Nonlinear Corrections and the Force Strength Residual in VERSF

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18 November 2026

General reader summary

The seven-state construction gives candidate force strengths close to the comparison values. This paper asks whether internal movement and the preservation of records can account for the remaining differences. It builds connected models in which every internal adjustment is counted once, then tests what those models actually produce.

For one specified connection, the calculation removes about 82 per cent of the remaining hypercharge discrepancy. Hypercharge helps produce electromagnetism. With that connection, the weak comparison stays unchanged. Allowing different connections opens another possibility: changing colour and hypercharge together can improve both comparisons without directly changing the weak response. The paper gives a working example, but its two connections are chosen using the measured differences, so it is a fit rather than a prediction.

Keeping a record fixed also changes quantum fluctuations and produces a positive effect on the calculated stiffness. In the compact model tested here, that effect still fails to produce the relative changes required by the measurements. The paper establishes which conclusions follow from the equations and which depend on how physical quantities are connected to the model. Deriving those connections and their observable meaning remains necessary to establish the three force strengths.

Abstract

We calculate nonlinear and joint-response corrections to the seven-state VERSF wheel candidate with inverse squared gauge couplings $Z_A = (31/59)K_A$. The Gaussian wheel has no additional source-dependent auxiliary determinant. A compact group-valued completion gives leading quantum and static corrections that fail the scale- and common-normalisation-free comparison. A positive coupled wheel–participation action reproduces the conditional 81.7 per cent reduction of the hypercharge residual and yields its exact dependence on source placement. Its zero relaxed colour and weak corrections hold for specified axis embeddings. General source covectors give a rank-one compliance response and admit a two-parameter, softening-only fit of the linearised comparison; the axis embedding is a declared construction choice. A preserved alternating group word leaves the classical coefficient unchanged but adds positive leading quantum stiffness. Every subset of the tested whole-factor locks nevertheless retains a positive transverse slope, opposite to the required negative correction. The result is a solved set of finite constructions, including their propagation, source dependence and limits. Physical source admission and observable matching remain open; the three measured gauge strengths are not derived.

Contents

1 The numerical target 3
2 What the original construction already includes 3
3 A nonlinear completion of the wheel 3
4 The calculated correction 4
5 Comparison after calibrating the strong interaction 5
6 What the mixed current response must supply 6
7 Published record and matching responses 7
8 The common action calculation 9
9 A coupled wheel and participation response 10
10 Quantum response of a preserved record 13
11 Verification and conclusion 15
Appendix A The site matrices 16
Appendix B Sources and reproduction 16
References 17

1 The numerical target

The fixed candidate [1] has unit matter vertices and inverse squared gauge couplings

$$Z_A^{(0)} = sK_A, \qquad s = \frac{31}{59}, \qquad (K_C, K_W, K_Y) = \left(6, \frac{13}{2}, \frac{21}{2}\right). \qquad (1)$$

The precision comparison [2] uses the strong interaction to determine the comparison scale. With its stated Standard Model inputs, highest available SMDR running mode and zero additional native finite matching, that scale is $\mu_0 = 8.08995379 \times 10^{13}$ GeV. The required boundary correction is

$$\Delta Z_{\mathrm{req}} = Z^{\mathrm{SM}}(\mu_0) - Z^{(0)} = (0,\ 0.02714224049,\ -0.09022285612). \qquad (2)$$

These are corrections to $Z = 1/g^2$, not to g. The weak coefficient must increase by 0.794736 per cent and the hypercharge coefficient must decrease by 1.635376 per cent relative to the candidate. The strong value is a calibration input. The matching and experimental assumptions of [2] remain in force.

Status convention. Exact results refer to the written actions. The compact completion and the coupled Gaussian family are well-posed mathematical constructions with declared source embeddings, interactions and record conditions. Neither is offered as the admitted microscopic realisation of the full VERSF master action. Recovering an inherited coefficient by construction establishes consistency, not independent physical selection. The static, quantum and alternative boundary prescriptions are separate calculations; their outputs are combined only when derived within one parent. Each fluctuating variable and determinant is counted once. Experimental couplings enter the comparison and explicitly labelled diagnostic fits, including the source-direction fit in Section 9.3. Perturbative statements concern their stated orders. One admitted realisation would suffice; uniqueness is not required.

2 What the original construction already includes

For one curvature component F, the auxiliary action of [1] is

$$S_0(F, R) = \frac{1}{2} \| \chi F - R \|^2_{\pi,\mathrm{Tr}} + \frac{1}{2}\langle R, LR\rangle_{\pi,\mathrm{Tr}}, \qquad L = I - P. \qquad (3)$$

The hub row of P is uniform; each rim row assigns weight $1/4$ to itself, the hub and its two neighbours. The stationary weights are $(7,4,4,4,4,4,4)/31$. The normalised profile is $\chi = (24, -7, -7, -7, -7, -7, -7)/\sqrt{168}$ and $L\chi = (31/28)\chi$.

Completing the square gives $R_* = (I + L)^{-1}\chi F$ and the coefficient in (1). The auxiliary Hessian is independent of F. Therefore its determinant has no curvature response. This holds for arbitrary non-Abelian curvature, including the commutator in F.

Exact result. The original auxiliary sector supplies no further field-dependent Gaussian correction. Adding another auxiliary variance or determinant to (1) would count the same fluctuations twice. Ordinary Standard Model gauge and matter contributions included in [2] also cannot be reused as an additional native correction. A new effect requires a changed interaction, measure, dynamical attachment or finite matching calculation.

3 A nonlinear completion of the wheel

Keep the wheel, stationary weights, profile and 50-address representation of [1]. Replace the seven algebraic variables by $U_i \in SU(3) \times SU(2) \times U(1)$ with product Haar measure. For a dimensionless cell source fT, define

$$\frac{V_f(U)}{w} = \sum_i \pi_i \,\mathrm{ReTr}\left(I - U_i^\dagger e^{i\chi_i fT}\right) + \sum_{i<j} \omega_{ij}\,\mathrm{ReTr}\left(I - U_i^\dagger U_j\right), \quad \omega_{ij} = \pi_i P_{ij}. \qquad (4)$$

Here $w > 0$ is the common energy unit. Each term is nonnegative and invariant under simultaneous gauge conjugation. Expansion about the identity reproduces (3) exactly to quadratic order. The local minimum has $U_i = \exp(i\xi_i fT) + O(f^3)$, where $\xi = (I + L)^{-1}\chi = (28/59)\chi$. Consequently $V_{\min}''(0)/w = s\mathrm{Tr}T^2$.

