The Electroweak Gauge-Curvature Dynamics in VERSF

▲ **Programme Milestone — Standard Model Gauge-Dynamics Series**

Deriving the W/B Field Strengths, the Gauge Kinetic Form, and the Source-Coupled Field Equations from Local Electroweak Connection Closure

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Successor to *The Electroweak Representation and Connection Closure in VERSF* and *The Substrate Anomaly-Inadmissibility Theorem in VERSF*.

Headline result — from electroweak connection form to gauge dynamics.

The electroweak representation paper derives the local comparison structure

$\mathcal{A}^{EW}_\mu = g\, W^i_\mu T_i + g'\, B_\mu Y,$

acting on the one-generation chiral matter skeleton

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

with electroweak representation algebra

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

The anomaly-inadmissibility theorem then strengthens the charge ledger: only anomaly-free source ledgers persist as VERSF record-current sectors.

The present paper advances from **connection form** to **gauge-curvature dynamics**. The central claim is that once local weak/hypercharge comparison is required to be connection-valued, refinement-stable, anomaly-admissible, and source-current preserving, the admissible leading gauge dynamics are fixed:

$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g\, \varepsilon_{ijk} W^j_\mu W^k_\nu,$

$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu,$

with the unique leading kinetic form

$$\mathscr{L}^{EW}_{gauge} = -\tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu}.$$

Coupling to the already-derived chiral matter currents yields the unbroken electroweak field equations

$$(D_\nu W^{\nu\mu})^i = g J^\mu_i, \quad \partial_\nu B^{\nu\mu} = g' J^\mu_Y,$$

together with the Bianchi closure identities they presuppose.

This is not a derivation of electroweak symmetry breaking, the photon, W/Z masses, the Higgs vev, the Weinberg angle, fermion masses, Yukawa couplings, CKM, PMNS, or three generations. It derives the **unbroken electroweak gauge-dynamics layer** on which the downstream closure-norm condensation and mass modules act.

General Reader Summary

The preceding papers gave VERSF two large pieces of Standard Model structure.

First, a candidate matter table: electron-like matter, neutrino-like matter, up-like and down-like quarks, left-handed pairs, right-handed singlets, and the unique anomaly-rigid charge pattern that makes the table consistent.

Second, the operating structure of the electroweak force: the weak interaction acts only on left-handed pairs, while hypercharge acts as the shared charge label that helps determine electric charge.

But a force is not a set of labels. A force must have fields — a way of carrying comparison information from point to point. If a particle carries a weak state here and a weak state there, the theory needs a rule for comparing them. That rule is a connection. The predecessor paper derived the shape of that connection: three weak directions, W, and one hypercharge direction, B.

This paper asks the next question: once that connection exists, what dynamics must it have?

The answer is curvature. If a connection tells the theory how to compare states from point to point, its curvature measures what happens when comparison is carried around a tiny closed loop. If the comparison returns changed, the connection carries field strength. In ordinary language: the force field is the twist or mismatch produced by local comparison transport.

VERSF reads this curvature as a real record-layer quantity, not a bookkeeping device. A connection with no curvature is pure convention — a choice of local labels. A connection with curvature carries physical field content that no relabelling can remove. The paper then shows that the only leading, stable, local, source-preserving way to give dynamics to that curvature is the familiar gauge-field form: one curvature-square term for the weak fields and one for the hypercharge field. Nothing stronger is assumed; nothing weaker suffices.

Three structural facts fall out along the way, each with a one-line reason. The weak field interacts with itself, because weak rotations do not commute — doing rotation A then B differs from B then A, and the field remembers the difference. The hypercharge field does not interact with itself, because hypercharge rotations commute. And neither field can carry a mass at this layer, because a bare mass term would let physics depend on an arbitrary choice of local labels — which is exactly what a connection forbids. That last fact is why the W and Z masses observed in nature must come from a later mechanism, not from the gauge layer itself.

The paper is careful about what it does not do. It does not derive why the W and Z bosons are massive. It does not derive the photon, the Weinberg angle, the Higgs mechanism, or fermion masses. Those belong to the downstream electroweak-breaking and mass modules, which act on the structure built here.

The milestone is narrow but real: VERSF now has a continuous route from matter representation to electroweak connection, and from electroweak connection to gauge-curvature dynamics. The electroweak force is no longer only a labelling scheme acting on matter — it is a dynamical field layer with equations of motion.

Contents

Abstract

The preceding VERSF papers derive a one-generation chiral matter skeleton, the electroweak representation algebra acting on it, the local electroweak connection form, and the substrate inadmissibility of anomalous chiral source ledgers. The matter skeleton is

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

with anomaly-rigid hypercharge ledger

$L_L : (1, 2, -\frac{1}{2}), e_R : (1, 1, -1),$

$Q_L : (3, 2, \frac{1}{6}), u_R : (3, 1, \frac{2}{3}), d_R : (3, 1, -\frac{1}{3}).$

The electroweak representation paper derives

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

and the local comparison structure

$\mathcal{A}^{EW}_\mu = g W^i_\mu T_i + g' B_\mu Y,$

while explicitly leaving the gauge dynamics, kinetic terms, and field equations owed. The anomaly-inadmissibility paper shows that only anomaly-free chiral source ledgers are substrate-admissible persistent record-current sectors.

The present paper supplies the next layer: the unbroken electroweak gauge-curvature dynamics. The local comparison connection has a unique gauge-covariant curvature

$F^{EW}_{\mu\nu} = \partial_\mu \mathcal{A}^{EW}_\nu - \partial_\nu \mathcal{A}^{EW}_\mu + i [\mathcal{A}^{EW}_\mu, \mathcal{A}^{EW}_\nu],$

which decomposes over the direct-sum algebra into non-abelian weak curvature and abelian hypercharge curvature,

$F^{EW}_{\mu\nu} = g W^i_{\mu\nu} T_i + g' B_{\mu\nu} Y,$

with component field strengths

$$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g\, \varepsilon_{ijk} W^j_\mu W^k_\nu,$$

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu.$$

The curvature obeys the Bianchi closure identities ($D_{[\lambda} F^{EW}_{\mu\nu]} = 0$) as an exact structural consequence of its definition. The leading local, Lorentz-compatible, gauge-covariant, refinement-stable curvature norm — parity-even as a derived property, not a premise — is then

$$\mathscr{L}^{EW}_{gauge} = -\tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu},$$

with the normalization fixed by canonical field rescaling and the numerical values of (g, g') left undetermined. Variation gives the unbroken electroweak source equations

$$(D_\nu W^{\nu\mu})^i = g J^\mu_i, \quad \partial_\nu B^{\nu\mu} = g' J^\mu_Y,$$

with source currents

$$J^\mu_i = :\bar{\psi}_L \gamma^\mu T_i \psi_L:, \quad J^\mu_Y = :\bar{\psi} \gamma^\mu Y \psi:.$$

The result is conditional on the inherited connection closure, the anomaly-admissible source ledger, the emergent Lorentzian record geometry, and the curvature-norm admissibility principle stated below. It does not derive electroweak symmetry breaking, the photon, W/Z masses, Weinberg mixing, gauge coupling values, Higgs dynamics, fermion masses, or three generations. It derives the unbroken gauge-dynamical layer required before those downstream modules can act.

