

Self-Entangled Potential Dynamics 5.1: Potential Axiom and Generative Ontology (Full Revised Edition)

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Quantum gravity unification remains the core unresolved challenge of contemporary fundamental physics. Dominant mainstream frameworks suffer dual foundational fractures in ontology and category theory: string theory assumes a fixed 10-dimensional geometric background with spacetime only an effective low-energy approximation, failing to explain the joint origin of light speed c and cosmological constant Λ ; loop quantum gravity treats discrete spin networks as primal ontology, lacking a monistic substrate unifying quantum matter and continuous geometry; noncommutative geometry and asymptotic safety schemes pre-bifurcate "quantum matter" and "gravitational spacetime", inherently bearing cross-scale coupling barriers and unavoidable non-normalizability of quantum gravity.

On the mathematical side, quantum groups $U_q(\mathfrak{sl}_2)$ and Lusztig small quantum groups are widely applied to low-dimensional topology and non-Hermitian condensed matter dynamics, yet prior work only treats q as a bare deformation parameter without layering temperature-resolved physical phases; inverse limit sheaf structures are restricted to algebraic topology and never deployed as primal self-generating operators to model cosmic emergence. Philosophically, most quantum gravity frameworks violate strict falsifiability criteria, relying on indirect cosmological evidence without controllable laboratory decisive experiments, while many introduce unobservable metaphysical hypotheses blurring mathematical structure and philosophical metaphor.

The 4.0/5.0 iterations of **SEPD** (formerly Self-Entangled Polar-Dual Dynamics) established an initial monistic algebraic substrate but carried two critical flaws: binary "polar-dual" terminology split the underlying ontology, conflating the monistic potential substrate with two manifest modes; second, mathematical structure and cultural imagery were not strictly separated, inviting metaphysical misinterpretation. This full revision v5.1 δ delivers three core upgrades: 1. Terminology reconstruction: obsolete binary terms "polar-dual, polar substrate" are eliminated; the potential algebra $\mathcal{P} = C(\mathbf{T})$ is designated sole primal ontology, with self-entanglement $\otimes$ as the unique generative operator. Mathematical formalisms are rigorously separated from the cultural anchor metaphor "Hidden Dragon"; 2. Expanded theoretical scope: a unified generative framework for optics and co-origin Λ -c cosmology is constructed, embedding time, light, and gravitation entirely within potential manifest dynamics; 3. Complete experimental formalization: a low-temperature satellite orbital experiment Exp4 is introduced, furnishing dual ground+space falsifiable tests for cosmological predictions. All four experimental pipelines contain hard falsification thresholds complying strictly with Popper's demarcation criterion of falsifiability.

This manuscript adheres to the academic priority principle: mathematical rigor first, experimental verdict as ultimate criterion. All analogies to the Qian trigram of the I Ching are confined to Appendix F as auxiliary comparisons and excluded from all axioms, derivations, and physical predictions. All incomplete mathematical constructions (non-compact Lorentzian quantum groups, Standard Model spectrum embedding) are fully disclosed without overextrapolation. No ad-hoc corrective hypotheses are introduced; a single negative decisive experimental result fully falsifies the complete framework.

DOCUMENT BASE SPECIFICATION

Document: Full Revised Manuscript **SEPD** 5.1
Template: Dual-column Chinese-English compatible LaTeX template
Compile Pipeline: XeLaTeX $\rightarrow$ BibTeX $\rightarrow$ XeLaTeX $\rightarrow$ XeLaTeX

Font, Mathematics and Typesetting Rules

1. Encoding: UTF-8 universal character support; main serif font Times New Roman, sans-serif Arial, monospace Consolas; automatic Chinese-English intercharacter spacing disabled globally.
2. Mathematical Notation: Standard AMS math

suite, bold vector notation, script alphabets, physical differential operators, SI unit formatting enforced.

3. Typesetting Tools: Native support for vector figures, three-line formal tables, multi-row cells, colored text, hyperlinks; hyperlinks colored blue, citation markers red, uniform resource locators cyan.
4. Custom Shorthand Symbols Defined:
 - Γ (bold): deformation observation parameter
 - $\mathcal{P}$ (script): potential algebra
 - $\mathcal{H}$ (script): Hilbert modular space
 - $\mathcal{C}$ (script): manifest tensor category
 - $\otimes$: exclusive self-entanglement binary operator
 - et al.: standard multi-author shorthand for foreign literature
 - **SEPD**: bolded theoretical acronym

Version Remarks

This framework was originally titled *Self-Entangled Polar-Dual Dynamics (SEPD: Self-Entangled Polar-Dual Dynamics)*. Version 5.1 formalizes the renaming. The core mathematical architecture inherits all logical foundations of **SEPD** 5.0; only terminology and structural semantics receive precise normalization. The acronym **SEPD** is retained for academic continuity. This manuscript enforces a strict separation principle: mathematical referents and cultural anchor imagery are strictly partitioned. All physical predictions are independently falsifiable, with no untestable metaphysical postulates embedded in formal derivations.

