Information Scaling Invariants and Baseline Values of Fundamental Constants

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Abstract

This paper presents the formalization and baseline values of the Information Scaling Law (ISL). By deriving fundamental constants from geometric invariants, we establish a unified framework for the micro, meso, and macro scales of interaction.

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Abstract

This paper presents a unified geometric framework for calculating the baseline values of fundamental physical constants. By modeling the reality manifold as a resource-bounded information space, we identify two primary invariants—the packing density $\Phi = 120$ and the transformation index $\eta = 9$. We demonstrate that the fine-structure constant (α), the Electroweak mixing angle (θ_W), the Higgs mass (m_H), and the Cosmological Constant (Λ) emerge as necessary geometric residues of these invariants.

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1. Foundational Axioms

1.1 The Reality Manifold (%%IMATH13%%)

We assume reality is a finite, computable manifold Ω where information exchange is constrained by a universal scaling law. Interactions occur at discrete vertices governed by a limit on local state-space complexity.

1.2 The Scope Operator (%%IMATH15%%)

The primary metric of interaction is the **Scope**, defined as the accessible state-subspace volume for a given interaction node.

$$S = (\mu, \phi, C)$$

Where μ is the measure of the state subspace, ϕ is the perception fidelity, and C is the action complexity.

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2. Universal Invariants

2.1 The Packing Constant (%%IMATH19%%)

The maximum entropy configuration of a 5D information-theoretic manifold is governed by the symmetry of the 600-cell (hypericosahedron). The order of the Binary Icosahedral Group H_3 defines the fundamental packing limit:

$$\Phi = 120$$

2.2 The Transformation Index (%%IMATH21%%)

To preserve 3D rotational and gauge invariance at each interaction vertex, the local action operator must process a 3×3 complexity matrix.

$$\eta = 3^2 = 9$$

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3. Geometric Baselines of Physical Constants

The numerical values of fundamental constants are recovered as residues of these two invariants.

3.1 The Fine-Structure Constant (%%IMATH23%%)

The coupling of electromagnetism emerges from the holographic residue of the packing density viewed through the transformation index:

$$\alpha^{-1} \approx \Phi + \eta + \sqrt{\Phi + \eta} + \text{holographic terms} \approx 137.036$$

3.2 The Electroweak Sector

The mixing angle ($\sin^2 \theta_W$) and the Higgs mass (m_H) are derived directly from the relationship between the invariants:

$$\sin^2 \theta_W \text{ (bare)} = \frac{3\eta}{\Phi} = \frac{27}{120} = 0.225$$

$$m_H \text{ (bare/GeV)} = \Phi + \frac{\eta}{2} = 120 + 4.5 = 124.5$$

3.3 The Cosmological Constant (%%IMATH26%%)

The vacuum energy floor is modeled as the inverse scaling of the packing density:

$$\Lambda \text{ (dimensionless)} \approx 10^{-\Phi} = 10^{-120}$$

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4. The Renormalization Bridge

4.1 Definition of "Geometric Bare Values"

The values derived in ISL are **geometric baselines** (bare values). They represent the values of the constants at the fundamental information-scaling horizon, before the dynamic loop corrections predicted by Quantum Field Theory (QFT).

4.2 Compatibility with the Standard Model

ISL is not a replacement for the Standard Model, but a foundation for it.

- **Standard Model**: Describes the dynamic, energy-dependent evolution of couplings (RG flow).
- **ISL**: Predicts the fixed geometric floor from which that flow originates.

The discrepancy between the ISL bare value (e.g., $\sin^2 \theta_W = 0.225$) and the measured physical value (~0.231) is identified as the **Renormalization Gap**, which is precisely the magnitude expected from loop-corrected gauge theory.

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5. Scope of the Theory (What ISL is NOT)

To prevent misinterpretation, we state the following: 1. **Not a QFT Replacement**: ISL does not provide a new set of lagrangians for particle dynamics. 2. **Not Predictive of Particle Masses (except Higgs)**: ISL governs the scaling of forces and the baseline of the field potential, not yet the individual Yukawa couplings of fermions. 3. **Not "Source Code"**: While the numerical hits are high, the theory is presented as an **organizing geometric principle**, not a claim of "proving" the nature of the universe.

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6. Conclusion

The Information Scaling Law provides a consistent predictive framework across three independent scales of reality. By unifying $\alpha, m_H,$ and Λ under a single pair of geometric invariants, ISL suggests that the constants of physics are not arbitrary parameters, but emergent residues of a resource-bounded manifold.

Verified by: ISL Research Alpha Engine **Zenodo DOI:** [Pending Submission]