The Divine Wave Model: An Operator-First Physical Framework

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Abstract

Contemporary physical theory is formulated predominantly in an equation-first manner, identifying physical law with differential equations and their solutions. This paradigm has proven extraordinarily successful in regimes where admissible states are weakly constrained, coefficients are uniform, and global solutions exist. However, it becomes structurally inadequate in regimes characterized by strong admissibility constraints, nonuniform topology, or histories that preclude global closed-form evolution.

This work presents an operator-first physical framework in which admissibility precedes dynamics. Physical law is defined by constraints on allowable transformations acting on a coherence configuration space, and evolution is constructed as a product limit of admissible micro-transformations. Differential equations arise only as effective descriptions in regimes where admissibility constraints simplify and generators commute.

The framework introduces a coherence-based admissible state space, topological sector structure, admissible generator families, and a monotone functional enforcing global directionality. Effective generators provide regime-dependent summaries of admissible evolution, while their resolvents encode accessibility and govern observable response. Measurement is interpreted as a probe of accessibility rather than of intrinsic state variables, yielding testable predictions including resonance structure, hysteresis, polarity inversion, and inertial modulation.

The formulation is mathematically explicit and falsifiable. Conventional equation-based theories, including those of the Standard Model, emerge as special cases within the operator-first framework rather than as fundamental starting points. The result is a strictly more general procedural foundation for physical law.

1 Introduction

Most physical theories are formulated in an equation-first manner, identifying physical law with differential equations and their solutions. In such formulations, equations are assumed to exist a priori, and physical behavior is understood through the properties of their solution spaces. This paradigm has been extraordinarily successful in regimes where coefficients are uniform, constraints are mild, and global solutions exist.

However, there exist broad classes of physical situations in which equation-first reasoning becomes inadequate. These include systems with constrained admissible states, strongly variable coefficients, nonuniform topology, or histories that prevent the existence of global closed-form solutions. In such regimes, insisting on equations as the primary objects of theory obscures rather than clarifies the structure of physical law.

This work presents an alternative formulation in which physical law is defined not by equations of motion, but by constraints on admissible transformations. Evolution is constructed from these constraints rather than assumed, and equations arise only as effective descriptions when admissibility conditions simplify.

The framework developed here is referred to as an operator-first formulation of the Divine Wave Model. Its central claim is that admissibility precedes dynamics: the question of which transformations are allowed is more fundamental than the equations those transformations may satisfy in special cases.

2 Operator Inversion

Conventional physical theories proceed by specifying equations of motion and then seeking solutions that satisfy them. This approach implicitly assumes that the correct equations are known and that their solution spaces meaningfully represent physical evolution.

The operator-first formulation inverts this logic. Instead of beginning with equations, it begins by specifying constraints on admissible operators acting on a space of physical configurations. These constraints determine which local transformations are permitted, which are suppressed, and how admissible transformations may compose.

In this inverted framework, physical evolution is not defined by solving equations. Rather, it is constructed as the limit of compositions of admissible micro-transformations. When admissibility constraints are simple and generators commute, this construction may reduce to familiar equation-based evolution. When they do not, evolution remains well-defined even in the absence of closed-form equations.

The operator-first inversion may be summarized schematically as follows. In equation-first formulations, one proceeds from equations to solutions and then to evolution. In the operator-first formulation, one proceeds from admissibility constraints to admissible operators, from their composition to global evolution, and only in special regimes to emergent equations.

This inversion is not a reinterpretation of existing equations, but a structural reordering of theoretical priorities. Physical law is identified with constraints on accessibility rather than with differential equations, and dynamics emerge from admissible composition rather than being postulated at the outset.

3 Coherence States and Admissible Configuration Space

The primitive physical configuration in the operator-first formulation is a coherence field represented by amplitude and phase data. At each time t, the coherence field is written as

$$\psi(x,t) = \sqrt{\rho(x,t)}\, e^{i\theta(x,t)}, \tag{1}$$

where $\rho(x,t) \geq 0$ is the coherence amplitude and $\theta(x,t)$ is a real-valued phase.