This completion uses the nonlinear trace-bond form of [3]; it does not copy the triangle's numerical slopes onto a wheel. The seven-site action is written explicitly and its response is recalculated. A compact bond law is additional information beyond the Gaussian parent. The profile is an energy profile, not a replacement for the ordinary matter connection. Relating the dimensionless source to geometric curvature remains part of physical matching.

For a canonical quantum test, declare the stationary-weighted bi-invariant metric and Hamiltonian

$$H_f = -\frac{\hbar^2}{2m}\sum_i \pi_i^{-1}\Delta_{G,i} + V_f, \qquad \eta = \frac{\hbar}{\sqrt{mw}} > 0. \qquad (5)$$

The group metric uses $t_b = T_b/\sqrt{K_b}$. Equation (5) supplies independent motion that the original algebraic auxiliaries did not possess. It is a conditional dynamical completion, not a derivation of m. On the compact configuration space it is a well-defined quantum problem. We calculate its leading small-η response.

As a separate measure check, also define $F_\vartheta(f) = -w\vartheta\log\int d\mu_H \exp\left[-V_f/(w\vartheta)\right]$. Its small-$\vartheta$ correction comes from a static integral. This defines the alternative static ensemble.

4 The calculated correction

Let $A(f)$ be the 84-dimensional potential Hessian in orthonormal left-invariant frames at the classical minimum. The seven-site matrix and its spectrum are

$$M = I + \Pi^{1/2}L\Pi^{-1/2}, \qquad A(0) = M \otimes I_{12}, \qquad \mathrm{spec}M = \left\{1, \frac{3}{2}, \frac{3}{2}, 2, 2, \frac{59}{28}, \frac{9}{4}\right\}. \qquad (6)$$

The first zero-point term is $w\eta\mathrm{Tr}\sqrt{A(f)}/2$. The two representation contractions are those of [3], but the site coefficients are calculated from (4):

$$Q_T = \sum_b \mathrm{Tr}\left(T^2 t_b^2\right), \qquad C_T = \sum_b \mathrm{Tr}\left([T, t_b]^\dagger [T, t_b]\right). \qquad (7)$$

Proposition 1. For (4)–(5), the local ground-energy curvature is

$$\frac{E_0''(0)}{w} = sK_T - \eta\left(a_q Q_T + b_q C_T\right) + O(\eta^2), \qquad \left(a_q, b_q\right) = (0.817810332765,\ 0.009696896416). \qquad (8)$$

Both coefficients are positive. For the alternative static integral,

$$\frac{F_\vartheta''(0)}{w} = sK_T - \vartheta(a_s Q_T + b_s C_T) + O(\vartheta^2), \quad a_s = \frac{107698309}{88723728}, \quad b_s = \frac{6727}{205379}. \qquad (9)$$

Derivation. Write $A'(0) = J \otimes B_T$ and $A''(0) = N \otimes M_T$, with the site matrices given in the Appendix. Their representation factors satisfy $\mathrm{Tr}M_T = Q_T$ and $\| B_T \|_F^2 = C_T/4$. In an eigenbasis of M, write $\widetilde{N} = O^T N O, \tilde{J} = O^T J O$ and $v_i = \sqrt{\lambda_i}$. Differentiating the matrix square root gives

$$a_q = -\frac{1}{4}\sum_i \frac{\widetilde{N}_{ii}}{v_i}, \qquad b_q = \frac{1}{16}\sum_{ij} \frac{\tilde{J}_{ij}^2}{v_i v_j\left(v_i + v_j\right)}. \qquad (10)$$

Here N is negative definite, so $a_q > 0$, and the mixing term gives $b_q > 0$. The static coefficients follow by replacing these expressions with $a_s = -\mathrm{Tr}(M^{-1}N)/2$ and $b_s = -\mathrm{Tr}(M^{-1}JM^{-1}J)/8$. Haar-measure and metric-curvature terms, and the quantum displacement of the minimum, enter beyond the leading order in

(8). The static determinant uses Haar volume in moving orthonormal frames; no separate source Jacobian is added. ▫

Table 1. Responses calculated from the compact wheel. Each slope multiplies its own positive expansion parameter. The columns refer to the two ensembles defined in Section 3.

Sector	Q_A	C_A	Quantum slope	Static slope
Colour	$1447/819$	3	−1.473988799	−2.242898929
Weak	$38/21$	2	−1.499241062	−2.262019269
Hypercharge	$4976/2457$	0	−1.656257312	−2.458353416

The contraction Q_A includes all shared matter-charge blocks. The non-Abelian mode mixing is retained in C_A. Sterile addresses contribute neither. All three leading corrections soften the energy response.

5 Comparison after calibrating the strong interaction

A colour correction changes the scale selected by the strong interaction. It is therefore insufficient to compare only the signs in Table 1. Let $v_A = dZ_A^{\mathrm{SM}}/d\log\mu$ at μ_0. The same SMDR calculation as [2] gives

$$v = (0.08921684504,\ 0.03965440033,\ -0.08714349019), \qquad \widehat{\delta Z}_A = \delta Z_A - \frac{v_A}{v_C}\delta Z_C \quad (A = W, Y). \qquad (11)$$

The hats denote the correction after linearised colour recalibration. The quantum and static results are respectively

$$\left(\widehat{\delta Z}_W, \widehat{\delta Z}_Y\right) = \eta(-0.8440941342, -3.0959913484) + O(\eta^2), \qquad (12)$$

$$\left(\widehat{\delta Z}_W, \widehat{\delta Z}_Y\right) = \vartheta(-1.2651132252, -4.6491284968) + O(\vartheta^2). \qquad (13)$$

Both have the wrong weak sign. This is not a failure to choose their amplitude: every positive sufficiently small amplitude moves weak response away from the target.

For a size diagnostic, retain the calculated leading boundary and solve the strong-scale condition using the full SMDR evolution. This uses the exact running of the truncated boundary; it does not calculate the omitted nonlinear orders.

Table 2. Empirical minus candidate weak and hypercharge coefficients after colour recalibration. The quantum amplitude is varied, not derived from physical time or energy units.

η	Scale in 10^{13} GeV	Weak residual	Hypercharge residual
0	8.08995	+0.02714224	−0.09022286
0.005	7.44853	+0.03136277	−0.07474294
0.010	6.85797	+0.03558343	−0.05926309
0.020	5.81364	+0.04402511	−0.02830361
0.030	4.92836	+0.05246729	+0.00265558

Choosing $\eta = 0.02914223$ solely to cancel the hypercharge residual gives a weak residual of $+0.05174312$, about 1.53 per cent of the corrected weak coefficient. This is a one-observable diagnostic fit, not a predicted fluctuation strength. The static check gives the same failure: its hypercharge-only amplitude is $\vartheta = 0.01940667$, leaving $+0.05169603$ in the weak coefficient.

