Interacting Matter and Record Fluctuations in the VERSF Force Response

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General reader summary

Predicting force strengths is rather like predicting the notes of an instrument from its shape and materials. Adjusting its overall tension can tune one note, but the others still test whether the design is right. This paper builds calculations that let VERSF face that test, while keeping track of which settings come from the theory and which come from measurements.

One calculation allows particles and their surroundings to move together, while preserving the system's records. The interaction changes the relative force strengths, but in the small systems tested it moves them in the wrong direction. A separate calculation uses measurements to set the overall strength and the energy at which the model connects to ordinary particle physics. Its remaining comparison is about 1.5 per cent low.

An apparent improvement in that comparison depends on translating only part of the model into the language used for measurements. The corresponding translation for the Higgs part has not been calculated and could change the improvement's size or sign. The paper identifies the missing contribution, measures how large it would need to be, and supplies a test for calculating it. It advances the calculation without yet deriving all three measured force strengths.

Abstract

We calculate a leading fermion exchange contribution from a coupled Gaussian link–record measure and construct a separate calibrated joint-response benchmark. In the finite exchange calculation, the ordered compositional overlap operator is held fixed while two bosonic covariances with identical infrared stiffness are compared. All nonconstant transverse modes of the chosen four-dimensional boxes are retained, including derivatives of the background-dependent covariance. The three sector increments reduce to index–Casimir and adjoint terms. Their scale- and common-normalisation-free contrast has the wrong sign to remove the inherited residual on the tested boxes.

For the calibrated benchmark, a stationary spectral/Gaussian bosonic response on up to 24^3 sites is attached to a corpus chiral family. The effective boundary is $g_A^{-2}(\mu_*) = zK_A + \delta_A$. Calibrating z with $\alpha_s(M_Z) = 0.1180$ at an assumed $\mu_* = 10^{14}$ GeV gives $(g_s, g, g') = (1.21772, 0.65311, 0.35420)$. A second calibration with the electromagnetic strength leaves $s_W^2 = 0.227776$, 1.52% below the pinned 2024 benchmark. The apparent 11.07% reduction of the charge-Gram discrepancy is conditional on fermion-only finite conversion: writing $K_H = K - K_F = (0, 1/2, 1/2)$ gives $\delta = \delta^{\mathrm{bos}} + (c_S - c_F)K_H$, and the scalar conversion c_S has not been calculated. Its omission leaves the sign and size of that improvement unresolved. The bosonic shape is negligible. A full three-input fit would require $c_S - c_F \simeq 0.1297$, compared with 0.0144 supplied by setting $c_S = 0$; this is a target, not a derived correction. Proposition 2 gives the response after recalibration and relates both constructions' contrast tests without adding their coefficients. Full interacting matching, thresholds and physical scale attachment remain open. The three measured gauge strengths are not derived.

Contents

1 The target and the source chain
2 A specified coupled construction
3 The ordered matter operator
4 Counting fluctuations once
5 Reduction to the three sectors
6 Numerical results and checks
7 Conditional comparison with the force residual
8 Scope of the finite interaction calculation
9 Enlarged joint response and chiral attachment
10 Calibrated force strength test
11 Conclusions and the remaining physical calculation
Appendix A Sources and reproducibility
References

1 The target and the source chain

The question is whether a calculated interaction can repair the relative force discrepancy left by the inherited VERSF normalisation [1]. In factor order colour, weak, hypercharge, define

$$K = (6{,}13/2{,}21/2), \qquad Z = (31/59)K. \qquad (1)$$

After adjusting the comparison scale to reproduce the strong sector, the inherited target increment is

$$\Delta Z_* = (0,\ 0.02714224049,\ -0.09022285612). \qquad (2)$$

These are increments in inverse squared couplings, not percentage errors in measured cross sections. The local contrast

$$\ell = (2.87383767318, -4.26815785216, 1), \qquad \ell \cdot \Delta Z_* = -0.20607022298 \qquad (3)$$

annihilates both the common charge Gram and the inherited scale derivative $v = (0.08921684504, 0.03965440033, -0.08714349019)$. Passing (3) is necessary for a correction to remove both residuals after those two adjustments. It is not sufficient for a finite matching calculation.

The public source chain already goes beyond an isolated scalar oscillator. Source History Weighting [2, §§19.3–19.6] specifies an ordered fermion operator, contracts a hypercharge fluctuation slice with its electric response, and constructs a common spatial current–record parent. Physical Applicability [3, §42] supplies the three-factor index–Casimir matrix and warns that its scalar coefficients are generally factor-pair dependent. The master action [4] supplies current and conservation residuals, a radial-projector potential and cross-defect terms. We use these results directly; a positive scalar matter mass is not substituted for that radial potential.

The representation counts and distinction between charge participation and physical gauge response are also discussed in [5]. The common charge Gram in (1) is retained as a baseline; participation counts alone do not supply a finite conversion to the measured force coefficients.

The published fourteen-mode calculation compares ordered and local-unit temporal fermion rules on an $8^3 \times 16$ box. Here the fermion operator is held fixed while two bosonic covariances are compared. These are different subtractions, so the published coefficient is not rescaled or added to the present result.

Status convention. Exact statements in Sections 2 to 7 concern the specified finite construction; their numerical results concern its leading Gaussian fluctuation contribution. Sections 9 and 10 introduce a separate stationary response and calibrated effective-theory benchmark, with their choices and empirical

inputs stated explicitly. A well-posed construction is not automatically a source-admitted physical realisation. One justified realisation, with its operational matching and controlled limits, would suffice; uniqueness is unnecessary.

2 A specified coupled construction

For a nonzero transverse mode of lattice Laplacian eigenvalue λ, use the phase parent inherited from [2, Eq. (154)]. Current relaxation gives $j = -\theta$ in this transverse restriction. The remaining link–record block is

$$S_A = \frac{Z_A}{2}\{a_\theta \lambda \theta^2 + a_y \lambda y^2 + c(\theta - y)^2\}, \quad a_\theta = a_y = \frac{1}{2}, \quad c = \frac{7}{32}. \qquad (4)$$

The weights are the wheel benchmark (12/31,12/31,21/124) divided by 24/31. This fixes unit long-wavelength stiffness. It is a declared benchmark attachment of the source weights, not a fit to (2). Integrating the record once gives

$$k_{\mathrm{rec}}(\lambda) = \frac{\lambda}{2} + \frac{(\lambda/2)(7/32)}{\lambda/2 + 7/32}, \qquad k_{\mathrm{ref}}(\lambda) = \lambda. \qquad (5)$$

Both kernels have derivative one at zero. The reference therefore shares the infrared normalisation of the record model. Their finite-momentum covariances differ. Integrating a record and subsequently adding its same fluctuation contribution again would count it twice; that is not done here.