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0. Notation, Conventions, and Firewalls

Notation

$\mathcal{A}^{EW}_\mu$ denotes the inherited local electroweak connection,

$$\mathcal{A}^{EW}_\mu = g W^i_\mu T_i + g' B_\mu Y.$$

T_i are the weak generators, acting as $\sigma_i/2$ on L_L and Q_L and as zero on e_R, u_R, d_R.

Y is the hypercharge generator, scalar on each weak irreducible sector.

The electroweak representation algebra is

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

with structure relations

$[T_i, T_j] = i\, \varepsilon_{ijk} T_k$, $[T_i, Y] = 0$, $[Y, Y] = 0$.

The electric/source-charge convention remains

$Q = T_3 + Y$.

W^i_μ are the three weak connection components. B_μ is the hypercharge connection component. $W^i_{\mu\nu}$ and $B_{\mu\nu}$ denote the corresponding curvature components. Repeated indices are summed; i, j, k range over the weak algebra directions; μ, ν, λ are indices on the emergent 4-manifold.

The covariant derivative convention is

$D_\mu = \partial_\mu + i\, \mathcal{A}^{EW}_\mu$.

With this convention the signs of the non-abelian terms follow Appendix A. The alternative convention $D_\mu = \partial_\mu - i\, \mathcal{A}_\mu$ flips the sign of the commutator term without changing the physics.

Antisymmetrisation over bracketed indices is denoted $[\lambda\mu\nu]$ and taken with unit weight.

Hypercharge convention

This paper uses $Q = T_3 + Y$. Papers using $Q = T_3 + Y_{SM}/2$ translate by $Y_{SM} = 2Y$.

Representation firewall

This paper does not rederive the matter skeleton or the electroweak representation algebra. It inherits

L_L, e_R, Q_L, u_R, d_R,

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

$\mathcal{A}^{EW}_\mu = g\, W^i_\mu T_i + g'\, B_\mu Y$.

Its task is to derive the curvature, kinetic form, and field equations associated with that inherited connection — nothing upstream of it.

Electroweak-breaking firewall

This paper does not derive $SU(2)_L \times U(1)_Y \to U(1)_{EM}$. It does not derive the photon, W/Z masses, the Weinberg angle, the Higgs vev, closure-norm condensation, or the broken-phase gauge eigenstates. Those belong downstream. No broken-phase datum enters any premise or proof below; F10 audits this.

Mass firewall

This paper does not derive fermion masses, Yukawa couplings, CKM, PMNS, neutrino masses, generation hierarchy, or Higgs-sector mass structure. No mass-sector datum enters any premise or proof below; F11 audits this.

Coupling-value firewall

This paper does not compute the numerical values of g or g′. It derives where those couplings enter and the form of the dynamics they normalize.

Renormalisation firewall

This paper derives the leading classical record-layer gauge dynamics. It does not derive renormalised electroweak perturbation theory, running couplings, gauge fixing, ghost structure, loop corrections, or S-matrix observables.

0′. Predictive-Content Ledger

Object	Grade	Status
Chiral matter skeleton	Inherited / Conditional	From matter-representation theorem
Electroweak algebra	Inherited / Conditional	From representation closure
Local W/B connection form	Inherited / Conditional	From connection closure
Anomaly-admissible ledger	Inherited / Conditional	From anomaly-inadmissibility theorem
Local curvature F^EW_μν	Exact given connection	Derived here (Theorem 1)
Weak field strength W^i_μν	Exact given connection	Derived here (Theorem 1)
Hypercharge field strength B_μν	Exact given connection	Derived here (Theorem 1)
Non-abelian weak self-term	Exact given $\mathfrak{su}(2)$	Derived here (Theorem 1)
Bianchi closure identities	Exact given connection	Derived here (Theorem 2)
Curvature-square kinetic form	Conditional theorem	Given GD-1–GD-7 (Theorem 3)
Absence of unbroken W/B mass terms	Exact within gauge covariance	Derived here (Theorem 4)
Absence of leading W/B kinetic cross-term	Exact within direct-sum algebra	Derived here (Theorem 5)
Electroweak source currents	Inherited / Derived	From representation currents (Prop. 6)

Object	Grade	Status
Source-coupled field equations	Conditional theorem	Derived by variation (Theorem 7)
Current closure	Conditional	Requires anomaly-admissible ledger (Prop. 8)
Gauge coupling values	Owed	Not derived
Gauge kinetic term from microscopic substrate action	Owed in strongest form	Curvature-norm principle used here
Electroweak breaking	Downstream	Not derived
Photon / W / Z mass eigenstates	Downstream	Not derived
Renormalised electroweak theory	Owed	Not derived

0″. Inherited Infrastructure

The paper inherits three layers.

0″.1 Chiral matter skeleton

The one-generation matter skeleton is

$L_L = (\nu_L, e_L), e_R,$

$Q_L = (u_L, d_L), u_R, d_R,$

with hypercharge ledger

$L_L : (1, 2, -\frac{1}{2}), e_R : (1, 1, -1),$

$Q_L : (3, 2, \frac{1}{6}), u_R : (3, 1, \frac{2}{3}), d_R : (3, 1, -\frac{1}{3}).$

The optional sterile singlet is $\nu_R : (1, 1, 0)$; the minimal skeleton excludes it from the leading uniqueness claim.

0″.2 Electroweak representation and connection

The representation closure gives

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

and the local comparison theorem gives

$$\mathcal{A}^{EW}_\mu = g\, W^i_\mu T_i + g' B_\mu Y.$$

That result supplies the connection form but not its dynamics. The predecessor paper logs the gauge dynamics explicitly as owed; the present paper discharges exactly that debt at the classical leading order.

0″.3 Anomaly-admissible source ledger

The anomaly-inadmissibility theorem establishes that a chiral gauge/source ledger with nonzero anomaly class cannot persist as a VERSF record-current sector.

The electroweak source ledger is therefore not merely anomaly-checked; it is anomaly-admissible. This matters for the present paper because gauge dynamics require sources whose currents close consistently. A gauge field cannot be consistently sourced by a ledger that leaks.

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1. Purpose and Claim Level

The predecessor electroweak paper derives the local connection form. A connection form alone is not yet gauge dynamics.

A connection says how matter states are locally compared. A gauge field exists when that comparison has curvature. Dynamics arise when the curvature carries a local cost — an action.

The present paper derives the leading unbroken electroweak gauge dynamics associated with the inherited connection. The target chain is

local connection → curvature → curvature norm → gauge kinetic form → source-coupled field equations.

