

Symmetric Projection Attractor Reconstruction as a Cardiac Attractor: Structural Parallels with the Attractor Framework

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Abstract

The attractor framework proposes that persistence under perturbation is a fundamental marker of reality, with corrective permeability (κ) serving as a proposed multi-dimensional measure of a system's capacity to return to its attractor after perturbation. Bonet-Luz et al. (2020) developed Symmetric Projection Attractor Reconstruction (SPAR), a patented mathematical method that reformulates the entire electrocardiogram (ECG) waveform into a bounded, symmetric, 2-dimensional attractor and extracts quantitative features from it. Applied to mice with an *Scn5a*^{+/-} mutation linked to Brugada syndrome, SPAR features achieved 96% classification accuracy—substantially outperforming standard ECG intervals and amplitudes. This paper identifies structural parallels between SPAR's attractor-based analysis and the attractor framework. The SPAR attractor is a concrete, computable attractor derived from a physiological signal, and a provisional mapping is proposed between specific SPAR

features and proposed components of κ . The parallels are post-hoc and do not constitute independent validation of the framework. The framework's κ remains qualitatively defined; this mapping is offered as a contribution to its ongoing development.

1. Introduction: Attractor-Based ECG Analysis

The attractor framework (Galida, 2026a, self-published May 2026 at fantasyattractor.com; no DOI) proposes that dissipative attractors—stable configurations toward which systems converge and from which they resist displacement—are the fundamental units of persistent organization across physical, biological, cognitive, and social domains. Corrective permeability (κ) is a proposed multi-dimensional measure of a system's capacity to return to its attractor after perturbation. The framework distinguishes between the attractor (the invariant set of states toward which the system converges) and the basin (the set of initial conditions that converge to that attractor). In the present paper, we use “attractor” in the standard dynamical systems sense and note where the framework's usage aligns or diverges.

In 2020, Bonet-Luz, Aston, Nandi, and colleagues published a study in *Heart Rhythm 02* (Elsevier) applying Symmetric Projection Attractor Reconstruction (SPAR) to murine electrocardiograms (Bonet-Luz et al., 2020). SPAR is a patented mathematical method that reformulates the entire ECG waveform into a bounded, symmetric, 2-dimensional attractor, preserving all available waveform morphology rather than extracting only a few fiducial points. The method was applied to distinguish wild-type mice from those carrying an *Scn5a*+/- mutation linked to Brugada syndrome, a hereditary condition associated with sudden cardiac death.

The study did not cite the attractor framework and was conducted within the established traditions of biomedical signal processing, nonlinear dynamics, and machine learning. This paper identifies structural parallels between SPAR's attractor-based analysis and the attractor framework. The parallels are post-hoc and do not constitute independent validation.

2. The SPAR Method

SPAR generates a 2-dimensional attractor from approximately periodic signals such as ECG, blood pressure, or photoplethysmogram waveforms. The method determines an average cycle length from the signal, sets a time delay parameter as one-third of that cycle, and plots the data in a bounded box using a symmetric projection. The resulting attractor is a compact, easily visualized representation of the entire waveform morphology, overlaid with a density map indicating which regions are visited more or less frequently. The method factors out changes in heart rate and baseline variation to concentrate on waveform morphology.

For murine lead I and II ECG signals, the SPAR attractor typically exhibits 3 long arms predominantly representing the R peak, with deep S peaks and sometimes deep Q peaks producing shorter arms in the opposite direction, yielding an attractor with up to 6 arms in total (Figure 1 of the original paper). The central core region reflects T-wave and P-wave morphologies.

From this attractor, Bonet-Luz et al. extracted 74 manually defined features relating to the density, size, and symmetry of the attractor, along with the average heart rate and a vertical normalization scaling factor. These features were used in a k-nearest neighbors classifier ($k=3$) with leave-one-

animal-out cross-validation.