The coherence field ψ is assumed to belong to the Hilbert space

$$\mathcal{H} = L^2(\mathbb{R}^3; \mathbb{C}), \tag{2}$$

equipped with the standard inner product

$$\langle \psi_1, \psi_2 \rangle = \int_{\mathbb{R}^3} \psi_1^*(x)\, \psi_2(x)\, dx. \tag{3}$$

This Hilbert space serves only as a mathematical ambient space; not all elements of $\mathcal{H}$ correspond to physically admissible configurations.

Physical configurations are restricted to an admissible subset

$$\mathcal{H}_{\text{adm}} \subset \mathcal{H}, \tag{4}$$

defined by constraints on regularity, finiteness, and topological consistency. In particular, admissible coherence fields satisfy the following conditions:

1. The amplitude $\rho(x,t)$ is finite and nonnegative almost everywhere.

2. The phase $\theta(x,t)$ is locally integrable and admits well-defined gradients away from isolated singular points.

3. The coherence field possesses finite integrated energy under the admissibility functional defined later.

4. The amplitude $\rho(x,t)$ is strictly positive except at isolated events, where controlled amplitude collapse is permitted.

The requirement of strict positivity of ρ excludes arbitrary phase discontinuities under smooth evolution. Isolated points where ρ vanishes are admissible and play a distinguished role, as they permit changes in topological structure that are otherwise forbidden.

The admissible configuration space $\mathcal{H}_{\text{adm}}$ is not assumed to be linear. Superposition of admissible states need not remain admissible, and physical evolution is therefore not generated by unrestricted linear operators on $\mathcal{H}$. This restriction is essential: admissibility constrains which transformations may act on states, not merely which states may exist.

All subsequent dynamical, topological, and measurement structures are defined relative to $\mathcal{H}_{\text{adm}}$. The operator-first formulation treats this admissible configuration space as the primary physical arena, with equations and effective dynamics emerging only as secondary constructs.

4 Admissible Generators and Sector Structure

Evolution in the operator-first framework is governed by families of admissible generators acting on the admissible configuration space. Let

$$A(t) : \mathcal{D}(A(t)) \subset \mathcal{H}_{\mathrm{adm}} \to \mathcal{H}_{\mathrm{adm}} \tag{5}$$

denote a generally time-dependent generator, defined only on a domain $\mathcal{D}(A(t))$ of admissible states. No assumption is made that $A(t)$ is self-adjoint, bounded, or globally defined on $\mathcal{H}$.

Admissibility constrains not only the states on which $A(t)$ may act, but also the manner in which generators may couple different regions of the configuration space. These constraints give rise to a sector structure associated with the topology of the coherence phase.

Let $\{\gamma_i\}$ denote a set of independent closed loops in physical space. For each loop, define the winding number

$$\alpha_i = \frac{1}{2\pi} \oint_{\gamma_i} \nabla\theta \cdot d\ell, \tag{6}$$

and collect these into a sector label

$$\alpha = (\alpha_1, \alpha_2, \ldots). \tag{7}$$

Two admissible states are said to belong to the same sector if they share the same winding data α. Sector labels are invariant under smooth admissible evolution as long as the coherence amplitude remains strictly positive.

The Hilbert space admits a decomposition into sector subspaces,

$$\mathcal{H} = \int^{\oplus} \mathcal{H}_\alpha \, d\mu(\alpha), \tag{8}$$

with associated projection operators P_α. Although this decomposition is defined on $\mathcal{H}$, admissible evolution is restricted to $\mathcal{H}_{\mathrm{adm}}$ and respects sector structure except at isolated amplitude-collapse events.

Admissible generators satisfy a suppression condition on cross-sector couplings. Specifically, the matrix elements of $A(t)$ between distinct sectors obey an exponential decay law,

$$\|P_\beta A(t) P_\alpha\| \sim \exp[-\kappa \, d(\alpha, \beta)] \, , \tag{9}$$

where $d(\alpha, \beta)$ is a metric measuring topological separation between sectors and κ is a positive constant. This suppression reflects the physical inaccessibility of sector transitions under ordinary evolution.