Central Claim

Given the inherited electroweak connection

$$\mathcal{A}^{EW}_\mu = g\, W^i_\mu T_i + g' B_\mu Y$$

and the gauge-dynamics premises GD-1–GD-9 below, the unique leading unbroken electroweak gauge-dynamical layer is

$$\mathcal{L}^{unbroken}_{EW} = \bar{\psi}\, i \gamma^\mu D_\mu \psi - \tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu},$$

with D_μ acting by the inherited chiral electroweak representation.

Two claim levels must be distinguished. Theorems 1, 2, 4, and 5 are exact given the inherited connection and algebra: they are structural consequences requiring no new physical premise. Theorems 3 and 7 are conditional: they invoke the curvature-norm admissibility principle GD-6, which is the single genuinely new dynamics premise of this paper and its principal remaining debt. The result is a gauge-dynamics theorem, not an electroweak-breaking theorem.

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2. Gauge-Dynamics Premises

GD-1 — Connection inheritance

The local electroweak comparison structure is

$\mathcal{A}^{EW}_\mu = g W^i_\mu T_i + g' B_\mu Y$.

Status: Inherited from the electroweak representation and connection closure paper.

Falsifier: Failure of the inherited connection theorem.

GD-2 — Curvature as local comparison residue

The physical field strength of a local comparison structure is its curvature: the infinitesimal failure of parallel comparison around a closed local loop to return identically.

Status: Standard differential-geometric structure, interpreted in VERSF as local commitment-transport residue.

Falsifier: A VERSF local connection whose physical field strength is not its loop-comparison curvature.

GD-3 — Record-layer locality

The leading gauge dynamics are local in the record-layer continuum limit.

Status: Inherited from the field-reconstruction programme.

Falsifier: Leading gauge dynamics require unavoidable nonlocal terms.

GD-4 — Lorentz / emergent-metric compatibility

The leading gauge-dynamical scalar is compatible with the emergent Lorentzian record geometry.

Status: Inherited from the metric/transport programme.

Falsifier: Electroweak gauge dynamics fail to couple to the emergent metric structure in Lorentz-compatible form.

GD-5 — Gauge covariance of local comparison

Physical dynamics of the connection are invariant under local changes of weak/hypercharge branch basis. Only gauge-covariant curvature data may enter the leading action.

Status: Required by local comparison being conventional up to local branch-frame choice.

Falsifier: Physical observables depend on arbitrary local weak/hypercharge basis choice.

GD-6 — Curvature-norm admissibility

The leading local cost of connection curvature is the positive quadratic norm of the curvature, taken with an invariant inner product on the gauge algebra.

Status: Conditional. This is the principal new dynamics premise of the paper, and Debt 1.

Falsifier: The substrate supplies a different leading local curvature cost not equivalent to the Yang–Mills quadratic norm.

GD-7 — Derivative minimality / refinement hierarchy

Among local gauge-covariant scalars, the leading dynamics are the lowest nontrivial derivative-order terms. Higher-derivative curvature terms are refinement-suppressed.

Status: Inherited from the refinement hierarchy.

Falsifier: Higher-derivative terms are not suppressed and dominate leading gauge dynamics.

GD-8 — Anomaly-admissible sources

Only anomaly-admissible source currents consistently source local gauge fields.

Status: Inherited from the anomaly-inadmissibility theorem.

Falsifier: A nonzero-anomaly source ledger consistently sources persistent gauge dynamics.

GD-9 — Minimal unbroken electroweak field content

At this layer the connection contains only the inherited W^i_μ and B_μ fields, with no additional anomaly-carrying gauge sectors or hidden commuting grades.

Status: Minimal-skeleton condition.

Falsifier: Additional unavoidable local gauge directions exist at the same representation layer.

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3. From Local Connection to Curvature

The local connection tells the theory how to compare internal weak/hypercharge states at neighbouring record-layer points. Let

$$D_\mu = \partial_\mu + i \mathcal{A}^{EW}_\mu.$$

The gauge curvature is defined by the commutator of covariant comparisons:

$$[D_\mu, D_\nu] = i F^{EW}_{\mu\nu}.$$

Expanding,

$$F^{EW}_{\mu\nu} = \partial_\mu \mathcal{A}^{EW}_\nu - \partial_\nu \mathcal{A}^{EW}_\mu + i [\mathcal{A}^{EW}_\mu, \mathcal{A}^{EW}_\nu].$$

Because

$$\mathcal{A}^{EW}_\mu = g W^i_\mu T_i + g' B_\mu Y,$$

and because

$$[T_i, T_j] = i \varepsilon_{ijk} T_k, [T_i, Y] = 0, [Y, Y] = 0,$$

the curvature decomposes over the direct sum:

$$F^{EW}_{\mu\nu} = g W^i_{\mu\nu} T_i + g' B_{\mu\nu} Y,$$

with component field strengths

$$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g \varepsilon_{ijk} W^j_\mu W^k_\nu,$$

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu.$$

The weak curvature contains a self-comparison term because weak branch rotations do not commute. The hypercharge curvature is abelian because Y commutes with itself and with the T_i.

The decomposition is itself informative: the commutator term produces no W–B mixed component and no B–B self-term, because the algebra places all noncommutativity inside the weak block. The block structure of the curvature is thus forced by the block structure of the algebra — a fact reused in Theorem 5.

This is the first genuine gauge-dynamical object of the paper.

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4. Curvature as Commitment-Transport Residue

In VERSF terms, the curvature is not a mathematical convenience.

The connection $\mathcal{A}^{EW}_\mu$ compares weak/hypercharge states between neighbouring record-layer points. A closed infinitesimal comparison loop asks:

If the substrate carries this weak/hypercharge record around a tiny loop, does the internal ledger return unchanged?

If it does, the connection is locally flat. If it does not, the mismatch is curvature.

Thus $F^{EW}_{\mu\nu}$ is the local record-layer residue of electroweak comparison transport. For weak transport, the residue has two parts:

1. ordinary local variation of the weak connection;
2. non-abelian self-comparison — carrying weak rotation A then weak rotation B is not the same as carrying B then A, and the transport residue records the difference.

For hypercharge transport, only the abelian variation remains.

VERSF reading

A flat connection is pure local comparison convention: it can be gauged to zero on any simply-connected record patch, and no local measurement distinguishes it from no connection at all. A curved connection is physical electroweak field content: no branch-frame redefinition removes it, because the curvature transforms covariantly rather than by shift.

The field strength is therefore the local obstruction to trivializing the electroweak comparison structure over a record patch. Gauge-invariant content lives exactly in what the loops fail to close.

