half-life > 10^{34} years — effectively eternal. The proton is composite, but its stability derives from baryon number conservation, not merely nuclear binding energy.
- Neutrinos oscillate between flavours, but the underlying mass eigenstates are stable on cosmological timescales. Their exact Compton frequencies are not yet known to metrological precision — only mass-squared differences have been measured — but they are theoretically invariant.

These three metronomes do not need energy input to persist. Their frequencies are invariant (known for electron and

proton; theoretically invariant for neutrinos). Any clock based on one agrees with any other after accounting for relativity, as confirmed by atomic clock comparisons.

---

3. Time as the Coupling Between Metronomes and Memory

Time is not a primitive substance. It is the relationship between the metronome ensemble and dissipative memory.

- The three metronomes provide a metric — an invariant ruler for "how much" duration has passed.
- Memory provides direction — which events are past, which are future.
- Without metronomes, change would be unmeasurable — no ruler.
- Without memory, change would be reversible and directionless — no before/after.

Both are necessary for what we operationally call time.

As a working placeholder, let the rate of memory inscription be $dM/dt=f(M,\nu)$ $dM/dt=f(M,\nu)$, where $\nu\nu$ is a characteristic metronome frequency and M M is the current accumulated memory state. Two limiting cases anchor the idea:

- As $\nu\to 0$ $\nu\to 0$ — no metronome — duration becomes undefined. Change occurs but cannot be quantified as a metric interval. This is the "no ruler" condition.
- As dissipation $\to 0$ $\to 0$ — no memory — M M remains constant. Change leaves no trace, so there is no before/after. This is the "no arrow" condition.

What binds all dissipative systems — a bacterial cell, a human

brain, a galaxy, a social institution — is the continuous **recycling of the same three eternal metronomes**. Every dissipative system operates by exchanging electrons, protons, and neutrinos with its environment. The metronomes are the invariant substrate; the memory is the transient pattern. The coupling is the recycling.

Thus, time is not merely a coordinate; it is the ongoing, irreversible reconfiguration of eternal components into transient, memory-bearing structures.

The three metronomes are time-symmetric at the level of intrinsic persistence. The arrow of time comes from dissipative systems that accumulate history. Time is the coupling between these two regimes.

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4. Thermodynamic Information Theory and Persistence

The persistence functional P(x)$P(x)$ measures how deep an attractor basin is — formally, the depth of the basin in the system's phase space (the energy or Lyapunov function value required to escape the basin). Higher PP means a more stable attractor.

- In a dissipative attractor, maintaining memory requires continuous energy export to counteract thermal noise.
- Landauer's principle: erasing one bit costs at least kBTln□2$k_B T \ln 2$ of free energy. Retaining memory against thermal fluctuations requires energy input.

We interpret P(x)$P(x)$ as a measure of information retention: systems with higher PP preserve mutual information between past and present for longer. The decay rate −P˙/P$-\dot{P}/P$ relates to entropy production, connecting the attractor framework to

non-equilibrium thermodynamics.

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5. Consequences and Applications

- **Clocks** — Atomic clocks derive stability from electron transitions. The three metronomes guarantee cross-calibration.
- **Aging** — Biological aging is the accumulation of irreversible memory, measured against metronomes like circadian rhythms.
- **Critical slowing down** — As a system approaches a bifurcation, $-\dot{P}/P$–$\dot{P}/P$ decreases, providing early-warning signals (rising autocorrelation, variance) in physiology, ecology, and social systems.
- **Hysteresis in beliefs** — Fantasy attractors exhibit hysteresis — the path of belief change differs when accumulating vs. removing evidence. The hysteresis loop area quantifies memory.[1]
- **Cosmological time** — The cosmic microwave background is a memory of the early universe (here "memory" is metaphorical). Atomic clocks measure the duration since those imprints were formed.

[1] *Fantasy attractor*: in the attractor framework, a dissipative structure (typically a belief system) with abnormally low corrective permeability, resistant to updating despite counter-evidence.

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6. Relation to the Broader Attractor

Framework

The metronome-memory distinction is a special case of the conservative vs. dissipative attractor dichotomy. It sharpens the “eternal skeleton / transient dance” metaphor.

The three metronomes are the most fundamental layer of the eternal skeleton – the collection of conservative structures that persist without decay and provide the stable background against which dissipative change occurs.

The framework does not claim that time is “made of” attractors. It claims that the measurement and experience of time rely on the interaction of these two persistence regimes. Because every dissipative system continuously recycles the same eternal metronomes, all such systems are materially unified across space and time. That unity is what makes a universal, relational time possible.

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7. Open Questions and Refinements

- **Formalising P(x)$P(x)$** – Rigorous derivation for deterministic (Lyapunov), stochastic (escape time), and information-theoretic (surprisal) cases.
- **Coupling equations** – Specify dM/dt=f(M,ν)$dM/dt=f(M,\nu)$. Can it be tested empirically?
- **Category clarity** – Conservative attractors span strict symmetry-protected invariants (elementary particles) and emergent approximate invariants (clocks). Future work should stratify these.
- **Falsifiability** – Concrete falsifiers: a persistent system without dissipation, or a social attractor that never updates despite counter-evidence.
- **Relation to other relational accounts** – Converges with Barbour (1999) and Rovelli (1996). The difference: the

present framework identifies the two required poles (conservative metronomes providing metric invariance; dissipative memory providing direction) and grounds both in attractor dynamics.

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8. Conclusion

Time is not a primitive. It is the relational coupling between:

- the three fundamental conservative attractor classes — electron, neutrino mass eigenstates (collectively), and proton — which provide invariant metric structure (the metronome), and
- dissipative systems that accumulate irreversible state inscription (memory).

What binds all dissipative systems — from a bacterium to a brain to a galaxy — is the continuous recycling of the same three eternal metronomes. The metronomes are the invariant substrate; memory is the transient pattern; time is the coupling.

This account respects how physics measures time, explains the arrow via entropy and information persistence, and offers transferable concepts across neuroscience, ecology, sociology, and AI.

The dance has three metronomes and a memory.

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