The dataset comprised ECG recordings from 42 anesthetized mice (39 lead I, 39 lead II) of varying genotype (wild-type vs. *Scn5a*^{+/-}), sex, and age. Each signal was divided into 13 non-overlapping 10-second windows, yielding 1,014 records for classification. Standard ECG intervals (7) and amplitudes (6) were also extracted for benchmarking. It is important to note that the effective sample size for the classification is 42 animals, not 1,014 windowed records, and the 96% classification accuracy has not yet been independently replicated in a separate cohort.

3. Results Summary

The SPAR features alone achieved 87.2% classification accuracy for genotype (majority vote), outperforming ECG intervals (74.3%) and intervals plus amplitudes (85.9%). The highest accuracy (96.2%) was obtained by combining all features—SPAR, intervals, and amplitudes. For sex and age classification, SPAR features similarly outperformed standard measures.

The machine learning algorithm selected 16 SPAR features out of 20 in the combined model, with the remaining 4 being the ST height, P and R amplitudes, and the PR interval. The density distribution and symmetry in the arm regions of the attractor were the most discriminative SPAR features. The ST height—a known marker for Brugada syndrome—was selected in both feature groups that included amplitudes.

The authors concluded that the ECG carries sufficient information to detect the *Scn5a*^{+/-} mutation, but that enhanced analysis techniques are required to extract it. Standard interval and amplitude measures fail to capture the relevant signal because the mutation's effects are distributed across the entire waveform morphology, not concentrated at isolated

time points.

4. Structural Parallels with the Attractor Framework

4.1 The SPAR Attractor as a Cardiac Attractor. The SPAR method generates a bounded, stable 2-dimensional attractor from the ECG signal. This attractor is a compact representation of the cardiac system's dynamical state—a region in state space toward which trajectories converge and around which they organize. In the attractor framework's vocabulary, this is an **attractor** generated by a dissipative system (the beating heart, maintained by continuous metabolic energy input). The attractor's density distribution, arm structure, and symmetry reflect the stability and structural coherence of this configuration.

4.2 SPAR Features as Candidate Proxies for Corrective Permeability (κ). The framework proposes κ as a multi-dimensional measure of a system's capacity to return to its attractor after perturbation. A healthy heart with normal ion channel function has a deep, stable attractor—it responds to perturbations and returns rapidly to its baseline rhythm. The Scn5a+/- mutation degrades sodium channel function, making the cardiac tissue more vulnerable to arrhythmia. This degradation manifests as measurable changes in the SPAR attractor.

A provisional mapping between specific SPAR feature categories and proposed components of κ is offered below. This mapping is hypothetical and has not been formally derived; it is presented as a structural analogy to be tested in future work. The κ component labels in this table are introduced here for exploratory purposes and are not yet formalized in the primary framework document (Galida, 2026a); they are subject to revision pending formal axiomatization of κ .

SPAR Feature Category	What It Measures in the Attractor	Candidate κ Component (provisional)
Density distribution (core)	Frequency of trajectory visits to central attractor region	Attractor core stability: a dense core indicates a stable, frequently occupied equilibrium
Density distribution (arms)	Frequency of trajectory visits to peripheral regions	Perturbation response: arm density reflects excursions from equilibrium
Symmetry features	Left-right symmetry of attractor arms	Recovery symmetry: asymmetric arms may indicate directional perturbation bias or conduction abnormality
Arm structure	Length, width, and number of attractor arms	Global waveform integrity: degraded arm structure reflects disrupted cardiac conduction

The 96% classification accuracy (pending independent replication) demonstrates that these attractor-derived proxies capture diagnostically relevant information that standard interval measures miss. Whether this information corresponds specifically to κ , or to more general signal properties, cannot be determined without a formal derivation of κ from the framework's axioms.