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5. The Electroweak Curvature Theorem

Theorem 1 — Electroweak Curvature Theorem

Given the inherited local electroweak connection

$$\mathcal{A}^{EW}_\mu = g\, W^i_\mu T_i + g'\, B_\mu Y,$$

the unique gauge-covariant local comparison curvature is

$$F^{EW}_{\mu\nu} = g\, W^i_{\mu\nu} T_i + g'\, B_{\mu\nu} Y,$$

with

$$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g\, \varepsilon_{ijk} W^j_\mu W^k_\nu,$$

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu.$$

Proof

A local connection determines covariant derivatives $D_\mu = \partial_\mu + i\, \mathcal{A}^{EW}_\mu$. The infinitesimal closed-loop comparison residue is measured by the commutator $[D_\mu, D_\nu]$, which is a multiplication operator — the derivative terms cancel — and so defines a local, algebra-valued, antisymmetric tensor $F^{EW}_{\mu\nu}$ through $[D_\mu, D_\nu] = i\, F^{EW}_{\mu\nu}$. Expanding the commutator gives the universal curvature expression

$$F^{EW}_{\mu\nu} = \partial_\mu \mathcal{A}^{EW}_\nu - \partial_\nu \mathcal{A}^{EW}_\mu + i\, [\mathcal{A}^{EW}_\mu, \mathcal{A}^{EW}_\nu].$$

Under a local gauge transformation U, the connection transforms inhomogeneously while $F^{EW}_{\mu\nu} \to U F^{EW}_{\mu\nu} U^{-1}$: the curvature is covariant, and it is the unique antisymmetric two-index object built from $\mathcal{A}$ and one derivative with that property, up to overall normalization, since the inhomogeneous shift of the connection cancels only in this combination. Substituting the direct-sum electroweak connection and using

$$[T_i, T_j] = i\, \varepsilon_{ijk} T_k,\ [T_i, Y] = 0,\ [Y, Y] = 0$$

yields the stated decomposition. No further local curvature tensor can be built from the same connection at first derivative order. ■

Reading

The result is exact once the connection is accepted. The differential geometry is standard; the VERSF work is the interpretation licensed by GD-2 — curvature is the committed record-layer residue of local electroweak comparison, and therefore physical field content rather than notation.

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6. The Bianchi Closure Identity

The curvature is not free data. It descends from a connection, and that descent imposes an exact differential constraint.

Theorem 2 — Bianchi Closure Identity

The electroweak curvature obeys

$D_{[\lambda} F^{EW}_{\mu\nu]} = 0,$

which decomposes as

$(D_{[\lambda} W_{\mu\nu]})^i = \partial_{[\lambda} W^i_{\mu\nu]} - g\, \varepsilon_{ijk} W^j_{[\lambda} W^k_{\mu\nu]} = 0,$

$\partial_{[\lambda} B_{\mu\nu]} = 0.$

Proof

The identity follows from the Jacobi identity of covariant derivatives:

$[D_\lambda, [D_\mu, D_\nu]] + [D_\mu, [D_\nu, D_\lambda]] + [D_\nu, [D_\lambda, D_\mu]] = 0.$

Substituting $[D_\mu, D_\nu] = i F^{EW}_{\mu\nu}$ gives $D_{[\lambda} F^{EW}_{\mu\nu]} = 0$. Projecting onto the T_i and Y blocks of the direct sum gives the component forms. ■

Reading

The Bianchi identities are the homogeneous half of the electroweak field equations: they hold identically, before and independently of any action principle. In VERSF terms they say that comparison residue itself closes under comparison transport — curvature cannot be created or destroyed by relabelling, only moved. The sourced equations of Theorem 7 supply the other, dynamical half. The identities also certify internal consistency: any candidate field configuration violating them cannot descend from a connection and is therefore outside the inherited structure by GD-1.

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7. The Curvature-Norm Kinetic Theorem

The curvature gives the field strength. Dynamics require an action — a local cost for curvature.

The admissible leading gauge-dynamical term must be:

1. local (GD-3);
2. Lorentz-compatible (GD-4);
3. gauge-covariant (GD-5);
4. of lowest nontrivial derivative order (GD-7).

No parity condition is assumed. Parity-evenness of the leading local dynamics is derived, not premised: the parity-odd quadratic scalars are disposed of in the proof as total derivatives with vanishing local field equations, and the parity-odd sector is deferred to Debt 9.

The curvature $F^{EW}_{\mu\nu}$ is gauge-covariant. Its quadratic norm is the unique leading scalar satisfying these conditions. Because the algebra is the direct sum $\mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y$, the invariant quadratic form splits into weak and hypercharge blocks, carrying two independent scales. That two-parameter freedom of the block-diagonal invariant form is exactly the freedom carried by g and g′; this is why Theorem 3 fixes the form but not the couplings, and why the coupling values are Debt 2 rather than a gap in the uniqueness claim. With canonical normalization,

$$\mathscr{L}^{EW}_{gauge} = -\tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu}.$$

Theorem 3 — Curvature-Norm Kinetic Theorem

Given GD-1–GD-7, the unique leading unbroken electroweak gauge kinetic form is

$$\mathscr{L}^{EW}_{gauge} = -\tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu},$$

up to overall field normalization and possible topological total-derivative terms.

Proof

By GD-2, the physical field strength is the curvature; by GD-5, only gauge-covariant curvature data may enter. The exhaustion over candidate scalars runs as follows.

Order zero in curvature. Terms built from the bare connection are excluded by gauge covariance (Theorem 4 treats the mass case explicitly).

Order one in curvature. A Lorentz-scalar linear in $F^{EW}_{\mu\nu}$ requires contracting the antisymmetric pair $\mu\nu$. The metric contraction $g^{\mu\nu} F_{\mu\nu}$ vanishes by antisymmetry. The ε-contraction $\varepsilon^{\lambda\sigma\mu\nu} F_{\mu\nu}$ is a two-index density, not a scalar; tracing it against further curvature leaves the quadratic sector. A trace over the algebra, tr $F_{\mu\nu}$, vanishes on the $\mathfrak{su}(2)$ block (traceless generators) and on the $\mathfrak{u}(1)$ block reduces to an abelian total derivative with no local field equations. No nontrivial linear term survives.

Order two in curvature. A quadratic Lorentz scalar requires an invariant bilinear form on the algebra. On the simple factor $\mathfrak{su}(2)$, the invariant bilinear form is unique up to normalization (proportional to the Killing form). On $\mathfrak{u}(1)$ the quadratic form is likewise unique up to normalization. Cross-pairings vanish by the argument of Theorem 5. Hence the invariant quadratic norm is block-diagonal. Of the two index contractions available at this order, the parity-odd scalars $W^i_{\mu\nu} \tilde{W}^{i\,\mu\nu}$ and $B_{\mu\nu} \tilde{B}^{\mu\nu}$ are total derivatives whose local field equations vanish; they belong to the topological/CP sector (Debt 9) and contribute nothing to the leading local dynamics. Only the parity-even contraction survives as local dynamics — evenness is thereby derived, not assumed. Canonical field rescaling fixes the coefficients to −¼ each.

Higher orders and higher derivatives. By GD-7 all such terms are refinement-suppressed relative to the quadratic norm.

