GHU Lab

User guide

English edition.

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Control names are kept as they appear in the application. Start with a reference, change one input at a time, and retain the assumptions with your result.

Carles Marín

Scientific sources and attribution accompany each guide. This manual documents the instrument; it does not claim novelty for the formulas.

Current web guide

Contents

1 Getting started: choose, calculate, interpret and save **3**

2 Hierarchy **4**

3 Design a scale **6**

4 Count a rung **8**

5 Atlas **10**

6 Same potential? **11**

7 Anomalies & proton **13**

8 Escape from proton decay **14**

9 Multiplets & parities **16**

10 Screen a table **18**

11 Collider **19**

12 Selection rule **21**

13 Model calculator **22**

14 eta-meter **24**

15 Five dimensions **25**

16 SU(N) builder **27**

17 Paper models **29**

18 4D spectrum **30**

19 Anomalies **32**

20 Brane matter **33**

21 Scan **35**

22 One model, every verdict **36**

23 Simulator **38**

24 Boundary conditions **39**

25 Classify an orbifold **41**

26 Name the relations **42**

27 Conjugate boundary conditions **44**

28 Brane kinetic terms **45**

29 Gravity–gauge · 3D **47**

30 The literature **48**

31 Simulator: 5D builder predictions **50**

32 Simulator: Higgs production from a top KK tower **51**

33 Simulator: the 4D neutrino ring **53**

34 Neutrino decays, Majoron channels and coherence **55**

35 Maru–Nago SU(6): families and the Wilson minimum **56**

36 Warped SU(6): running and UV boundary terms **58**

37 Three active flavours and a rank 2 or rank 3 extension **59**

38 Fixed light inputs: distinguish the heavy ring **61**

39 Finite-temperature SU(3): potential and coexistence **62**

40 Nucleation, percolation and conditional gravitational waves **64**

41 RS anomaly flow and baryon current **65**

42 Higgs rates, total width and experimental comparisons **66**

43 First KK gluon at the LHC: couplings, widths, $t\bar{t}$ / dijet limits and the m($t\bar{t}$) spectrum **68**

44 Boundary research: spectra, profiles, anomalies and certified response **70**

45 Quantization and certificates **75**

46 Hypotheses: local response and experimental context **77**

47 Glossary **79**

1 Getting started: choose, calculate, interpret and save

Choose a laboratory task, run a reference example and understand what its result does and does not establish.

Open web guide

The guide index groups tools by scientific family and lets you search by task, input or result. Every menu section has a short How to use panel with a direct link here. Experiments inside a section and the three Simulator modes also have their own guides. English and Spanish pages describe the same tools; English control labels remain recognizable in both languages.

First steps

1. Not sure where to start? Every menu section, Simulator mode and experiment card has a Demo button (in "How to use this section" or in the card heading): it presses the real controls for you, explains each step and ends with how to read the result.
2. Choose a task in the guide index or select a family in the application menu.
3. Start from a reference or preset before changing one input at a time.
4. Read the units, assumptions and result status with the plot.
5. Save the inputs and source record with any result you want to compare or share.

Controls and inputs

Menu / section selector. Changes the active tool. Some experiments live inside a parent section rather than in the main menu. Use Open tool from a guide to reach the correct section and mode.

How to use / Full guide. The short help stays with the application; the full guide opens separately so you can keep your working inputs. Change the help language and open the matching full guide.

Presets and reference buttons. Load a documented example; they can replace the corresponding model inputs. Save your current work before loading another reference.

Save, export and permalink controls. Capture the supported inputs or outputs. Availability and formats vary by tool. Keep units, version, source data and assumptions with the downloaded record.

Reading the results

Calculated value or numerical check. A result within the implemented model and numerical settings; convergence tests address their stated numerical question.

Certificate or formal theorem. A machine-checked or rigorously bounded statement with explicit hypotheses. It does not certify the full physical model.

Experimental comparison. Uses a named dataset and hypothesis. A reference overlay, range check and statistical likelihood are not interchangeable.

Unknown, unresolved or not evaluated. A boundary of the calculation. It must not be converted into an allowed, excluded or impossible conclusion.

The laboratory contains several distinct models. A green check, a converged sum, a formal theorem and agreement with an experimental reference each establish different things. Always retain the stated assumptions.

Worked example: A first 5D workflow

1. Open SU(N) builder and load a supported reference.
2. Inspect the potential and its located vacuum.
3. Continue to KK spectrum, then the anomaly audit.
4. Inspect brane filtering if the reference requires it.
5. Use Simulator to read scale calibration and dimensionful outputs.
6. Save the complete model record before exploring another input.

Each step answers a different question. Passing one check does not replace the next or establish complete phenomenological viability.

Scope and limitations

- Separate SU(7), SU(4), flat 5D, warped, thermal and neutrino-ring models must not be combined without a defined matching calculation.
- A finite scan does not establish nonexistence outside its stated domain.
- The current guides describe the current instrument; archived HTML editions and videos retain their own dates and scope.
- The self-contained application keeps its short help offline. Full web guides and external references require access to their files or websites.