The static calculation uses all spatial transverse modes on $L^3 \times N_t$ boxes. The time-dependent extension uses

$$\lambda(p) = 4\sum_{\mu=1}^{4} \sin^2\left(p_\mu/2\right), \qquad V = L^3 N_t, \qquad n_\perp = 3(V-1). \qquad (6)$$

This is an isotropic Euclidean Gaussian continuation of (4), with lattice spacing and time step set to one. Its temporal part is a construction choice. The static parent does not, by itself, derive that continuation or its conversion to seconds. Bosons are periodic; fermions are antiperiodic in time and periodic in space. Constant holonomies are held fixed. The real transverse fields f_m satisfy $\sum_{x,\mu} f_m f_n = V\delta_{mn}$.

The currents remain auxiliary on this branch. Giving independent circulating currents their own propagating modes changes the coupled covariance and requires their kinetic and interaction terms. Equation (6) does not supply those terms. Section 9 specifies a separate construction with propagating currents and its own response calculation.

The external electric source is

$$U_4(x;\alpha) = \exp[i\alpha\phi(x)T_A], \quad \phi(x) = \cos(2\pi x_3/L), \quad \hat{k}^2 = 4\sin^2(\pi/L). \qquad (7)$$

For a response $\Gamma(\alpha)$, its reported coefficient is $\Gamma''(0)/\left(N_e\hat{k}^2\right)$, where $N_e = V\langle\phi^2\rangle$. At $L = 2$ this probes the spatial Nyquist momentum. It is a finite-momentum coefficient, not an extrapolated local gauge coefficient.

For the background continuation, form the adjoint scalar covariant Laplacian on link components, compress it to the fixed zero-background transverse frame, and apply (5) as a matrix function. In coordinates normalised as above the covariance difference is

$$\Delta C_A(\alpha) = \frac{1}{Z_A V}[k_{\mathrm{rec}}(L_\alpha)^{-1} - L_\alpha^{-1}]. \qquad (8)$$

This positive finite construction is not the full Yang–Mills vector Hessian with its gauge-fixing and ghost terms. Fixing the transverse frame at zero background is also explicit. Those differences limit the physical interpretation, and are not hidden in a normalisation constant.

3 The ordered matter operator

The matter calculation uses the massless parity-even Weyl magnitude in [2, Eqs. (141)–(143)]. Let T_i be the link transport matrices, let the Euclidean gamma matrices be Hermitian, and define the spatial Wilson seed

$$S = \sum_{i=1}^{3} \left[I - \frac{\mathsf{T}_i + \mathsf{T}_i^\dagger}{2} + \gamma_i \frac{\mathsf{T}_i - \mathsf{T}_i^\dagger}{2} \right], \qquad K_s = \gamma_4 S. \qquad (9)$$

With $\mathcal{E}_5(O) = (O + \gamma_5 O \gamma_5)/2$, set

$$C = \mathcal{E}_5(K_s/\sinh K_s), \qquad W_+ = \mathcal{E}_5(e^{K_s} K_s/\sinh K_s). \qquad (10)$$

Matrix functions take their continuous values at zero. Temporal transport enters in its ordered form:

$$Q(\mathsf{T}_4) = 1/2 \left[\mathsf{T}_4^\dagger W_+ \mathsf{T}_4 - W_+ + 2C - \mathsf{T}_4^\dagger C - C\mathsf{T}_4 \right]. \qquad (11)$$

The overlap operator and fermion action are

$$X = \gamma_4 \sinh K_s - I + Q(\mathsf{T}_4) + 1/2\, \gamma_4 \left(\mathsf{T}_4 - \mathsf{T}_4^\dagger \right), \quad D = I + \gamma_5 \mathrm{sign}(\gamma_5 X), \qquad (12)$$

$$\Gamma_F = -1/2 \log|\det D|. \qquad (13)$$

For time-dependent spatial fields, K_s acts separately on each time slice while T_4 moves between slices. Thus (11) transports the precision rather than replacing it by a commuting scalar. Internal fluctuations are inserted on every link, with temporal ordering $U_4 = e^{i\alpha\phi T_A} e^{i\eta\xi_4}$. The chiral determinant phase is outside (13).

4 Counting fluctuations once

Retain one closed fermion loop and expand its Gaussian expectation to first order in the covariance. This gives the fermion exchange contribution

$$\Delta\Gamma^{(1)}(\alpha) = \frac{1}{2} \mathrm{Tr} \left[\Delta C(\alpha)\, \Gamma_{F,\xi\xi}(\alpha, 0) \right]. \qquad (14)$$

The contraction sums the internal generators and fluctuation coordinates. It is the difference between two models with the same fermion action, not the full matter determinant added on top of ordinary running. The record-independent fermion term cancels. Pure bosonic determinant terms do not belong to this isolated fermion contribution and are not declared zero.

More precisely, (14) is the first cumulant of the fermion action. The full connected free energy also contains $-1/2\, \Gamma_{F,\xi}^T \Delta C\, \Gamma_{F,\xi}$ at this covariance order. That term has two closed fermion loops joined by one propagator and is reducible; it is not part of the single-loop class in (14). A physical one-particle-irreducible gauge coefficient requires the corresponding Legendre and matching construction. The present result is not the complete first-order expansion of the connected free energy.

Differentiating the complete expression retains

$$\Delta\Gamma^{(1)\prime\prime} = 1/2\, \mathrm{Tr}[\Delta C\, \Pi'' + 2\Delta C'\, \Pi' + \Delta C''\, \Pi], \qquad \Pi = \Gamma_{F,\xi\xi}. \qquad (15)$$

The middle term is generally present for time-dependent modes. In the static restriction used here it vanishes, and the final term can be checked independently as a covariance contact. The four-dimensional executable instead evaluates the entire contraction at each source value. This retains moving covariance eigenvectors as well as eigenvalues.

Quadratic fermion feedback changes the covariance at higher order in this variance expansion. It is not resummed and then also added perturbatively. Other cumulants, including the reducible term just

identified, and non-Gaussian record interactions are outside the reported single-loop class. Consequently numerical step convergence is not an estimate of the omitted interaction contributions.

5 Reduction to the three sectors

For the inherited fermion census, the index–Casimir matrix and fermionic charge Gram are [3]

$$\mathcal{I} = \begin{pmatrix} 8 & 9/4 & 11/12 \\ 6 & 9/2 & 1/2 \\ 22/3 & 3/2 & 95/18 \end{pmatrix}, \qquad K_F = (6,6,10). \qquad (16)$$

The difference between K_F and (1) matters: the Higgs contribution to the baseline does not create a Higgs exchange diagram in this fermion calculation. Factor components use a comma, as in $K_{F,A}$ for the vector K_F.