The quadratic curvature norm is therefore the unique leading admissible form. ■

Remark — Division of Labour

The exhaustion in the proof — resting on GD-3, GD-4, GD-5, GD-7 — establishes uniqueness of form only: if a leading local curvature cost exists, it is the block-diagonal quadratic norm. GD-6 supplies what the exhaustion cannot: existence (the coefficient of the norm is nonzero, so that curvature carries cost at all and the dynamics are nontrivial) and sign (the cost is positive — a stiffness, not an instability). The second point is not decorative: an algebra-invariant negative norm on the $\mathfrak{u}(1)$ block is fully consistent with GD-1–GD-5 and GD-7; only GD-6 excludes it. Uniqueness from GD-3/4/5/7; existence and positivity from GD-6.

Reading

The kinetic term is the local stiffness of electroweak comparison curvature: curvature in the weak/hypercharge comparison structure carries physical cost and therefore propagating field content. Positivity of the invariant norm (GD-6) is what makes the cost a stiffness rather than an instability — the record layer resists curvature; it does not reward it.

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8. Why No Unbroken Gauge Mass Term Appears

A mass term for the connection would have the schematic form

$m^2_W W^i_\mu W^{i \mu}$ or $m^2_B B_\mu B^\mu$.

Such terms are not built from curvature. They depend directly on the connection components — but the connection components are not gauge-invariant local objects: under local branch-frame redefinition they shift inhomogeneously.

Theorem 4 — No Unbroken W/B Mass Term

Given local electroweak comparison invariance (GD-5), no direct mass term for W^i_μ or B_μ is admissible in the unbroken representation phase.

Proof

Under a local gauge transformation the connection transforms as $\mathcal{A}_\mu \to U \mathcal{A}_\mu U^{-1} - i (\partial_\mu U) U^{-1}$. The inhomogeneous shift term makes any polynomial in the bare connection — in particular the quadratic contraction $W^i_\mu W^{i \mu}$ or $B_\mu B^\mu$ — non-invariant, and no local compensating term built from the connection alone restores invariance. Since local weak/hypercharge branch-frame choice is conventional, physical dynamics cannot depend on such a term. The only admissible leading local expressions are curvature-based, and the curvature norm contains no connection-square piece. Hence no unbroken Proca-type mass term appears. ■

Reading

This theorem is why electroweak symmetry breaking must be a downstream module, not a patch on this layer. If W and Z masses appear in nature — and they do — they cannot appear as bare unbroken connection masses. They must arise from a later vacuum structure that changes which combinations of the connection remain gauge-redundant and which acquire stiffness against the vacuum. The unbroken layer derived here is exactly massless, and exactly because comparison is local convention.

The restriction in the proof to terms built from the connection alone is essential and deliberate. With additional field content, gauge-invariant mass is possible — Stückelberg and condensate mechanisms are exactly of this kind. That is not an objection to the theorem; it is the theorem read forward: mass requires new vacuum or field structure beyond the connection, which is precisely what the downstream closure-norm module supplies.

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9. Why No Leading Cross-Term Appears

Could the leading kinetic form contain a mixed weak–hypercharge term of the form $B_{\mu\nu} W^{3 \mu\nu}$?

The direct-sum algebra blocks it.

Theorem 5 — No Leading W/B Kinetic Cross-Term

For the minimal electroweak representation algebra $\mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y$, the leading gauge-covariant kinetic form contains no weak–hypercharge cross-term.

Proof

A mixed quadratic term requires an invariant bilinear pairing $\kappa(T_i, Y)$ between the weak generators and the hypercharge generator. Invariance of κ under the algebra gives

$\kappa([T_j, T_i], Y) + \kappa(T_i, [T_j, Y]) = 0$,

and since $[T_j, Y] = 0$, this forces $\kappa([T_j, T_i], Y) = 0$ for all i, j. Because $\mathfrak{su}(2)$ is perfect — $[\mathfrak{su}(2), \mathfrak{su}(2)] = \mathfrak{su}(2)$ — the commutators span the full weak block, hence $\kappa(T_k, Y) = 0$ identically. The invariant bilinear form is therefore block-diagonal, and no leading cross-term $B_{\mu\nu} W^{i \mu\nu}$ exists. As a representation-level corollary: $\mathrm{tr}(T_i Y) \propto \mathrm{tr}(T_i) \cdot Y = 0$ on each weak irreducible sector, since the T_i are traceless. ■

Scope note

This does not derive the absence of kinetic mixing in theories with multiple abelian factors. The proof makes the boundary exact: the exclusion rests on the perfectness of $\mathfrak{su}(2)$, and abelian factors are precisely where perfectness fails — $[\mathfrak{u}(1), \mathfrak{u}(1)] = 0$, so the invariance identity constrains nothing and two commuting generators admit a nonzero invariant pairing. If a second anomaly-admissible U(1) — for example gauged B−L in a ν_R-extended skeleton — is introduced, abelian kinetic mixing $B_{\mu\nu} B'^{\mu\nu}$ becomes a live, algebra-permitted question. That case is excluded here by the minimal field-content premise GD-9 and logged as a boundary condition. The absence of cross-terms is a theorem about the minimal skeleton, not about all extensions.

Reading

Before symmetry breaking, W^3 and B do not mix — not by assumption but because the algebra forbids an invariant pairing. The observed photon–Z mixing of nature is therefore necessarily a broken-phase phenomenon, produced by vacuum selection downstream, never by the unbroken kinetic layer. The Weinberg angle has no home at this layer; that is a derived firewall, not a stipulated one.

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10. Matter Coupling and Electroweak Currents

The representation-level covariant derivative is

$$D_\mu = \partial_\mu + i\, g\, W^i_\mu T_i + i\, g'\, B_\mu Y,$$

and the matter kinetic term is

$$\mathscr{L}_{matter} = \bar{\psi}\, i\, \gamma^\mu D_\mu \psi,$$

with ψ running over the inherited chiral skeleton and the T_i, Y acting sector by sector. Expanding the connection coupling gives

$$\mathscr{L}_{int} = -g\, W^i_\mu J^\mu_i - g'\, B_\mu J^\mu_Y,$$

up to the sign convention fixed by D_μ, where

$$J^\mu_i = :\bar{\psi}_L \gamma^\mu T_i \psi_L:, \quad J^\mu_Y = :\bar{\psi} \gamma^\mu Y \psi:.$$

The weak current is left-projected because T_i acts only on L_L and Q_L. The hypercharge current runs over all sectors, weighted by the hypercharge ledger.

A note on notation: the normal-ordering colons anticipate the quantum ledger of Proposition 8, where current closure becomes a genuinely quantum question. At the classical layer of this section and the next they may be read as trivial; no quantum input enters the derivation until Section 12, in keeping with the renormalisation firewall.