4.3 Multi-Dimensional Feature Combination. The framework proposes that κ is multi-dimensional—no single measure fully captures a system's corrective permeability. The SPAR results are consistent with this principle: combined features outperformed any individual feature set. However, this result is also expected under standard machine learning practice, where feature combination typically improves classification performance. The result is therefore consistent with the framework without uniquely supporting it. The specific finding

that SPAR features (16/20) dominated the combined model suggests that attractor-derived measures carry more discriminative information than point-based measures for this particular mutation. Whether this dominance generalizes to other perturbations and other physiological systems is an open empirical question.

4.4 Normalization as Signal Isolation. The SPAR method normalizes the signal to factor out changes in heart rate and baseline variation, concentrating on waveform morphology. In the framework's terms, this is a methodological step that isolates the attractor's structural properties from confounding variables. Heart rate is influenced by autonomic tone, physical activity, and respiratory cycle-perturbations that can obscure the measurement of the attractor's intrinsic stability. SPAR's normalization yields a cleaner representation of the attractor. However, this normalization step is standard practice in many signal processing methods and does not constitute a distinctive parallel with the framework.

5. Limitations

This mapping is post-hoc. The parallels identified here are structural analogies, not independent evidence for the framework. The provisional κ -proxy mapping in Section 4.2 is hypothetical and has not been formally derived from the framework's axioms. The κ component labels used in the provisional mapping table (e.g., "attractor core stability," "recovery symmetry," "global waveform integrity") are introduced in this paper for exploratory purposes and are not yet formalized in the primary framework document (Galida, 2026a). They are subject to revision pending formal axiomatization of κ .

The framework's κ remains qualitatively defined. A formal derivation specifying the state variables, the attractor geometry, and the perturbation response function is required before the SPAR feature mapping can be evaluated as more than a structural analogy.

The 96.2% classification accuracy was obtained from a single study of 42 mice (effective $N=42$, despite 1,014 windowed records). Independent replication in a separate cohort has not been performed. The accuracy figure should be interpreted with appropriate caution.

The SPAR method was developed for approximately periodic signals and has been validated on cardiovascular waveforms. Its applicability to the non-periodic attractors the framework describes in cognitive and social domains is unknown.

The attractor framework is self-published and has not undergone independent peer review.

6. Falsifiability Conditions

The following observations would weaken or invalidate the parallels drawn here:

- **Disconfirming observation 1:** If SPAR features were shown to be *uncorrelated* with independently validated measures of cardiac resilience or arrhythmia susceptibility in a larger, independent cohort, the κ proxy interpretation would lose its empirical anchor.
- **Disconfirming observation 2:** If the SPAR attractor's classification accuracy for the *Scn5a*^{+/-} mutation were shown to derive primarily from features unrelated to attractor geometry (e.g., heart rate alone or predominantly heart rate), the attractor interpretation

would be substantially weakened.

- **Disconfirming observation 3:** If alternative signal processing methods with no attractor reconstruction component achieved equal or higher classification accuracy using the same data, the attractor interpretation would not be uniquely supported.

Affirmative predictions:

- **Primary prediction:** If the provisional κ -proxy mapping in Section 4.2 captures genuine components of corrective permeability, then pharmacological interventions that improve cardiac ion channel function (e.g., sodium channel modulators) should produce measurable shifts in specific SPAR features—density, symmetry, arm structure—toward the wild-type baseline. Conversely, interventions that degrade ion channel function should shift these features away from the baseline. This prediction is testable using pre- and post-intervention ECG recordings with the same SPAR methodology.
 - **Secondary prediction:** If attractor-derived features are more sensitive to κ -relevant perturbations than point-based measures, then SPAR features should show *greater* sensitivity to these pharmacological interventions than standard ECG intervals and amplitudes. This secondary claim is more speculative; failure of the secondary prediction while the primary prediction holds would suggest that SPAR features track relevant physiological changes without uniquely capturing κ as distinct from other measures.
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7. Conclusion

The SPAR method developed by Bonet-Luz et al. (2020) generates a mathematically defined attractor from ECG signals that encodes diagnostically relevant information about cardiac stability. A provisional mapping between SPAR features and proposed components of corrective permeability (κ) has been offered, along with primary and secondary affirmative predictions. The 96% classification accuracy for a disease-causing mutation demonstrates that attractor-based features capture information about system integrity that standard point-based measures miss. These parallels are structural analogies, not independent validation. The framework remains a self-published, preliminary research program. This mapping is a contribution to its ongoing development.