The scale- and common-normalisation-free comparison is established in SGRI [9]. The following proposition applies that method locally to the higher-order running of [2] and to the compact completion (4)–(5).

Proposition 2. At leading order, an arbitrary common addition $\delta s K_A$ cannot make the compact-wheel correction satisfy both residuals.

Proof. After removing the scale direction as in (11), remove the common-K direction by defining

$$\mathcal{L}(\delta Z) = \widehat{\delta Z}_Y - \rho \widehat{\delta Z}_W, \qquad \rho = \frac{K_Y - (v_Y/v_C)K_C}{K_W - (v_W/v_C)K_C} = 4.2681578522. \qquad (14)$$

Then $\mathcal{L}(K) = 0$ and $\mathcal{L}(v) = 0$. The target is $\mathcal{L}\big(\Delta Z_{\mathrm{req}}\big) = -0.2060702230$. In contrast, the calculated quantum correction has $\mathcal{L} = +0.5067356584\eta$ and the static correction has $\mathcal{L} = +0.7505744492\vartheta$. Their signs disagree for positive amplitudes. A common addition cannot change either value. ▪

Equivalently, the complete correction must satisfy the transverse condition

$$\mathcal{L}(\delta Z) = \delta Z_Y - 4.2681578522\,\delta Z_W + 2.8738376732\,\delta Z_C = -0.2060702230. \qquad (15)$$

This is the one remaining linearised condition after scale and common normalisation have been removed. At fixed common normalisation, both projected residual equations must also hold. A positive raw weak correction is not required: colour softening can produce a positive weak shift through scale recalibration.

For fractional softenings $p_A = -\delta Z_A/(sK_A)$, the transverse condition becomes

$$p_W - (0.6215265060\,p_C + 0.3784734940\,p_Y) = -0.01413682003. \qquad (16)$$

Thus weak must soften by 1.41368 percentage points less than this weighted mean of colour and hypercharge. The compact quantum wheel instead gives $p_W = 0.4389837352\eta$ against a weighted mean of 0.4042206787η, explaining its positive $\mathcal{L}$ slope. A common fractional change leaves this difference unchanged.

This is a local, leading-order obstruction. It does not assert that the full finite-fluctuation theory has been solved. An uncomputed higher-order term would have to reverse the leading direction before it could repair the comparison. The formal linear fit of a common addition and quantum amplitude requires $\eta = -0.40666$, outside the positive physical domain and outside the small-parameter argument; it is evidence of incompatibility, not a candidate parameter choice.

6 What the mixed current response must supply

The nonlinear record paper [4] demonstrates current stiffening and record softening on its own source restriction. Using those scalar results for the wheel requires a shared current operator, source, conditional measure and responding matter. The source-history and representation-weighting papers [5–6] make precisely this dependence explicit.

A useful consequence of Proposition 2 is that a positive current correction proportional to the common trace Gram is insufficient, regardless of its size within this linearised test. A carrier with identical current dynamics in every address gives such a common term: differentiating the same function of a source charge twice produces its common coefficient times $\mathrm{Tr}T_A^2$. Interactions or weights that distinguish address families can produce a different direction.

The exact Gaussian conditional-current formula [5] identifies where such a contribution can occur. With real current coordinates, let

$$S(f, J, z) = S_b(f, z) + \frac{1}{2} J^T A(f, z) J - b(f, z)^T J, \qquad A > 0. \qquad (17)$$

At fixed remaining variables z, integrating J once gives $S_{\mathrm{red}} = S_b - b^T A^{-1} b/2 + \mathrm{Trlog} A/2$, up to a constant. Its source curvature includes

$$S_{\mathrm{red}}{}'' = S_b{}'' - \frac{1}{2}(b^T A^{-1} b)'' + \frac{1}{2}\mathrm{Tr}(A^{-1}A'' - A^{-1}A'A^{-1}A'). \qquad (18)$$

The contact and determinant terms can oppose the relaxation term. They must be evaluated inside the same remaining joint measure; its response also includes the connected fluctuation subtraction. Complex currents require their correct real multiplicity. A quantum calculation must use the corresponding joint transfer or Hamiltonian instead of treating this static formula as a ground-state energy.

The necessary additional direction is quantitative. If $\delta Z^{\mathrm{extra}}$ is added to the quantum completion, it must satisfy, at this order,

$$\mathcal{L}(\delta Z^{\mathrm{extra}}) = -0.2060702230 - 0.5067356584\eta. \qquad (19)$$

This is a test for a derived mixed response, not a prescription for its coefficients. The master-action and history-transfer sources [7–8] already define the common action and substantial parts of the joint construction. Published current-conservation elimination, record constraints and finite matching supply further explicit operands [6, 10–13]. Their complete evaluation on the physical carrier of the candidate is a distinct task. Sharing a stationary kernel does not establish that connection.

7 Published record and matching responses

The public corpus contains positive record-lock stiffness, negative participation response and a finite fermion conversion term. These results are evaluated here in their stated coordinates before any identification with physical gauge coefficients. Their presence prevents the compact-wheel obstruction from being read as an obstruction to all VERSF correction routes.

7.1 Record preservation and a positive stiffness increment

The complete native eighteen-coordinate construction of [6, Section 18] has six-component current, link and record coordinates (v, θ, y). Write $G = 3I - S - S^{\dagger}$, where S is the cyclic shift on six rim positions. With unit current weight and mixing, its weighted extension is

$$\mathcal{H}_{18} = \begin{pmatrix} I & I & 0 \\ I & w_\theta G + (\kappa_r + 1)I & -\kappa_r I \\ 0 & -\kappa_r I & w_y G + \kappa_r I \end{pmatrix}, \qquad w_\theta, w_y, \kappa_r > 0. \qquad (20)$$

The alternating unit vector is $f_3 = (1, -1, 1, -1, 1, -1)/\sqrt{6}$, with $Gf_3 = 5f_3$ and $P_3 = f_3 f_3^{\dagger}$. Eliminating v, y at fixed θ, and then repeating with the record variation constrained by $f_3^{\dagger} y = 0$, gives

$$K_{\theta,\mathrm{free}} = w_\theta G + \kappa_r I - \kappa_r^2 \left(w_y G + \kappa_r I\right)^{-1}, \qquad \Delta K_\theta = \frac{\kappa_r^2}{5w_y + \kappa_r} P_3. \qquad (21)$$

At unit weights this recovers the published increment $P_3/6$. Keeping the current instead gives $P_3/287$, with its alternating stiffness increasing from $35/41$ to $6/7$. These are alternative retained-coordinate reductions of one parent.

