

# The Electroweak Completion-Interface Theorem in VERSF

▲ Programme Milestone — Standard Model Completion-Interface Series

## Deriving the Unique Higgs-Doublet-Form Closure Interface as the Common Carrier of Weak-Branch Commitment, Electroweak Breaking, and Mass-Operator Attachment

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Successor to *The Broken Electroweak Phase in VERSF*, *The Electroweak Gauge-Curvature Dynamics in VERSF*, *The Electroweak Representation and Connection Closure in VERSF*, and *The Substrate Anomaly-Inadmissibility Theorem in VERSF*.

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### General Reader Summary

The preceding VERSF papers build a substantial amount of Standard Model structure. They derive a one-generation matter table, explain why the weak force acts only on left-handed pairs, derive the electroweak connection, show why the charge ledger must be anomaly-free, and show how a closure-norm vacuum splits the unbroken electroweak fields into the photon, the W bosons, and the Z boson.

One question remains exposed.

The broken electroweak paper requires an object with the form of the Higgs doublet. In VERSF it is not treated as a fundamental scalar inserted by hand — it is interpreted as the closure-interface orientation of the condensed substrate. That paper shows that *if* such an interface exists, and *if* it is weak-active, colourless, and electrically neutral in its vacuum direction, then it must carry the same representation as the Standard Model Higgs doublet.

Strong — but conditional. The present paper asks the deeper question:

#### **Why must the closure condensate carry an electroweak-facing interface at all?**

The answer is that the chiral electroweak matter sector cannot be completed by a featureless scalar closure norm.

The weak force acts on pairs — neutrino/electron, up/down. Left-handed matter carries an unresolved two-way weak structure. Right-handed matter does not. If the substrate is to complete this structure into stable physical records, it needs an interface that faces the weak branch. A scalar closure norm can register that the substrate has condensed, but it cannot say how the two weak options are related, completed, or attached to the right-handed singlet records. It has no weak handle.

The completion object must therefore carry weak structure — and once that is accepted, everything else is rigid. The smallest weak-active object is a doublet. It must be colourless, or it would break colour and make gluons massive. And charge bookkeeping in the electron and down-quark bridges pins down its remaining quantum number exactly. Together these force the interface into the form

$$\Phi_{cl} \sim (1, 2, +\frac{1}{2}).$$

That is the Higgs-doublet representation — and it automatically contains an electrically neutral direction, which is why the photon survives when the object condenses.

There is a bonus, proved here as a small theorem of its own: the substrate does not need to settle in any special direction. Whichever way it condenses, exactly one force is left untouched — and that force is electromagnetism. The photon's survival is guaranteed by geometry, not by a lucky alignment.

The decisive point is that this interface does more than break electroweak symmetry. The same object is exactly what is needed to connect left-handed weak doublets to right-handed singlets in the mass programme. Charged leptons and down-type quarks attach through  $\Phi_{cl}$ ; up-type quarks attach through its conjugate  $\tilde{\Phi}_{cl}$ ; neutrinos depend on which neutrino branch the programme selects.

So the paper is more than a hole-plugger. It establishes that the Higgs-like doublet is the common electroweak completion object of the Standard Model sector — the bridge between weak commitment, electroweak breaking, and mass attachment.

**In plain language: the Higgs-like interface is not merely the thing that gives W and Z their mass; it is the thing that lets the chiral electroweak matter table complete itself.**

One caveat is stated openly inside the paper: the algebra that pins down the quantum numbers is shared with the standard textbook argument, and what VERSF changes is the starting premise — a structural completion requirement in place of the empirical fact that fermions have mass. The deep substrate proof of that premise is still owed, and the paper says exactly where (§15, Debt 1).

That is the milestone.

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# Abstract

The Broken Electroweak Phase paper derives the photon, the W/Z directions, the weak-boson mass structure, and the tree-level relation  $m_W/m_Z = \cos \theta_W$  from closure-norm condensation acting on the derived electroweak gauge fields — conditional on the existence of an electroweak-facing closure interface

$$\Phi_{cl} = \rho\chi, \Phi_{cl} \sim (1, 2, +\frac{1}{2}),$$

with vacuum orientation

$$\langle \Phi_{cl} \rangle = (v/\sqrt{2}) (0, 1)^T.$$

That paper correctly identifies the remaining load-bearing premise BP-3: the origin of the electroweak-facing interface orientation  $\chi$ . The present paper supplies the forward completion theorem.

The central result is that a purely scalar closure norm cannot complete a chiral electroweak record layer. The inherited matter skeleton contains left-handed weak doublets  $L_L, Q_L$  and right-handed weak singlets  $e_R, u_R, d_R$ . Weak commitment therefore has two unequal faces: unresolved weak-branch structure on the left, and branch-committed singlet records on the right. A scalar closure norm  $\rho \sim (1, 1, 0)$  can measure condensation magnitude, but it cannot carry the weak index needed to complete the left-handed branch structure, cannot form an electroweak-singlet bridge between left doublets and right singlets, and cannot supply the representation carrier required by the already-developed VERSF mass/flavour attachment modules.

The minimal completion object must therefore be a weak-active, colourless interface carrying one weak branch index. Requiring charged-lepton and down-quark attachment to be electroweak-neutral fixes the interface hypercharge — in both the leptonic and hadronic channels, with the agreement of the two guaranteed by the anomaly-rigid ledger — as

$$Y_{\Phi} = +\frac{1}{2}, \text{ so } \Phi_{cl} \sim (1, 2, +\frac{1}{2}).$$

The up sector requires the conjugate interface

$$\tilde{\Phi}_{cl} = i\sigma_2 \Phi_{cl}^* \sim (1, 2, -\frac{1}{2}),$$

which is supplied automatically by the same object through the pseudo-reality of the SU(2) doublet.

The interface contains an electrically neutral component — and neutral alignment is a gauge choice, not an extra premise: SU(2)<sub>L</sub> acts transitively on fixed-norm doublet configurations, so condensation in any direction leaves one unbroken U(1), gauge-equivalent to  $Q = T_3 + Y$ . The broken electroweak phase theorem then follows: SU(2)<sub>L</sub> × U(1)<sub>Y</sub> → U(1)<sub>EM</sub>, with the photon as the vacuum-preserving direction and  $W_{\pm}, Z$  as the vacuum-disturbing directions.

Because the interface is bosonic, it contributes nothing to the fermionic triangle content, so the anomaly-admissible source ledger is preserved unchanged.

The result is not a new derivation of Yukawa coefficients, fermion masses, CKM, PMNS, the Higgs radial mass, the closure potential, or the numerical scale  $v$ . It derives the representation carrier that all those modules require. The Higgs-doublet-form object is thereby identified as the universal electroweak completion interface of the chiral Standard Model sector.

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# 0. Notation, Conventions, and Firewalls

## 0.1 Notation

The inherited one-generation chiral matter skeleton is

$$L_L = (v_L, e_L), e_R, Q_L = (u_L, d_L), u_R, d_R.$$

The inherited electroweak representation algebra is

$$\mathfrak{g}_{EW}^{\text{rep}} = \mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y.$$

The inherited local electroweak connection is

$$A_\mu^{\text{EW}} = g W_\mu^i T_i + g' B_\mu Y.$$

The weak generators act as  $T_i = \sigma_i/2$  on  $L_L$  and  $Q_L$ , and trivially on  $e_R, u_R, d_R$ .

The electric/source-charge convention is

$$Q = T_3 + Y.$$

The closure norm is  $\rho$ . The electroweak completion interface is

$$\Phi_{\text{cl}} = \rho\chi,$$

where  $\chi$  carries the electroweak-facing weak-branch orientation. The conjugate interface is

$$\tilde{\Phi}_{\text{cl}} = i\sigma_2 \Phi_{\text{cl}}^*.$$

Hypercharges are stated in the  $Q = T_3 + Y$  convention throughout. In the alternative convention  $Q = T_3 + Y_{\text{SM}}/2$ , the correspondence is  $Y_{\text{SM}} = 2Y$ .