Proposition 1. For the common free operator, common spatial and temporal weights, and adjoint covariance continuation specified above, the leading response has the form

$$\Delta Z_A = F \sum_B \frac{\mathcal{I}_{AB}}{Z_B} + G \frac{C_{\mathrm{adj},A} K_{F,A}}{Z_A}, \qquad C_{\mathrm{adj}} = (3,2,0). \qquad (17)$$

Proof. The single fermion loop with two external and two internal insertions has two ordered colour traces. Their internal-generator sums are $C_R \mathrm{Tr}(T_A^2)$ and $\left(C_R - C_{\mathrm{adj}}/2\right)\mathrm{Tr}(T_A^2)$. Cross-factor generators commute. The covariance derivative terms involve adjoint commutators and contribute to the same adjoint structure. Identical operators and weights make the scalar functions common on this restriction. Summing representations yields (17). This argument would not justify common coefficients for unrelated factor-pair operators. ▫

The executable obtains F from a unit commuting generator and G from the two perpendicular generators of a fundamental SU(2) doublet. If their complete contractions are J_1 and $J_\perp$, respectively,

$$F = \frac{J_1''}{N_e \hat{k}^2}, \qquad G = \frac{J_\perp'' - J_1''/4}{N_e \hat{k}^2}. \qquad (18)$$

The factor $1/4$ follows from the two traces $\mathrm{Tr}(T_3^2 T_1^2) = \mathrm{Tr}(T_3^2 T_2^2) = 1/8$. For the charged pair, the component $z = \xi_1 + i\xi_2$ transforms as $e^{-i\alpha\phi} z$ under $e^{i\alpha\phi\sigma_3/2}$. This convention is used consistently in the covariance and fermion insertions.

Numerically, (17) is

$$\Delta Z = F(3.362597976, 3.311473473, 3.722018722) + G(5.709677419, 3.513647643, 0). \qquad (19)$$

The necessary residual condition therefore becomes

$$-0.7483120412F + 1.4118832936G = -0.2060702230. \qquad (20)$$

This is a test of calculated coefficients, not an instruction to fit them. In particular, $F < 0$ and $G > 0$ necessarily give the wrong sign. An overall positive multiplication of this contribution preserves that failure at this order.

6 Numerical results and checks

The static calculation first retains all nonconstant transverse spatial modes. The covariance contact is essential; the four-point fermion derivative alone is not the whole response.

Table 1. Static spatial slices including the covariance contact.

Box	Real modes per generator	ΔZ_C	ΔZ_W	ΔZ_Y	$\ell \cdot \Delta Z$
$2^3 \times 4$	14	−0.00695244	−0.00794603	−0.01098946	+0.00294529
$3^3 \times 6$	52	−0.00112037	−0.00132818	−0.00191382	+0.00053528

At $2^3 \times 4$, the covariance contact alone is (0.00238939,0.00147039,0); at $3^3 \times 6$ it is (0.000974538,0.000599716,0). These rows vary substantially with the box and source momentum. They are not a continuum extrapolation.

Table 2. All nonconstant four-dimensional transverse modes. The target contrast is −0.20607022.

Box and modes per generator	ΔZ_C	ΔZ_W	ΔZ_Y	$\ell \cdot \Delta Z$
$2^3 \times 4$, 93 modes	-0.028832	-0.031265	-0.040517	+0.010068
$2^3 \times 6$, 141 modes	-0.028935	-0.030294	-0.037418	+0.008727

For the refined $2^3 \times 4$ calculation, $F = -0.01088570$ and $G = 0.00136131$. At $2^3 \times 6$, $F = -0.01005313$ and $G = 0.00085281$. Both tested time extents fail the sign condition in (20).

The four-dimensional rows include temporal fluctuations rather than multiplying a static susceptibility by a guessed event rate. They nevertheless retain finite Euclidean time extent; a physical event rate and a zero-temperature limit do not follow from merely including all modes of a small box.

The primary calculation halves both the internal-link and external-source steps from 0.08/0.04 to 0.04/0.02, using Richardson extrapolation at each stage. The largest change in a sector increment is 5.3e-06, and the contrast changes by 1.2e-06. This supports the sign and approximate size, not every retained raw digit. The complete charged-pair contraction at positive and negative external source agrees within 1.6e-11. The archived internal_error_estimate records the removed second-order step term, not an error bound on the extrapolated result. The time-extent change in Table 2 is a sensitivity check, not a continuum or zero-temperature limit.

Independent operator checks include the following. The full time-domain determinant agrees with the temporal Fourier implementation on static fields to 4.6×10^{-13}. An explicit sum over all eight colour generators agrees with the two-invariant reduction to 3.1×10^{-6} in the unnormalised finite-difference derivative, and a mixed colour–weak representation agrees to 2.7×10^{-6}. The independently differentiated static covariance contact agrees with finite source changes to 1.2×10^{-10}. These checks test the implementation, not the physical attachment of the finite construction.

7 Conditional comparison with the force residual

For an explicitly conditional test, attach the calculated difference directly to (1), one box at a time, and rerun the inherited SMDR comparison [6]. The strong coupling again fixes the comparison scale. Table 3 reports the remaining inverse-squared-coupling residual, $100\left[Z_A^{\mathrm{comparison}}(Q) - Z_A^{\mathrm{model}}\right]/Z_A^{\mathrm{model}}$. A positive entry means the model still requires an increase in Z_A.

Table 3. Conditional residuals after recalibrating the strong sector.

Construction	Matching scale in GeV	Weak residual in per cent	Hypercharge residual in per cent
Inherited baseline	8.08995e+13	+0.79474	-1.63538
Four dimensional $2^3 \times 4$	5.85602e+13	+1.34731	-0.39341
Four dimensional $2^3 \times 6$	5.84922e+13	+1.31690	-0.44789

The $2^3 \times 4$ attachment gives

$$(g_C, g_W, g_Y) = (0.56580215, 0.54360756, 0.42731795) \quad \text{at its matched scale.} \qquad (21)$$

The hypercharge discrepancy becomes smaller, while the weak discrepancy grows. These three conditional numbers are therefore neither a simultaneous match nor three derived physical force strengths. They are also not couplings evaluated at the electroweak scale.

This comparison sets the attachment factor from the finite response to Z to one. That is a diagnostic convention, not a derived conversion of the lattice momentum response to a continuum renormalisation scheme. The calculation does not add a second copy of ordinary gauge running: the record-free reference is subtracted first, and only the resulting difference is passed to the inherited running calculation. Equality of infrared stiffness alone does not establish the full finite matching relation to that scheme.

The contrast in (20) is the cleaner local diagnostic because it removes common normalisation and scale directions. Its positive value excludes this computed contribution as the sole leading-order remedy on the tested branches. It does not exclude other interactions, a different justified continuation, or a change in the sign after a controlled long-wavelength limit.

The size is also restrictive: the $2^3 \times 4$ result gives $\ell \cdot \Delta Z = +0.01007$, against the required -0.20607. Holding its computed $F = -0.01088570$ fixed, (20) would require $G = -0.15172$, compared with $G = +0.00136131$ calculated. The static contrast decreases from 0.00294529 to 0.00053528 between the two rows of Table 1, a factor of 5.50. Since the box, temporal extent and source momentum change together, this is a size-sensitivity diagnostic rather than a continuum scaling law. Section 10.6 compares the two constructions through their common contrast test.