The canonical cell weights $w_\theta = w_y = 12/31$ and $\kappa_r = 21/124$ are printed in [10, Proposition 54]. They give $\Delta k_{\mathrm{link}} = 49/3596 = 0.01362625139$ and, after division by the alternating face eigenvalue five, $\Delta k_{\mathrm{face}} = 49/17980 = 0.002725250278$. This link increment is independent of the positive current weight and its mixing coefficient, since the shifted current square is eliminated exactly. Multiplying the face increment by the weak trace $13/2$ gives $637/35960 = 0.01771412681$, but this is only a conditional trace multiple: it is not a derived ΔZ_W without the physical source map.

Source overlap test. The profile χ in (3) is constant on the rim. Therefore $f_3^{\dagger}\chi_{\mathrm{rim}} = 0$ exactly. A direct alternating-record constraint leaves this profile's quadratic response unchanged on the symmetric branch. Assigning the weak source an alternating profile would also change its baseline calculation. The positive native response is established, while its direct import into (1) fails this classical overlap test. Section 9.4 extends the zero to a symmetric Gaussian joint parent. Section 10 shows that a separate compact record constraint can nevertheless alter quantum response; it does not identify that constraint with the native record coordinate.

7.2 The D41 participation response

The published D41 history reduction [11–12] supplies

$$\begin{aligned} H_p &= \frac{1}{49}\begin{pmatrix} 36 & 18 & 36 \\ 18 & 26 & 26 \\ 36 & 26 & 47 \end{pmatrix}, \quad m_p = \frac{1}{49}(36,26,47)^T, \\ W_p &= H_p - \epsilon_D m_p m_p^T, \qquad \epsilon_D = \frac{0.004648154590676}{0.0551296278772322} = 0.0843131863873. \end{aligned} \tag{22}$$

The common positive factor in the original history metric cancels from the ratios. The clamped diagonal response and the relaxed compliance response are different boundary conditions:

$$\begin{aligned} \varrho_A^{\mathrm{clamp}} &= \frac{(W_p)_{AA}}{(H_p)_{AA}}, \quad \varrho^{\mathrm{clamp}} = (0.9380556182,\ 0.9552623909,\ 0.9191281682), \\ \varrho_A^{\mathrm{relax}} &= \frac{(H_p^{-1})_{AA}}{(W_p^{-1})_{AA}}, \quad \varrho^{\mathrm{relax}} = (1,\ 1,\ 0.9866359992). \end{aligned} \tag{23}$$

The identity $H_p e_Y = m_p$ explains the second result: the rank-one inverse update changes only the hypercharge diagonal entry. Direct inversion reproduces both published readings [10, Section 43]. The matrix W_p is positive.

For a conditional attachment test, replace (1) by $Z_A = sK_A\varrho_A$, keeping $s = 31/59$. The relaxed reading gives $\delta Z = (0,0,-0.07372851308)$. It reduces the hypercharge residual in (2) to -0.01649434304, removing 81.7 per cent of that residual's magnitude, while leaving the weak residual unchanged. This is a size-and-sign result under the declared attachment, not a percentage closure of the physical derivation.

The clamped reading produces a different result, shown in Table 3. The history matrix is not itself a gauge-energy Hessian. Section 9 supplies an explicit positive joint parent and counts its auxiliaries once. It reproduces these readings for one source placement and calculates their dependence on that choice; microscopic identification of this parent remains separate.

7.3 The finite fermion conversion

Completed Event Weighting [13, Section 14.8] evaluates the massless continuum Weyl contribution to momentum-subtraction to MS conversion. Its finite term follows from

$$\int_0^1 x\,(1-x)\log[x(1-x)]\,dx = -\frac{5}{18}, \qquad C_{\mathrm{Weyl}} = \frac{5}{72\pi^2} = 0.0070361933085. \tag{24}$$

With fermion index vector $K_F = (6,6,10)$ in the conventions of (1), the conversion is

$$\delta Z^{\mathrm{Weyl}} = -C_{\mathrm{Weyl}}K_F = (-0.04221715985, -0.04221715985, -0.07036193308). \tag{25}$$

This is a finite conversion, distinct from the running already included in [2]. Its application to the native wheel boundary is a sensitivity control: equality of that native definition with continuum momentum

subtraction has not been established. Gauge and scalar finite terms, native-regulator conversion and common-observable matching remain outside this isolated term.

7.4 Comparison in the fixed running convention

For each row, the strong-scale condition is solved again using the retained SMDR flow of [2]. No amplitude is fitted, and the rows are separate tests rather than contributions to a sum.

Table 3. Published response controls applied to the wheel boundary. Residuals are empirical running coefficient minus candidate coefficient at each row's strong-calibrated scale.

Boundary test	Scale in 10^{13} GeV	Weak residual	Hypercharge residual
Original wheel	8.08995	+0.02714224	−0.09022286
Weyl finite term alone	5.04022	+0.05059707	+0.02137394
Conditional clamped D41	0.906925	+0.09317979	+0.54666087
Conditional relaxed D41	8.08995	+0.02714224	−0.01649434

The relaxed D41 reading helps hypercharge without changing weak response. The clamped reading and the isolated Weyl term overshoot hypercharge and increase the weak residual. Under the local comparison (14), their transverse contributions are respectively -0.0737285131, -0.3552422244 and -0.0114976952. Each has the favourable transverse sign, but that fact alone does not establish agreement in both coefficients at fixed normalisation. Ratios of these projections are not global percentages of experimental disagreement removed.

8 The common action calculation

The current and conservation terms are already explicitly related in the public source [10, Proposition 53]. Let D_U map vertex amplitudes to transported edge differences, $d_J = j - \kappa D_U \rho$ and $d_T = Z_\sigma \rho + D_U^\dagger j$, where Z_σ denotes the refinement derivative, not a gauge coefficient. For positive diagonal metric blocks W_J, W_T, exact current elimination gives

$$\begin{aligned} Q &= Z_\sigma + D_U^\dagger \kappa D_U, \qquad C_J = W_J + D_U W_T D_U^\dagger, \\ R_T &= \left(W_T^{-1} + D_U^\dagger W_J^{-1} D_U\right)^{-1}, \\ K_\rho &= H_V + Q^\dagger R_T Q. \end{aligned} \tag{26}$$

The current integral also contributes its determinant, with the multiplicity appropriate to real or complex fields. The retained density kernel alone is insufficient for the complete response. Cross-defect weights require the corresponding full-metric Schur reduction; gauge derivatives must act on the incidence, metric, background and other responding blocks before evaluation at the reference state.

