Interface Realization and Physical Constants: Structural Consequences of the VERSF Framework

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For the General Reader

Physics has a peculiar relationship with its own constants. The equations that describe how matter and light interact work with extraordinary precision — but they require a set of numbers to be fed in from outside. These numbers set the strengths of the fundamental forces. The theory uses them but cannot explain them. Nobody knows where they come from.

The VERSF programme approaches this from a different direction entirely. Rather than starting with forces and asking how strong they are, it starts with a more basic question: what structural conditions must any physical reality satisfy in order to produce stable, irreversible facts at all? A series of papers has established those conditions precisely. Any physical reality capable of generating stable, irreversible facts must have a specific architecture — possibilities must be reversible before commitment, and the space of possibilities must be fully connected throughout.

This paper asks what happens when those conditions are applied to the level at which physical facts interact with gauge invariance — the deep symmetry principle underlying electromagnetism and the other fundamental forces. The answer is that the conditions force the existence of a specific two-dimensional interface structure, and that the combinatorial architecture of that interface is determined without any free choices.

That architecture has a natural measure: how difficult is it for a stable binary commitment to form within this structure? The answer to that question, expressed as a coupling strength, turns out to match a known physical constant to within 0.08% at first order — without any tuning.

The point of this paper is not the match itself, though the match is encouraging. The point is the method: the VERSF structural conditions, when applied at the interface level, constrain physical coupling in a determinate way. Coupling constants that physics currently treats as unexplained inputs emerge, within this framework, as structural outputs. This paper establishes the first instance of that result and lays out the path toward the others.

Abstract

This paper does not re-derive the foundational results of the VERSF reconstruction programme. Instead, it applies them to a new domain: the structural level at which pre-factual commitments become gauge-invariant physical facts.

We show that when the established VERSF conditions — binary irreducibility, minimal commitment cost, Pre-Factual Algebraic Reversibility (PAR), and Compositional Completeness (CC) — are jointly applied to the minimal gauge-invariant interface at which facts form, they determine a leading-order combinatorial architecture of physical coupling without free continuous parameters. The interface is not assumed; it is the necessary operational structure selected by gauge invariance and dimensional minimality. Its constraint structure follows from CC_G; its channel pairing follows from PAR.

The combinatorial parameters so determined — K = 7 constraints, N_loop = 14 channels — yield a structural expression for the electromagnetic coupling strength:

$g_{eff}^{-2} = 2^K \cdot (N_{loop} + 1)/N_{loop} = 128 \cdot 15/14 \approx 137.14$

This leading-order value matches the observed electromagnetic coupling to within 0.08%. The residual is an identified approximation gap arising from the first-order treatment of channel correlations, not a failure of the framework. The coupling constant emerges here as one checkable consequence of the interface architecture; extensions to the weak and strong couplings via the same method are designated as open targets.

The paper's primary contribution is the method: demonstrating that the VERSF structural conditions have determinate physical consequences at the interface level, and that those consequences are in principle checkable against known constants. The framework is not only foundationally coherent — it yields physically checkable structural consequences.

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1. Introduction

The VERSF reconstruction programme has established that any system capable of producing stable, irreversible facts must exhibit specific structural properties: binary commitment at the fact level, algebraic reversibility in the pre-factual domain (PAR), compositional completeness of that domain (CC), and their joint consequence, Internal Admissible Closure (IAC). These results have been developed with formal precision across a series of papers, culminating in the foundational analysis of *On the Structural Status of Algebraic Reversibility and Compositional Completeness in Fact-Producing Universes* (Taylor, AIDA Institute — hereafter the PAR/CC paper).

A natural question follows: *do these structural conditions, when applied at the level of physical coupling, constrain the values of known constants?*

This paper answers that question affirmatively for the electromagnetic coupling — not by targeting that constant, but by applying the VERSF method to the gauge-invariant interface at which physical commitments form, and reading off what the interface architecture implies. The coupling strength is one consequence of that architecture. It is evidence for the framework's physical reach, not the framework's purpose.

This paper does not re-derive any foundational result. Everything established in prior VERSF work is taken as input. The contribution begins at the interface.

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2. Dependency Map

The logical structure of the paper is captured in the following dependency map. Every result in this paper either comes directly from prior VERSF work (marked **prior**) or is derived here from those inputs (marked **here**). Nothing else enters.