Proposition 6 — Source-Current Coupling

Given the inherited electroweak representation, the only leading local source coupling of the connection to matter is through the weak current J^μ_i and the hypercharge current J^μ_Y:

$$\mathscr{L}_{int} = -g\, W^i_\mu J^\mu_i - g'\, B_\mu J^\mu_Y.$$

Proof

The connection couples by replacing ∂_μ with D_μ in the local matter kinetic term — minimal coupling is forced, since any non-minimal local coupling involves the curvature and enters at higher operator dimension, hence is refinement-suppressed by GD-7. Since the connection is valued only in T_i and Y, the currents produced by variation are exactly those associated with these generators. No right-handed weak current appears because T_i annihilates the right singlets. ■

Reading

The currents are not new objects: they are the record-currents of the representation layer, now identified as the sources of the gauge layer. The chirality structure of the weak current — left pairs couple, right singlets do not — is inherited, not imposed.

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11. Source-Coupled Field Equations

The unbroken electroweak Lagrangian at this layer is

$$\mathscr{L}^{\text{unbroken\_EW}} = \bar{\psi}\, i\, \gamma^\mu D_\mu \psi - \tfrac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \tfrac{1}{4} B_{\mu\nu} B^{\mu\nu}.$$

Theorem 7 — Electroweak Source-Coupled Field Equations

Given the curvature-norm kinetic form and the inherited matter coupling, the unbroken electroweak gauge fields obey

$$(D_\nu W^{\nu\mu})^i = g\, J^\mu_i,$$

$$\partial_\nu B^{\nu\mu} = g'\, J^\mu_Y,$$

where

$$(D_\nu W^{\nu\mu})^i = \partial_\nu W^{i\,\nu\mu} - g\, \varepsilon_{ijk} W^j_\nu W^{k\,\nu\mu}$$

in the sign convention of this paper.

Proof

Vary the action with respect to W^i_μ and B_μ. For the non-abelian weak field, the variation of the curvature is the covariant derivative of the variation, $\delta W^i_{\mu\nu} = (D_\mu \delta W_\nu - D_\nu \delta W_\mu)^i$; integrating by parts against the kinetic term yields the covariant divergence of $W^{\nu\mu}$, and the matter term supplies $g J^\mu_i$. For the abelian hypercharge field the variation is ordinary and gives $\partial_\nu B^{\nu\mu} = g' J^\mu_Y$. Together with the Bianchi identities of Theorem 2 these constitute the complete leading field-equation set. ■

Reading

The W and B fields are now dynamical, source-responsive fields — not labels on a connection. Three structural features are worth naming.

First, the weak field self-sources: expanding the covariant divergence moves the non-abelian term to the right-hand side as a field-valued current, so weak curvature carries weak charge. The hypercharge field does not self-source, because it carries no hypercharge.

Second, the antisymmetry of $W^{\nu\mu}$ and $B^{\nu\mu}$ makes the equations integrable only if the total right-hand currents close — the consistency condition developed in Section 12.

Third, the equations are first-order in curvature and second-order in the connection, the minimal dynamical order — a direct expression of GD-7.

---

12. Gauge Covariance and Current Closure

The field equations must be compatible with source-current closure.

Taking the covariant divergence of the weak equation and using the antisymmetry of the field strength gives, as a consistency requirement,

$$(D_\mu J^\mu)^i = 0,$$

and likewise for the hypercharge sector

$$\partial_\mu J^\mu_Y = 0.$$

Classically these follow from gauge covariance and the matter field equations: they are the Noether closures of the local symmetry. Quantum mechanically they are not automatic — chiral measures can fail to preserve them. Their quantum survival is exactly the anomaly-admissibility of the source ledger.

Proposition 8 — Current Closure Condition

The unbroken electroweak gauge field equations are consistent only when the chiral source ledger is anomaly-admissible.

Proof

The covariant divergence of $(D_\nu W^{\nu\mu})^i$ vanishes identically by antisymmetry of $W^{\nu\mu}$ and the algebra, so the weak equation forces $(D_\mu J^\mu)^i = 0$; likewise $\partial_\mu \partial_\nu B^{\nu\mu} = 0$ forces $\partial_\mu J^\mu_Y = 0$. If the quantum chiral source ledger carries a nonzero anomaly class, these closures fail at one loop, and the field equations demand a conserved source while the ledger supplies a leaking one. By the substrate anomaly-inadmissibility theorem, such a ledger is not physically admissible as a persistent record-current sector. Therefore consistent source-coupled gauge dynamics require anomaly-admissible matter. ■

Scope note

The one-loop failure in question is that of the consistent (Wess–Zumino) anomaly; the covariant-divergence language above is classical shorthand, and the consistent/covariant distinction — including which divergence the anomaly class obstructs — is handled in the anomaly-inadmissibility paper, whose admissibility class is the one inherited here through GD-8. The conclusion of Proposition 8 is insensitive to the choice: vanishing of the anomaly class kills both forms.

Reading

This is where the anomaly paper becomes load-bearing for dynamics. A gauge field can only be consistently sourced by a ledger that closes. The VERSF result is therefore not merely

connection → field strength.

It is

anomaly-admissible connection → consistent source-coupled gauge dynamics.

---

13. Relation to Substrate Anomaly-Inadmissibility

The anomaly-inadmissibility paper proved that a nonzero anomaly class prevents a source ledger from persisting as a record-current sector. The present paper uses that theorem as a dynamical consistency condition.

Without anomaly closure, the field equations would demand a conserved source while the quantum matter ledger supplied a leaking one; the gauge dynamics would be incoherent. With anomaly closure, the gauge field equations and matter currents co-exist consistently.

Consequence

The anomaly theorem is no longer only about charge-table rigidity. It is the precondition for electroweak gauge dynamics. The chain becomes

matter skeleton → electroweak connection → anomaly-admissible source ledger → gauge-curvature dynamics.

Each arrow is a theorem in its own paper, and the arrows compose: the hypercharge ledger that anomaly-rigidity uniquely selects is the same ledger whose currents source the field equations derived here. The rigidity result upstream is what makes the source structure downstream non-adjustable.

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14. Relation to Closure-Norm Electroweak Breaking

This paper derives the unbroken gauge-dynamics layer. It does not derive the broken vacuum.

The downstream closure-norm condensation module acts on the gauge-dynamical structure derived here. Its task is to show how a closure-norm condensate selects a vacuum direction and confers stiffness — mass — on some connection directions while leaving one electromagnetic direction unbroken.

The logical sequence is

$\mathfrak{su}(2)_L \oplus \mathfrak{u}(1)_Y \rightarrow \mathcal{A}^{EW}_\mu \rightarrow W^i_{\mu\nu}, B_{\mu\nu} \rightarrow \mathscr{L}^{EW}_{gauge} \rightarrow$ closure-norm condensation $\rightarrow U(1)_{EM}$, W/Z masses.

The present paper supplies the third and fourth links. Two of its theorems fix the shape of the downstream problem in advance: Theorem 4 shows the masses cannot be placed at this layer, so any mass mechanism must act through the vacuum rather than the action; Theorem 5 shows W^3–B mixing cannot be placed at this layer, so the Weinberg angle must be a property of the condensate direction, not of the kinetic form.