Equation (26), the common action [7], and the record and history constructions [6, 8, 11–14] provide existing ingredients for this task. Their definition should not be described as absent dynamics. The finite-cell evaluation and its attachment to one physical gauge carrier remain distinct from the definition of those ingredients. A refinement parameter also needs its stated physical time attachment before its frequency is interpreted as duration.

Sections 9 and 10 instantiate two finite responses using these ingredients. A complete physical return must specify one common gauge-covariant parent, the allowed record variations, the source profiles and the joint measure or transfer. It must recover (21) and (23) in their respective restrictions, retain the current determinant, and reproduce 31/59 only when the original profile and assumptions of (3) are restored. Finite matching must use that same definition of the gauge response. These requirements attach the retained response to the same physical source and measure.

9 A coupled wheel and participation response

9.1 Positive parent and source embeddings

Use the wheel data of (3) and the participation data (H_p, m_p, ϵ_D) of (22). Then $H_p^{-1}m_p = e_Y$, $h_p = m_p^T H_p^{-1} m_p = 47/49$, $\left(H_p^{-1}\right)_{YY} = 833/123$ and $\beta_D = \epsilon_D h_p = 0.0808718318409$. Write $\lambda = 31/28$ and let $L^{1/2}$ denote the positive square root in the stationary inner product.

For each gauge generator introduce a three-component retained participation coordinate q, a three-component wheel variable r_i at each site, and a real scalar history variable h_i at each site. The three entries of q are an internal multiplicity index. They are not three different physical gauge fields. Each copy of q, r, h transforms in the adjoint representation of its own gauge factor; an Abelian adjoint is a singlet. All carriers are referred to one gauge frame. This avoids inserting the off-diagonal entries of H_p as forbidden colour–weak–hypercharge kinetic mixing.

Set $d_0 = \chi q - r$ and $d_1 = L^{1/2} r$. Choose real coefficients $c_0^2 + c_1^2 = 1$. The joint action is

$$\mathcal{S}_c(q, r, h) = \frac{1}{2}\sum_i \pi_i \left[d_{0i}^T H_p d_{0i} + d_{1i}^T H_p d_{1i} + h_i^2 + 2\sqrt{\epsilon_D}\, h_i m_p^T (c_0 d_{0i} + c_1 d_{1i})\right]. \qquad (27)$$

The history variable h is an effective Schur representation of the inherited history reduction. Its elimination implements the D41 subtraction once within this parent. This model contains 31 coordinates per generator, or 372 for all twelve generators. With one retained source per generator, the relaxed reading eliminates 360 auxiliary coordinates.

The positive defect metric has Schur margin $1 - \epsilon_D h_p = 1 - \beta_D > 0$. Its pullback in (27) is positive because χ is a nonconstant positive-eigenvalue mode. Eliminating h yields the D41 subtraction on the chosen combination of residuals. Eliminating all wheel variables at $\epsilon_D = 0$ gives sH_p exactly.

For a generator in factor A, hold $q_A = \gamma_A f_A$. Two boundary prescriptions are defined before the comparison. In the clamped prescription the other two q entries are zero, and $\gamma_A^2 = K_A/\left(H_p\right)_{AA}$. In the relaxed prescription they are auxiliary variables, and $\gamma_A^2 = K_A\left(H_p^{-1}\right)_{AA}$. Both recover sK_A when $\epsilon_D = 0$. These normalisations specify different source embeddings with the same reference response. Choosing q_A as the retained coordinate is an axis embedding in the participation basis of (22). It is inherited as a prescription from the diagonal and compliance readings in (23); no physical source map in this construction selects it. Gauge covariance alone allows other linear functionals of the three copies within each adjoint channel.

Equation (27) extends the positive participation parent and the separate adjoint channels of [12, Sections 3 and 5.8]. The full three-component multiplicity in each channel, the coefficients c_0, c_1, and its connection to the wheel are additional construction data. The source's history matrix alone does not select them. In particular, this is not the 50-address matter action with its microscopic readout maps already evaluated.

9.2 Exact joint elimination

Only the wheel eigenmode χ couples to q. Every other mode contributes a source-independent Gaussian factor. Define

$$\zeta = \frac{\left(-c_0 + \sqrt{\lambda}\, c_1\right)^2}{1 + \lambda}, \qquad 0 \le \zeta \le 1, \qquad a_p(\zeta) = \frac{\epsilon_D(1 - \zeta)}{1 - \beta_D \zeta}. \qquad (28)$$

Proposition 3. Elimination of r and h together gives the participation Hessian

$$S_q(\zeta) = s\left[H_p - a_p(\zeta) m_p m_p^T\right], \qquad S_q(\zeta)^{-1} = \frac{1}{s}\left[H_p^{-1} + \frac{\epsilon_D(1 - \zeta)}{1 - \beta_D} e_Y e_Y^T\right]. \qquad (29)$$

Proof. In the source mode the r block is $(1+\lambda)H_p$. Its elimination leaves the direct term sH_p, the bath stiffness $1-\beta_D\zeta$, and a mixed column whose squared scalar prefactor is $\epsilon_D s(1-\zeta)$. Eliminating that bath gives the first expression. The rank-one inverse identity and $H_p^{-1}m_p = e_Y$ give the second. Direct simultaneous elimination gives the same result. ▫

For the declared source embeddings, the three coefficients therefore follow without fitting:

$$Z_A^{\mathrm{clamp}}(\zeta) = sK_A\left[1 - a_p(\zeta)\frac{n_A}{49}\right], \qquad (n_C, n_W, n_Y) = (36,26,47), \qquad (30)$$

$$Z_C^{\mathrm{relax}} = sK_C, \qquad Z_W^{\mathrm{relax}} = sK_W, \qquad Z_Y^{\mathrm{relax}}(\zeta) = \frac{sK_Y}{1 + \dfrac{\epsilon_D(1-\zeta)}{(1-\beta_D)\left(H_p^{-1}\right)_{YY}}}. \qquad (31)$$

For the axis embeddings specified in Section 9.1, the first two relaxed corrections vanish for every common placement in (27). Varying that placement changes the response amplitude while preserving the inverse-update direction. This result does not extend to arbitrary source embeddings.