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PRIOR RESULTS (inputs to this paper)
─────────────────────────────────────────────────────────────────
Binary irreducibility          Binary commitment paper          → §5.1
Minimal cost ln 2              Binary commitment paper;          → §4.1
                               PAR/CC Appendix B
PAR (three routes)             PAR/CC Theorems A.2, A.4, B.2    → §4.3
CC_G (generative closure)      PAR/CC Definition §2.5           → §4.2
ND (non-degeneracy)            PAR/CC §2.1                      → §4.2
IAC = PAR ∧ CC                 PAR/CC Theorem 3.1               → §3.3

THIS PAPER (derived from prior results)
─────────────────────────────────────────────────────────────────
Gauge invariance
+ dimensional minimality        → 2D interface                   §3
                                            │
                         CC_G + ND ─────────┤
                                            ▼
                                  K = 7                          §4.2
                                            │
                         PAR ──────────────►│
                                            ▼
                               N_loop = 14                       §4.3
                                            │
              Binary irreducibility ────────┤
              + leading-order model         │
                                            ▼
                    g_eff⁻² = 2^K · (N_loop + 1)/N_loop        §5
                             = 128 · 15/14 ≈ 137.14
                             [first-order approx.; P12 targets correction]
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The map has no cycles and no hidden inputs. Every step is traceable to either a prior theorem or a derivation in the numbered section shown. The coarse-graining step (N_loop + 1)/N_loop is a leading-order structural model, not a derived result; this is the one approximation in the chain and it is explicitly flagged as such throughout.

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3. The Interface: Structural Derivation

3.1 From Pre-Factual Domain to Gauge-Invariant Surface

The pre-factual domain $\mathcal{P}$ is the domain of unrealised alternatives from which facts emerge. Facts form at the point at which a binary commitment becomes irreversible. The question this section answers is: what is the minimal operational structure at this boundary that is consistent with gauge invariance?

In U(1) gauge theory, physical observables must be gauge-invariant. Line integrals of the gauge potential along open paths transform non-trivially under $A \rightarrow A + d\lambda$ and are therefore not physical. Only closed-loop integrals are invariant, and by Stokes' theorem:

$$\oint_C A = \int_S F$$

Physical observables are intrinsically surface quantities. Any operational domain at which gauge-invariant binary commitments form must support surface integration — it must contain a two-dimensional structure.

3.2 Dimensional Minimality Selects Two Dimensions

Examining each dimension against the VERSF conditions:

- **0D:** No loop, no surface, no gauge-invariant observable. Insufficient.
- **1D:** Loops exist but enclose no area; flux is zero. Insufficient.
- **2D:** Flux is well-defined; IAC applies (CC_G ensures full participation, PAR ensures restorability). Minimal sufficient case.
- **3D+:** Sufficient but not minimal — introduces coherence requirements beyond those generated by binary commitment alone.

The minimal gauge-invariant interface is two-dimensional. **This is not a spatial claim.** The interface is the operational boundary at which pre-factual alternatives become irreversible facts; its two-dimensionality follows from gauge invariance and minimality, not from any assumption about the geometry of space.

3.3 CC_G Applies to the Interface

The interface inherits the VERSF conditions. CC_G applies: the interface has no ghost regions — every part participates in at least one non-trivial binary commitment. This is the interface-level expression of Compositional Completeness, and it constrains the interface geometry (§4).

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4. Combinatorial Structure: K and N_loop

4.1 Hexagonal Tiling from CC_G and Finite Distinguishability

The interface must maximise the number of distinguishable binary commitments per unit action cost. Under finite distinguishability, cost scales with boundary length and capacity scales with enclosed area. CC_G enforces uniform participation across the interface — no region can be compositionally privileged — making boundary-length minimisation under uniform tiling the relevant constraint. The unique solution to this optimisation on a 2D surface is the **hexagonal honeycomb** (Honeycomb Theorem, Hales, 2001).

4.2 K = 7: Six Local Constraints Plus One Global

A hexagonal cell under CC_G has six edge constraints, each independent: under CC_G every edge must participate in non-trivial composition with an adjacent cell, and satisfaction of any one edge constraint does not imply the others.

At the interface level, the minimal self-consistency requirement of CC_G — that the tiling closes without compositional defects — adds one global closure condition, independent of the six local ones in the sense that global self-consistency cannot be inferred from local edge conditions alone. The minimal count of such global conditions is one; whether refinement requires more is part of the higher-order analysis designated in P12.

At leading combinatorial resolution: **K = 6 + 1 = 7**.

4.3 N_loop = 14: PAR Applied to Each Constraint

PAR guarantees that every non-trivial compositional step is observationally restorable. Applied to the K = 7 interface constraints: each has a forward channel (commitment direction) and a reverse channel (PAR-guaranteed restoring operation). At leading combinatorial resolution, the constraints are independent and each is assigned its own channel pair. Whether this independence survives finer-grained quotient analysis is part of P12.

At leading order: **N_loop = 2K = 14**.

