Contrast and Being:
A Structural Ontology of Physics and Perception

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For my mother, grandmother, and wife, without whom this work would not be.

Composed without training, sustained by vision, and offered in the hope that it may clarify for others what once stood indistinct for me.

Abstract

We present a structural framework in which continuity, discreteness, and temporal appearance emerge from the interaction between structural contrast and observer-dependent resolution thresholds. Observable phenomena are not treated as primitive features of reality, but as thresholded expressions of modulated variation. Infinitesimals, energy, time, and quantum events are reinterpreted as discernibility-conditioned manifestations of latent structure.

This approach replaces the assumption of ontic continuity or quantization with a general criterion for appearance based on accumulated contrast. Classical calculus is recovered in the limit of vanishing thresholds, while quantum phenomena are reframed as deterministic transitions across perceptual boundaries.

The result is a unified ontology in which structure is primary and appearance is resolution-relative, offering a threshold-based account of measurement, emergence, and temporal flow.

Contents

1 Introduction and Motivation

Continuity, discreteness, and the flow of time are among the most fundamental features of physical theory and perceptual experience. Yet prevailing frameworks typically assume these concepts as primitives: infinitesimals are idealized, derivatives are defined via limiting procedures, and time is introduced as an external parameter or coordinate.

This work proposes a different foundation. We posit that all observable form—whether spatial variation, temporal change, or quantum event—emerges from the interaction between structural contrast and resolution thresholds. Contrast refers to the magnitude of modulation between neighboring states; a resolution threshold defines the minimal integrated contrast required for discernibility by an observer or instrument.

In this framework, observable phenomena do not arise automatically from physical fields or configurations. They appear only when structural contrast accumulates beyond a discernibility threshold. Events, trajectories, and temporal flows are not ontological primitives but emergent appearances—resolved modulations of latent structure. Where modulation exists but remains below threshold, structure is real but unmanifest.

This ontological shift enables a unified treatment of classical analysis, quantum measurement, and perceptual experience. Rather than assuming continuity or discreteness, we derive both from a single generative principle: the accumulation of contrast relative to resolution. In the limit of vanishing thresholds, classical calculus is recovered; in finite-resolution regimes, quantized appearance, temporal asymmetry, and measurement events arise naturally.

The revised manuscript proceeds as follows:

- Section 2 formalizes contrast, discernibility, and resolution.
- Section 3 explores threshold-based calculus and infinitesimals.
- Section 4 unifies continuity and discreteness as perceptual regimes.
- Section 5 introduces the Hampshirean Emergence Criterion.
- Section 6 analyzes measurement, quantization, and observer effects.
- Section 7 generalizes the theory to multiplicity and directional structure.
- Section 8 reformulates time as an emergent perceptual structure.
- Section 9 offers a philosophical synthesis and conclusion.

2 Contrast, Discernibility, and Resolution Thresholds

We begin by formalizing the structural entities at the heart of this framework: contrast, contrast density, and observer-dependent resolution thresholds. These definitions establish the operational conditions under which latent structure becomes phenomenally manifest.

Definition 1 (Contrast Between States)**.** *Let $f : \mathbb{R}^n \to \mathbb{R}$ be a scalar field. For two points $x, x' \in \mathbb{R}^n$, the contrast between them is defined as:*

$$c(x, x') = |f(x') - f(x)|.$$

This measures the absolute structural difference between states.

Definition 2 (Contrast Density)**.** *The contrast density $\kappa(x)$ at a point x is the local rate of contrast per unit displacement:*

$$\kappa(x) = \lim_{\delta x \to 0} \frac{|f(x + \delta x) - f(x)|}{\|\delta x\|}.$$

This reflects the intensity of structural modulation around x.

Definition 3 (Total Contrast Over a Region)**.** *Let $\Omega \subset \mathbb{R}^n$ be a measurable region. The total contrast over Ω is:*

$$C(\Omega) = \int_\Omega \kappa(x)\, dx.$$

This captures the integrated structural variation across Ω.