## 0.2 Representation firewall

This paper inherits the chiral matter skeleton, the electroweak representation algebra, the hypercharge ledger, and the local W/B connection. It does not rederive them. Its task is narrower:

Why must the closure condensate carry the electroweak-facing interface object required by the broken electroweak phase and by mass-operator attachment?

## 0.3 Broken-phase firewall

This paper does not rederive the W/Z mass matrix, the photon/Z rotation, or the tree-level weak mass relation. Those are derived in the Broken Electroweak Phase paper, conditional on  $\Phi_{cl} \sim (1, 2, +\frac{1}{2})$ . The present paper supplies the origin of that interface.

## 0.4 Mass firewall

This paper does not compute Yukawa coefficients, charged-lepton masses, quark masses, neutrino masses, CKM angles, PMNS angles, or generation hierarchy. It derives the representation interface through which the existing mass/flavour modules must attach. In particular, no observed mass, mixing angle, or Higgs-sector measurement is used anywhere in the derivation — the argument is internal to the chiral representation structure.

## 0.5 Higgs-radial firewall

This paper derives the electroweak representation of the completion interface. It does not compute the Higgs-like radial mass, self-coupling, decay rates, or the full scalar potential.

## 0.6 Coupling and scale firewall

This paper does not compute  $g$ ,  $g'$ ,  $e$ , or  $v$ . It derives the interface representation and the completion role. Numerical coupling values and the condensation scale remain downstream debts.

# 0'. Predictive-Content Ledger

Object	Grade	Status
Chiral matter skeleton	Inherited / Conditional	From matter-representation programme
Left weak doublets $L_L, Q_L$	Inherited / Conditional	From electroweak representation closure
Right weak singlets $e_R, u_R, d_R$	Inherited / Conditional	From chiral locking / right-singlet exclusion
Hypercharge ledger	Inherited / Conditional	From anomaly-rigid source ledger
Local W/B connection	Inherited / Conditional	From connection closure
Nonzero closure norm $\rho$	Inherited / Conditional	From closure-substrate programme
Scalar closure insufficiency	Derived here	Theorem 1
Necessity of weak-facing completion interface	Derived here	Proposition 2
Minimal weak-doublet interface	Derived here	Theorem 3

Object	Grade	Status
Hypercharge $Y_\Phi = +\frac{1}{2}$	Derived here	Theorem 4
Colourlessness of interface	Derived here	Theorem 5
$\Phi_{cl} \sim (1, 2, +\frac{1}{2})$	Derived here	Theorem 6
$\tilde{\Phi}_{cl} \sim (1, 2, -\frac{1}{2})$	Derived here	Theorem 7
Neutral vacuum alignment as gauge choice	Derived here	Lemma 8, §12
Completion-to-breaking bridge	Derived here	Theorem 9, §12
Anomaly-ledger preservation by interface	Derived here	Remark, §10
Charged-lepton attachment carrier	Derived here	Proposition 10, §13
Down-quark attachment carrier	Derived here	Proposition 10, §13
Up-quark attachment carrier	Derived here	Theorem 7 and Proposition 10, §13
Neutrino attachment carrier	Conditional	Depends on neutrino module
Broken electroweak phase	Downstream / Imported consequence	Follows from Broken Phase paper once interface exists
Higgs radial dynamics	Owed	Not derived
Numerical $v$	Owed	Not derived
Yukawa coefficients	Existing modules / Not this paper	Not derived here
Three generations	Owed	Not derived

## 0''. Inherited Infrastructure

The present paper stands on six inherited layers.

### 0''.1 Fermionic and chiral matter layer

The prior matter-representation programme supplies the one-generation chiral skeleton

$L_L, e_R, Q_L, u_R, d_R$ .

The crucial structural asymmetry:  $L_L$  and  $Q_L$  are weak doublets, while  $e_R, u_R, d_R$  are weak singlets.

### 0''.2 Electroweak representation layer

The electroweak representation paper derives

$su(2)_L \oplus u(1)_Y$ ,

with weak action confined to left-handed doublets and hypercharge as the commuting source grade.

### **0".3 Source-charge ledger**

The anomaly-inadmissibility paper establishes that the source ledger must be anomaly-admissible in order to persist as a physical record-current sector. The hypercharge ledger is therefore not optional bookkeeping — it is the source-grade structure that any completion interface must respect.

### **0".4 Gauge-connection layer**

The electroweak connection paper derives the local comparison structure

$$A_{\mu}^{\text{EW}} = g W_{\mu}^i T_i + g' B_{\mu} Y.$$

The completion interface must be compatible with this connection.

### **0".5 Gauge-curvature layer**

The gauge-curvature paper derives the unbroken W/B field strengths and kinetic structure. This matters because the interface derived here is the object that later acts on those gauge fields by condensation.

### **0".6 Broken-phase conditional layer**

The Broken Electroweak Phase paper proves that if a closure interface  $\Phi_{\text{cl}} \sim (1, 2, +\frac{1}{2})$  condenses in its neutral direction, then the photon, W, and Z structure follows. The present paper derives why that interface must exist as the electroweak completion carrier.

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## **1. Purpose and Claim Level**

The purpose of this paper is to derive the electroweak completion interface.

The key problem: a chiral electroweak matter skeleton contains left-handed weak doublets and right-handed weak singlets. A scalar closure norm can condense, but a scalar has no weak branch index. It cannot complete weak-branch commitment, cannot bridge left doublets to right singlets in a gauge-neutral way, and cannot supply the carrier needed by the mass/flavour modules.

Therefore, if the chiral electroweak sector is to become a complete persistent record layer, it requires an electroweak-facing interface. The paper proves that the minimal such interface is

$$\Phi_{\text{cl}} \sim (1, 2, +\frac{1}{2}).$$

This is exactly the Higgs-doublet-form object of the Standard Model — but its VERSF interpretation differs. It is not introduced as an elementary scalar field. It is the closure-completion interface of the chiral electroweak record layer.

## Central Claim

Given:

1. the inherited chiral electroweak matter skeleton;
2. weak unresolved branch structure on  $L_L, Q_L$ ;
3. right-singlet committed sectors  $e_R, u_R, d_R$ ;
4. source-charge preservation;
5. colour preservation;
6. local completion of left–right chiral records;
7. minimality and the absence of extra low-energy exotics;

the unique minimal completion interface is

$$\Phi_{\text{cl}} \sim (1, 2, +\frac{1}{2}), \text{ with conjugate } \tilde{\Phi}_{\text{cl}} \sim (1, 2, -\frac{1}{2}).$$

This same interface is the object used downstream for electroweak breaking and mass-operator attachment.

## Claim level

The result is **Exact** as a representation theorem given the inherited chiral/electroweak skeleton and the completion premises CI-1–CI-9 below, and **Conditional** on that inheritance. The paper does not claim to derive the numerical scale  $v$ , the radial Higgs-like dynamics, or Yukawa coefficients. It derives the representation object without which those modules cannot be Standard-Model-facing.

## 2. Completion-Interface Premises

### CI-1 — Inherited chiral electroweak skeleton

The matter sector contains left-handed weak doublets  $L_L, Q_L$  and right-handed weak singlets  $e_R, u_R, d_R$ .

*Status:* Inherited. *Falsifier:* Failure of the chiral/electroweak representation papers.

## **CI-2 — Weak-branch commitment structure**

The weak-active left-handed sectors carry a two-branch unresolved commitment module:

$$L_L = (v_L, e_L), Q_L = (u_L, d_L).$$

*Status:* Inherited / Conditional from the weak-commitment programme. *Falsifier:* Weak-active matter is not two-branch.

## **CI-3 — Right-commitment closure**

The right-handed sectors are weak-branch committed singlets. They carry no unresolved weak-doublet structure.