Boundary

This paper does not identify the photon as a mixture of B_μ and W^3_μ, does not derive the Weinberg angle, and does not derive the W/Z mass matrix. It prepares the unbroken gauge fields those later results require.

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15. The Unbroken Electroweak Gauge-Dynamics Theorem

Theorem 9 — Unbroken Electroweak Gauge-Dynamics Closure

Given:

1. the inherited chiral matter skeleton (0″.1);
2. the inherited electroweak representation algebra (0″.2);
3. the inherited local connection form (GD-1);
4. anomaly-admissible source ledgers (GD-8);
5. local curvature as comparison residue (GD-2);
6. curvature-norm admissibility (GD-6);
7. derivative minimality and Lorentz compatibility (GD-3, GD-4, GD-7);
8. minimal unbroken field content (GD-9);

the VERSF record-layer electroweak sector admits the unique leading unbroken gauge-dynamical Lagrangian

$$\mathscr{L}^{\text{unbroken\_EW}} = \bar{\psi}\, i\, \gamma^\mu D_\mu \psi - \frac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu},$$

with

$$D_\mu = \partial_\mu + i\, g\, W^i_\mu T_i + i\, g' B_\mu Y,$$

$$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g\, \varepsilon_{ijk} W^j_\mu W^k_\nu,$$

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu,$$

homogeneous identities

$$D_{[\lambda} F^{EW}_{\mu\nu]} = 0,$$

and source equations

$$(D_\nu W^{\nu\mu})^i = g\, J^\mu_i, \quad \partial_\nu B^{\nu\mu} = g' J^\mu_Y,$$

consistent if and only if the source ledger is anomaly-admissible.

Proof

The inherited connection gives the covariant derivative. Theorem 1 gives the field strengths; Theorem 2 gives the Bianchi identities. Theorem 3 gives the unique leading kinetic form; Theorems 4 and 5 exclude mass and cross-terms. Proposition 6 gives the source currents from the inherited representation. Theorem 7 gives the field equations by variation. Proposition 8 supplies the current-closure condition required for consistency, discharged by GD-8. ■

Status

Exact given GD-1–GD-9. Conditional as a VERSF physical derivation, because the curvature-norm admissibility principle (GD-6) and the microscopic emergence of gauge dynamics from substrate closure transport remain to be derived in deeper substrate terms (Debt 1).

16. What Has Actually Been Derived

This paper derives, conditionally on GD-1–GD-9:

1. the electroweak curvature from the inherited W/B connection;
2. the non-abelian weak field strength;
3. the abelian hypercharge field strength;
4. the Bianchi closure identities as exact structural constraints;
5. the interpretation of curvature as local commitment-transport residue;
6. the leading curvature-square kinetic form and its uniqueness;
7. the absence of unbroken direct W/B mass terms;
8. the absence of a leading weak–hypercharge kinetic cross-term in the minimal skeleton;
9. the source-coupled unbroken electroweak field equations;
10. the dependence of gauge-dynamical consistency on anomaly-admissible source currents;
11. the unbroken electroweak gauge-dynamics layer required by downstream electroweak breaking.

This paper does not derive:

1. numerical values of g, g′;
2. the gauge kinetic term from a fully microscopic substrate action;
3. electroweak symmetry breaking;
4. photon emergence;
5. the Weinberg angle;
6. W/Z masses;
7. the Higgs vev;
8. Yukawa couplings;
9. fermion masses;
10. CKM or PMNS structure;
11. three generations;
12. renormalised electroweak perturbation theory;
13. gauge fixing and ghost structure;
14. nonperturbative electroweak effects;
15. the coefficients of the topological $W\tilde{W}$ and $B\tilde{B}$ sectors.

17. Open Debts

Debt 1 — Microscopic derivation of curvature-norm admissibility

The paper uses the curvature-norm principle (GD-6): the leading local cost of connection curvature is the quadratic invariant norm. A deeper substrate-dynamics paper must derive this directly from closure transport, refinement stability, and record-current stiffness — including both the nonvanishing of the norm (existence of the cost) and its positivity (stiffness rather than instability), which are exactly the two things GD-6 supplies in Theorem 3 that the uniqueness exhaustion cannot. This is the principal remaining debt.

Debt 2 — Coupling values

The paper derives where g and g′ enter. It does not derive their numerical values or their running.

Debt 3 — Gauge-field quantisation

The paper gives the classical record-layer gauge dynamics. Gauge fixing, ghosts, BRST structure, perturbative quantisation, and renormalisation remain owed.

Debt 4 — Electroweak symmetry breaking

The downstream closure-norm condensation module must act on the unbroken gauge dynamics derived here to produce the broken phase.

Debt 5 — Weinberg angle and photon

The photon and Z directions require vacuum selection and mixing after symmetry breaking. Theorem 5 shows they cannot arise earlier.

Debt 6 — W/Z masses

Gauge boson masses must arise from the downstream condensate. Theorem 4 shows they cannot arise as unbroken mass terms.

Debt 7 — Full colour gauge dynamics

This paper derives electroweak gauge dynamics only. The continuous colour lift and QCD gauge-curvature dynamics remain a separate module, to which the methods of Theorems 1–3 are expected to transfer with $\mathfrak{su}(3)$ in place of $\mathfrak{su}(2) \oplus \mathfrak{u}(1)$.

Debt 8 — Hidden gauge-sector exclusion

The minimal skeleton excludes additional gauge directions by GD-9. A stronger theorem should show that no hidden low-energy gauge directions are forced by the substrate, and should treat abelian kinetic mixing in ν_R-extended ledgers (Section 9, scope note).

Debt 9 — Topological sector

The CP-odd total-derivative terms $W \tilde{W}$ and $B \tilde{B}$ carry no local field equations but may carry global record-layer content. Their coefficients, and whether the substrate fixes or forbids them, remain owed.

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18. Falsification Conditions

F1 — Connection failure

If the inherited W/B connection form fails, the curvature dynamics derived here lose their base.

F2 — Curvature non-physicality

If local comparison curvature is not the physical field strength of a VERSF connection, Theorem 1 loses its physical reading.

F3 — Bianchi failure

If admissible electroweak field configurations violate D_[λ F^EW_μν] = 0, they do not descend from a connection and GD-1 fails.

F4 — Curvature-norm failure

If the leading local gauge-dynamical cost is not the quadratic curvature norm, Theorem 3 fails.

F5 — Gauge-covariance failure

If physical dynamics depend on arbitrary local weak/hypercharge branch-frame choices, the gauge-dynamics construction fails.

F6 — Unbroken mass leakage

If direct W/B mass terms are admissible before symmetry breaking, Theorem 4 fails and the layer separation from electroweak breaking collapses.