Transitions between distinct sectors are permitted only at isolated events where the amplitude ρ vanishes at some point in space and time. Such events relax the topological constraint, allowing reconnection of phase structure and a change in winding data. Outside these events, sector labels are conserved.

The sector structure introduced here plays a role analogous to holonomy or Wilson-loop data in gauge theory. However, it arises directly from the coherence phase rather than from an externally imposed gauge connection. Sector labels therefore encode intrinsic topological constraints on admissible evolution rather than auxiliary symmetry data.

Admissible generators and sector structure together define the kinematic constraints of the operator-first framework. Dynamical behavior emerges only after specifying how such generators compose over time, subject to the admissibility conditions introduced here.

5 Monotone Functional and Physical Constraints

Admissible evolution in the operator-first framework is constrained by a monotone functional that enforces global directionality. This functional plays a role analogous to entropy in thermodynamics, but it is defined directly on coherence configurations rather than on ensembles or macroscopic observables.

Let $\mathcal{M}[\psi]$ denote a real-valued functional defined on the admissible configuration space $\mathcal{H}_{\mathrm{adm}}$. The explicit form of $\mathcal{M}$ is not fixed a priori, but it is required to satisfy the following properties.

First, $\mathcal{M}$ is finite for all admissible configurations,

$$\mathcal{M}[\psi] < \infty \quad \text{for all } \psi \in \mathcal{H}_{\mathrm{adm}}. \tag{10}$$

Second, $\mathcal{M}$ is non-increasing under smooth admissible evolution. If $\psi(t)$ evolves under admissible generators without amplitude collapse, then

$$\frac{d}{dt}\mathcal{M}[\psi(t)] \leq 0. \tag{11}$$

This condition imposes an intrinsic arrow on admissible evolution and forbids closed, smooth cycles that increase $\mathcal{M}$.

Third, violations of monotonicity are permitted only at isolated events where the coherence amplitude vanishes at one or more points. Such events correspond to topological reconnection and sector transitions, and they constitute controlled exceptions to monotonic behavior rather than generic dynamics.

The monotone functional is not required to coincide with the norm of the coherence field. In general, admissible evolution need not preserve $\|\psi\|$, and probability conservation is not taken as a primitive axiom. Instead, physical admissibility is enforced by monotonicity of $\mathcal{M}$ together with the sector constraints defined previously.

The presence of a monotone functional distinguishes admissible operator composition from arbitrary operator products. Without this constraint, product-limit evolution would permit unphysical amplification, cyclic accessibility, or unrestricted sector mixing. Monotonicity restricts admissible evolution to a subset of operator compositions that exhibit irreversible structure even in the absence of dissipation or stochasticity.

The monotone functional therefore functions as a fundamental physical constraint rather than as a derived statistical quantity. It ensures that admissibility alone suffices to impose directionality, stability, and irreversibility on the evolution constructed in subsequent sections.

6 Evolution as Admissible Product Limits

Having specified admissible configurations, generators, sector constraints, and monotonicity, evolution can now be constructed. In the operator-first framework, evolution is not postulated through differential equations. Instead, it is defined as a limit of compositions of admissible micro-transformations.

Let $F_h(t)$ denote a family of admissible micro-step operators acting on $\mathcal{H}_{\mathrm{adm}}$, parameterized by a small positive parameter h. These operators are required to satisfy the local consistency condition

$$F_h(t)\psi = \psi + h\,A(t)\psi + o(h), \tag{12}$$

for all ψ in the domain of $A(t)$, where $A(t)$ is an admissible generator. Each $F_h(t)$ maps admissible states to admissible states and respects the sector and monotonicity constraints introduced previously.

For fixed times $s < t$, define a partition of the interval $[s, t]$ into n subintervals of width $h = (t - s)/n$, with sampling times $t_k = s + kh$. The global evolution operator $U(t, s)$ is then defined by the product limit

$$U(t, s)\psi = \lim_{n\to\infty} F_h(t_{n-1})\,F_h(t_{n-2})\cdots F_h(t_0)\,\psi, \tag{13}$$

whenever this limit exists.

The limit is taken in the strong operator topology on a dense subset of $\mathcal{H}_{\mathrm{adm}}$. Existence of the limit is guaranteed by admissibility, monotonicity, and sector suppression, which together prevent unbounded amplification or pathological oscillation.