*Status:* Inherited from chiral locking / right-singlet exclusion. *Falsifier:* Right-handed sectors carry nontrivial weak-doublet action.

## **CI-4 — Completion requirement**

A persistent chiral electroweak record layer must permit local completion of the left-handed weak-branch structure against the corresponding right-handed singlet sectors without violating electroweak source charge.

This is not yet a mass claim. It is a representation-completion claim: the chiral skeleton must admit electroweak-neutral completion channels if it is to support downstream mass/inertia modules.

*Status:* Completion premise — the load-bearing structural premise of this paper. *Falsifier:* A persistent chiral matter sector can remain permanently non-completable between left weak doublets and right singlets, with no admissible completion channel required.

## **CI-5 — Scalar closure norm alone is not enough**

The scalar closure magnitude  $\rho \sim (1, 1, 0)$  cannot carry a weak branch index and cannot by itself complete a weak doublet against a weak singlet.

*Status:* Derived — Theorem 1. *Falsifier:* A scalar singlet closure norm is shown to complete weak-branch chiral records without any weak-facing interface.

## **CI-6 — Minimality**

The completion interface is minimal: it introduces no hidden weak-branch dimension, no colour support, and no extra low-energy gauge sector beyond what is needed to complete the inherited electroweak skeleton.

*Status:* Minimality condition. *Falsifier:* A higher representation or additional sector is substrate-forced at the same layer.

## CI-7 — Source-charge preservation

Completion operators must be singlets under the full gauge group  $SU(3)_C \times SU(2)_L \times U(1)_Y$  before condensation and must preserve electric/source charge after condensation. Gauge invariance of physical operators is not electroweak-specific: an operator carrying an uncancelled colour index is as inadmissible as one carrying an uncancelled weak or hypercharge index.

*Status:* Required by the anomaly-admissible source ledger and local gauge consistency.  
*Falsifier:* A physical mass/completion operator carries uncancelled charge under any factor of  $SU(3)_C \times SU(2)_L \times U(1)_Y$ .

## CI-8 — Colour preservation

The completion interface must not break colour. It must therefore carry no colour support.

*Status:* Required by low-energy colour preservation. *Falsifier:* The electroweak completion interface carries colour at leading order.

## CI-9 — No hidden low-energy completion carrier

No additional low-energy object besides the minimal closure interface participates at leading order in electroweak completion.

*Status:* Minimal-skeleton condition. *Falsifier:* Another unavoidable low-energy completion object exists and changes the interface representation.

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# 3. The Problem Left by the Broken Electroweak Phase Paper

The Broken Electroweak Phase paper proves the following conditional result: if the closure condensate carries

$$\Phi_{cl} \sim (1, 2, +\frac{1}{2}),$$

and if its neutral component condenses, then

$$SU(2)_L \times U(1)_Y \rightarrow U(1)_{EM},$$

with the photon as the massless stabiliser direction and the W/Z bosons as vacuum-disturbing directions.

Structurally powerful — but it leaves the origin of  $\Phi_{cl}$  exposed. Why should the closure condensate carry electroweak orientation at all? A scalar closure norm would not break electroweak structure; it would simply condense as a singlet. The interface orientation  $\chi$  must therefore be derived, not merely assumed.

The present paper reverses the direction of argument. Instead of

W/Z masses require a weak-doublet interface,

it argues

chiral electroweak completion requires a weak-doublet interface,

and the broken phase then follows as a downstream consequence. This is the key upgrade. The interface is no longer a special object introduced to produce W/Z masses — it is the universal completion carrier of the chiral electroweak sector. The two arguments also have different evidential character: the first reasons backwards from observed boson masses, while the second is internal to the representation structure and invokes no measured quantity at all.

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## 4. Weak-Branch Commitment and Chiral Completion

The electroweak matter skeleton has a striking asymmetry:

$$L_L = (v_L, e_L), Q_L = (u_L, d_L)$$

are weak doublets, while

$$e_R, u_R, d_R$$

are weak singlets.

In VERSF language, the left-handed sectors retain weak unresolved branch structure; the right-handed sectors are branch-committed. This creates a completion problem.

A weak doublet cannot be directly identified with a weak singlet. The doublet carries a weak branch index; the singlet does not. A persistent chiral record layer therefore needs an interface capable of absorbing — completing — the weak branch index while preserving the source ledger.

This interface must do three things:

1. carry a weak index;
2. carry the compensating hypercharge grade;
3. remain colourless.

A scalar closure norm satisfies only the third. It has no weak-branch structure and no compensating hypercharge. The completion interface must therefore be more than the scalar closure magnitude — it must be an oriented closure object:

$$\Phi_{\text{cl}} = \rho\chi,$$

where  $\rho$  is the magnitude of closure and  $\chi$  is the weak-facing completion orientation.

## 5. Why Scalar Closure Is Insufficient

A scalar closure norm has representation

$$\rho \sim (1, 1, 0).$$

It is gauge-invariant and therefore blind to weak orientation. This is valuable for describing condensation magnitude, but insufficient for electroweak completion.

Consider a generic charged-lepton completion channel. The left-handed lepton is a weak doublet; the right-handed charged lepton is a singlet. A scalar closure norm cannot contract the weak index of the left doublet. The operator

$$\bar{L}_L \rho e_R$$

still carries the uncontracted weak-doublet structure of  $\bar{L}_L$ , so it is not an electroweak singlet. The same failure appears in the quark sector:

$$\bar{Q}_L \rho d_R, \bar{Q}_L \rho u_R$$

are not electroweak singlets. They fail weak-index closure, and they independently fail hypercharge closure.

### Theorem 1 — Scalar Closure Insufficiency

A purely scalar closure norm  $\rho \sim (1, 1, 0)$  cannot complete the inherited chiral electroweak matter skeleton into electroweak-neutral left–right attachment channels.

## Proof

A completion channel between a left-handed weak doublet and a right-handed weak singlet must be an  $SU(2)_L$  singlet. Since  $L_L$  and  $Q_L$  are doublets while  $e_R$ ,  $u_R$ ,  $d_R$  are singlets, the completion object must carry a weak-doublet index able to contract with the conjugate left doublet. The scalar  $\rho$  carries no weak index; therefore  $\bar{L}_L \rho e_R$ ,  $\bar{Q}_L \rho d_R$ , and  $\bar{Q}_L \rho u_R$  cannot be weak singlets. This failure alone is decisive.

The hypercharge audit fails independently. For the charged-lepton attempt,

$$Y(\bar{L}_L) + Y(\rho) + Y(e_R) = +\frac{1}{2} + 0 - 1 = -\frac{1}{2} \neq 0.$$

For the down-quark attempt,

$$Y(\bar{Q}_L) + Y(\rho) + Y(d_R) = -\frac{1}{6} + 0 - \frac{1}{3} = -\frac{1}{2} \neq 0.$$

For the up-quark attempt,

$$Y(\bar{Q}_L) + Y(\rho) + Y(u_R) = -\frac{1}{6} + 0 + \frac{2}{3} = +\frac{1}{2} \neq 0.$$

Scalar closure therefore fails both weak-index closure and hypercharge closure — two independent obstructions, either of which is fatal. It cannot be the completion carrier. ■

## Reading

This theorem invokes no observed  $W/Z$  masses. It is internal to the chiral electroweak representation. The scalar norm alone cannot complete the left–right structure of the matter skeleton; therefore the closure condensate must carry an electroweak-facing interface if it is to serve as the completion object of the Standard Model sector.

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# 6. The Necessity of a Completion Interface

Since scalar closure is insufficient, the completion object must carry electroweak representation data. Write

$$\Phi_{cl} = \rho\chi.$$

The scalar  $\rho$  records closure magnitude; the interface orientation  $\chi$  carries the weak branch index and source-grade data required for completion. The interface is not an arbitrary new field — it is

the missing representation carrier required to make the inherited chiral matter skeleton locally completable.