Definition 4 (Resolution Threshold and Discernibility)**.** *Let $\rho_O(\Omega)$ be the resolution threshold of observer O over region Ω. The structure in Ω is said to be discernible if:*

$$C(\Omega) = \int_\Omega \kappa(x)\, dx \geq \rho_O(\Omega).$$

Otherwise, the structure remains latent—present but not resolvable by the observer.

Discernibility therefore depends not solely on the structure of the field f, but on the interplay between modulation and perceptual resolution. This framework separates ontological variation from phenomenological appearance, setting the foundation for all that follows.

3 Threshold-Based Calculus and Infinitesimals

Classical calculus relies on the idealization of infinitesimals and continuous variation. In contrast, our framework reconstructs differential structure as a threshold-relative phenomenon: infinitesimals are not ontologically primitive, but represent modulations that remain unresolved by an observer's resolution threshold.

3.1 Discernible and Latent Variation

Let $f : \mathbb{R}^n \to \mathbb{R}$ be a scalar field and δx a small displacement vector. The contrast across this displacement is:

$$c(x, x + \delta x) = |f(x + \delta x) - f(x)|.$$

This modulation is *discernible* if:

$$\frac{c(x, x + \delta x)}{\|\delta x\|} \geq \frac{\rho_O}{\delta x},$$

and *latent* otherwise. Infinitesimals, in this framework, are modulations below the resolution threshold—they exist structurally but are not resolved perceptually.

3.2 Contrast Quotients and Derivatives

The contrast quotient,

$$Q(x, \delta x) = \frac{|f(x + \delta x) - f(x)|}{\|\delta x\|},$$

approximates the magnitude of local variation. It becomes a perceptual rate of change only when it crosses threshold:

$$Q(x, \delta x) \geq \frac{\rho_O}{\delta x}.$$

In the limit as $\delta x \to 0$ and $\rho_O \to 0$, this quotient recovers the classical derivative:

$$\lim_{\delta x \to 0} Q(x, \delta x) = \|\nabla f(x)\|.$$

3.3 Structural Energy and Latency

We now reinterpret energy as accumulated discernible contrast. Define the *structural energy* $E(\Omega)$ over region Ω as:

$$E(\Omega) := \int_\Omega \kappa(x)\, dx.$$

This quantifies not the raw presence of structure, but its resolved manifestation. Where $\kappa(x)$ is nonzero yet $E(\Omega) < \rho_O(\Omega)$, we speak of *latent energy*: a reservoir of structural modulation below the threshold of appearance.

In this reinterpretation, the derivative is no longer a primitive operation but the boundary of discernibility—the point at which modulation becomes sufficiently intense to resolve. Latency and emergence are thus not properties of a function alone, but of its structural relationship to an observer's threshold.

4 Continuity, Discreteness, and Classical Limits

Conventional physics treats continuity and discreteness as mutually exclusive ontologies. In this framework, both emerge from the same structural field, modulated by resolution. Appearance is continuous where contrast supersaturates threshold, and discrete where it only intermittently crosses it.

4.1 Discreteness: Intermittent Threshold Crossings

Suppose contrast density $\kappa(x)$ fluctuates and only occasionally satisfies

$$\int_{\Omega_i} \kappa(x)\, dx \geq \rho_O(\Omega_i)$$

for distinct subregions $\{\Omega_i\}$. Appearance is then punctuated, and events are resolved only within those local intervals. This produces the phenomenology of particles, flashes, or momentary percepts.

4.2 Continuity: Sustained Supersaturation

If contrast density remains above threshold throughout an open interval:

$$\kappa(x) > \frac{\rho_O}{\delta x}, \quad \forall x \in (x_0, x_0 + \varepsilon),$$

appearance is smooth and uninterrupted. This regime underlies classical experiences of motion, trajectories, and continuous fields.