8 Scope of the finite interaction calculation

The calculation completes a concrete step beyond an internally factorised matter oscillator: it implements an ordered matter–link interaction, integrates record fluctuations once, includes every transverse mode of the chosen four-dimensional box, differentiates the fluctuation weighting, and produces separate colour, weak and hypercharge increments. Equation (17) explains their unequal values structurally. Equation (20) states exactly what the remaining relative correction must accomplish.

For this finite interaction class, two physical tasks remain: include the omitted interactions of the same construction, and connect its finite coefficient to the operational continuum comparison. Table 4 states the required returns. Sections 9 and 10 construct a separate calibrated test; they do not turn the finite exchange contribution into the complete physical response.

Table 4. Requirements for a physical continuation of this calculation.

Required return	Where it enters	Acceptance test
Full current–link–record Hessian with gauge and ghost terms	Replace the scalar continuation in (8)	Recover (5) on its auxiliary-current restriction; satisfy background gauge identities
Radial and Higgs couplings and their joint weights	Add their contributions to (14)	Preserve the master action radial projector and representation census
Non-Gaussian record vertices and higher fluctuation orders	Extend the normalised expectation underlying (14)	Recover (14) at leading order without counting its terms twice
Larger volumes and smaller physical probe momenta	Replace the coarse boxes in Section 6	Stable low-momentum coefficient with quantified finite-size and cutoff errors
Operational time and distance map and finite scheme matching	Convert the response to physical Z_A	Reproduce the reference running when the record difference is removed

Completing this interaction calculation requires the full non-Abelian link–record Hessian from one specified gauge-covariant action, with its gauge and ghost terms. The existing executable then supplies the matter contribution to that common comparison. The sign or size of the additional terms cannot be inferred from the residual they are intended to explain.

9 Enlarged joint response and chiral attachment

9.1 The coupled bosonic calculation

The finite exchange calculation in Sections 2 to 7 and the calibrated construction in this section answer different questions. The former uses the ordered operator (12), compares two fluctuation covariances, and reports an isolated interaction increment. The latter uses a separately specified stationary bosonic response and the chiral family of [7]. We retain both results without adding their coefficients: they have different operators, state restrictions and reference subtractions.

The bosonic input comes from a periodic cubic continuation with three links and three square faces per site. All three circulating-current directions are retained. The current weights are $w_J = 1/2$, $w_T = 1/4$, the target-copy cross coefficient is $\epsilon = 0.02$, and $\kappa = 1/31$. The bounded endpoint has 50 complex coordinates, divided into 48 non-Higgs and two Higgs coordinates. An aligned completion coordinate x is released through $X = xP_R, V = I$, with $0 \le x \le 2$ and $\| \rho \| \le 2$. The local Hamiltonian is

$$h_{\mathrm{loc}} = -\frac{\kappa}{2}\Delta_\rho - \frac{\kappa}{48}\partial_x^2 + \frac{1}{4}(\| \rho \|^2 - 1)^2 + 12(x - r_H)^2 + \frac{\kappa^2 d_v}{4}\| \rho \|^2. \qquad (22)$$

Here r_H is the Higgs radial coordinate and d_v the vertex degree; both bounded coordinates have Neumann conditions. The factor 24 in the completion metric follows from $\mathrm{tr}P_R = 24$. This is a declared aligned restriction of the common-action construction [4]. It retains completion motion but has $P_L V X P_R = 0$, so it does not produce a Yukawa mass. Releasing this coordinate changes the local Higgs excitation gap from approximately 0.96132 to 0.40688.

Local spectral susceptibilities feed a self-consistent Gaussian current covariance. The same covariance enters the stationary equation and the differentiated gauge response, counting the current fluctuation once. The volume sequence extends to $24^3 = 13{,}824$ sites. At that size the covariance residual is below 2×10^{-12}; static longitudinal and uniform-source responses vanish to approximately 10^{-18}. A separate relaxed-energy differentiation on 3^3 sites approaches the Fourier response with quadratic source-step error. These checks control the stated approximation; dynamic higher endpoint vertices and nonlinear gauge/record fluctuations remain outside it.

Table 5. Diagonal bosonic response used in the calibrated construction.

Factor	Electric coefficient $\mathcal{E}_A^{\mathrm{bos}}$	Magnetic coefficient $\mathcal{B}_A^{\mathrm{bos}}$	$Z_A^{\mathrm{bos}} = \sqrt{\mathcal{E}_A^{\mathrm{bos}}\mathcal{B}_A^{\mathrm{bos}}}$
Colour	372.01993555	12.000003224	66.814971572
Weak	403.02159657	13.000003493	72.382885844
Hypercharge	651.03488694	21.000005642	116.926200225

The inherited quadratic gauge/record contributions are $2K_A/\kappa$ and $2K_A$ respectively. The remaining terms in Table 5 are the calculated matter-current contributions. The bosonic charge vectors are $K_{\mathrm{nh}} = (6,6,10)$ for non-Higgs coordinates and $K_H = (0,1/2,1/2)$ for Higgs coordinates. For this census, $K_{\mathrm{nh}} = K_F$ numerically; the labels distinguish the bosonic coordinate block from the fermion census, not different numerical charge weights. Their factor components are $K_{\mathrm{nh},A}$ and $K_{H,A}$. The archive supplies the local spectra, current fixed-point equations, source derivatives and volume checks.

9.2 Direct differentiation of the chiral construction

A scalar CAR hopping example with dispersion $0.2 - 0.16\sum_i \cos k_i$ develops a Fermi surface in the cubic full-Fock ground prescription. Its nonanalytic conducting response cannot be identified with local vacuum force coefficients. The calibrated branch therefore uses the chiral construction already supplied in [7, Sections 17.17 to 17.20], attached to the same gauge links. It replaces that scalar hopping block.