## Proposition 2 — Completion-Interface Necessity

Given the inherited chiral electroweak skeleton, right-singlet closure, and the requirement of electroweak-neutral left–right completion (CI-4), the closure condensate must present an electroweak-facing interface orientation  $\chi$ . A scalar closure norm alone is insufficient.

### Proof

By CI-4, the chiral electroweak record layer must admit local completion between weak-active left doublets and weak-singlet right sectors. By Theorem 1, a scalar closure norm cannot supply such completion: it carries no weak index and no compensating hypercharge. The closure condensate must therefore include an interface orientation carrying electroweak representation data. Denote that object  $\chi$  and write the completion order parameter as

$$\Phi_{\text{cl}} = \rho\chi,$$

with  $\rho$  supplying condensation magnitude and  $\chi$  supplying electroweak-facing completion structure. ■

## Reading

Stated as a proposition rather than a theorem deliberately: the result is an immediate corollary of CI-4 together with Theorem 1, and its claim-weight rests entirely on CI-4. It closes the logical gap identified as BP-3 in the broken-phase paper. The interface orientation is no longer introduced because the W and Z need mass — it is required because the chiral electroweak matter skeleton cannot be completed by a scalar alone. The remaining structural exposure is CI-4 itself, whose deeper substrate derivation is recorded as Debt 1.

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## 7. The Minimal Weak-Interface Theorem

The completion interface must carry one weak branch index. The smallest such object is a weak doublet. A weak singlet cannot complete a doublet–singlet chiral bridge. A triplet or higher representation introduces more weak structure than the inherited two-branch module requires and generically deforms the broken-phase mass relation.

### Theorem 3 — Minimal Weak-Interface Theorem

The minimal electroweak completion interface transforms as a weak doublet:

$\chi \sim 2$  under  $SU(2)_L$ .

### Proof

A completion interface must contract with  $\bar{L}_L$  and  $\bar{Q}_L$ , each of which transforms as the conjugate of a weak doublet. For irreducible representations, the trivial representation appears in  $A \otimes B$  if and only if  $B$  is conjugate to  $A$ . The conjugate of  $\mathcal{T}$  is  $2$ ; hence

$$\mathcal{T} \otimes R \ni 1 \Leftrightarrow R = 2,$$

for all  $R$  at once — no case-by-case checking is required. Illustratively,  $\mathcal{T} \otimes 2 = 1 \oplus 3$  contains the singlet while  $\mathcal{T} \otimes 1 = \mathcal{T}$  and  $\mathcal{T} \otimes 3 = 2 \oplus 4$  do not, but these checks are illustration; the conjugacy criterion is the proof. A singlet interface therefore fails (consistently with Theorem 1), and every representation other than the doublet fails the doublet–singlet bridge. The doublet is the unique representation that closes the weak index, and it is simultaneously the smallest nontrivial  $SU(2)$  representation, so minimality is automatic rather than merely preferred. Because the  $SU(2)$  doublet is pseudo-real, its conjugate is again a doublet — a fact used in Theorem 7. ■

### Reading

The weak doublet is not borrowed from the Standard Model. It is the unique representation that completes weak-doublet matter against weak-singlet matter without leaving an uncanceled weak index — uniqueness here is representation-theoretic, not aesthetic.

## 8. Hypercharge Fixing from Charge-Preserving Completion

Let the interface carry unknown hypercharge  $Y_\Phi$ :

$$\Phi_{cl} \sim (1, 2, Y_\Phi).$$

Gauge-neutral completion of the charged-lepton channel requires the operator

$$\bar{L}_L \Phi_{cl} e_R$$

to have total hypercharge zero. With  $Y(L_L) = -\frac{1}{2}$  and  $Y(e_R) = -1$ , so that  $Y(\bar{L}_L) = +\frac{1}{2}$ ,

$$+\frac{1}{2} + Y_\Phi - 1 = 0 \Rightarrow Y_\Phi = +\frac{1}{2}.$$

The down-quark channel gives the same result:

$$\bar{Q}_{L\Phi} + Y_{\Phi} - \frac{1}{3} = 0 \implies Y_{\Phi} = +\frac{1}{2}.$$

Two structurally distinct sectors — leptonic and hadronic — select the same interface hypercharge; the precise status of that agreement is stated in the Reading below.

## Theorem 4 — Hypercharge Fixing Theorem

The minimal weak completion interface has hypercharge  $Y_{\Phi} = +\frac{1}{2}$ . Therefore

$$\Phi_{cl} \sim (1, 2, +\frac{1}{2}).$$

### Proof

By Theorem 3 the interface is a weak doublet. Electroweak-neutral completion of the charged-lepton channel gives

$$Y(\bar{L}_L) + Y_{\Phi} + Y(e_R) = +\frac{1}{2} + Y_{\Phi} - 1 = 0,$$

hence  $Y_{\Phi} = +\frac{1}{2}$ . The down-quark channel gives

$$Y(\bar{Q}_L) + Y_{\Phi} + Y(d_R) = -\frac{1}{6} + Y_{\Phi} - \frac{1}{3} = 0,$$

again yielding  $Y_{\Phi} = +\frac{1}{2}$ . The same hypercharge is thus forced in each channel, with the agreement of the two determinations guaranteed by the ledger identity  $Y(\bar{L}_L) + Y(e_R) = Y(\bar{Q}_L) + Y(d_R) = -\frac{1}{2}$ . (The up-quark channel closes through the conjugate interface — Theorem 7 — and is therefore not a counter-constraint.) ■

## Reading

The interface hypercharge is not read off the broken W/Z sector or the observed Higgs — it is fixed by charge-preserving completion of the chiral matter skeleton. The status of the two-channel agreement should be stated precisely. Given the inherited ledger, the agreement is automatic: both determinations reduce to the identity  $Y(\bar{L}_L) + Y(e_R) = Y(\bar{Q}_L) + Y(d_R) = -\frac{1}{2}$ , which the anomaly-rigid ledger already fixes. The double determination is therefore not an independent result performed here; it is a consistency property of the anomaly-admissible ledger — anomaly closure and completion closure select compatible interfaces. That compatibility is nontrivial as a property of the ledger: a charge assignment could pass an anomaly audit and still demand incompatible interfaces in the leptonic and hadronic sectors, in which case no single universal completion carrier would exist. The result is recorded here with its correct home — the ledger.

# 9. Colour Neutrality and the Non-Breaking of Colour

The completion interface must be colourless. The charged-lepton channel carries no colour index at all. The quark channels contract  $\bar{Q}_L$ , which carries anti-colour, against  $u_R, d_R$ , which carry colour; colour already closes between the quark fields. A coloured interface would either leave an uncontracted colour index in the lepton channel or obstruct minimal colour-singlet completion in the quark channels — and, upon condensation, would break  $SU(3)_C$ .

## Theorem 5 — Colour-Neutral Completion Theorem

The minimal electroweak completion interface is colourless:

$$\Phi_{cl} \sim (1, 2, +\frac{1}{2}).$$

### Proof

The exclusion does not come from the quark channels, and it is important to say so precisely. Nontrivial colour representations  $R$  with  $1 \in \mathcal{F} \otimes R \otimes 3$  exist — the minimal case is the octet, since  $\mathcal{F} \otimes 3 = 1 \oplus 8$  gives  $\mathcal{F} \otimes 8 \otimes 3 = 8 \oplus (8 \otimes 8)$ , and  $8 \otimes 8 \supset 1$ . A colour-octet interface  $(8, 2, +\frac{1}{2})$  therefore closes both quark channels at the colour level; quark-channel closure alone cannot force colourlessness.