4.3 Classical Calculus as Limiting Case

Let $\rho_O \to 0$—the observer resolves all modulations. Then every region Ω satisfies

$$\int_\Omega \kappa(x)\, dx \geq \rho_O(\Omega),$$

and all variation becomes manifest. Classical calculus is recovered as the limiting case of universal discernibility. Infinitesimals are no longer latent, and continuity arises from global supersaturation of contrast.

4.4 Interpretation

Continuity and discreteness are not opposites but modes of thresholded perception. A single structural field may yield either depending on resolution. Classical mechanics assumes global supersaturation; quantum behavior reflects episodic threshold crossings. Both are special cases of a unified ontological substrate.

5 Quantization and the Hampshirean Emergence Criterion

Quantization, in this framework, is not a fundamental ontology but a resolution-conditioned appearance. Observable events occur when structural modulation accumulates enough contrast to exceed a threshold. This provides a deterministic yet observer-relative account of discrete phenomena.

5.1 Threshold-Driven Events

Let $\kappa(x, t)$ be the contrast density of a field over space-time. Suppose there exist regions $\Omega_i \subset \mathbb{R}^n \times \mathbb{R}$ such that:

$$\int_{\Omega_i} \kappa(x, t)\, dx\, dt \geq \rho_O(\Omega_i),$$

while $\kappa(x, t)$ remains subthreshold elsewhere. Then discernible events appear only in $\{\Omega_i\}$—these are the "quantum" events.

5.2 Latent Modulation and Apparent Randomness

A field may be structured yet fail to cross the threshold. In this case, the timing and location of observable events appears random, though it is determined by contrast geometry and observer capacity. The apparent indeterminacy of quantum mechanics arises from subthreshold modulation, not ontological stochasticity.

5.3 The Hampshirean Emergence Criterion

Theorem 1 (Hampshirean Emergence Criterion)**.** *Let $\kappa(x,t)$ be a contrast density field and $\rho_O(\Omega)$ the resolution threshold of observer O over region $\Omega \subset \mathbb{R}^n \times \mathbb{R}$. Then a structure becomes phenomenally discernible if and only if:*

$$\int_\Omega \kappa(x,t)\,dx\,dt \geq \rho_O(\Omega).$$

This criterion applies to all manifestations: waves, particles, trajectories, and time. Observable reality is composed of thresholded contrast crossings.

5.4 Interpretation

Quantized events are not a sign of inherent discreteness, but of field modulation constrained by perceptual resolution. What appears to be a particle or measurement collapse is instead a structural transition from latent to resolved modulation.

6 Measurement, Observer Dependence, and Quantum Appearance

Quantum paradoxes—such as wave-particle duality, measurement collapse, and observer dependence—arise from conflating perceptual appearance with ontological state. This section reframes measurement as the discernible saturation of latent modulation, not an ontic transition.

6.1 Appearance Without Collapse

Let $\psi(x,t)$ denote a latent contrast field. Though it evolves deterministically, it becomes discernible only where threshold is crossed:

$$\int_\Omega \kappa(x,t)\,dx\,dt \geq \rho_O(\Omega).$$

There is no collapse—just episodic appearance through resolution.

6.2 Wave–Particle Duality as Threshold Artifact

Wave-like behavior arises when contrast is spatially extended and below pointwise threshold. Particle-like behavior emerges when contrast localizes and saturates resolution. Both derive from the same field, conditioned by the observer's discernibility geometry.

6.3 Observer Dependence Without Subjectivity

Thresholds differ between observers or instruments. Thus, appearance is observer-relative without invoking subjectivity or consciousness. Measurement is structural resolution, not metaphysical collapse.

6.4 Measurement Events as Contrast Saturation

Each measurement is a contrast crossing—localized in space and time, modulated by the field and observer's resolution. This resolves the system-observer ambiguity: the transition is not ontological, but epistemic and threshold-driven.

6.5 Interpretation

This reformulation dissolves longstanding paradoxes by decoupling appearance from existence. Quantum events are neither inherently probabilistic nor collapsed; they are threshold-conditioned manifestations of continuous, structured fields.