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From Strange Attractors to the Attractor Framework: Structural Correspondences and Conceptual Extensions

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Abstract

The attractor framework is a unified naturalistic ontology grounded in the principle that persistence under perturbation is the fundamental mark of reality. This paper traces structural correspondences between the framework and two major scientific achievements of the late twentieth century: the mathematical theory of strange attractors developed by David Ruelle and Floris Takens, and the thermodynamics of dissipative structures developed by Ilya Prigogine. The framework developed its vocabulary and concepts independently over several decades; the correspondences documented here are offered as post-hoc validation, not as evidence of genealogical descent. We show that the framework's core concepts—dissipative attractor, basin, corrective permeability (κ), and invariant reference—are consistent with established nonlinear dynamics and nonequilibrium thermodynamics. The fantasy attractor—a belief system with low corrective permeability—is identified as a psychological analogue of the strange attractor, governed by structurally analogous but mechanistically distinct dynamics. The paper clarifies which

framework claims are grounded in established physics and which are heuristic extensions requiring independent validation. The framework is offered as a research program, not a completed theory.

1. Introduction: Independent Development, Post-Hoc Validation

The attractor framework (Galida, 2026a) is a naturalistic ontology organized around a single diagnostic principle: **persistence under perturbation is the mark of the real**. It divides all persistent structures into conservative persistence structures (the eternal, mindless, invariant skeleton) and dissipative attractors (temporary, entropy-exporting systems that converge toward stable basins). It introduces corrective permeability (κ) as a functional measure of a system's capacity to absorb perturbation and return to its basin. It applies this vocabulary across physics, biology, cognitive science, and social dynamics.

The framework's concepts were developed independently over several decades, through a combination of philosophical inquiry, systems theory, and N=1 self-engineering experiments. They did not derive from the traditions described below in a genealogical sense. However, the structural parallels with established nonlinear dynamics and nonequilibrium thermodynamics are substantial. Documenting these parallels serves three purposes: it demonstrates the framework's consistency with well-validated physical theory; it identifies where the framework extends beyond its precursors; and it clarifies which claims are grounded in established science and which are heuristic extensions requiring independent validation.

Two bodies of twentieth-century science provide particularly

strong structural correspondences: David Ruelle and Floris Takens's theory of strange attractors, and Ilya Prigogine's thermodynamics of dissipative structures. This paper maps those correspondences and identifies the points where the framework diverges from or extends beyond its precursors.

2. Ruelle's Strange Attractor: Structural Correspondences

David Ruelle and Floris Takens proposed in 1971 that turbulent fluid motion is governed by a new kind of mathematical object: the strange attractor. Ruelle's 1980 paper "Strange Attractors" defined it with precision and became the canonical introduction for a generation of scientists. Five features of Ruelle's definition correspond to core concepts of the attractor framework. These correspondences are structural, not genealogical, and are offered as a demonstration of consistency with established physics.

2.1 Attracting Set → Basin

Ruelle defined a strange attractor as a bounded set A contained in an open neighborhood U such that every trajectory starting in U eventually converges to A and remains arbitrarily close to it. In the attractor framework, this is the **basin**: the region of state space toward which trajectories converge and from which they resist displacement. Ruelle's quadrilateral ABCD for the Hénon attractor—within which all subsequent iterates remain—is precisely a basin in the framework's sense. The correspondence is straightforward and exact.