What forces it is the lepton channel together with colour preservation. The lepton channel carries no colour index: an interface in any nontrivial colour representation leaves an uncontracted colour index in  $\bar{L}_L \Phi_{cl} e_R$ , rendering the operator colour-charged and inadmissible under CI-7. Independently, any coloured interface with nonzero vacuum value breaks  $SU(3)_C$ , violating CI-8; and any coloured enlargement of the singlet interface is non-minimal under CI-6. Since the universal interface must serve the leptonic and hadronic channels with a single carrier, it must be a colour singlet. ■

## Reading

The interface is electroweak-active but colour-inert — exactly the structure required downstream: electroweak breaking occurs, colour remains unbroken, and the gluons remain massless.

The corrected exclusion structure exposes a fact worth keeping visible: it is the *lepton* channel that is load-bearing for colourlessness. A hypothetical quark-only completion sector would tolerate a colour-octet interface at the representation level, excluded then only by colour preservation upon condensation. It is the demand for one universal carrier serving leptons and quarks alike that forces the singlet outright.

---

## 10. The Universal Electroweak Completion-Interface Theorem

The results now combine. A scalar closure norm is insufficient (Theorem 1). The completion object must carry a weak index (Proposition 2). Minimality makes it a doublet (Theorem 3). Charge-preserving completion fixes hypercharge  $+1/2$  (Theorem 4). Colour preservation makes it a colour singlet (Theorem 5). Therefore

$$\Phi_{\text{cl}} \sim (1, 2, +1/2).$$

### Theorem 6 — Universal Electroweak Completion-Interface Theorem

Given the inherited one-generation chiral electroweak skeleton, the anomaly-admissible source ledger, weak-doublet left sectors, right-singlet committed sectors, local left–right completion, source-charge preservation, colour preservation, and minimality (CI-1–CI-9), the unique minimal electroweak completion interface is

$$\Phi_{\text{cl}} \sim (1, 2, +1/2).$$

#### Proof

Theorem 1 excludes scalar closure as a completion carrier. Proposition 2 establishes the necessity of an electroweak-facing interface orientation. Theorem 3 fixes the minimal weak representation as the doublet. Theorem 4 fixes the interface hypercharge as  $+1/2$ . Theorem 5 fixes the colour representation as the singlet. Combining,

$$\Phi_{\text{cl}} \sim (1, 2, +1/2).$$

Uniqueness: no weak singlet closes the weak index (Theorem 1); no coloured object is admissible (Theorem 5); no other hypercharge completes both the charged-lepton and down-quark channels (Theorem 4); higher weak representations fail the doublet–singlet bridge or violate minimality (Theorem 3). The only residual freedom is conjugation: a doublet with  $Y = -1/2$  is precisely  $\tilde{\Phi}_{\text{cl}}$ , related to  $\Phi_{\text{cl}}$  by  $i\sigma_2$ -conjugation, so the "alternative"  $(1, 2, -1/2)$  is not a distinct interface but the same completion package with the roles of  $\Phi_{\text{cl}}$  and  $\tilde{\Phi}_{\text{cl}}$  relabelled. Uniqueness therefore holds up to conjugation — which is uniqueness of the physical interface. ■

#### Remark — Anomaly-ledger preservation

The interface is bosonic. It contributes no fermionic triangle content, so the anomaly-admissibility audit of the source ledger is unchanged by its introduction. The completion

interface repairs the completion deficit of the chiral skeleton without reopening the anomaly ledger — the two consistency structures are compatible by construction.

## Reading

This is the central theorem of the paper. The Standard Model Higgs-doublet representation is recovered not by inspecting W/Z masses but by asking what interface is required to complete the chiral electroweak matter skeleton; the precise relation to the standard textbook quantum-number argument — what is shared, what is claimed as new — is stated in §15. The conjugation remark forecloses the last apparent loophole: there is one completion package, not two candidate interfaces.

---

# 11. The Conjugate Interface and the Up-Sector Necessity

The interface  $\Phi_{cl}$  completes the charged-lepton and down-quark channels. The up-quark channel requires the conjugate interface. Define

$$\tilde{\Phi}_{cl} = i\sigma_2 \Phi_{cl}^*.$$

Since  $\Phi_{cl} \sim (1, 2, +\frac{1}{2})$ , the conjugate transforms as

$$\tilde{\Phi}_{cl} \sim (1, 2, -\frac{1}{2}).$$

The up-quark channel is

$$\bar{Q}_L \tilde{\Phi}_{cl} u_R,$$

with hypercharge

$$Y(\bar{Q}_L) + Y(\tilde{\Phi}_{cl}) + Y(u_R) = -\frac{1}{6} - \frac{1}{2} + \frac{2}{3} = 0.$$

The same completion interface thus automatically supplies the conjugate object required by the up sector — no new degrees of freedom are introduced.

## Theorem 7 — Conjugate Interface Theorem

The universal completion interface  $\Phi_{cl} \sim (1, 2, +\frac{1}{2})$  necessarily supplies the conjugate carrier

$$\tilde{\Phi}_{cl} = i\sigma_2 \Phi_{cl}^* \sim (1, 2, -\frac{1}{2}),$$

which is the unique minimal completion carrier for the up-quark channel.

### Proof

The  $SU(2)$  doublet representation is pseudo-real:  $i\sigma_2$  intertwines  $\mathcal{T}$  with  $2$ , so  $i\sigma_2\Phi^*$  transforms again as a doublet. Complex conjugation reverses hypercharge, giving  $Y(\tilde{\Phi}_{cl}) = -1/2$ . The up-channel hypercharge audit closes only with this conjugate:

$$-1/6 - 1/2 + 2/3 = 0,$$

whereas using  $\Phi_{cl}$  gives

$$-1/6 + 1/2 + 2/3 = 1 \neq 0.$$

The up sector therefore requires  $\tilde{\Phi}_{cl}$ . Because  $\tilde{\Phi}_{cl}$  is constructed from  $\Phi_{cl}$  itself, the conjugate is fixed by — and contains no content beyond — the universal interface. Minimality (CI-6, CI-9) excludes a second independent doublet at this layer. ■

### Reading

The up sector is not an exception to be patched — it is the reason the conjugate interface must belong to the completion package. Pseudo-reality of the  $SU(2)$  doublet is doing genuine work here: it is why one object suffices for both hypercharge orientations, and hence why the single interface  $\Phi_{cl}$  and its conjugate generate exactly the attachment architecture of the Standard Model.

## 12. The Broken Electroweak Phase as Consequence, Not Input

The interface derived above contains two weak components. With  $Y_{\Phi} = +1/2$ , the component electric/source charges are

$$Q_{upper} = +1/2 + 1/2 = +1, \quad Q_{lower} = -1/2 + 1/2 = 0.$$

The interface therefore contains a neutral component — and no condensation direction needs to be assumed.

**Lemma 8 — Vacuum Transitivity.**  $SU(2)_L$  acts transitively on the fixed-norm configurations of a single doublet: the vacuum manifold  $\{\Phi : |\Phi| = v/\sqrt{2}\}$  is the three-sphere  $S^3$ , on which  $SU(2)_L$  acts freely and transitively. Any nonzero condensate is therefore gauge-equivalent to the neutral alignment

$$\langle \Phi_{\text{cl}} \rangle = (v/\sqrt{2}) (0, 1)^T.$$

Neutral alignment is a gauge choice, not a physical premise. In that gauge,

$$(T_3 + Y) \langle \Phi_{\text{cl}} \rangle = 0,$$

so condensation in any direction whatsoever leaves one unbroken  $U(1)$ , generated by  $Q = T_3 + Y$  — electromagnetism in the standard gauge. The conditional "if it condenses neutrally" is thereby discharged: the only physical premise is condensation itself.

The Broken Electroweak Phase theorem then applies immediately: the photon is the stabiliser connection, while the orthogonal weak directions acquire stiffness provided the closure-interface transport cost is positive.