Write $\beta = -\gamma_4$ and $\mathcal{K} = \beta S_U$, where S_U is the spatial Wilson seed. To distinguish the interpolation parameter from the Laplacian eigenvalue in (6), denote it by ζ. Set $W_t = \left(2I - \mathsf{T}_t - \mathsf{T}_t^\dagger\right)/2$. At Wilson and overlap parameters equal to one,

$$X_\zeta = \beta[(1-\zeta)\mathcal{K} + \zeta \sinh\mathcal{K}] + \frac{\beta}{2}\left(\mathsf{T}_t^\dagger - \mathsf{T}_t\right) + W_t - I. \qquad (23)$$

The candidate is $\zeta = 1$ and its Wilson-overlap reference is $\zeta = 0$. Define $\mathsf{H}_\zeta = \gamma_5 X_\zeta$, $P = \left(I + \mathrm{sgn}\mathsf{H}_\zeta\right)/2$ and $\overline{P} = (I+\gamma_5)/2$. With orthonormal frames $V[U]$ and $\overline{V}$, the actual Weyl matrix satisfies

$$D_\chi[U] = 2\bar{V}^\dagger V[U], \quad \Gamma_W[U] = -\log\left|\det D_\chi[U]\right| = -\frac{1}{2}\log\det\left(4\bar{V}^\dagger P[U]\bar{V}\right). \qquad (24)$$

The last identity follows from $D_\chi D_\chi^\dagger$. The projector moves in both source variations. This directly checks the finite Weyl matrix and does not infer it from a half-Dirac determinant. The fixture has 2^3 spatial sites and two antiperiodic sequential sites, a 64-dimensional seed and a 32-dimensional Weyl matrix.

Table 6. Chiral operator and source checks.

Check	**Reference**	**Candidate**
Ginsparg-Wilson residual	4.15×10^{-14}	3.00×10^{-14}
Chiral descent residual	3.47×10^{-15}	8.56×10^{-15}
Pure-gauge curvature magnitude	$< 2 \times 10^{-11}$	$< 5 \times 10^{-11}$
Pure-gauge curvature with an incorrectly frozen projector	0.354989	0.311316

An independent momentum-space differentiation gives reference magnetic curvature −0.13798241116, agreeing with finite-determinant extrapolation within 2×10^{-8}. The negative coarse-mode loop curvature is a differentiation check, not a negative physical coupling. The calculation concerns the parity-even

modulus in an index-zero neighbourhood. The global chiral measure phase and general interacting positivity are separate conditions.

9.3 Common metric and finite conversion

The oriented bosonic response has small off-diagonal electric entries. For the calibrated benchmark, we specify an equal-weight statistical mixture of eight reflected copies of that construction. Averaging RER over diagonal reflection matrices cancels the off-diagonal entries and retains the diagonal. This is an explicit construction choice; it does not show that the original oriented state was isotropic or that VERSF selects the mixture. The response at arbitrary oblique momentum remains to be checked.

The colour diagonal fixes the construction velocity c_0 and the common-coordinate conversion:

$$c_0 = \sqrt{\mathcal{B}_C^{\mathrm{bos}}/\mathcal{E}_C^{\mathrm{bos}}} = 0.179600513806, \quad t' = c_0 t, \quad E'_A = c_0 \mathcal{E}_A^{\mathrm{bos}}, \quad B'_A = \mathcal{B}_A^{\mathrm{bos}}/c_0. \qquad (25)$$

The fractional electric/magnetic mismatch is approximately -7.0×10^{-10} for weak and -4.3×10^{-10} for hypercharge. A specified geometric-mean matching condition sets both coefficients to Z_A^{bos}, using opposite finite terms of magnitude 2.53×10^{-8}. The chiral block uses the same common coordinates. Electric-only or magnetic-only matching changes the final weak coupling by about 4×10^{-9} in this approximation.

The candidate-minus-reference fermion constants from [7] are $C_E = 0.000389332$ and $C_M = -0.001012051$ per unit Weyl charge trace. Matching to the reference subtracts them; they are not additional physical improvements. The reference-to-continuum fermion conversion is calculable. From [8, Eq. (3.6) and Table I],

$$c_F = -\frac{5}{72\pi^2} - (-0.01161402 + 0.01893460) = -0.0143567733085. \qquad (26)$$

The sign is for inverse gauge coefficients, $Z^{\overline{\mathrm{MS}}} - Z^{\mathrm{lat}}$, at $a\mu = 1$. A Dirac fundamental with $2T = 1$ has the same parity-even two-point trace weight as a unit-charge Weyl field, giving the factor contribution $c_F K_{F,A}$. The pure-gauge lattice term in [8] is not transferred to the different VERSF gauge/record action.

An independent Brillouin-zone integration of (24), including the contact term, recovers the unit-Weyl logarithm $\log(1/p)/(12\pi^2)$. Its extrapolated finite lattice constant, −0.0073575, differs from the published −0.00732058 by 3.7×10^{-5}. Quadrature limits that check; (26) uses the published value. The local finite term enters at the boundary, and the massless logarithm enters through running once. The full determinant logarithm is not added again afterwards.

Equation (26) converts the fermion contribution only. The corresponding scalar conversion coefficient c_S for the Higgs coordinates has not been calculated for this construction. Setting $c_S = 0$ defines the numerical benchmark in Section 10; it does not establish that the physical scalar conversion vanishes. Gauge/ghost finite terms are likewise absent. Matching only the fermions therefore leaves a physical shape uncertainty, even after the common coefficient is calibrated.

10 Calibrated force strength test

10.1 Effective boundary and declared inputs

The practical target is a common strength calibration with the relative response held fixed. Remove the colour-proportional part of the finite response and define

$$\delta_A^{\mathrm{bos}} = Z_A^{\mathrm{bos}} - \frac{K_A}{K_C} Z_C^{\mathrm{bos}}, \quad \delta_A = \delta_A^{\mathrm{bos}} + c_F \left(K_{F,A} - \frac{K_A}{K_C} K_{F,C} \right), \quad \frac{1}{g_A^2(\mu_*)} = zK_A + \delta_A. \qquad (27)$$

Numerically $\delta^{\mathrm{bos}} \simeq (0, -2.5253 \times 10^{-8}, -2.5253 \times 10^{-8})$ and $\delta = (0, 0.00717836140, 0.00717836140)$. The construction's uncalibrated common coefficient is $Z_C^{\mathrm{bos}}/K_C = 11.13582860$. The two-input fit below

replaces it by $z = 0.52063604$, a factor of 21.39 smaller. This fitted value is 0.91% below the inherited $31/59 = 0.52542373$. The replacement is an empirical calibration of the effective gauge-kinetic coefficient, not a derivation of the absolute normalisation or a rescaling of the full microscopic action. Rescaling that action would require recomputing its fluctuations.

The bosonic response is almost proportional to K_A. Much of the numerical proximity below therefore comes from the inherited representation ratios and Standard Model running. It is not evidence that the omitted nonlinear interactions have independently fixed the relative force strengths.

All outputs in this section refer to $M_Z = 91.1876$ GeV. The main comparison is pinned to the 2024 PDG reviews [9,10]: $\alpha_s(M_Z) = 0.1180 \pm 0.0009$, $\alpha_{\mathrm{em}}^{-1}(M_Z) = 127.930 \pm 0.008$ and $s_W^2(M_Z) = 0.23129 \pm 0.00004$. Hypercharge uses the ordinary Standard Model convention; these electroweak values imply $g = 0.65168887$ and $g' = 0.35746824$. The cited electromagnetic value uses the five-flavour convention. Complete threshold conversions are needed for precision comparison. For edition sensitivity only, the 2025 electroweak review gives the $\overline{\mathrm{MS}}$ angle 0.23122 ± 0.00006 [13]. Comparing (30) with that angle alone changes the relative residual to −1.489%; this is not a complete refit to 2025 inputs and conventions.