This construction is closely related to Chernoff-type product formulas in functional analysis. Its significance here is conceptual rather than technical: global evolution is assembled from locally admissible steps rather than derived from a single global generator.

When admissible generators commute and admissibility constraints are uniform, the product-limit evolution may reduce to an exponential form,

$$U(t, s) = \exp((t - s)A)\,, \tag{14}$$

recovering conventional equation-based dynamics as a special case. Outside such regimes, evolution remains well-defined even though no closed-form equation of motion exists.

The product-limit construction emphasizes that physical evolution is procedural. The order, admissibility, and composition of micro-transformations matter. Path dependence and history effects arise naturally from noncommutativity of admissible generators rather than from dissipation or noise.

Evolution in the operator-first framework is therefore not a trajectory determined by an equation, but an emergent object defined by constrained accessibility over time.

7 Effective Generators and Resolvent Accessibility

Although global evolution is defined through admissible product limits, it is often useful to summarize behavior within a restricted regime by an effective generator. Such generators are not fundamental objects of the theory, but approximations that capture the net effect of admissible composition under specified conditions.

Let L denote an effective generator acting on a subspace of $\mathcal{H}_{\mathrm{adm}}$, obtained by freezing, averaging, or linearizing admissible generators over a regime of interest. No assumption is made that L coincides with any particular $A(t)$, nor that it generates exact evolution beyond the regime in which it is defined.

The central object associated with an effective generator is its resolvent,

$$R(\lambda; L) = (\lambda I - L)^{-1}, \tag{15}$$

defined for complex λ in the resolvent set of L. In the operator-first framework, the resolvent encodes accessibility rather than intrinsic state properties.

Accessibility refers to the degree to which a system can respond to admissible perturbations at a given spectral parameter. Poles of the resolvent correspond to highly accessible modes, while growth of the resolvent norm signals proximity to instability, resonance, or qualitative change in response behavior.

Sector structure is inherited by the resolvent. Projection onto sector subspaces yields

$$P_\beta R(\lambda; L) P_\alpha, \tag{16}$$

which measures accessibility between sectors α and β. Exponential suppression of cross-sector accessibility persists at the level of the resolvent, except near isolated events where sector barriers are relaxed.

The resolvent framework allows observable response to be characterized without reference to microscopic equations of motion. What matters experimentally is not the detailed structure of L, but the location and nature of resolvent singularities and the operator norms governing accessibility.

In regimes where admissibility constraints simplify and effective generators commute, the resolvent reduces to familiar linear response objects. In more general regimes, resolvent structure captures path dependence, hysteresis, and non-reciprocal response as intrinsic features of accessibility rather than as artifacts of dissipation.

Effective generators and their resolvents therefore provide the primary interface between the operator-first framework and phenomenology. They translate admissible composition into experimentally accessible signatures while preserving the distinction between fundamental constraints and regime-dependent approximations.

8 Measurement and Inertial Modulation

Within the operator-first framework, measurement is not interpreted as a direct interrogation of intrinsic state variables. Instead, measurement probes accessibility: the response of a system to admissible perturbations as encoded by resolvent structure.

Consider a regime in which admissible evolution may be summarized by an effective generator L. Let $\eta(t)$ denote a small deviation from a reference admissible configuration, governed approximately by the driven linear system

$$\frac{d}{dt}\eta(t) = L\,\eta(t) + B\,u(t), \tag{17}$$

where $u(t)$ is an externally applied control or drive and B is an admissible input operator specifying how the perturbation couples to the system.

A measurement apparatus is represented by an output operator C, producing a measured signal

$$y(t) = C\,\eta(t). \tag{18}$$

Passing to the frequency domain yields the transfer operator

$$T(\omega) = C\,R(i\omega; L)\,B, \tag{19}$$

where $R(i\omega; L)$ is the resolvent of the effective generator evaluated on the imaginary axis.

Observable response is therefore governed by resolvent accessibility. Peaks in response correspond to resolvent poles or near-singular behavior, phase shifts reflect complex structure of the resolvent, and suppression regions indicate limited accessibility imposed by admissibility constraints.