## Theorem 9 — Completion-to-Breaking Bridge

The universal completion interface of Theorem 6 is exactly the interface required by the Broken Electroweak Phase theorem. Once it acquires any nonzero vacuum value, it breaks

$$SU(2)_L \times U(1)_Y \rightarrow U(1)_{\text{EM}}.$$

### Proof

By Theorem 6,  $\Phi_{\text{cl}} \sim (1, 2, +\frac{1}{2})$ . By Lemma 8, any nonzero condensate is gauge-equivalent to the neutral alignment. In that gauge the occupied lower component has  $T_3 = -\frac{1}{2}$ , so its electric/source charge is  $Q = -\frac{1}{2} + \frac{1}{2} = 0$ ; the generator annihilating the vacuum is  $Q = T_3 + Y$ , whose stabiliser group is  $U(1)_{\text{EM}}$ . Condensation in any direction therefore leaves exactly one unbroken  $U(1)$ , identified as electromagnetism. The remainder — photon/Z rotation,  $W^\pm$  identification, tree-level mass structure — is the content of the Broken Electroweak Phase theorem, imported here as a downstream consequence. ■

### Remark — Custodial consistency

The tree-level relation  $m_W/m_Z = \cos \theta_W$  (equivalently  $\rho_{\text{EW}} = 1$  at tree level, in the standard electroweak  $\rho$ -parameter sense — distinct from the closure norm  $\rho$ ) is a known consequence of doublet-only breaking. The completion-forced doublet therefore lands, without adjustment, on the representation class that reproduces this relation. This is a consistency observation about the imported broken-phase result, not an input to the present derivation; it is recorded because a triplet or mixed-representation interface would generically have spoiled it, so the completion argument and the broken-phase phenomenology select the same object from opposite directions.

## Reading

The dependency is reversed, and the bridge now carries no directional premise. The interface is not chosen because it breaks electroweak symmetry correctly — it is required by chiral completion, and once it condenses at all it breaks electroweak symmetry correctly, with neutral alignment supplied by gauge freedom rather than assumption. That convergence, from a derivation in which no boson mass was consulted, is the programme advance.

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## 13. Attachment Audit for Existing Mass/Flavour Modules

The interface derived above supplies the representation carrier required by the existing VERSF Yukawa and flavour modules. This paper does not derive coefficients — it derives the admissible channels.

### 13.1 Charged leptons

$$\bar{L}_L \Phi_{cl e_R}.$$

Hypercharge:  $+\frac{1}{2} + \frac{1}{2} - 1 = 0$ . Weak:  $\mathcal{Z} \otimes 2 \supset 1$ . Colour:  $1 \cdot 1 \cdot 1 = 1$ . Verdict: admissible.

### 13.2 Down quarks

$$\bar{Q}_L \Phi_{cl d_R}.$$

Hypercharge:  $-\frac{1}{6} + \frac{1}{2} - \frac{1}{3} = 0$ . Weak:  $\mathcal{Z} \otimes 2 \supset 1$ . Colour:  $\mathcal{F} \otimes 3 \supset 1$ . Verdict: admissible.

### 13.3 Up quarks

$$\bar{Q}_L \tilde{\Phi}_{cl u_R}.$$

Hypercharge:  $-\frac{1}{6} - \frac{1}{2} + \frac{2}{3} = 0$ . Weak:  $\mathcal{Z} \otimes 2 \supset 1$ . Colour:  $\mathcal{F} \otimes 3 \supset 1$ . Verdict: admissible.

### 13.4 Neutrino channel

If a sterile singlet  $\nu_R \sim (1, 1, 0)$  is included, then

$$\bar{L}_L \tilde{\Phi}_{cl \nu_R}$$

has hypercharge  $+\frac{1}{2} - \frac{1}{2} + 0 = 0$ . Verdict: conditional on the neutrino module. If no sterile singlet is included, neutrino completion must proceed through the weak-commitment/Majorana/effective-operator branch treated elsewhere in the programme.

## Proposition 10 — Completion Attachment Audit

The universal completion interface and its conjugate provide exactly the minimal electroweak-neutral carriers required for charged-lepton, down-quark, up-quark, and conditional Dirac-neutrino attachment.

### Proof

The channel-by-channel audits above show that  $\Phi_{cl}$  completes charged leptons and down quarks, while  $\tilde{\Phi}_{cl}$  completes up quarks and optional Dirac neutrinos. Wrong-interface pairings fail hypercharge closure (Appendix A). No scalar singlet works, by Theorem 1. The interface package is therefore necessary and sufficient for minimal electroweak-neutral attachment. ■

### Reading

This is why the paper is more than a BP-3 closure. The same object required by electroweak breaking is required by the mass-attachment architecture. The Higgs-like doublet is the common interface linking gauge breaking and chiral completion — one carrier, three roles.

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## 14. Relation to the Broken Electroweak Phase Paper

The Broken Electroweak Phase paper takes

$$\Phi_{cl} \sim (1, 2, +\frac{1}{2})$$

as an input and derives

$$SU(2)_L \times U(1)_Y \rightarrow U(1)_{EM},$$

with  $W^\pm, Z, A$  and the tree-level structure

$$m_W = gv/2, m_Z = (v/2) \cdot \sqrt{(g^2 + g'^2)}, m_A = 0.$$

The present paper changes the status of that input. It proves that the interface representation is forced by chiral electroweak completion. The logical chain is thereby upgraded:

Before: given  $\Phi_{cl} \sim (1, 2, +\frac{1}{2}) \Rightarrow$  photon/W/Z structure.

Now: chiral electroweak completion  $\Rightarrow \Phi_{cl} \sim (1, 2, +\frac{1}{2}) \Rightarrow$  photon/W/Z structure.

The premise BP-3 of the broken-phase paper is discharged into Proposition 2 and Theorems 3–6 here, conditional on CI-4 and the inherited stack. Lemma 8 supplies a second, smaller upgrade. The broken-phase paper's vacuum-orientation section asserts — correctly, but without proof or number — that any nonzero doublet vacuum can be rotated to the neutral alignment by a local gauge transformation, with no neutrality proviso needed for the rotation itself. Lemma 8 proves that assertion and gives it a citable number, so the bridge requires only that the interface condenses — not that it condenses in a preferred direction. This is the crucial programme advance: the broken phase no longer rests on an assumed interface but on a derived one.

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## 15. Relation to the Standard Quantum-Number Argument

Stripped of VERSF vocabulary, Theorems 3–5 reproduce a known piece of representation theory. Standard treatments fix the Higgs quantum numbers by demanding gauge-invariant Yukawa bilinears: require  $\bar{L}_L \Phi e_R$ ,  $\bar{Q}_L \Phi d_R$ , and  $\bar{Q}_L \tilde{\Phi} u_R$  to be gauge singlets against the observed matter table, and  $(1, 2, +\frac{1}{2})$  falls out. This paper does not claim that algebra as new — representation theory does not care which framework runs it.

**What is shared.** Theorems 3–5 — doublet minimality, hypercharge fixing, colour neutrality — would appear with the same content in any framework demanding electroweak-neutral left–right bilinears against the same matter table and charge ledger.

**What is claimed as new.** The premise, not the algebra. The textbook route starts from an empirical input: fermions are observed to have Dirac masses, therefore Yukawa operators must exist, therefore the carrier must have these quantum numbers. The present paper replaces the empirical input with a structural one — CI-4, the claim that a persistent chiral record layer must admit electroweak-neutral left–right completion channels as a substrate requirement. Under CI-4 the interface is forced before any mass is consulted, and the admissibility of fermion mass operators becomes a downstream consequence of completion rather than the upstream justification for the carrier — nonzero masses additionally requiring nonzero coefficients, which remain Debt 4.

**The honest caveat.** CI-4 is currently graded Conditional (Debt 1, Appendix C). Until it is derived from substrate transport, a referee may fairly observe that CI-4 functions as "fermions have Dirac masses" restated in structural language. The paper's claim level is calibrated to that state: the representation theorems are Exact given CI-4 and the inherited stack; the elevation of the premise from empirical to structural is precisely what remains Owed. Discharging Debt 1 is therefore not housekeeping — it is where the novelty of this paper's framing is finally cashed or refuted.