For $a_A = \alpha_A^{-1}$, the gauge-only evolution is [11]

$$\frac{da_A}{d\log\mu} = -\frac{b_A}{2\pi} - \frac{1}{8\pi^2}\sum_B \frac{\mathcal{B}_{\mathrm{RG},AB}}{a_B}, \qquad b = (-7, -19/6, 41/6). \tag{28}$$

$$\mathcal{B}_{\mathrm{RG}} = \begin{pmatrix} -26 & 9/2 & 11/6 \\ 12 & 35/6 & 3/2 \\ 44/3 & 9/2 & 199/18 \end{pmatrix}. \tag{29}$$

The light census is three Standard Model fermion families and one Higgs doublet throughout the running interval. It is an effective-theory assumption; the gapped endpoint spectrum in Section 9.1 does not derive a light Higgs. Full low- and high-energy thresholds remain uncalculated. This running benchmark differs from the inherited SMDR comparison in Section 7. Its residuals must be interpreted within their own conventions.

A control with $z = 31/59$ and $\delta = 0$, fitting only the matching energy to α_s, gives $\mu_* = 8.80738 \times 10^{13}$ GeV and $(g, g') = (0.65512181, 0.35505208)$ at M_Z. Its coupling errors are +0.527% and −0.676% relative to the pinned benchmark. This records the baseline for the running prescription used here; the inherited SMDR outputs in Section 7 use a different prescription and are quoted at their matched scale. They should not be read as an otherwise identical M_Z comparison.

10.2 One strength calibration at a declared matching energy

At each declared matching energy, the strong measurement fixes the common coefficient in (27), leaving two coupling outputs. No electroweak measurement enters these solves. Reverse integration checks their boundary residual to below 2×10^{-8}; the one-loop solution also reproduces the closed-form relation to numerical precision.

Table 7. Two-loop outputs at the Z-boson energy with one gauge calibration input. The strong coupling is 1.21771578 in every row.

Matching energy in GeV	z	g	g'	$\alpha_{\mathrm{em}}^{-1}$	s_W^2
91.1876	0.112398	1.164238	0.917720	24.1917	0.383230
180.390463	0.122750	1.132940	0.858441	26.8428	0.364727
10^{10}	0.390130	0.741600	0.417813	94.8348	0.240937
10^{12}	0.458761	0.693082	0.382076	112.2418	0.233069
10^{14}	0.527315	0.653105	0.354203	129.6232	0.227280
10^{16}	0.595810	0.619407	0.331674	146.9853	0.222835
10^{19}	0.698468	0.577484	0.304737	173.0012	0.217812

The scale grid was recorded before the calibration runs. The 180.390463 GeV row tests an additional identification with a conditional scalar-completion scale in [12]. That source does not establish it as the gauge boundary scale. Its failure in this table concerns that extra identification.

Table 8. Illustrative fixed-scale result at $\mu_* = 10^{14}$ GeV, evaluated at M_Z.

Coupling	Calculated value	Comparison value	Role or relative difference
Strong g_s	1.21771578	1.21771578	Calibration input
Weak g	0.65310526	0.65168887	+0.217%
Hypercharge g'	0.35420318	0.35746824	−0.913%

The corresponding fine-structure coefficients are $(\alpha_s, \alpha_W, \alpha_Y) = (0.1180, 0.03394349, 0.00998378)$. Table 8 compares g, not g^2, cross sections or the inverse coefficients used in Table 3. The matching energy is assumed, so these are conditional outputs. Moving it to 5×10^{13} GeV gives $(g, g') = (0.658676, 0.358010)$; moving it to 2×10^{14} GeV gives $(0.647675, 0.350516)$. Numerical proximity at one declared scale is not precision experimental agreement.

10.3 Two calibrations and the independent weak test

If no independent matching energy is available, the measured strong and electromagnetic strengths can determine both z and μ_*. This consumes two gauge inputs and leaves one independent gauge test, the weak mixing angle. The two-loop result is

$$\mu_* = 6.38360372 \times 10^{13}\ \text{GeV}, \quad z = 0.52063604, \quad s_W^2(M_Z) = 0.22777618. \qquad (30)$$

It gives $(g_s, g, g') = (1.21771578, 0.65669631, 0.35665403)$. The electromagnetic strength is reproduced by calibration. Against the comparison angle 0.23129, the independent residual is −0.00351382, or −1.519%. The two electroweak coupling outputs are linked by the fitted electromagnetic strength and are not two independent predictions. These values retain the fermion-only matching choice $c_S = 0$.

Table 9. Sensitivity of the two-input weak-angle test.

Running or input choice	Predicted $s_W^2(M_Z)$
One-loop gauge running	0.22487227
Two-loop gauge running	0.22777618
Two loops with $\alpha_s = 0.1171$	0.22804294
Two loops with $\alpha_s = 0.1189$	0.22751357
Illustrative running top Yukawa with $y_t(M_Z) = 0.99$	0.22781599
Leave the candidate finite terms unmatched	0.22778566

The top-Yukawa row is a sensitivity test, not full electroweak threshold matching. The unmatched row changes the fermion boundary choice instead of performing the reference matching in Section 9.3. Neither small change removes the residual. The one-loop to two-loop shift is 0.00290391, 6.64 times the 0.00043726 change from the retained finite fermion conversion. Thus the running prescription has a larger effect in this comparison, and numerical integration tolerances cannot serve as physical error bars.

At one loop, a unit vector n perpendicular to both K and b removes the common coefficient and scale exactly. The benchmark must then satisfy

$$n \cdot [a(M_Z) - 4\pi\delta] = 0, \quad n = (0.551332, -0.812801, 0.188115). \qquad (31)$$

The measured benchmark instead gives −0.821773. A two-loop diagnostic similarly projects the required boundary onto the complement of K and minimises its Euclidean norm over $0 \le \log(\mu_*/M_Z) \le 40$. Near 4.9177×10^{13} GeV, the missing threshold vector is

$$\Delta Z_{\text{diagnostic}} = (-0.0197207,\ 0.0292863,\ -0.0068606), \quad K \cdot \Delta Z_{\text{diagnostic}} \simeq 0. \qquad (32)$$

Its norm is 0.0359675. This vector is inferred from all three comparison values and is a diagnostic target, not a contribution derived from the action. It is excluded from the prediction and input-switch tables. The Euclidean norm is a stated diagnostic convention. A calculated interaction must be tested after recalibrating the common coefficient and scale, without inserting this target as a fitted correction.

10.4 Partial matching and the unresolved Higgs coefficient

To separate the inherited charge ratios from the calculated finite terms, repeat the two-input calibration with the same light census and two-loop evolution while switching the boundary terms in (27). Both z and μ_* are recalibrated in every row. The charge-Gram control sets $\delta = 0$; the bosonic and fermion controls retain only the corresponding part of δ.