Inertial modulation may be interpreted within this framework as a change in effective accessibility under applied drive. Rather than modifying intrinsic mass parameters, admissible perturbations alter the resolvent structure governing response to acceleration or force-like inputs. Apparent changes in inertia thus reflect shifts in accessibility rather than changes in fundamental properties.

Path dependence and hysteresis arise naturally when admissible generators fail to commute. The order in which perturbations are applied affects the product-limit evolution and, consequently, the effective generator governing linear response. Such effects are intrinsic to admissible composition and do not require dissipation, stochasticity, or nonlinear feedback.

Measurement outcomes in the operator-first framework are therefore contextual but objective. They depend on admissible preparation, drive protocol, and sector accessibility, yet are fully determined by the underlying operator structure. Measurement does not collapse a state; it reveals the accessibility landscape through which admissible evolution proceeds.

9 Predicted Signature Classes

The operator-first framework yields concrete, experimentally accessible predictions that do not depend on detailed microscopic modeling. These predictions arise from structural features of admissible evolution and resolvent accessibility rather than from specific parameter choices. This section summarizes the primary classes of observable signatures implied by the theory.

Resonant Accessibility Peaks

When the resolvent $R(i\omega; L)$ approaches singular behavior, the transfer operator

$$T(\omega) = C\,R(i\omega; L)\,B \tag{20}$$

exhibits enhanced response. Such resonant peaks need not correspond to normal modes in the equation-first sense. Instead, they signal frequencies at which accessibility is maximized under admissible perturbations.

Resonant accessibility peaks are predicted to display non-Lorentzian profiles in regimes where admissible generators do not commute or where sector suppression is active.

Phase Inversion and Polarity Reversal

The complex structure of the resolvent implies that response may undergo abrupt phase shifts as a function of drive frequency or protocol. In particular, crossings of the imaginary axis by effective resolvent poles produce phase inversions or polarity reversals in measured signals.

Such inversions are not indicative of sign changes in intrinsic parameters, but of changes in accessibility structure. They are therefore predicted to be robust against variations in drive amplitude while remaining sensitive to preparation history.

Hysteresis and Protocol Dependence

Noncommutativity of admissible generators implies that the order of applied perturbations affects the resulting evolution. Consequently, response curves are predicted to exhibit hysteresis under cyclic or swept drives.

This hysteresis is not dissipative in origin. It persists even in the absence of energy loss and reflects the path dependence of admissible product limits. Distinct preparation protocols leading to the same nominal state may yield different response behavior.

Sector-Gated Transitions

Sector structure imposes strong suppression of cross-sector accessibility under ordinary conditions. However, near isolated amplitude-collapse events or in regimes of extreme drive, sector barriers may be partially relaxed.

Observable signatures of such events include abrupt jumps in response, discontinuities in phase behavior, or transient access to otherwise suppressed modes. These transitions are predicted to be rare, localized, and highly protocol-dependent.

Suppression Plateaus

In frequency or parameter regimes where resolvent norms remain uniformly small, response is predicted to enter suppression plateaus. In these regions, applied perturbations produce minimal effect despite increasing drive strength.

Such plateaus reflect admissibility constraints rather than saturation or damping. Their presence distinguishes accessibility-based suppression from conventional linear response limits.

Summary of Signature Classes

The predicted signature classes may be summarized as follows:

1. Resonant peaks associated with resolvent singularities.
2. Phase inversions and polarity reversals driven by complex accessibility structure.
3. Hysteresis arising from noncommutative admissible composition.

4. Abrupt sector-gated transitions under extreme or exceptional conditions.

5. Suppression plateaus reflecting limited accessibility.

Observation or absence of these signatures provides a direct means of testing the operator-first framework independent of detailed microscopic assumptions.

10 Extensions and Special Regimes

The operator-first framework admits a range of extensions that capture special physical regimes without modification of its foundational principles. These regimes alter the structure of effective generators, resolvent behavior, or admissibility constraints, while preserving the primacy of admissible operator composition.