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# 16. Relation to Yukawa, CKM, PMNS, and Flavour Modules

This paper does not restart the Yukawa programme. It supplies the derived representation carrier that the already-developed mass/flavour modules must use.

## 16.1 Yukawa operators

The existing Yukawa/completion-channel modules no longer need to assume a Higgs-doublet carrier. They inherit  $\Phi_{cl}$  from the completion-interface theorem.

## 16.2 Charged-lepton hierarchy

The charged-lepton module now attaches through a derived object,  $\bar{L}_L \Phi_{cl} e_R$ . The hierarchy belongs to the coefficient/module side, not to the representation carrier.

## 16.3 Quark hierarchy

The down and up sectors attach through different members of the same interface package:

$$\bar{Q}_L \Phi_{cl} d_R, \bar{Q}_L \tilde{\Phi}_{cl} u_R.$$

The quark mass modules thereby acquire a derived electroweak home.

## 16.4 CKM

CKM mixing belongs to basis misalignment between up- and down-sector completion operators. The present paper supplies the representation carriers against which that misalignment becomes Standard-Model-facing.

## 16.5 PMNS and neutrinos

PMNS depends on the neutrino branch selected — sterile Dirac, weak-commitment, Majorana-like, or another VERSF mechanism. This paper supplies the electroweak completion interface against which any such module can be audited.

## 16.6 Programme consequence

The mass/flavour programme now has a cleaner target:

derive the coefficients and basis misalignments — not the representation carrier.

The carrier is supplied.

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## 17. What Has Actually Been Derived

Derived here, conditionally on the inherited VERSF electroweak stack and CI-1–CI-9:

1. scalar closure insufficiency for chiral electroweak completion;
2. necessity of an electroweak-facing closure-interface orientation;
3. minimal weak-doublet structure of that interface;
4. hypercharge  $Y_\Phi = +\frac{1}{2}$  from charge-preserving charged-lepton and down-quark completion, with the two-channel agreement identified as a consistency property of the anomaly-rigid ledger;
5. colour-singlet status of the interface;
6. the universal completion interface  $\Phi_{cl} \sim (1, 2, +\frac{1}{2})$ , unique up to conjugation;
7. the conjugate carrier  $\tilde{\Phi}_{cl} \sim (1, 2, -\frac{1}{2})$ , supplied by pseudo-reality without new degrees of freedom;
8. charged-lepton, down-quark, up-quark, and conditional neutrino attachment channels;
9. the bridge from completion interface to broken electroweak vacuum — with neutral alignment shown to be a gauge choice rather than a premise — including anomaly-ledger preservation;
10. the upgrade of the Broken Electroweak Phase paper from conditional interface assumption to derived completion-interface inheritance.

Not derived here:

1. the numerical value of  $v$ ;
  2. the closure-norm potential;
  3. the Higgs radial mass or self-coupling;
  4. Yukawa coefficients;
  5. the charged-lepton mass hierarchy;
  6. the quark mass hierarchy;
  7. CKM mixing;
  8. PMNS mixing;
  9. the neutrino mass mechanism;
  10. three generations;
  11. gauge coupling values;
  12. loop-level electroweak precision structure.
- 

## 18. Open Debts

## **Debt 1 — Microscopic weak-commitment proof of the completion requirement**

This paper proves that scalar closure cannot complete the inherited chiral electroweak skeleton and that a weak-facing interface is required *if* left–right completion is required. A deeper weak-commitment paper should derive CI-4 directly from substrate transport: that persistent weak-branch commitment necessarily demands local completion against the right-committed sectors. Until then, CI-4 is the load-bearing structural premise of this paper and is graded Conditional. §15 states what turns on this debt: it is the entire difference between this derivation and the standard quantum-number argument.

## **Debt 2 — Closure-norm potential and $v$**

The interface representation is derived; the condensation scale is not. The microscopic potential or stability functional setting  $v$  remains owed.

## **Debt 3 — Higgs radial dynamics**

The radial excitation of  $\rho$  remains the natural Higgs-like scalar candidate. Its mass, self-coupling, decay rates, and relation to the observed 125 GeV scalar are not derived here.

## **Debt 4 — Yukawa coefficient derivation**

The paper derives the representation carriers; it does not derive the coefficients multiplying the attachment channels.

## **Debt 5 — Neutrino branch integration**

The neutrino sector remains conditional on the selected VERSF neutrino mechanism.

## **Debt 6 — Three generations**

The paper is one-generation at the representation level. Generation replication remains outside scope.

## **Debt 7 — Full quantum electroweak completion**

Gauge fixing, ghost structure, renormalisation, loop corrections, and precision electroweak observables remain owed.

# 19. Falsification Conditions

## F1 — Scalar completion succeeds

If a scalar singlet closure norm can complete weak-doublet to weak-singlet chiral records while preserving electroweak source charge, Theorem 1 fails.

## F2 — No completion requirement

If persistent chiral electroweak records require no left–right completion channels of any kind, the central premise CI-4 fails.

## F3 — Wrong weak representation

If the minimal completion interface is not a weak doublet, Theorem 3 fails.

## F4 — Wrong hypercharge

If the completion interface does not carry  $Y = +\frac{1}{2}$  (up to conjugation), the charged-lepton and down-quark channels do not close as stated, and Theorem 4 fails.

## F5 — Colour support

If the completion interface carries colour, Theorem 5 fails and downstream colour preservation is threatened.

## F6 — Up-sector obstruction

If the conjugate interface does not supply the up-sector channel, Theorem 7 fails.

## F7 — Broken-phase mismatch

If the derived completion interface cannot produce the broken electroweak phase when condensed, the bridge to the Broken Electroweak Phase paper fails.

## F8 — Mass contamination

If the derivation of the interface is shown to require observed fermion masses, Yukawa coefficients, CKM, PMNS, or the observed Higgs mass, the mass firewall fails.

## F9 — Hidden low-energy carrier

If another unavoidable low-energy completion carrier exists and contributes at the same order, CI-9 fails and the uniqueness clause of Theorem 6 loses force.

## F10 — Charge-ledger failure

If the inherited anomaly-admissible hypercharge ledger fails, the hypercharge-fixing theorem loses its base — and, by the channel-compatibility argument of §8, the very existence of a single common interface would be threatened.

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# 20. Milestone Statement

The result of this paper is:

chiral electroweak matter skeleton

- weak-branch commitment
- local completion
- source-charge preservation

⇒

$\Phi_{cl} \sim (1, 2, +\frac{1}{2}), \tilde{\Phi}_{cl} \sim (1, 2, -\frac{1}{2})$ .

The same interface:

1. completes weak-branch chiral matter records;
2. supplies the neutral vacuum carrier for electroweak breaking;
3. provides the representation attachment object for the existing mass/flavour modules.

The Higgs-doublet-form object is therefore not a postulate and not a one-purpose symmetry-breaking device. It is the universal electroweak completion interface of the VERSF Standard Model sector.

That is the intended milestone.

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# 21. Conclusion

The prior VERSF electroweak-breaking paper derives the photon, the W/Z directions, the weak-boson mass structure, and the tree-level relation  $m_W/m_Z = \cos \theta_W$  from closure-norm

condensation, given a weak-active neutral closure interface of Higgs-doublet form. The present paper derives why that interface exists.

The chiral electroweak matter skeleton cannot be completed by a scalar closure norm alone. Left-handed matter carries weak-doublet structure; right-handed matter is weak-singlet committed. Completing that structure while preserving electroweak source charge requires an interface carrying one weak branch index and the correct compensating hypercharge. Minimality makes the interface a weak doublet. Charged-lepton and down-quark completion fix its hypercharge as  $+\frac{1}{2}$ , the agreement of the two channels being guaranteed by the anomaly-rigid ledger. Colour preservation makes it a colour singlet. The result is

$$\Phi_{\text{cl}} \sim (1, 2, +\frac{1}{2}),$$

with conjugate

$$\tilde{\Phi}_{\text{cl}} \sim (1, 2, -\frac{1}{2})$$

forced by the up-quark channel through the pseudo-reality of the doublet — one physical interface, unique up to conjugation, carrying no new fermionic anomaly content.

