Rotational Invariance, Semantic Discreteness, and Combinatorial Emergence
A Structural Reconstruction of Physical Law

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Abstract

This work is intentionally formulated at a structural level, prior to any specific mathematical representation. Equations appear only as contingent realizations of deeper invariance, semantic, and stability constraints.

We present an axiomatic reconstruction of physical law based on rotational invariance, semantic discreteness at the Planck scale, and dissipative stability. These principles uniquely determine the existence of a norm and inner product, restrict local dynamics to a two-dimensional space of variations, and enforce a maximal differential order $m = 2$. Least-action dynamics emerges as a criterion of stability under coarse-graining.

We further show that the discretization of an underlying quantum fluid into a finite set of semantically stable patterns produces a limited number of fundamental building blocks n. While local dynamical freedom is constrained by m, global structural richness arises combinatorially from configurations of these discrete entities. Space and time are reinterpreted as emergent bookkeeping structures for stable relational configurations. Geometry itself is scale invariant; all observable forms, from particles to molecules and macroscopic structures, arise as stable extremal configurations of a universal action describing the interaction between a quantum fluid and invariant geometry.

Keywords

Rotational invariance; semantic discreteness; Planck-scale semantics; combinatorial emergence; scale-invariant geometry; least-action principle; entropy minimization; dissipative dynamics; quantum fluid; discrete particle identity; emergent space and time; axiomatic foundations of physics; natural philosophy

1 Structural Point of Departure

The present work continues a line of investigation in which physical law is approached from a structural and semantic perspective rather than from specific dynamical equations [1]. The guiding question is not which equations describe nature, but which structural constraints determine what can meaningfully exist, persist, and be observed.

Space, time, particles, and even geometry itself are not taken as primitive. They arise as stable relational patterns selected from an underlying dynamical substrate through invariance and dissipative selection.

2 Axioms

Axiom 1 (Rotational Invariance)**.** *There exist no physically distinguished directions in local space. All physically meaningful quantities must be invariant under rotations.*

Axiom 2 (Semantic Discreteness). *At sufficiently small scales (Planck scale), physical states possess a finite semantic capacity: only a finite number of locally distinguishable degrees of freedom exist.*

This axiom formalizes the interpretation of the Planck scale as a semantic threshold rather than merely a dimensional cutoff [2].

Axiom 3 (Locality and Composability). *Physical evolution is local and composable: finite changes arise from successive composition of infinitesimal changes.*

Axiom 4 (Dissipative Stability). *Among all dynamically admissible configurations, only those stable under microscopic fluctuations and coarse-graining persist as effective physical structures.*

This principle underlies the role of dissipation as a selector of physically meaningful structures [4, 3].

3 Rotational Invariance and Local Geometry

Proposition 1. *Rotational invariance uniquely determines (up to scale) a norm and an inner product.*

Corollary 1. *Every local variation admits a unique parallel–orthogonal decomposition relative to any direction.*

This decomposition exhausts all locally meaningful modes of change and forms the structural basis for classical mechanics, field theory, and variational principles [1].

4 Local Dynamics and the Semantic Bound $m = 2$

Consider a localized trajectory $x(t)$. Its first and second derivatives define velocity and acceleration.

Proposition 2. *All local dynamical variation lies in the plane spanned by velocity and acceleration.*

Definition 1 (Semantic Order). *The semantic order m is the number of locally independent modes of change that carry physically distinguishable information.*

Proposition 3. *Semantic discreteness and local planarity imply*

$$m = 2.$$

Corollary 2. *Fundamental physical laws are necessarily second order in time. Higher-order dynamics introduce no new local geometry and are generically unstable.*

This explains the universal appearance of second-order equations in mechanics, gravitation, and effective field theories.

5 Action and Dissipative Selection

Definition 2 (Action). *The action of a trajectory is defined as*

$$S = \int L(x, \dot{x})\, dt,$$

where L represents the coarse-grained local entropy cost or dissipation rate.

Proposition 4 (Least-Action Principle)**.** *Physical trajectories satisfy*

$$\delta S = 0.$$

Least action is interpreted here as a stability condition under dissipative coarse-graining rather than as a fundamental optimization postulate [4].

6 Discrete Building Blocks and Particle Identity

The underlying quantum fluid admits a continuum of microscopic fluctuations. Dissipative stability selects only a finite set of semantically stable patterns.

Definition 3 (Fundamental Building Blocks)**.** *Semantically stable patterns of the quantum fluid that persist under coarse-graining are called fundamental building blocks. Let n denote their number.*

Proposition 5. *Fundamental particles correspond to protected eigenmodes or topological classes of the quantum fluid and therefore possess discrete identities.*

Fractional or continuously variable identities are unstable and physically unrealizable.

7 Combinatorial Emergence and Relational Space

A crucial consequence of discretization is that relations can exist only between existing entities.

Proposition 6. *If the number of fundamental building blocks is finite ($n < \infty$), then the space of physically meaningful relations is finitely generated.*

While local dynamical freedom is constrained by $m = 2$, global structural richness arises from the combinatorics of configurations of discrete entities:

$$\text{configurations} \sim \binom{n}{k}, \quad k \geq 2.$$

Corollary 3. *Complexity originates not from increased local dynamical freedom, but from combinatorial growth in relational configuration space.*

8 Scale-Invariant Geometry and Emergent Form

Proposition 7. *If geometry possessed an intrinsic scale, that scale would be semantically prior to dynamics, contradicting semantic discreteness.*

Corollary 4. *Geometry is scale invariant. No preferred lengths or shapes are encoded in geometric structure itself.*

This perspective is consistent with earlier analyses of scale invariance and fractal structure emerging above the Planck threshold [3].

Theorem 1 (Emergence of Form)**.** *Particles, molecular structures, and macroscopic forms are stable extremal configurations of a universal action governing the interaction between a quantum fluid and scale-invariant geometry.*

9 Emergence of Space and Time

Proposition 8. *Spatial and temporal notions arise as effective bookkeeping structures for stable relational configurations under invariant, dissipative dynamics.*

Space encodes stable relational configurations; time orders irreversible dissipative transitions. Both are emergent and relational, extending the relational views of Leibniz and Mach within a dissipative and semantic framework.

10 Conclusion

This work synthesizes a series of earlier investigations into a unified natural philosophy of physics [1, 2, 3, 4]. Physical law is reinterpreted as the stable outcome of invariance, semantic discreteness, and dissipative selection. Geometry is scale invariant, particles are discrete, local dynamics is simple, and global complexity arises combinatorially from relational configurations.

References

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