7 Identity, Multiplicity, and Directional Structure

Multiplicity, directionality, and dimensionality do not require an ontology of intrinsic parts or vectors. They emerge when contrast structures become discernible in differentiated ways across space.

7.1 Emergence of Objects and Identity

Let $\kappa(x)$ be a contrast density field over $\Omega \subset \mathbb{R}^n$, and suppose there exist disjoint subregions $\{\Omega_i\}$ such that:

$$\int_{\Omega_i} \kappa(x)\, dx \geq \rho_O(\Omega_i), \quad \forall i.$$

Each region Ω_i then appears as a distinct object to observer O. Identity emerges when contrast remains resolved across time:

$$\int_{\Omega} \kappa(x,t)\, dx \geq \rho_O(\Omega), \quad \forall t \in [t_0, t_1].$$

Persistent discernibility defines perceived continuity of identity.

7.2 Latent Overlap and Apparent Non-Interaction

Contrast structures below threshold may coexist without interacting phenomenally. Two modulations may overlap structurally but appear independent if only one exceeds the resolution threshold.

7.3 Directional Inference from Contrast Gradients

Let $f : \mathbb{R}^n \to \mathbb{R}$ be a scalar field. Direction emerges when contrast is anisotropic and resolvable:

$$\nabla f(x) = \arg\max_{\hat{v}} \lim_{\varepsilon \to 0} \frac{f(x + \varepsilon \hat{v}) - f(x)}{\varepsilon}.$$

This vector defines the direction of maximal discernible modulation.

7.4 Thresholded Direction and Dimensionality

A field appears directional only if modulation saturates threshold in a given orientation:

$$\frac{|f(x + \delta \hat{v}) - f(x)|}{\delta} \geq \frac{\rho_O}{\delta}.$$

Perceptual dimensionality is defined as the maximal number of orthogonal directions along which contrast exceeds threshold. Spatial structure is thus a thresholded inference from local gradients.

7.5 Interpretation

Identity, multiplicity, and directionality are not metaphysical absolutes. They emerge as discernibility structures conditioned by resolution, revealing a unified origin for what appears as objecthood, orientation, and dimensional complexity.

8 Time as Thresholded Structure

Time is not an external parameter in this framework, but an emergent phenomenon arising when contrast modulates above threshold across temporal intervals. The perception of change, duration, and temporal flow is conditioned by discernibility.

8.1 Appearance of Temporal Change

Let $\kappa(t)$ represent temporal contrast density. For an interval $[t_0, t_0 + \Delta t]$, change is perceived if:

$$\int_{t_0}^{t_0 + \Delta t} \kappa(t)\, dt \geq \rho_O(\Delta t).$$

If this condition is not met, modulation remains latent and time is not experienced.

8.2 Latent Duration and Non-Emergence of Time

Suppose contrast modulates but fails to exceed threshold:

$$\int_{t_0}^{t_0 + \Delta t} \kappa(t)\, dt < \rho_O(\Delta t).$$

No perceptual segmentation occurs. From the observer's standpoint, no time passes.

8.3 Resolution Geometry and Temporal Asymmetry

Temporal experience depends on resolution structure. Two observers O_1 and O_2 embedded in the same field may perceive different temporal flows due to:

$$\kappa(t) \geq \rho_{O_1}, \quad \kappa(t) < \rho_{O_2}.$$

This leads to asymmetric experience of time despite symmetric structure.

8.4 The Clock Asymmetry Lemma

Lemma 1 (Clock Asymmetry)**.** *Let O_1 and O_2 be observers in the same field. If contrast modulates differently with respect to each observer's threshold, then one may perceive time while the other does not.*

8.5 Temporal Limits and Emergence Window

Theorem 2 (Temporal Non-Emergence at Infinite Resolution)**.** *If $\rho_O \to 0$, all contrast is instantly resolved and no segmentation occurs. Time disappears due to total saturation.*

Theorem 3 (Temporal Non-Emergence at Infinite Threshold)**.** *If $\rho_O \to \infty$, no contrast is resolved. Time does not emerge due to absence of appearance.*

Corollary 1 (Temporal Emergence Window)**.** *Time arises only when observer thresholds fall within a finite, bounded interval:*

$$0 < \rho_O < \infty.$$

Outside this window, time vanishes.