For $c = (1,0)$ the response enters the mismatch term and $\zeta = 28/59$. For $c = (0,1)$ it enters the restoring term and $\zeta = 31/59$. For $c = \left(\sqrt{s}, \sqrt{1-s}\right)$, $\zeta = 0$ and the response is aligned with the surviving source combination. This last choice reproduces the multiplicative D41 reading in (23). In the source mode its coupling to the shifted wheel variable vanishes. Reproducing that favourable value therefore demonstrates a consistent realisation of the prescription, not a new selection principle for it. The orthogonal choice has $\zeta = 1$ and gives no correction.

9.3 Comparison with the running couplings

The comparison retains the running, input and zero additional finite matching convention of Section 1. The strong interaction calibrates the scale; the required correction is (2). No placement or source amplitude is fitted in Table 4.

Table 4. Relaxed joint responses for the axis embeddings. The strong-calibrated scale remains μ_0 in all rows. Residuals are empirical running coefficient minus model coefficient.

Placement	ζ	Weak residual	Hypercharge residual	Hypercharge discrepancy removed
No response at source	1	+0.02714224	−0.09022286	0%
Restoring term	31/59	+0.02714224	−0.05498563	39.06%
Mismatch term	28/59	+0.02714224	−0.05123689	43.21%
Surviving source combination	0	+0.02714224	−0.01649434	81.72%

The final row has couplings g_W and g_Y respectively 0.39658 per cent above and 0.15163 per cent below their running comparison values. The original differences were +0.39658 and −0.82106 per cent. This is close agreement in a specified conditional model. Colour is calibrated rather than independently predicted, and the construction and matching assumptions remain material.

For the axis-clamped reading, every nonzero correction has the same weak-to-colour ratio,

$$\frac{\delta Z_W}{\delta Z_C} = \frac{169}{216} = 0.7824074074, \qquad \widehat{\delta Z}_W = \delta Z_C\left(\frac{169}{216} - \frac{v_W}{v_C}\right) < 0, \qquad (32)$$

where $v_A = dZ_A^{\mathrm{SM}}/d\log\mu$ and $v_W/v_C = 0.444472\ldots$ at the reference point. The target weak correction is positive. Thus the local clamped correction has the wrong weak sign for every $\zeta < 1$. Full recalibration at 21 fixed placements confirms that the weak discrepancy never improves. For the mismatch placement, the

scale is $2.44685477 \times 10^{13}$ GeV and the residuals are $(+0.06321343, +0.25777332)$. The aligned case reproduces the clamped control in Table 3, with residuals $(+0.09317979, +0.54666087)$.

The exclusion is exact for the axis-relaxed source prescription. The axis-clamped prescription has the wrong local direction and fails at every tested finite placement; its finite scan is not a global monotonicity proof for the running flow. Neither statement excludes tilted source covectors.

To see the distinction, retain $u_A^T q = \gamma_A f_A$ with nonzero real covector u_A, relax its complementary directions and choose $\gamma_A^2 = K_A u_A^T H_p^{-1} u_A$. Equation (29) gives

$$Z_A^{\mathrm{relax}}(u_A, \zeta) = \frac{sK_A}{1 + d(\zeta)\,\dfrac{(u_A)_Y^2}{u_A^T H_p^{-1} u_A}}, \qquad d(\zeta) = \frac{\epsilon_D(1-\zeta)}{1-\beta_D}. \tag{33}$$

The suffix Y on $(u_A)_Y$ denotes the third participation coordinate, also for a colour or weak channel; it does not mix different physical gauge fields. The zero follows when this covector component vanishes. The ratio $(u_A)_Y^2/\left(u_A^T H_p^{-1} u_A\right)$ ranges from zero to $\left(H_p\right)_{YY} = 47/49$. At $\zeta = 0$, the attainable fractional softening therefore ranges continuously from zero to $\beta_D = 0.08087183184$ in each channel.

In particular, solving the two linearised strong-recalibrated targets with $\delta Z_W = 0$ gives

$$\begin{aligned} \delta Z &= (-0.06106623838,\ 0,\ -0.03057576656), \\ -\frac{\delta Z_A}{sK_A} &= (0.01937047346,\ 0,\ 0.00554215124)_A. \end{aligned} \tag{34}$$

These softenings are attainable. For $\zeta = 0$, one example is $u_C = (1,0,0.6777163363)^T$, $u_W = e_W$ and $u_Y = (-0.6719290065,0,1)^T$, using the baseline normalisations above. Direct elimination of the full parent reproduces (34). Colour softening shifts the comparison scale and supplies the required positive projected weak response, despite zero raw weak change.

The two orientation parameters in this example are fitted to the linearised targets. Their values are not predictions, and the example is not a replacement for full running and physical matching. It demonstrates that the obstruction cannot be extended to all source embeddings. The outstanding input is a physically justified source covector and its normalisation, including the microscopic map from the matter carrier; assigning the participation axes by name does not provide that map.

9.4 Motion and preservation of an alternating record

After selecting one retained source, write the full quadratic action as

$$\mathcal{S}(f, x) = \frac{1}{2} k_0 f^2 + f j^T x + \frac{1}{2} x^T C x, \qquad C > 0. \tag{35}$$

For any specified positive, source-independent inertia matrix M_x, the Hamiltonian $\mathcal{H} = 1/2\, p^T M_x^{-1} p + \mathcal{S}$ is a complete harmonic dynamical construction. Its Euclidean response and normal-frequency matrix are

$$Z(\omega_E) = k_0 - j^T (C + \omega_E^2 M_x)^{-1} j, \qquad \Omega^2 = M_x^{-1/2} C M_x^{-1/2}. \tag{36}$$

In real time $\tau \geq 0$, the zero-temperature covariance is $\langle x(\tau) x(0)^T \rangle = (\hbar/2) M_x^{-1/2} \Omega^{-1} e^{-i\Omega\tau} M_x^{-1/2}$ at zero source; ω_E in (36) instead denotes Euclidean frequency. The ground-state energy has the exact source dependence

$$E_0(f) = \frac{1}{2}(k_0 - j^T C^{-1} j) f^2 + \frac{\hbar}{2} \mathrm{Tr}\Omega. \tag{37}$$

Consequently, harmonic motion and the Gaussian determinant provide no additional static correction beyond the joint Schur complement. This holds for every such positive inertia, so changing these inertias cannot supply another static correction for a fixed source embedding. A frequency-dependent response still

exists. Frequencies in the supplied example are dimensionless; no physical event rate or conversion to seconds is derived by declaring an inertia.