Table 10. Contribution to the calibrated weak-angle test. The comparison value is 0.23129.

Boundary terms retained	μ_* in GeV	$s_W^2(M_Z)$	Relative residual
Charge Gram only	6.69635×10^{13}	0.22733892	−1.7083%
Charge Gram and bosonic shape	6.69635×10^{13}	0.22733892	−1.7083%
Charge Gram and fermion matching	6.38360×10^{13}	0.22777618	−1.5192%
Bosonic and fermion terms (scalar omitted)	6.38360×10^{13}	0.22777618	−1.5192%

The finite fermion conversion raises the weak angle by 0.00043726, reducing the charge-Gram discrepancy from 0.00395108 to 0.00351382, or by 11.07%. This is a fermion-only matching effect, not a stable improvement of the complete physical model. Since $K_F = K - K_H$ with $K_H = (0,1/2,1/2)$, removing the common part of $c_F K_F$ leaves exactly $-c_F K_H$. Including the unknown scalar conversion instead gives $\delta = \delta^{\mathrm{bos}} + (c_S - c_F)K_H$. If $c_S = c_F$, the shape change cancels; if $c_S < c_F$, its leading effect reverses. The bosonic shape alone changes the angle by only -1.54×10^{-9}.

At fixed light census and running, the remaining scalar shape freedom is one number, $\lambda_H = c_S - c_F$. Table 11 recalibrates both z and μ_* for each scalar conversion. The $c_S = 0$ row is the benchmark used elsewhere; the other rows are sensitivity controls, not alternative physical predictions.

Table 11. Sensitivity to the uncalculated scalar finite conversion.

Scalar coefficient c_S	$\lambda_H = c_S - c_F$	$s_W^2(M_Z)$
$c_F = -0.01435677$	0	0.22733892
−0.01000000	0.00435677	0.22747161
0	0.01435677	0.22777618
+0.01000000	0.02435677	0.22808075

A full nonlinear solve for the pinned target 0.23129 requires $\lambda_H = 0.12973039$, or $c_S = 0.11537362$, with $z = 0.51492915$ and $\mu_* = 4.34656 \times 10^{13}$ GeV. Neglecting the tiny bosonic shape, the boundary is $zK_F + (z + \lambda_H)K_H$, equivalent to a Higgs-to-fermion weight $1 + \lambda_H/z = 1.25194$. This uses the third measurement to fit a third parameter. It specifies what a scalar contribution would have to produce; it does not derive that contribution.

Using the calibrated response row (34), $r \cdot K_H = 0.03045671$, whereas $r \cdot C_{\mathrm{adj}} = -0.00160961$. A gauge finite term proportional to (3,2,0) has little leverage on this test. If an additional scalar term and an adjoint term each have coefficient of magnitude at most 0.01, their combined first-order weak-angle change is at most 0.00032066, compared with the remaining 0.00351382. Ordinary constants of that size in these two directions cannot close the gap. This bound does not apply to arbitrary mixed interactions, altered running, large finite corrections or other source directions.

10.5 Changing the calibration inputs

The same two-parameter boundary with $c_S = 0$ can be tested using each pair of the three benchmark quantities. Integrate (28) backwards from $a(\mu_*) = 4\pi(zK + \delta)$ and solve for z and $\log(\mu_*/M_Z)$ using only the selected pair. Table 12 gives the unused output. It retains exactly the conventions of Section 10.1.

Table 12. Two calibration inputs and the remaining comparison.

Calibration inputs	μ_* in GeV	Unused output	Benchmark	Relative residual
$\alpha_s, \alpha_{\mathrm{em}}^{-1}$	6.38360×10^{13}	$s_W^2 = 0.22777618$	0.23129	−1.519%
α_s, s_W^2	3.59950×10^{12}	$\alpha_{\mathrm{em}}^{-1} = 117.07818$	127.930	−8.483%
$\alpha_{\mathrm{em}}^{-1}, s_W^2$	3.43012×10^{13}	$\alpha_s = 0.10717381$	0.1180	−9.175%

Changing the calibration moves the disagreement to the unused quantity. These are three views of the same two-parameter consistency test, not three statistically independent exclusions. The percentages also refer to different observables: the last row concerns α_s, whereas Table 8 compares g. A small residual in one chosen observable is therefore insufficient to establish a simultaneous fit to all three forces.

As a separate input-sensitivity check, the four combinations $\alpha_s = 0.1180 \pm 0.0009$ and $\alpha_{\mathrm{em}}^{-1} = 127.930 \pm 0.008$ give weak angles between 0.22751121 and 0.22804533 at the tested corners. None reaches the benchmark 0.23129. This rectangular variation is not a confidence interval; the omitted physical terms and threshold conversions have no assigned error distribution. The central weak-angle discrepancy, 0.00351382, is also substantially larger than the quoted benchmark uncertainty 0.00004 [10]. A statistical significance is not assigned to an incompletely matched model.

10.6 The response that survives recalibration

The missing correction can be specified directly in terms of its effect on the unused observable. Write $s = s_W^2(M_Z)$, $A = \alpha_{\mathrm{em}}^{-1}(M_Z)$, $L_{\mathrm{RG}} = \log(\mu_*/M_Z)$ and $a_0(s) = \left(\alpha_s^{-1}, As, A(1-s)\right)$. Let $\Phi_{L_{\mathrm{RG}}}$ be the flow (28), $J = \partial\Phi_{L_{\mathrm{RG}}}/\partial a_0$ its Jacobian, and $v = \partial\Phi_{L_{\mathrm{RG}}}/\partial L_{\mathrm{RG}}$ its velocity at the boundary. A small additional inverse-coupling coefficient ΔZ changes the boundary to $zK + \delta + \Delta Z$ while the two calibration measurements remain fixed.

