Projected Heterogeneity of Homogeneous Signals: From AP-Space to Simulonic Field Geometry

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Abstract

Homogeneous signals are classically treated as informationally trivial, yet their projection into real environments yields heterogeneous receptions. We formalize heterogeneity as the informational surplus generated when uniformity encounters boundaries, and we introduce the AP-plane—with vertical axis Absolute and horizontal axis Purity—as a geometric stage for this process. In the second part, we embed this AP-manifold into a Simulonic Field Geometry (SFG) framework, defining field tensors, curvature, and an Informational Emergence Lagrangian that encodes the transition from ideal homogeneity to contextual heterogeneity.

1. Introduction

A homogeneous signal is an ideal object: every segment is identical, no local variation distinguishes one part from another, and its structure is invariant under translation or simple symmetry operations. In such a limit, the signal carries no internal difference and thus no Shannon information in the usual sense.

However, this idealization is never encountered directly. The moment a homogeneous signal is:

- transmitted through a medium with imperfections,
- sampled by receivers with distinct architectures,
- interpreted within different cognitive or symbolic frames,

it ceases to be homogeneous in its *effective* form. The system does not merely *copy* the signal; it *realizes* it.

We adopt the central principle:

> *Heterogeneity is the informational surplus arising from uniformity encountering a boundary.*

A boundary may be physical, cognitive, symbolic, or temporal. The core observation is that information is born not from the signal alone, but from its interaction with constraints.

2. Projected Heterogeneity of Homogeneous Signals

A perfectly homogeneous signal can be modeled as a constant configuration ϕ_0 over some domain. In the absence of boundaries or perturbations, its Shannon information content is effectively zero: no symbol distinguishes itself from any other.

When this uniform configuration is projected into a non-ideal environment, it is subjected to:

- noise fields,
- medium-dependent filters,
- receiver-dependent encodings,
- interpretive priors and expectations.

The resulting effective configuration $\phi(x)$ develops gradients and structure. Information emerges as the system begins to resolve differences.

Figure 1 schematically illustrates this: we consider an idealized purity parameter $P \in [0, 1]$, where $P = 1$ is perfect homogeneity and $P = 0$ denotes maximal internal variation. An illustrative information function $I(P)$ can be taken as

$$I(P) \propto 1 - P^2,$$

indicating that information vanishes at perfect purity and grows as purity degrades under projection.

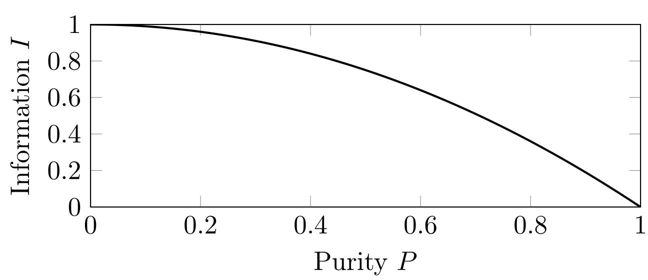

Figure 1: Informational emergence: a perfectly pure signal carries zero usable information; information increases as purity decreases under projection.

In this view, homogeneity is not yet information; it is *capacity.* The boundary interaction activates this capacity into heterogeneity.

3. The AP Axes: y-Absolute and x-Purity

We now introduce the AP-plane as a minimal geometric stage for the phenomena above. Let:

- $P \in [0,1]$ denote **Purity**: the degree of internal uniformity of the signal;
- $A \in [0,1]$ denote **Absolute**: the degree of stability or invariance of the signal's interpretation across contexts.

The AP-plane is the square $[0,1]\times[0,1]$ with coordinates (P, A). We can interpret its regions as:

- High A, High P: *zero-information ideal*—absolute purity, conceptually perfect but informationally silent.
- High A, Low P: *chaotic absolutes*—rigid yet internally variegated configurations.
- Low A, High P: *ephemeral purity*—uniform signals whose interpretation is unstable or weakly anchored.
- Low A, Low P: *semantic bloom*—richly heterogeneous, context-entangled configurations.