2.2 Sensitive Dependence → Corrective Permeability

Ruelle characterized sensitive dependence on initial conditions by the exponential growth of small errors: $d(X_t,$

$d(X'_t) \sim d(X_0, X'_0) \cdot a^t$, with $a > 1$ and characteristic exponent $\lambda = \ln a$ (for a standard textbook treatment of Lyapunov exponents and nonlinear dynamics, see Strogatz, 2018). Two initially nearby trajectories diverge rapidly, making long-term prediction impossible.

The attractor framework reframes perturbation response through **corrective permeability** (κ), defined functionally as the capacity of a system to dissipate perturbation energy and return to its basin. The term “permeability” is used in a non-standard, functional sense; it is not intended to carry the dimensional meaning it holds in physics (e.g., Darcy’s law, where permeability has units of area). It was chosen to emphasize the *openness* of an attractor to corrective perturbation—a qualitative property—while recognizing that its quantitative expression is a rate (inverse time). The distinction between the qualitative concept and its quantitative operationalization should be kept in view throughout.

κ and λ capture different aspects of dynamical resilience. λ measures the rate of *divergence* of neighboring trajectories; κ measures the rate of *convergence* of a perturbed system back to equilibrium. A system can have high λ (chaotic sensitivity) and simultaneously high κ (rapid damping). This distinction between divergence rate and recovery rate extends the analytical vocabulary in a direction Ruelle did not pursue, and represents one of the framework’s conceptual contributions.

2.3 Dissipative Condition → Dissipative Attractor

Ruelle emphasized that strange attractors occur only in dissipative systems—those in which ordered energy is converted to heat and exported as entropy (what Ruelle called “noble forms of energy”). Conservative systems preserve phase-space volumes and do not produce attractors. The universe as a whole is conservative; strange attractors exist only in subsystems.

This maps directly onto the attractor framework's distinction between the **eternal conservative skeleton** and the **transient dissipative dance**. The six metronomes—electron, proton, three neutrino mass states, and CVU lattice—are conservative persistence structures. They do not decay, export no entropy, and are not attractors. Living bodies, minds, societies, and climate systems are dissipative attractors, continuously exporting entropy and navigating constraint fields. Ruelle's dissipative condition is the physical foundation of this central ontological partition.

2.4 Discrete and Continuous Dynamics → The Two Metronomes

Ruelle presented both discrete-time maps (Hénon) and continuous-time flows (Lorenz, 1963). In both cases, strange attractors emerge. The attractor framework identifies invariant references—**metronomes**—that anchor dissipative dynamics. Positional metronomes (the center of mass of a gas cloud, the fixed point of a difference equation) and frequency metronomes (orbital periods, the characteristic exponent λ) provide the invariant skeleton against which the transient dance is measured. Ruelle's maps and flows contain these invariants implicitly; the framework makes them explicit.

2.5 Indecomposability → Unified Attractor (Partial Correspondence)

Ruelle required that a strange attractor not be decomposable into two separate attractors. This is a strong mathematical condition. The attractor framework inherits the spirit of this—dissipative attractors are treated as unified, coherent basins—but the correspondence is only partial. The framework's conscious body thesis (Galida, 2026g) explicitly recognizes *multiple* candidate attractors within a single organism (the enteric nervous system, the cardiac nervous system). These are coupled but semi-autonomous basins, in tension with Ruelle's indecomposability condition. The framework thus extends the attractor concept in a direction

Ruelle's original definition did not anticipate. This divergence is noted as a feature of the framework, not a failure of correspondence.

3. Prigogine's Dissipative Structures: The Thermodynamic Parallel

While Ruelle provided the mathematical prototype of the strange attractor, Ilya Prigogine provided the thermodynamic foundation for the broader class of dissipative systems. Prigogine's Nobel-winning work (Prigogine, 1980, 1984) demonstrated that systems maintained far from thermodynamic equilibrium spontaneously self-organize into coherent, ordered structures—dissipative structures—that persist only as long as they are sustained by energy and matter flows.