F7 — Cross-term failure

If a genuine leading gauge-invariant W/B kinetic cross-term exists in the minimal skeleton, Theorem 5 fails.

F8 — Source-current failure

If the inherited electroweak currents do not source the W/B fields in the derived form, Theorem 7 fails.

F9 — Anomaly-source failure

If anomalous ledgers can consistently source persistent gauge fields, Proposition 8 and the link to anomaly-inadmissibility fail.

F10 — EWSB contamination

If the derivation is shown to require broken-phase data — the Weinberg angle, W/Z masses, or the Higgs vev — the unbroken-phase firewall fails.

F11 — Mass contamination

If the derivation is shown to require fermion masses, Yukawa couplings, CKM, or PMNS input, the mass firewall fails.

F12 — Hidden-sector obstruction

If unavoidable extra gauge directions appear at the same representation layer, GD-9 fails and the minimal unbroken theorem is incomplete.

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19. Milestone Statement

The result of this paper is

electroweak connection + curvature closure + curvature-norm admissibility + anomaly-admissible source ledger ⟹ unbroken electroweak gauge dynamics.

Explicitly:

$\mathcal{A}^{EW}_\mu = g W^i_\mu T_i + g' B_\mu Y$

gives

$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g\, \varepsilon_{ijk} W^j_\mu W^k_\nu$,

$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu$,

with

$\mathscr{L}^{EW}_{gauge} = -\frac{1}{4} W^i_{\mu\nu} W^{i\,\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$,

homogeneous identities

$D_{[\lambda} F^{EW}_{\mu\nu]} = 0$,

and source equations

$(D_\nu W^{\nu\mu})^i = g J^\mu_i$, $\partial_\nu B^{\nu\mu} = g' J^\mu_Y$.

The paper therefore upgrades the programme from

electroweak representation / connection

to

electroweak gauge-curvature dynamics.

That is the intended milestone.

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20. Conclusion

The previous VERSF papers derived the chiral matter skeleton, the electroweak representation algebra, the local W/B connection form, and the substrate inadmissibility of anomalous chiral source ledgers.

The present paper moves the programme one layer forward.

A local connection is not yet a dynamical gauge field. It becomes one when its local comparison curvature is treated as physical record-layer content. The curvature of the inherited electroweak connection decomposes into the non-abelian weak field strength and the abelian hypercharge field strength, obeying exact Bianchi closure. The leading admissible local action is the invariant quadratic curvature norm, giving the unbroken electroweak gauge kinetic structure — with no mass term possible at this layer, no weak–hypercharge mixing possible at this layer, and consistency contingent on anomaly-admissible sources.

The result is not yet the full electroweak theory. It does not derive symmetry breaking, the photon, W/Z masses, the Weinberg angle, the Higgs vev, or fermion masses. But it supplies the gauge-dynamical layer those later modules require — and it fixes, by theorem, where those later modules must act: through the vacuum, not through the action.

The programme has now advanced:

fermion algebra → chiral matter skeleton → electroweak representation / connection → substrate anomaly admissibility → unbroken electroweak gauge dynamics.

The remaining work is sharper: derive the curvature-norm action directly from substrate closure dynamics, compute or constrain the coupling constants, quantise the gauge sector, complete the colour-gauge dynamics, and let closure-norm condensation act on the derived electroweak gauge fields to produce the broken-phase photon, W, and Z.

Appendix A — Component Conventions

This paper uses

$D_\mu = \partial_\mu + i \mathcal{A}_\mu$,

so that

$[D_\mu, D_\nu] = i F_{\mu\nu}$,

with

$F_{\mu\nu} = \partial_\mu \mathcal{A}_\nu - \partial_\nu \mathcal{A}_\mu + i [\mathcal{A}_\mu, \mathcal{A}_\nu]$.

For

$\mathcal{A}_\mu = g W^i_\mu T_i + g' B_\mu Y$, $[T_i, T_j] = i \varepsilon_{ijk} T_k$,

this gives

$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu - g \varepsilon_{ijk} W^j_\mu W^k_\nu$.

If one instead defines $D_\mu = \partial_\mu - i \mathcal{A}_\mu$, the commutator convention changes and the sign of the non-abelian self-term flips; the two conventions are equivalent. Under a local gauge transformation $U(x)$,

$\mathcal{A}_\mu \to U \mathcal{A}_\mu U^{-1} - i (\partial_\mu U) U^{-1}$, $F_{\mu\nu} \to U F_{\mu\nu} U^{-1}$, $\psi \to U \psi$, $D_\mu \psi \to U D_\mu \psi$.

The emergent-metric signature and γ-matrix conventions follow the fermionic Fock-space reconstruction paper. Antisymmetrisation $[\lambda\mu\nu]$ is with unit weight: $X_{[\lambda\mu\nu]} = \frac{1}{6} (X_{\lambda\mu\nu} + \text{cyclic} - \text{anticyclic})$ for a general tensor, reducing to ⅓ × the cyclic sum for tensors already antisymmetric in the last pair. Since the Bianchi identity is homogeneous, the overall ⅓ is immaterial to its content but is retained for exactness of convention.

Appendix B — Allowed and Excluded Leading Operators

Candidate term	Status	Reason
$W^i_{\mu\nu} W^{i\,\mu\nu}$	Allowed	Leading weak curvature norm (Theorem 3)
$B_{\mu\nu} B^{\mu\nu}$	Allowed	Leading hypercharge curvature norm (Theorem 3)
$W^i_\mu W^{i\,\mu}$	Excluded in unbroken phase	Not gauge-invariant; Theorem 4
$B_\mu B^\mu$	Excluded in unbroken phase	Not gauge-invariant; Theorem 4
$B_{\mu\nu} W^{i\,\mu\nu}$	Excluded	No invariant pairing; perfectness of $\mathfrak{su}(2)$ (Theorem 5)
$g^{\mu\nu} F_{\mu\nu}$, $\mathrm{tr}\, F_{\mu\nu}$	Vanishing / boundary	Antisymmetry; tracelessness or abelian total derivative
$W^i_{\mu\nu} \tilde{W}^{i\,\mu\nu}$	Topological / not derived	Total-derivative CP sector; coefficient not fixed (Debt 9)
$B_{\mu\nu} \tilde{B}^{\mu\nu}$	Topological / not derived	Total-derivative CP sector; coefficient not fixed (Debt 9)
Higher-derivative curvature terms	Suppressed / owed	Refinement hierarchy (GD-7) places downstream
Non-minimal $\bar{\psi} \sigma^{\mu\nu} F_{\mu\nu} \psi$ couplings	Suppressed / owed	Higher operator dimension; refinement-suppressed
Abelian kinetic mixing $B_{\mu\nu} B'^{\mu\nu}$	Excluded by field content	GD-9; reopens in ν_R-extended multi-U(1) ledgers
Higgs / condensate mass terms	Downstream	Belong to the EWSB module
Fermion mass / Yukawa terms	Firewalled	Belong to the mass-attachment programme