TERMINOLOGY BOUNDARY SPECIFICATION

To eliminate conceptual conflation, the following rigid terminology partition is enforced throughout the text:

1. Mathematical Referents: The terms *self-entanglement* (corresponding to sheaf inverse limit $\varprojlim \mathcal{O}(U)$, exclusively describing self-restricting algebraic structure) and *potential* (referring to algebraic object $\mathcal{P}$) are used exclusively in all axioms, equations, and experimental parameter definitions.
2. Cultural Anchor: The phrase *Hidden Dragon* exclusively references the line *Ninth Initial: Hidden Dragon, No Action* from the Qian trigram of the *I Ching*. It only describes structural isomorphism between $\mathcal{P}$ and its unit element e (latent generative capacity without manifest realization, acausal, decoupled from observable phenomena). It carries no mathematical definitional weight and prohibits figurative extension into formal physics.
3. Relational Clarification: "Hidden Dragon" functions as a cross-disciplinary auxiliary analogy for self-entangled potential. It does not alter the independent validity of all mathematical constructions. Any interpretation framing "Hidden Dragon" as mysticism, autonomous philosophical ontology, or foundational metaphor violates this manuscript's academic stance.

PRELIMINARY MATHEMATICAL PREREQUISITES (SECTION 0)

Unified symbolic and algebraic language is established below; complete rigorous proofs are deferred to Appendix B:

1. Deformation Algebra $\mathcal{P} = C(\Gamma)$: field of complex rational functions, generic point stalk over deformation space $\text{Def}(U(\mathfrak{sl}_2))$.
2. Sheaf inverse-limit self-entanglement operator $\otimes$: $\mathcal{P} \otimes \mathcal{P} = \varprojlim \mathcal{O}(U)$, commutative and idempotent.
3. Observation parameter factorization $\Gamma = |\Gamma|e^{i\theta}$: $|\Gamma| = e^{-\beta\hbar\omega_0}$ (inverse thermal resolution parameter), observation phase $\theta \in [0, \pi/2]$.

4. Manifest Category $\mathcal{C}_\Gamma$: rigid tensor category populated by all $\mathcal{H}$ modules and Hamiltonian operator sheaf modules.
5. Non-semisimple singular point $\Gamma = i$: fourth root of unity; projective modules carry Jordan block spectral singularities, the structural origin of all fundamental physical constants.

CORE AXIOMS (SECTION 1)

Axiom 1: Potential Axiom

A single undifferentiated dynamical potential algebra $\mathcal{P} = C(\Gamma)$ exists (generic stalk of deformation space $\text{Def}(U(\mathfrak{sl}_2))$, structurally analogous to the cultural anchor "Hidden Dragon"), equipped with self-entanglement binary operation $\otimes$ (sheaf inverse limit, distinct from algebraic multiplication and physical spacetime winding). The operator satisfies four primitive axioms:

1. Idempotency: $\mathcal{P} \otimes \mathcal{P} = \mathcal{P}$. Potential sustains self-identity via internal self-restriction; no external generation of novel objects, only accumulation of potential difference.
2. Self-entanglement unit element e : there exists identity $e = 1 \in \mathcal{P}$, such that for all $x \in \mathcal{P}$, $e \otimes x = x \otimes e = x$. e forms the intrinsic core of generative potential, isomorphic to the latent property of "Hidden Dragon", the ultimate anchor for all manifest states.
3. Non-manifestity: $\mathcal{P}$ is not an object within the collection of objects of manifest category $\mathcal{C}_\Gamma$. Potential lies outside all observable manifest structures and cannot be directly measured.
4. Operativity: a one-parameter family of transformation operators $\{\mathcal{O}_\Gamma\}$ ($\Gamma \in \mathbb{C} \setminus \{0\}$) exists, projecting $\mathcal{P}$ into two mutually exclusive manifest modes: inverse quotient disjunction $\mathcal{O}_{\Gamma^{\text{inv}}} (\theta \rightarrow 0)$ and quotient collapse manifestation $\mathcal{O}_{\Gamma^{\text{pos}}} (\theta \rightarrow \pi/2)$.

Fundamental Distinction from Dual-Substrate Frameworks

This axiom rejects a priori separation of two independent algebras. Discrete quantum sheaf $\mathcal{H}$ and continuous geometric sheaf $\hat{\mathcal{H}}$ are both derivative products of the monistic potential algebra mediated by manifest operators. The idempotent identity $\mathcal{P} \otimes \mathcal{P} = \mathcal{P}$ prevents ontological infinite regress by forbidding unregulated self-proliferation of primal substrate. The non-manifestity axiom strictly partitions underlying generative structure from observable manifest objects, eliminating the widespread conceptual conflation of equating potential algebra directly to quantum fields or spacetime manifolds.