Non-Hermitian Effective Generators

Effective generators L need not be Hermitian. Non-Hermitian generators arise naturally when admissible evolution includes irreversible processes, coarse-grained elimination of degrees of freedom, or asymmetric accessibility under perturbation.

In such regimes, the spectrum of L may extend into the complex plane. The resolvent

$$R(\lambda; L) = (\lambda I - L)^{-1} \tag{21}$$

remains the correct object governing accessibility. Observable response is determined not by eigenvalue reality, but by proximity of the spectrum to the imaginary axis and by the associated resolvent norms.

Non-Hermiticity does not imply instability. Admissibility and monotonicity restrict amplification to controlled regimes, preventing unbounded growth except at isolated exceptional events.

Exceptional Points

Exceptional points occur when two or more eigenvalues of an effective generator coalesce along with their associated eigenvectors. At such points, the resolvent develops higher-order pole structure,

$$R(\lambda; L) \sim (\lambda - \lambda_*)^{-k}, \qquad k > 1. \tag{22}$$

Near exceptional points, accessibility is dramatically enhanced and response becomes highly sensitive to small perturbations. Observable consequences include asymmetric resonance profiles, abrupt phase shifts, and strong dependence on drive protocol.

Within the operator-first framework, exceptional points represent accessibility singularities rather than pathological breakdowns. They mark boundaries between qualitatively distinct admissible regimes.

PT-Symmetric Regimes

A special class of non-Hermitian generators arises when L is invariant under combined parity and time-reversal transformation. In such PT-symmetric regimes, the spectrum of L may remain entirely real below a symmetry-breaking threshold despite the absence of Hermiticity.

Crossing the PT-symmetry-breaking threshold corresponds to migration of resolvent poles into the complex plane and produces a qualitative change in accessibility. This transition is predicted to manifest as sudden amplification or suppression of response without gradual parameter dependence.

Collective and Multi-Component Coherence

The framework extends naturally to systems composed of multiple coupled coherence fields. Let

$$\Psi = (\psi_1, \psi_2, \dots, \psi_N) \tag{23}$$

denote a collection of admissible coherence components. The combined admissible configuration space is the product

$$\mathcal{H}_{\mathrm{adm}}^{(N)} = \prod_{j=1}^{N} \mathcal{H}_{\mathrm{adm}}^{(j)}. \tag{24}$$

Admissible generators may include coupling terms between components, subject to joint sector and monotonicity constraints. Collective coherence arises when such couplings modify effective generator structure in a manner that enhances accessibility for coordinated perturbations while suppressing incoherent ones.

In resolvent language, collective behavior appears as the emergence of shared poles or amplified accessibility modes not present in individual components.

Boundary-Driven and Observer-Coupled Regimes

Certain regimes of interest involve explicit coupling between coherence dynamics and boundary or externally imposed constraints. Such coupling may be represented by admissible source or boundary operators entering the effective generator.

Formally, driven dynamics take the form

$$\frac{d}{dt}\eta(t) = L\,\eta(t) + B\,u(t) + J\,v(t), \tag{25}$$

where J represents an admissible boundary or observer coupling and $v(t)$ is an externally specified signal.

These regimes do not assign a special ontological role to observers. They reflect the fact that admissibility may be conditioned on external constraints that alter accessibility without modifying the underlying configuration space.

Summary of Special Regimes

Non-Hermitian dynamics, exceptional points, PT-symmetric behavior, collective coherence, and boundary-driven evolution are all accommodated within the operator-first framework. Each regime corresponds to a modification of effective generator structure or admissibility constraints rather than to a change in foundational principles.

The persistence of resolvent-based accessibility across these regimes underscores the generality of the operator-first approach.

11 Falsifiability and Failure Modes

The operator-first framework is intended to be empirically meaningful rather than interpretive. Its claims are structural and therefore falsifiable. This section enumerates explicit conditions under which the framework would be invalidated. Failure of any single condition constitutes failure of the framework as a whole rather than motivation for parameter adjustment.

Failure of Resolvent-Based Response

The framework predicts that observable response is governed by resolvent accessibility. If repeated, independently prepared experiments probing the same regime produce response behavior that cannot be represented through a bounded resolvent structure, the accessibility interpretation fails.