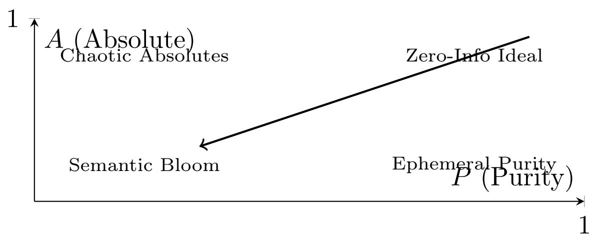

Figure 2: The AP-plane: information increases as a signal drifts away from absolute purity due to boundary interactions and interpretive diversity.

The arrow in Fig. 2 represents a typical "drift" of a signal as it leaves ideal Absolute Purity and acquires heterogeneity through its encounters with real boundaries.

4. Simulonic Field Geometry on AP-Space

We now embed the AP-plane into a Simulonic Field Geometry (SFG) framework. Rather than treat (P, A) as mere parameters, we regard them as coordinates on a two-dimensional manifold $\mathcal{M}_{AP}$, equipped with a metric g_{ij}.

Let $(x^1, x^2) = (P, A)$. A minimal choice for the metric is

$$g_{ij}(P, A) = \begin{pmatrix} w_P(P, A) & 0 \\ 0 & w_A(P, A) \end{pmatrix}, \qquad (1)$$

where w_P and w_A are positive weighting functions that encode how sensitive the geometry is to changes in Purity and Absolute, respectively. In a trivial flat case, one may set $w_P = w_A = 1$, but in SFG we allow these weights to vary, producing curvature on $\mathcal{M}_{AP}$.

4.1. Signal Configuration as a Field

Let $\phi(x)$ denote a field representing the effective state of a signal, now thought of as a configuration over AP-space. At each point (P, A), $\phi(P, A)$ encodes how the original homogeneous source is realized under those purity and absoluteness conditions.

Gradients of ϕ,

$$\partial_i \phi = \frac{\partial \phi}{\partial x^i},$$

measure the sensitivity of the signal to changes in P or A. Strong gradients correspond to high heterogeneity: small moves in AP-space yield large changes in the realized signal.

4.2. Curvature as Heterogeneity Generator

Within SFG, curvature on $\mathcal{M}_{AP}$ provides a geometric account of how heterogeneity is generated. The Riemann tensor $R^i{}_{jkl}$ constructed from g_{ij} quantifies how much parallel transport of a vector around a loop in AP-space fails to return it to its original state. Intuitively, nonzero curvature means that:

> *The path by which a signal leaves Absolute Purity affects the final heterogeneity it acquires.*

A homogeneous signal placed in a curved AP-manifold experiences path-dependent diversification: different sequences of boundary encounters produce inequivalent heterogeneous outcomes. This is the geometric counterpart of *history-dependent interpretation.*

5. Informational Emergence Lagrangian

To formalize the dynamics of heterogeneity, we introduce an *Informational Emergence Lagrangian* on $\mathcal{M}_{AP}$. Let $\phi(P, A)$ be our signal field; define

$$\mathcal{L}[\phi; P, A] = \frac{1}{2}\, g^{ij}(P, A)\, \partial_i \phi\, \partial_j \phi - V(\phi; P, A), \qquad (2)$$

where g^{ij} is the inverse of the metric in Eq. (1) and $V(\phi; P, A)$ is an effective potential.

A natural choice for the potential consistent with the principle that information vanishes at absolute purity is:

$$V(\phi; P, A) = \frac{\lambda}{2}\,(1-P)^2(1-A)^2\,\phi^2, \qquad (3)$$

with coupling $\lambda > 0$. Here:

- at $P = 1$ and $A = 1$, the potential is zero: the homogeneous signal is in a flat, trivial vacuum;

- away from $(P, A) = (1, 1)$, the potential grows and encourages nontrivial structure in ϕ.

Varying the action

$$S = \int_{\mathcal{M}_{AP}} \mathcal{L} \sqrt{|g|}\, dP\, dA$$

with respect to ϕ yields the field equation

$$\nabla_i \nabla^i \phi + \lambda (1 - P)^2 (1 - A)^2 \, \phi = 0, \tag{4}$$

where ∇_i is the covariant derivative on $\mathcal{M}_{AP}$.