This transforms the status of the Higgs-like object in VERSF. It is not merely the thing that breaks electroweak symmetry. It is the universal completion interface through which the chiral electroweak matter table becomes a complete, charge-preserving, Standard-Model-facing record structure. Once the interface condenses — in any direction, neutral alignment being a gauge choice rather than a premise — the broken electroweak phase theorem applies: the photon is the vacuum-preserving direction, W and Z are the vacuum-disturbing directions, and the same object that completes the matter table also breaks the gauge sector and supplies the attachment carrier for the mass/flavour modules.

The programme has therefore advanced:

matter skeleton → electroweak representation → anomaly-admissible ledger → gauge-curvature dynamics → **universal completion interface** → broken electroweak phase.

The next work is sharply defined: derive  $v$ , the closure potential, and the Higgs-like radial dynamics, discharge CI-4 at the substrate level, and integrate the existing mass/flavour modules against the interface derived here.

The Standard Model Higgs-doublet form has been repositioned. It is no longer an unexplained scalar insertion. In VERSF, it is the minimal completion interface of chiral electroweak reality.

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## Appendix A — Gauge-Neutrality Audit

Hypercharges are in the convention  $Q = T_3 + Y$ .

Channel	Operator	Hypercharge sum	Weak closure	Colour closure	Verdict
Charged lepton	$\bar{L}_L \Phi_{cl}$ $e_R$	$+1/2 + 1/2 - 1 = 0$	$\mathcal{T} \otimes 2 \supset 1$	1	Admissible
Down quark	$\bar{Q}_L \Phi_{cl}$ $d_R$	$-1/6 + 1/2 - 1/3 = 0$	$\mathcal{T} \otimes 2 \supset 1$	$\mathcal{F} \otimes 3 \supset 1$	Admissible
Up quark	$\bar{Q}_L \tilde{\Phi}_{cl}$ $u_R$	$-1/6 - 1/2 + 2/3 = 0$	$\mathcal{T} \otimes 2 \supset 1$	$\mathcal{F} \otimes 3 \supset 1$	Admissible
Dirac neutrino	$\bar{L}_L \tilde{\Phi}_{cl}$ $\nu_R$	$+1/2 - 1/2 + 0 = 0$	$\mathcal{T} \otimes 2 \supset 1$	1	Conditional
Wrong up	$\bar{Q}_L \Phi_{cl}$ $u_R$	$-1/6 + 1/2 + 2/3 = 1$	closes	closes	Inadmissible
Wrong down	$\bar{Q}_L \tilde{\Phi}_{cl}$ $d_R$	$-1/6 - 1/2 - 1/3 = -1$	closes	closes	Inadmissible
Wrong lepton	$\bar{L}_L \tilde{\Phi}_{cl}$ $e_R$	$+1/2 - 1/2 - 1 = -1$	closes	closes	Inadmissible
Scalar charged lepton	$\bar{L}_L \rho e_R$	$+1/2 + 0 - 1 = -1/2$	fails	closes	Inadmissible
Scalar down	$\bar{Q}_L \rho d_R$	$-1/6 + 0 - 1/3 = -1/2$	fails	closes	Inadmissible
Scalar up	$\bar{Q}_L \rho u_R$	$-1/6 + 0 + 2/3 = +1/2$	fails	closes	Inadmissible

Two features of the table are load-bearing. First, every admissible channel closes in all three columns simultaneously — hypercharge, weak, and colour — with no channel rescued by one column alone. Second, the wrong-interface rows close in the weak and colour columns and fail only in hypercharge: the hypercharge ledger, not weak structure, is what forces the  $\Phi_{cl}/\tilde{\Phi}_{cl}$  division of labour between the down-type and up-type sectors.

## Appendix B — Why Alternative Completion Interfaces Fail

### B.1 Scalar singlet (1, 1, 0)

Fails weak-index closure and hypercharge closure (Theorem 1). It cannot bridge left doublets to right singlets.

### B.2 Weak singlet with hypercharge (1, 1, Y)

Still fails weak-index closure:  $\mathcal{T} \otimes 1 = \mathcal{T}$  contains no singlet. Hypercharge freedom can repair one number but cannot contract a doublet index.

### B.3 Weak triplet (1, 3, Y)

Fails the doublet–singlet bridge:  $\mathcal{T} \otimes 3 = 2 \oplus 4$  contains no singlet, so no left-doublet–right-singlet channel closes. It also introduces non-minimal weak structure and, if condensed, generically deforms the tree-level broken-phase mass relation (the electroweak  $\rho$ -parameter). Excluded on both completion and minimality grounds.

### B.4 Coloured interface ( $R_C \neq 1, 2, Y$ )

Not excluded by the quark channels: nontrivial representations with  $1 \in \mathcal{T} \otimes R_C \otimes 3$  exist, the octet being the minimal case, so quark-channel colour closure succeeds for  $R_C = 8$ . Excluded instead by the lepton channel — an uncontracted colour index in  $\bar{L}_L \Phi e_R$ , violating CI-7 — by colour breaking upon condensation (CI-8), and by minimality against the singlet (CI-6). See the corrected exclusion structure in Theorem 5: the lepton channel is load-bearing.

### B.5 Doublet with wrong hypercharge (1, 2, $Y \neq \pm 1/2$ )

Fails charged-lepton and down-quark completion, and its conjugate fails the up channel. Verified over the three attachment channels: the charged-lepton channel closes only at  $Y = +1/2$  ( $+1/2 + Y - 1 = 0$ ), the down channel only at  $Y = +1/2$  ( $-1/6 + Y - 1/3 = 0$ ), and the up channel only at  $Y = -1/2$  ( $-1/6 + Y + 2/3 = 0$ ); no other assignment closes any of the three. And  $Y = -1/2$  is not an alternative but the conjugate of the  $Y = +1/2$  interface (Theorem 6, uniqueness clause).

### B.6 Multiple independent low-energy interfaces

Violates CI-6 and CI-9, generically alters the  $W/Z$  mass matrix, and introduces extra scalar states. Multi-interface scenarios lie outside the minimal completion skeleton and would require separate substrate justification.

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## Appendix C — Claim-Status Ledger

Claim	Status	Comment
Scalar closure alone cannot complete chiral electroweak records	Derived	Theorem 1
A weak-facing interface is required	Derived given completion premise CI-4	Proposition 2

Claim	Status	Comment
Completion premise CI-4 itself	Conditional / Structural	Deep substrate proof owed — Debt 1
Minimal weak doublet	Derived	Theorem 3
Hypercharge $+1/2$	Derived	Theorem 4 — channel agreement is a ledger property (§8)
Colour singlet	Derived	Theorem 5
$\Phi_{cl} \sim (1, 2, +1/2)$ , unique up to conjugation	Derived	Theorem 6
$\tilde{\Phi}_{cl} \sim (1, 2, -1/2)$	Derived	Theorem 7
Anomaly-ledger preservation by interface	Derived	Remark, §10
Broken phase from interface condensation	Imported theorem / Downstream	From Broken Electroweak Phase paper
Neutral vacuum alignment is a gauge choice	Derived	Lemma 8, §12 — vacuum transitivity
Completion-to-breaking bridge	Derived	Theorem 9, §12
Attachment package necessary and sufficient	Derived	Proposition 10, §13
Novelty relative to textbook quantum-number argument rests on CI-4	Conditional	§15 — Debt 1
Custodial (tree-level $\rho_{EW} = 1$ ) consistency	Consistency observation	Remark, §12 — not an input
Yukawa coefficients	Owed / Existing modules	Not derived
Higgs radial mass	Owed	Not derived
$v$	Owed	Not derived
Three generations	Owed	Not derived