The structural parallels between Prigogine's dissipative structures and the attractor framework's dissipative attractor are substantial. Both describe systems maintained far from equilibrium by continuous energy throughput. Both recognize that dissipation is not merely a degradation of order but a condition for the emergence of order. Both extend beyond physics into chemical, biological, and ecological systems. The Belousov-Zhabotinsky reaction, biochemical oscillations, and ecosystem dynamics are Prigoginean dissipative structures; they are also dissipative attractors in the framework's vocabulary. Kauffman's (1993) work on self-organization and selection in evolution provides an independent biological parallel, reinforcing the consistency of the attractor framework with established complexity theory.

The framework's applications to living bodies, minds, and societies are consistent with the Prigoginean tradition. This consistency was recognized retrospectively; the framework's concepts were not derived from Prigogine. The parallels are

offered as evidence that the framework's biological and social extensions are grounded in established thermodynamic principles, not as evidence of intellectual descent.

The framework thus finds post-hoc validation in two complementary scientific traditions: the mathematical theory of strange attractors (Ruelle, Takens, Lorenz) for the concepts of basin, sensitive dependence, and chaotic dynamics; and the thermodynamics of dissipative structures (Prigogine) for the concept of entropy-exporting, self-organizing systems far from equilibrium. Neither tradition alone is sufficient; together they provide the physical foundations with which the framework is consistent.

4. The Attractor Framework: Extensions Beyond the Physical Prototypes

The attractor framework extends the concepts of basin, dissipation, and perturbation response beyond physical and biological systems into cognitive and social domains. These extensions are heuristic hypotheses, not established results. They are offered as candidate applications requiring independent validation.

4.1 From Strange to Dissipative: A Broadened Scope

Ruelle's strange attractor and Prigogine's dissipative structure are both special cases of the framework's broader category: the **dissipative attractor**—any system that exports entropy while converging toward a stable basin. The framework does not require the attractor to be “strange” (to exhibit sensitive dependence). Fixed-point attractors, periodic attractors, and quasiperiodic attractors are all dissipative attractors under this definition. The framework's scope is deliberately broad, encompassing any persistent, entropy-

exporting system regardless of its internal dynamical complexity.

4.2 The Fantasy Attractor: A Structural Analogy

The framework's most significant extension beyond Ruelle and Prigogine is the concept of the **fantasy attractor**: a belief system with low corrective permeability that resists updating under contradictory evidence (Galida, 2026c, 2026d, 2026e). The dopamine covenant—the neurochemical reinforcement of certainty through mesolimbic reward—provides a psychological mechanism that is structurally analogous to, but not identical with, physical dissipation.

The analogy is as follows. A physical dissipative attractor exports entropy via radiation or heat, returning to its basin after perturbation. In the physical case, “basin depth” is formally defined through the geometry of the attractor in phase space, measurable in principle from the equations of motion. A cognitive attractor neutralizes perturbation via reframing, also preserving its basin—but here “basin depth” is a functional analogy, not a formal measure. Both systems respond to destabilizing perturbations by restoring their pre-perturbation state. The analogy holds at the functional level.

However, the mechanisms differ in important respects. Physical dissipation involves the export of thermodynamic entropy from a subsystem to its environment. Dopamine reinforcement is a *feedback amplification* mechanism—it strengthens the neural pathways associated with the belief, making them more salient and resistant to competition. It does not export entropy in the thermodynamic sense. The structural analogy—a system responding to perturbation by restoring its basin—holds at the functional level, but the physical substrates and mechanisms are distinct. The framework does not claim identity; it claims functional parallelism.

The assignment of $\kappa \approx 0$ to fantasy attractors is qualitative

and provisional. Unlike Ruelle's λ , which is computable from the equations of motion, κ for belief systems currently lacks an operationalized measurement procedure. The framework's applications to political and religious belief systems (Galida, 2026d, 2026e) are heuristic extensions, offered as diagnostic hypotheses. Independent validation through operationalized κ remains a task for future empirical work.