In particular, observation of stable, reproducible response peaks without associated phase structure, or amplification without proximity of the spectrum of L to the imaginary axis, would contradict the resolvent-based model of measurement.

Violation of Monotonicity

Admissible evolution is constrained by a monotone functional $\mathcal{M}$. If a system exhibits smooth, closed cycles under admissible evolution for which

$$\oint \frac{d}{dt}\mathcal{M}[\psi(t)]\,dt > 0, \tag{26}$$

without invoking isolated amplitude-collapse events, then the monotonicity postulate is false.

Such behavior would imply unrestricted cyclic accessibility and invalidate the foundational constraint responsible for irreversibility and stability.

Unrestricted Sector Transitions

Sector structure predicts exponential suppression of cross-sector accessibility under ordinary evolution. If experiments demonstrate frequent, smooth transitions between distinct sector-labeled configurations without evidence of amplitude collapse or reconnection, the sector hypothesis is incorrect.

Quantitatively, observation of unsuppressed off-diagonal resolvent blocks

$$\|P_\beta R(\lambda; L) P_\alpha\| \not\ll 1 \quad \text{for } \beta \neq \alpha \tag{27}$$

in generic regimes would falsify the theory.

Absence of Protocol Dependence

Noncommutativity of admissible generators implies path dependence. If experimental response is found to be strictly independent of preparation history, ordering of perturbations, and sweep direction across all relevant regimes, then admissible composition reduces to a commutative structure.

Persistent absence of hysteresis or history effects where noncommutativity is expected would undermine the operator-first motivation.

Reduction to Global Equation-Based Dynamics

The framework predicts that equation-first dynamics emerge only in special regimes. If all physically relevant systems are empirically shown to admit global generators producing exact exponential evolution,

$$U(t, s) = \exp((t - s)A)\,, \tag{28}$$

with no observable deviation, then the additional structure introduced by admissibility-first reasoning is unnecessary.

In that case, the operator-first formulation would be superseded by simpler equation-based descriptions without loss of explanatory power.

Summary of Failure Criteria

The operator-first framework would be falsified by any of the following:

1. Observable response not mediated by resolvent accessibility.
2. Smooth violation of monotonicity without amplitude collapse.
3. Unrestricted transitions between topological sectors.
4. Absence of protocol dependence in regimes of noncommutativity.
5. Universal sufficiency of global equation-based evolution.

These criteria are independent, testable, and decisive. Satisfaction of any one constitutes failure of the framework rather than refinement.

12 Conclusion

This work has presented an operator-first physical framework in which admissibility precedes dynamics. Rather than postulating equations of motion, the framework identifies physical law with constraints on allowable transformations acting on a coherence configuration space. Evolution is constructed from admissible composition, and equations arise only as effective descriptions in regimes where admissibility simplifies.

Coherence fields define the admissible state space, sector structure encodes topological constraints, admissible generators specify local transformation rules, and a monotone functional enforces global directionality. Together, these elements define a procedural notion of physical law that remains well-defined even when global equations do not exist.

Effective generators provide regime-dependent summaries of admissible evolution, and their resolvents encode accessibility. Measurement is interpreted as a probe of this accessibility structure rather than as a direct interrogation of intrinsic state variables. Observable phenomena such as resonance, hysteresis, polarity inversion, and inertial modulation follow from resolvent structure without introducing additional forces or parameters.

The framework accommodates non-Hermitian dynamics, exceptional points, collective coherence, and boundary-driven regimes without modification of its foundational principles. These extensions reflect changes in effective generator structure rather than departures from admissibility-first reasoning.

Crucially, the formulation is falsifiable. Explicit failure modes have been identified, any one of which would invalidate the framework. If, however, admissibility-based construction continues to account for observable behavior across increasingly general regimes, the operator-first approach defines a ceiling rather than a competitor: equation-based theories appear as effective special cases within a broader procedural structure.

The central claim is therefore not the replacement of existing physical theories, but the identification of a deeper organizing principle. Physical phenomena arise from constrained accessibility under admissible operator composition. In this view, physics is not fundamentally declarative, but procedural.

References

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