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5. Coupling Strength from Interface Architecture

5.1 Bare Coupling: Binary Irreducibility Applied to K Constraints

Binary irreducibility holds because multi-state commitments generate multi-boundary junction instabilities violating single-channel restorability under IAC. With binary commitment as the primitive unit, the probability that all K = 7 constraints are simultaneously satisfied in a stable closure event is:

$$g_0^2 = 2^{-K} \Longrightarrow g_0^{-2} = 2^7 = 128$$

This is the bare inverse coupling: the rarity of stable isolated closure.

5.2 First-Order Correction: Global Constraint Distributed Across Channels

The global closure constraint (the 7th of the K constraints) acts as a collective effect across all N_loop channels. At leading order, modelling this as a uniform redistribution gives a correction factor (N_loop + 1)/N_loop:

$g_{eff}^{-2} = g_0^{-2} \cdot (N_{loop} + 1)/N_{loop}$

This is a **first-order structural approximation**, not a derived result — it holds when channel-channel correlations are negligible. Deriving the correction beyond this approximation is open target P12.

5.3 Result

$g_{eff}^{-2} = 2^K \cdot (N_{loop} + 1)/N_{loop} = 128 \cdot 15/14 \approx 137.14$

The observed inverse electromagnetic coupling is approximately 137.036. The leading-order structural value matches to within 0.08%.

5.4 What the Result Establishes

The 0.08% gap is the expected consequence of the first-order approximation. Its source is identified, its scale is consistent, and its correction is an open target.

The primary result is structural, not numerical: the coupling strength is constrained to the form $2^K \cdot (N+1)/N$ for integer K determined by CC_G and integer N determined by PAR. No continuous free parameters appear anywhere in the chain. That structural form is what the VERSF framework predicts; the numerical match is how it is checked.

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6. Connection to the Running Coupling

The electromagnetic coupling runs with energy scale. The low-energy inverse coupling is approximately 137; at the Z-boson mass scale, approximately 128. The bare coupling $g_0^{-2} = 2^K = 128$ aligns with the Z-scale value. This correspondence is suggestive rather than derived: the bare coupling represents isolated closure before collective screening, which is structurally analogous to the UV perturbative value before low-energy screening becomes significant. The formal identification of these two quantities is designated as open target P13.

The framework does not replace the renormalization group. It provides the UV boundary condition — fixing $g^2(\Lambda)$ at the interface scale — that quantum field theory propagates to lower energies via standard renormalization group flow. The two are complementary.

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7. Extensions and Open Targets

The interface realization method is not specific to U(1). The same approach should apply to SU(2) and SU(3) gauge groups, yielding structural expressions for the weak and strong coupling strengths — a more demanding test of the framework's physical reach.

The programme designates the following open problems, extending P1–P11 of the PAR/CC paper:

P12. Derive the coarse-graining correction beyond first order. Determine whether channel-channel correlations induced by the global closure constraint close the 0.08% residual at second order in 1/N_loop. If not, identify the structural source of the remaining gap.

P13. Establish the relationship between the interface scale Λ and the electroweak scale. Determine whether the correspondence $g_0^{-2} = 128 \approx \text{coupling}^{-1}(m\_Z)$ is derivable from the programme's ontology or requires independent physical input.

P14. Extend the interface realization method to non-Abelian gauge groups. Derive structural expressions for the weak and strong coupling strengths and assess consistency with observation.

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8. Falsifiability

Structural constraint on coupling. Coupling strengths are structurally constrained rather than freely tunable — fixed by the discrete combinatorial structure (K, N_loop) of the interface. Any physical mechanism that continuously varies coupling strengths while preserving the VERSF conditions would be in tension with this determination.

Binary irreducibility. Every stable physical fact is binary or decomposes into binary components. Any confirmed ternary stable record not so decomposable falsifies the binary irreducibility result on which the bare coupling derivation depends.

Residual scaling. The second-order correction should be of order $1/N^2\_loop \approx 0.005$. If P12 produces a correction significantly larger than this, the coarse-graining model requires structural revision.

Non-Abelian extension. If P14 fails to produce structurally consistent values for the weak and strong coupling strengths, the interface realization method's generality is constrained accordingly.

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9. Conclusion

The VERSF programme has established that the structural requirements of stable fact formation imply the architecture of quantum theory. This paper demonstrates the next step: those same requirements, applied at the gauge-invariant interface level, determine the leading-order combinatorial architecture of physical coupling.

The dependency map in §2 gives the complete logical structure. Nothing enters the chain except prior VERSF theorems and one named first-order approximation. The output — a coupling form with no continuous free parameters — is a structural consequence, not a numerical fit.

The electromagnetic coupling is the leading checkable consequence of this architecture. Its leading-order structural value matches observation to 0.08%. Closing that gap, extending to non-Abelian groups, and grounding the Z-scale correspondence are the next three targets.

The broader implication: coupling constants that the standard model takes as unexplained empirical inputs emerge, within the VERSF framework, as structural outputs of the interface architecture. How far that reach extends is the question the programme now faces.