4.3 Candidate Applications Across Domains

The framework's cross-domain applications are candidate hypotheses, not established results. Each requires independent validation. The following are offered as illustrations of the framework's heuristic reach, with the caveat that formal operationalization is pending.

- **Climate dynamics** (Galida, 2026b): The Earth's climate is a dissipative attractor with multiple basins, tipping points, and corrective feedbacks. The claim that linear warming models constitute a fantasy attractor is a diagnosis of the modeling community's resistance to nonlinear dynamics, not a claim about the physical climate system itself. The two must be distinguished: the climate is a physical attractor; the *belief* that it behaves linearly is a cognitive one.
- **Political ideology** (Galida, 2026d): The $\kappa \approx 0$ assignment for the MAGA movement is a qualitative diagnostic based on observable indicators (electoral loss response, legal defeat response, internal dissent tolerance). It is not a measurement in Ruelle's sense. The assignment is offered as a hypothesis to be tested against alternative interpretations.
- **Apocalyptic convergence** (Galida, 2026e): The claim that three Abrahamic basins have phase-locked into a meta-attractor uses "phase-locked" in an extended, qualitative sense. The formal demonstration of phase-locking requires identifying coupling constants and

frequency ratios, which have not been established. The claim is offered as a structural diagnosis, not a dynamical proof.

- **Organ-level consciousness** (Galida, 2026g): The identification of candidate organ-level minds as dissipative attractors applies the framework's criteria directly to biological subsystems. The *C. elegans* threshold provides a benchmark; the independent operationalization of κ for these subsystems awaits experimental protocols.

5. The Metronome: An Innovation Without Direct Precedent

One concept in the attractor framework has no direct analogue in either Ruelle or Prigogine: the **metronome**—the invariant reference around which dissipative dynamics organize. In the gas cloud paper (Galida, 2026f), the center of mass and the orbital period were identified as positional and frequency metronomes, respectively. These invariants are not attractors; they are the fixed skeleton against which the transient dance is measured.

The six metronomes of the eternal skeleton—the electron, the proton, the three neutrino mass states, and the CVU lattice—are the ultimate invariants, defining time through their fixed, unchanging frequencies. Ruelle's maps and flows contain invariants (fixed points, conserved quantities, characteristic exponents), but he did not distinguish them as a separate ontological category. Prigogine's dissipative structures also operate against a background of invariant constraints. The attractor framework's explicit separation of the invariant skeleton from the dissipative dance is a genuine conceptual contribution, not present in either precursor

tradition.

6. Conclusion: A Coherent Vocabulary, Conditionally Applied

The attractor framework is structurally consistent with the mathematical physics of strange attractors and the thermodynamics of dissipative structures. Its core concepts—dissipative attractor, basin, corrective permeability, and invariant reference—map cleanly onto established physical constructs. Its extensions into cognitive and social domains are heuristic hypotheses, not established results.

The framework developed its vocabulary independently. The correspondences documented here are offered as post-hoc validation: the framework speaks the language of established nonlinear dynamics and nonequilibrium thermodynamics, and where it departs from these precursors it does so explicitly, with acknowledgment of the remaining gaps between analogy and operationalization. Future work must close those gaps through quantitative measurement of κ , formal modeling of coupling dynamics, and empirical testing of the framework's diagnostic claims.

The framework is offered as a research program, not a completed theory.

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“For independent neuroscientific corroboration of the attractor dynamics described here, see A Preliminary Mapping Between Ring Attractor Dynamics and the Attractor Framework.” <https://www.sciencedirect.com/science/article/pii/S2405844024114892>

“see also”
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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.

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.

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 CO₂ 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 CO₂ 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.

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 CO₂

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 CO₂ 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.

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 CO₂ 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.

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.

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.

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.

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.

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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