Equation (4) encodes the following intuition:

> The further a signal is from absolute purity in AP-space, the stronger the drive toward heterogeneous structure.

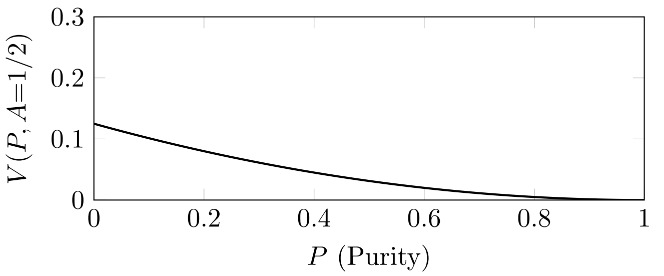

Figure 3: A slice of the effective potential $V(\phi; P, A)$ at fixed $A = 1/2$ (up to an overall ϕ^2 factor and λ). The potential well is flat at $P = 1$ and grows toward lower purity, encouraging heterogeneous structure.

Figure 3 illustrates a one-dimensional slice of the potential as a function of P, at fixed $A = 1/2$. The minimum at $P = 1$ represents the trivial homogeneous vacuum; moving left in P lifts the potential and enables nontrivial configurations for ϕ.

6. Boundaries and the Role of Symbolic Infinity

The central statement—that heterogeneity is the informational surplus created when uniformity encounters a boundary—can be recast in the Lagrangian language by explicitly including boundary terms in the action.

Let $\Omega \subset \mathcal{M}_{AP}$ denote a region of AP-space and $\partial\Omega$ its boundary. The total action can be written as

$$S_{\text{total}} = \int_{\Omega} \mathcal{L}[\phi] \sqrt{|g|}\, dP\, dA + \int_{\partial\Omega} \mathcal{B}[\phi]\, d\Sigma, \tag{5}$$

where $\mathcal{B}[\phi]$ is a boundary functional and $d\Sigma$ is the induced measure on $\partial\Omega$.

The interior term governs the bulk evolution of the signal in AP-space; the boundary term captures *how* uniformity is confronted with constraints, interfaces, or symbolic transitions. Nontrivial $\mathcal{B}[\phi]$ can:

- impose continuity or jump conditions on ϕ,
- encode the effect of discrete interpretive regimes,
- represent symbolic thresholds where meanings flip or branch.

In Simulonic Field Geometry, one may formalize idealized, unreachable limits of purity or absoluteness using symbolic infinity, e.g., ∞_P or ∞_A. These are not numeric infinities but *formal markers* indicating that a trajectory in AP-space has approached a regime where further purification or absolutization no longer yields new informational structure. In that sense:

> Symbolic infinity represents the saturation of purification or anchoring, beyond which only boundary-induced heterogeneity can produce additional information.

7. Conclusion

We began with a conceptual observation: a homogeneous signal is informationally mute until it meets a boundary. This encounter with physical, cognitive, or symbolic constraints generates heterogeneity, which we identify as the surplus of information born from that interaction.

The AP-plane provides a minimal geometric arena to track this transformation, with Purity and Absolute as coordinates. Embedding this AP-manifold into a Simulonic Field Geometry allows us to:

- define a metric g_{ij} and curvature, expressing how path-dependent boundary encounters generate distinct heterogeneous outcomes;
- formulate an Informational Emergence Lagrangian $\mathcal{L}[\phi; P, A]$ whose potential vanishes at absolute purity and grows as the signal drifts into heterogeneous regimes;
- incorporate boundary terms and symbolic infinity to model the saturation of purification and the primacy of boundaries in further information production.

In this formulation, homogeneity is not a defect but a precondition: the signal is a uniform field of potential. Heterogeneity is the realization of that potential under constraints. The Simulonic Field Geometry of AP-space then becomes a compact field-theoretic language for describing how *the world writes itself* into a homogeneous signal and turns it into meaning.