Axiom 2: Dual Manifestation and Mutual Implication

$\mathcal{H}$ and $\hat{\mathcal{H}}$ constitute two mutually exclusive manifest modes of potential. The two categories mutually imply one another yet carry no direct canonical mapping: $\hat{\mathcal{H}}$ becomes an empty background absent $\mathcal{H}$, while $\mathcal{H}$ exists as disconnected fragments without $\hat{\mathcal{H}}$. All cross-layer coupling requires mediation through $\mathcal{P}$.

Axiom 3: Potential Interdiction Theorem

No covariant functor $\Phi : \mathcal{H} \otimes \hat{\mathcal{H}} \rightarrow \text{joint Hilbert space}$ exists. Discrete quantum sheaf $\mathcal{H}$ and continuous geometric sheaf $\hat{\mathcal{H}}$ cannot couple directly; all cross-scale dynamical interactions require mediation via potential algebra $\mathcal{P}$. This statement is a direct logical corollary of $\mathcal{P}$'s idempotency and non-manifestity, not an externally imposed constraint.

Physical Interpretation of Categorical Constraint

The Potential Interdiction Theorem is a unique structural signature exclusive to **SEPD**, directly resolving the core mathematical barrier of quantum gravity. If a direct covariant coupling between

$\mathcal{H}$ and $\mathcal{K}$ existed, quantum fluctuations and geometric curvature would interact without intermediate substrate, permitting direct quantization of gravitation. This interdiction proves such cross-category mappings are categorically non-existent, requiring all cross-scale interactions to transit the potential algebra. The framework naturally reproduces the observed ultraviolet divergences and non-renormalizability of quantum gravity without ad-hoc renormalization group corrections.

GENERATIVE MANIFEST DYNAMICS (SECTION 2)

Time: Weathering Decay Rate

Time does not exist as an independent background coordinate; it is an intrinsic kinematic byproduct of manifest projection operations:

1. $\mathcal{P}$ Layer (Potential Algebra): Timeless. Idempotent self-entanglement eliminates sequential ordering; the phrase "Hidden Dragon, No Action" encodes acausal, unordered latent potential.
2. $\mathcal{H}$ Layer (Discrete Inscriptions): Proper time $\tau_{\mathcal{H}} \propto |\Gamma - i|^{-1}$, quantifying local weathering and disjunction decay rate of discrete quantum inscriptions.
3. $\mathcal{K}$ Layer (Continuous Manifold): Coordinate time $t_{\mathcal{K}}$, global trace parameter left by quotient collapse expansion.
4. Arrow of Time: Arises from irreversible weathering following initial spectral displacement of Γ away from singular root i . Local suppression of decoherence (freezing the temporal arrow) is achieved by tuning $\Gamma \rightarrow i$, corresponding to latent potential returning to unmanifest equilibrium isomorphic to the Hidden Dragon state.

Paradigmatic Break from Conventional Temporal Ontology

This framework overturns the foundational presupposition of classical physics: Newtonian mechanics and general relativity embed time as an independent background container; loop quantum gravity reduces time to an evolution parameter over discrete spin networks. Within **SEPD**, time carries no autonomous ontology and only emerges as a byproduct of potential projection and inscription weathering. As Γ converges to spectral singularity i , weathering decay rates asymptotically vanish, inducing local decoherence suppression and frozen temporal arrows. This effect is directly measurable via microcavity relaxation experiment Exp1.

Light: Manifest Coupling Stitch

Light is neither an independent particle nor standalone wave phenomenon; it acts as the coupling stitch at the scanning boundary between inverse disjunction operator $\mathcal{O}_{\Gamma^{\text{inv}}}$ and quotient collapse operator $\mathcal{O}_{\Gamma^{\text{pos}}}$:

1. Photon (Particle Form): Discrete inscription unit within $\mathcal{H}$ layer, direct output of inverse disjunction $\mathcal{O}_{\Gamma^{\text{inv}}}$.
2. Electromagnetic Wave (Wave Form): Manifold ripples on $\mathcal{K}$ layer, spreading trace product of quotient collapse $\mathcal{O}_{\Gamma^{\text{pos}}}$.
3. Light Speed c : Universal propagation bound of manifold spreading traces, determined by universal spectral singularity property $\rho(\lambda) \sim |\lambda - \lambda_{\text{EP}}|^{-1/2}$ at $\Gamma = i$.
4. Refractive Index n : Medium-localized deformation parameter Γ_{med} drag strength over manifest coupling stitches, satisfying linear proportionality $n - 1 \propto |\Gamma_{\text{med}} - i|$.