Let a full-row-rank constraint $C_h x = 0$ preserve a linear record. Its constrained increment is

$$\Delta Z = j^T C^{-1} C_h^T \left(C_h C^{-1} C_h^T\right)^{-1} C_h C^{-1} j \geq 0. \qquad (38)$$

The hub–rim source is invariant under rim rotation. The alternating record has angular label three. For a rotation-invariant quadratic parent and an equivariant source map, their mixed vector $C_h C^{-1} j$ vanishes. This includes a direct alternating constraint on h in (27), checked by constrained elimination, and any equivariant Gaussian extension by the native eighteen-coordinate block $\mathcal{H}_{18}$ of (20) [6, Section 18; 10, Proposition 54]. The extension may change the unconstrained baseline; the alternating lock still adds zero to this rotation-invariant source. A source-dependent record condition, a different source map or a non-invariant background falls outside this zero statement.

10 Quantum response of a preserved record

The static zero does not extend automatically to an interacting quantum action. Test this directly in the compact wheel (4)–(5), retaining its potential, stationary-weighted group metric and common parameter $\eta = \hbar/\sqrt{mw}$.

For a selected entire gauge factor, preserve the group word on the rim,

$$\mathcal{W}(U) = U_1 U_2^{-1} U_3 U_4^{-1} U_5 U_6^{-1} = I. \qquad (39)$$

The constrained Hamiltonian uses the induced metric on the locally regular constraint submanifold. Protecting an entire adjoint factor preserves simultaneous gauge conjugation; partial Cartan locks are not assumed. This is a declared coherent record realisation in the compact variables. It is not an identification already derived between these variables and the separate record coordinate y of (20).

On the locally unique symmetric branch, all rim elements equal V. For right-invariant variations $U_i(t) = e^{itX_i}V$, the differential of (39) is $i\sum_{i=1}^{6}(-1)^{i+1} X_i$. For left-invariant variations $U_i(t) = Ve^{itX_i}$, it is $i\mathrm{Ad}_V \sum_{i=1}^{6}(-1)^{i+1} X_i$. Both conventions give the same alternating-mode kernel on the symmetric branch. The unconstrained classical minimum already satisfies (39), so its classical coefficient remains sK_A.

Use $t_b = T_b/\sqrt{K_b}$ and let $\mathcal{B}$ contain the generators whose alternating record is protected. Embed the unit rim vector f_3 in the seven-site orthonormal coordinates by setting its hub entry to zero. The site Hessian matrices of (6) and Appendix A obey $Mf_3 = (9/4)f_3, Jf_3 = 0$ and $f_3^T N f_3 = -33635/83544$.

Proposition 4. Restricting (5) to the induced metric of (39) gives the exact leading difference

$$\frac{E_{0,\mathrm{locked}}'' - E_{0,\mathrm{free}}''}{w} = \eta\,\frac{33635}{501264}\sum_{b\in\mathcal{B}} \mathrm{Tr}\left(T_A^2 t_b^2\right) + O(\eta^2). \qquad (40)$$

Derivation. The symmetric minimum already lies on the constraint surface, so its first potential derivative is zero. Its constrained Hessian is the ambient Hessian projected onto the allowed tangent space. The excluded alternating mode has square-root frequency $3/2$ and no first-derivative mixing because $Jf_3 = 0$. Removing its contribution to the second derivative of $\mathrm{Tr}\sqrt{A}/2$ adds $-1/4\,(f_3^T N f_3)/(3/2) = 33635/501264$ for each protected generator. The two invariant-frame conventions therefore give the same tangent restriction. ▫

This is a positive quantum stiffness increment with coefficient 0.067100370264. It arises from removing fluctuations whose zero-point curvature was negative. It is computed by restricting the same Hamiltonian. For a protected weak factor, the three contractions are $(9/26, 3/4, 15/52)$.

Table 5. Quantum slopes and the transverse test. Each entry multiplies the same positive η. Weak and hypercharge columns use strong recalibration; $\mathcal{L}$ also removes common normalisation. Entries are total slopes relative to the classical wheel.

Protected alternating record	Weak slope	Hypercharge slope	$\mathcal{L}/\eta$
None	−0.84409413	−3.09599135	+0.50673566
Weak factor	−0.80409263	−3.05394821	+0.37804608
Colour factor	−0.81675942	−2.92659180	+0.55946635
Hypercharge factor	−0.84270377	−3.05574300	+0.54104970
All factors	−0.77536756	−2.84430031	+0.46509081

The weak lock contributes $(+0.04000150, +0.04204314)\eta$ after strong recalibration and reduces the transverse slope by 0.12868958η. Colour and hypercharge locks increase that slope by 0.05273069η and 0.03431405η, respectively. Only the weak lock improves this invariant comparison. Whole-factor increments add at this order, so the smallest transverse slope among all eight subsets is the weak-only value $+0.37804608\eta$. Every subset has the opposite sign to the target in (15). Proposition 2 therefore extends to all these locks, including an arbitrary common normalisation adjustment. Higher orders, other record observables and nonuniform backgrounds remain outside this leading-order result.

11 Verification and conclusion

The calculation constructs all twelve generators on the 50-address carrier and the full 84-dimensional compact-wheel Hessian. The representation contractions agree with the exact fractions in Table 1. The derivative formulas are checked against direct finite-source Hessians and eigenvalue calculations at four source spacings. At the smallest spacing, the quantum coefficient discrepancy is below 2.1×10^{-7}; step variation confirms the finite-difference convergence. The static coefficients are also evaluated in exact rational arithmetic. The Gaussian limit reproduces $31/59$.

The complete eighteen-coordinate Schur calculations reproduce both unit-weight record-lock increments, with matrix discrepancy below 5×10^{-16}, and reproduce the canonical-weight expression in Section 7.1. The D41 ratios are recomputed from the unrounded source coefficients. The Weyl integral agrees with $-5/18$ to floating-point precision. Table 3 uses the full retained running after colour recalibration; it does not rely on the linearised scale projection.

The comparison uses the pinned SMDR implementation and physical-input set of [2], with source code and calculation results retained in the accompanying archive. No Standard Model loop already present in that test is added again. The nonlinear coefficient calculation uses no measured coupling. The explicitly labelled diagnostics use the hypercharge residual to choose an amplitude in Section 5 and the two linearised residuals to choose source orientations in Section 9.3. The derivative comparison and running checks establish numerical consistency, not a bound on the omitted nonlinear orders or physical matching effects.