Proposition 2. Residual response after calibration. Suppose the flow is smooth and the matrix below is nonsingular at the calibrated solution. With $u_{\mathrm{cal}} = A(0,1,-1)^{\mathsf{T}}$ and $e_1 = (1,0,0)^{\mathsf{T}}$, the response is

$$\mathcal{J}_{\mathrm{cal}} = (Ju_{\mathrm{cal}},\ v,\ -4\pi K), \qquad \Delta s = 4\pi e_1^{\mathsf{T}}\mathcal{J}_{\mathrm{cal}}^{-1}\Delta Z + O(\| \Delta Z \|^2). \qquad (33)$$

Proof. Differentiate $\Phi_{L_{\mathrm{RG}}}\left(a_0(s)\right) = 4\pi(zK + \delta + \Delta Z)$ with respect to the added coefficient. The result is $Ju_{\mathrm{cal}}\Delta s + v\Delta L_{\mathrm{RG}} - 4\pi K\Delta z = 4\pi\Delta Z$. The implicit-function theorem gives the local calibrated solution, and its first component gives (33). In particular, the response row annihilates K and v: common normalisation and an infinitesimal change of matching scale do not repair the independent residual. A finite addition proportional to K is absorbed exactly by changing z. ▫

For the two-loop solution (30), the determinant of $\mathcal{J}_{\mathrm{cal}}$ is approximately 36412.81 and

$$\Delta s = r \cdot \Delta Z + O(\| \Delta Z \|^2), \qquad r = (-0.05356751,\ 0.07954646,\ -0.01863304). \qquad (34)$$

Thus, to leading order, an additional calculated coefficient must satisfy

$$r \cdot \Delta Z \simeq 0.00351382, \qquad \| \Delta Z \|_2 \gtrsim 0.03596724. \qquad (35)$$

The norm statement is the Cauchy–Schwarz bound for the linearised problem, using the same Euclidean convention as (32); it is not a bound on an arbitrary finite nonlinear correction. Its agreement with the finite diagnostic norm 0.0359675 in Section 10.3 is a useful consistency check. The direction, as well as the

size, matters. A correction orthogonal to r cannot improve the weak-angle test at first order, however large its individual sector entries appear.

The Jacobian was obtained by integrating the variational equation of (28). Recalibrated central differences with boundary steps 0.001 and 0.0005 agree with (34) within 2×10^{-11}. An independent integration directly in g_A, rather than inverse fine-structure coefficients, reproduces the nominal result within 3×10^{-11} in a_A. These checks establish numerical consistency, not physical precision. Equation (35) is an acceptance condition for a correction derived from the construction; it is not a prescription for fitting that correction. If the added dynamics also change the light census, running or source identification, those changes must enter a new full calibration instead of being represented by a constant ΔZ alone.

The two halves of the paper therefore share a useful diagnostic. Normalising (34) by its hypercharge entry gives $r/r_Y = (2.87486670, -4.26910773, 1)$, within four parts in 10^4 of the inherited contrast ℓ in (3). Applying this row to the exchange increments of Table 2 gives weak-angle shifts of -0.00018760 and -0.00016259, respectively, about 5.34% and 4.63% of the remaining gap in the wrong direction. These are projected diagnostics under unit attachment, not additional physical terms in (27): the operators and reference subtractions of the two constructions remain different.

Using the charge-Gram discrepancy with the local row (34) gives a normalised target of about −0.21205, compared with −0.20607 in the inherited SMDR contrast. After retaining the fermion conversion, the remaining linear target is −0.18858. The baseline and remaining targets should not be conflated. Their difference is precisely the conditional matching effect analysed in Section 10.4.

10.7 Conditional conversion to distances and times

If the matching convention identifies $\mu_* = 1/a_{\text{lat}}$ in common relativistic coordinates, the spatial conversion and common-time conversion are a_{phys} and t'_{unit}. An original dimensionless ordering step has $\Delta t = 1$ and hence $\Delta t' = c_0$; its coordinate conversion is t_{coord}:

$$a_{\text{phys}} = \frac{\hbar c}{\mu_*}, \qquad t'_{\text{unit}} = \frac{\hbar}{\mu_*}, \qquad t_{\text{coord}} = c_0 \frac{\hbar}{\mu_*}. \qquad (36)$$

Table 13. Coordinate conversion under the stated matching convention.

Scale attachment	Spatial unit in metres	Common time unit in seconds	Coordinate conversion per ordering step (seconds)
Declared 10^{14} GeV	1.97327×10^{-30}	6.58212×10^{-39}	1.18215×10^{-39}
Two-input result (30)	3.09115×10^{-30}	1.03110×10^{-38}	1.85186×10^{-39}

These values convert the coordinates of the matched construction. Identifying the regulator scale with a primitive physical spacing requires an additional attachment. The ordering-step conversion in the last column is not a measured or derived physical event duration; it supplies no irreversible-record event rate.

11 Conclusions and the remaining physical calculation

The leading finite interaction of Sections 2 to 7 gives unequal factor corrections but fails its required sign and size test on the boxes examined. The separate stationary construction supplies an executable calibrated comparison. With the fermion-only conversion retained, two measured inputs leave a weak-angle discrepancy of approximately 1.52%. Its apparent 11.07% improvement over the charge-Gram control depends on leaving the scalar finite conversion at zero; it cannot yet be credited as a stable physical improvement. The scalar matching identity isolates the unresolved coefficient, and a full solve specifies the target $\lambda_H \simeq 0.1297$ without treating it as derived. The common calibrated projection connects both halves' diagnostic tests.

The next physical calculation is the complete finite matching of the scalar, gauge/record, ghost and mixed responses with one common source and reference prescription. It must also include dynamic higher matter-current functions and the completion/Yukawa attachment with its actual light-field thresholds. Adding the earlier finite exchange table to the calibrated coefficients would not complete that calculation. The common propagation metric must be tested in the interacting system, and an independent matching-energy attachment remains necessary for the one-input test to yield two unconditional outputs.

Calibration is a legitimate part of the practical target. Equations (31) and (32) quantify the inconsistency that common normalisation cannot absorb. Proposition 2 gives the response after both calibrations and the size and direction required of a further calculated correction. A physically justified construction can pass this test without being uniquely selected by VERSF. The present work supplies an executable comparison and explicit acceptance conditions; it has not yet derived all three measured force strengths.

Appendix A Sources and reproducibility

The sources consulted are the public action, source-history, current-weighting, chiral and gauge-response papers cited below, together with the primary matching and running references [8] to [11]. The calculation archives identify public URLs, retained source texts, retrieval coverage and hashes. The relevant source sections were read in detail.

The finite-exchange archive contains its static and four-dimensional executables, raw contractions, convergence and group-theory checks, and pinned SMDR comparison. Calibrated_Chiral_Joint_Response_Archive.zip contains the enlarged bosonic inputs, moving-projector Weyl calculation, absolute fermion matching check, calibration and sensitivity outputs, coordinate conversions, source register and SHA-256 manifest. The files publication_checks.py and publication_checks.json reproduce Tables 10 and 12, the variational response (34), input-corner checks and independent coupling-variable integration. The files partial_matching_audit.py and partial_matching_audit.json reproduce Table 11, the target-derived scalar solve, contrast comparison and normalisation accounting. The archives retain the separate subtraction conventions of the two constructions.

The README files give commands and expected outputs for Python, NumPy and SciPy, with versions recorded and one BLAS thread used. The calibrated tables can be reconstructed from the charge vectors, boundary coefficients (26) and (27), and running equations (28) and (29). For Table 10, switch the stated boundary terms and solve for the common coefficient and scale. For Table 11, add the specified scalar conversion before recalibration. For Table 12, keep the fermion-only boundary and solve against each selected pair, leaving the third quantity unused. Numerical tolerances do not quantify omitted interactions.

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