8.6 Relational Temporal Induction

Definition 5 (Relational Temporal Induction)**.** *Let observer A exist in a closed system Ω_A below threshold, so that time is not locally resolved. If A becomes aware of another system Ω_B where contrast exceeds threshold and time emerges, then A may experience time relationally via contrastive knowledge.*

8.7 Interpretation

Time is not absolute but an emergent structure dependent on discernibility. It can fail to appear locally yet arise relationally from contrast with modulating systems. Structural saturation, not external flow, governs temporal perception.

9 Philosophical Synthesis and Ontological Summary

This framework proposes a threshold-based structural ontology that dissolves classical binaries—continuous vs. discrete, real vs. apparent, deterministic vs. random—by grounding appearance in contrast modulation and resolution.

9.1 Being and Appearance

Structure exists whether or not it is resolved. Contrast may be latent, present in the field but imperceptible. Appearance is not fundamental—it is thresholded discernibility. Reality is structured, but perception is filtered through resolution.

9.2 Measurement Without Collapse

Measurement is not ontic interaction but epistemic saturation. The wavefunction never collapses; it remains a latent contrast field. Observed outcomes are local regions of threshold crossing. Randomness reflects contrast structure, not metaphysical indeterminacy.

9.3 Time and Identity as Emergence

Time flows where contrast modulates above threshold. Identity persists when structural discernibility is sustained. Multiplicity emerges from localized resolution. All are phenomenological effects of contrast geometry.

9.4 The Role of the Observer

Observers are embedded, not external. Their thresholds condition appearance without invoking subjectivity. Observer dependence is structural, not psychological. The system and the observer share the same contrast field, but resolve it differently.

Final Principles

- Structure is ontologically primary.
- Contrast modulates structure.
- Discernibility is thresholded.
- Appearance is resolution-conditioned.
- Continuity, discreteness, and time are emergent.
- Measurement is contrast saturation.

Conclusion. Contrast structures space. Resolution governs appearance. From their interaction emerges a unified ontology of continuity, discreteness, identity, direction, time, and quantum events. Classical and quantum behaviors appear not as separate realities, but as thresholded modes of the same structural field.

Appendix A: Recovery of Classical Calculus in the Vanishing Threshold Limit

Though the threshold-based framework replaces infinitesimals and continuity with structural discernibility, classical calculus emerges naturally as a special case.

A.1 The Limit of Vanishing Threshold

Let the observer's resolution threshold tend toward zero:

$$\rho_O \to 0.$$

In this limit, any nonzero structural modulation becomes discernible:

$$\int_\Omega \kappa(x)\, dx \geq \rho_O(\Omega)$$

is automatically satisfied for all sufficiently small Ω. Therefore, all structure becomes manifest, and the entire contrast field appears continuous.

A.2 Infinitesimals as Universal Discernibility

With vanishing threshold, contrast quotients are always resolved:

$$Q(x, \delta x) = \frac{|f(x + \delta x) - f(x)|}{\|\delta x\|} \to \|\nabla f(x)\|.$$

Thus, infinitesimals reappear as perceptually manifest transitions, and the classical derivative is recovered from the limit of structural discernibility.

A.3 Continuity as Supersaturated Appearance

If $\kappa(x)$ is everywhere bounded away from zero and $\rho_O \to 0$, the field appears smooth and uninterrupted. The result is a phenomenology of continuity, identical to classical expectations.

Conclusion. Classical calculus is a limiting regime of the general contrast-resolution framework. It describes the case in which all modulation becomes visible—i.e., when appearance saturates structure globally.