The simultaneous 31-coordinate Gaussian elimination agrees with (29)–(31) to 1.13×10^{-13} across four named placements and sixteen additional angles. Positivity holds analytically for the full family. With q unscaled and the site variables in π-orthonormal coordinates, the minimum across the twenty archived placements is 0.03217826. An angular scan followed by local refinement gives approximately 0.03217659. These coordinate-dependent eigenvalues are numerical checks, not a universal spectral bound. The alternating constraint changes the retained matrix by less than 3.4×10^{-16}, and the dynamical pole decomposition agrees with direct inversion to 9.3×10^{-14}.

The compact record calculation uses the full 84-dimensional unconstrained Hessian, retaining 81 coordinates for a weak lock and 72 for an all-factor lock. Direct finite-source checks at steps 0.01, 0.005 and 0.0025 reproduce (40), with maximum discrepancy 1.97×10^{-7} at the smallest step. The exact projected

spectral derivative agrees to 4.6×10^{-16}; direct variation of the group word verifies both invariant-frame differentials to 6.0×10^{-10}. These checks validate the leading coefficient, not the omitted $O(\eta^2)$ term.

The arbitrary-source formula (33) agrees with full-parent elimination to 5.3×10^{-14} across ninety tests of varied covectors, placements and channels. The fitted example (34) agrees to 2.3×10^{-14}. The transverse test was evaluated for all eight whole-factor lock subsets.

The joint Gaussian construction realises the favourable 81.7 per cent hypercharge adjustment inside one positive action. Its relaxed colour and weak corrections vanish for the specified axis embeddings at every placement. General source covectors can soften those channels too: the explicit two-parameter fit shows that softening alone can meet both linearised comparison targets. Thus the axis result constrains a source prescription, not the full relaxed class. Varying source-independent positive inertias leaves these static results unchanged.

The compact construction establishes positive quantum stiffness from preserving an alternating record with zero classical overlap. Its decisive limitation is the transverse sign in Table 5: every whole-factor subset fails even after scale and common normalisation are removed. The weak-only lock helps that test most; the colour and hypercharge locks move it away from the target.

The next physical calculation must supply a justified source embedding and a complete correction satisfying (15), rather than a positive raw weak correction. In fractional terms, weak must soften 1.41368 percentage points less than the weighted colour–hypercharge mean in (16). At fixed common normalisation the two projected residuals must also be reproduced. The common action [7] defines the residual metric through realisation maps; evaluating those maps on this carrier must determine the source covectors, their normalisations, responding matter, allowed record variations and the associated source-dependent Hessian or transfer. The source-direction fit identifies a possible route but does not supply this physical derivation.

The paper establishes solved finite responses, their dependence on source choice and a positive quantum record mechanism. It leaves physical admission, observable matching and the physical clock to a consistent realisation. The three measured physical strengths remain unestablished.

Appendix A The site matrices

These formulas specify the calculation without relying on a numerical Hessian stencil. Define $u_i = \chi_i - \xi_i$ and $d_{ij} = \xi_j - \xi_i$. The site matrices are

$$\begin{aligned} N_{ii} &= -u_i^2 - \sum_{j \neq i} \frac{\omega_{ij}}{\pi_i} d_{ij}^2, \quad N_{ij} = \frac{\omega_{ij} d_{ij}^2}{\sqrt{\pi_i \pi_j}}, \\ J_{ij} &= -\frac{\omega_{ij} d_{ij}}{\sqrt{\pi_i \pi_j}}, \qquad\qquad J_{ji} = -J_{ij} \quad (i < j). \end{aligned} \tag{41}$$

Set $J_{ii} = 0$. The off-diagonal expression for N applies for $i \neq j$; unsupported edges have zero weight. Thus N is the negative sum of a strictly positive diagonal matrix and a weighted graph Laplacian in orthonormal coordinates. It is negative definite. The representation matrices are $(M_T)_{ab} = \mathrm{ReTr}(T^2\{t_a, t_b\}/2)$ and $(B_T)_{ab} = \mathrm{ReTr}(i t_a T t_b)$. They are respectively symmetric and antisymmetric. Hence $J \otimes B_T$ is symmetric, as a Hessian derivative must be.

The finite-source Hessian uses the exact group exponentials along $U_i = \exp(i\xi_i f T)$. The discrepancy of this path from the nonlinear minimum begins at cubic order in f and does not affect the second source derivative used here. The scripts also evaluate the full matrix spectral-derivative expression independently of its two-contraction reduction.

Appendix B Sources and reproduction

The sources consulted are the public VERSF paper catalogues and the gauge-response dependency chain cited below. The source inventory, document hashes, search coverage and sections examined are retained in the calculation archive. Its coverage records distinguish catalogue-wide searching from close reading of the relevant papers.

The compact-wheel scripts construct the full representation and Hessian, verify the exact static coefficients and perform the running comparisons. The record-response calculations reconstruct the native record-lock block, the D41 matrices and the Weyl integral directly from the displayed equations. The joint-response scripts additionally assemble the full positive parent, solve the simultaneous elimination and propagation, and restrict the compact Hessian to the record-preserving tangent space. Machine-readable outputs preserve the values in Tables 1–5. The source-direction and transverse-response checks are supplied with their diagnostic fit explicitly labelled; they also distinguish the sampled parent eigenvalue from the angular-scan minimum and verify both group-word frame conventions. The archive contains a self-contained joint-response calculation package with scripts, results, source excerpts and the pinned running inputs. These local results are reproducible without access to private native arrays.

References

1. Taylor, K. *Testing the Wheel Relaxation Route to Physical Gauge Couplings in VERSF*. Companion construction manuscript, 2026, Sections 4–5. Action and conventions are restated in (1)–(3).
2. Taylor, K. *Precision Test of the Wheel Coupling Candidate in VERSF*. 17 November 2026. Inputs, source commit and results are retained in the calculation archive. SMDR: Martin, S. P. and Robertson, D. G., *Standard Model parameters in the tadpole-free pure MS scheme*, Physical Review D 100, 073004 (2019), arXiv:1907.02500. Implementation: SMDR, commit 5c4dd92c918cadb7f91ad3795694f8398b5c287a. Its highest mode contains selected higher-loop contributions, not a complete five-loop Standard Model calculation.
3. Taylor, K. *Physical Matter Record Dynamics and Gauge Response in VERSF*. Sections 16.6–16.8. Public paper.
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