If something is unclear

The guide opens a different-looking part of the Simulator. Check the model selector: builder, neutrino ring and Higgs production are distinct modes.

A changed input gives no new valid result. Read the validation message. Some panels retain the last valid result until the input is corrected.

You cannot find a calculation. Search the guide index, including embedded experiments, or use the related guides at the end of a page.

Sources and attribution

- Laboratory documentation and reproducibility
- SU(7) certification: statements, assumptions and attribution

2 Hierarchy

Calculate a compactification scale and Higgs mass for a chosen SU(7) bulk content, and compare the moment approximation with the implemented full Fourier potential.

Open web guide

Use this tool to see how changing bulk matter changes the scale associated with an extra dimension. A smaller nonzero Wilson phase can correspond to a larger compactification scale. The tool lets you compare an inexpensive small-angle approximation with calculations of the same implemented

potential. Begin with the named examples; only interpret a changed model after checking which assumptions you changed.

First steps

1. Start with a Table 1 row so the selected matter content has a named reference.
2. Read the gauge-seed choice before comparing any numbers. Changing it changes the potential.
3. Compare the approximate and full-potential minima, masses and scales. Then change one multiplicity and repeat.
4. Open the approximation and uncertainty diagnostics; use their own coupling and W-mass conventions when reading their results.

Controls and inputs

Bulk multiplicities. Counts of the eight supported representation/parity types. These are discrete choices of matter content, not measured probabilities. Load one published row, then change one count by one.

Gauge seed. Selects the printed gauge weights or the candidate split. The seed changes the Fourier coefficients and the arithmetic conditions. Repeat the same content under both choices and retain the seed in any comparison.

Published rows and pre-registered sixth row. Load explicitly recorded contents. A row is a reproducible input, not a promise that its printed phase will be reproduced. Read the printed value and the laboratory value side by side.

Robustness: g_4, model span and winding cutoff. Separate a coupling scenario from numerical convergence. Increasing the number of Fourier terms tests truncation; a coupling span is an assumed model range. Change the cutoff while holding the physical inputs fixed, then vary the coupling separately.

Reading the results

Wilson phase, Higgs mass and compactification scale. Read which potential and convention produced each value. Compare the approximate and full-Fourier columns at matching inputs, with GeV and TeV kept distinct.

Distance to a ceiling. A conditional bound for the stated approximation. It is not automatically an attainable content or a bound for every full-potential vacuum.

Uncertainty budget and experimental references. Numerical bounds, recorded W-mass input uncertainty, coupling scenarios and unquantified physical effects have separate meanings. The ATLAS and CMS Higgs-mass entries are separate comparisons.

A ceiling here belongs to its stated moment approximation, seed, coupling and mass window. A numerical result, an interval certificate for a fixed potential and agreement with a published physical model are different claims. The published-phase discrepancy remains open.

Worked example: Compare an approximation with its full potential

1. Load a Table 1 row and leave the seed unchanged.
2. Record the approximate phase, Higgs mass and scale.

3. Open the moment/full-Fourier comparison and read the differences and available bounds.
4. Increase the Fourier cutoff in the diagnostic and compare again without changing g_4.

You can distinguish a truncation effect from an approximation error. Agreement between these calculations does not resolve the physical gauge-determinant question.

Formulas and conventions

$$1/R_5 = 2\ m_W\ /\ \alpha$$

The scale conversion in this SU(7) convention, for a nonzero phase. The factor belongs to this convention; do not transfer it unchanged to a different model's phase variable.

Scope and limitations

- The physical choice of gauge determinant still requires reconciliation with the literature. The eight reconstructed fermion tables do not settle that separate issue.
- The small-angle moment approximation has a domain of validity. Check its error against the full potential before using a derived mass or ceiling.
- Higher-loop and other physical theory uncertainties are not quantified by a Fourier-tail bound. The displayed uncertainty components are not a complete statistical confidence interval.

If something is unclear

The scale is absent or an output is declined. Check for a symmetric or flat potential and for a zero phase. Read the stated reason rather than replacing a missing value with zero.

Two panels give different masses. Compare their seed, potential, coupling, W-mass anchor and approximation labels before comparing their digits.

Sources and attribution

- SU(7) certification dossier: formula attribution and unresolved physical scope
- Part VII: model conventions and current record
- Implementation and source attribution

3 Design a scale

Search for integer bulk contents compatible with a target compactification scale and Higgs-mass window under the displayed SU(7) moment conventions.

Open web guide

Use this when you have a desired scale and want to know whether the allowed integer matter choices can reach it. The reachable-set plot explains why a continuous target slider does not imply a continuous family of available theories. Some gaps can be certified arithmetically; other searches end because their computational budget is exhausted.

First steps

1. Choose the gauge seed and enter the target scale and Higgs-mass window in the displayed units.
2. Run the design search or inspect a rung separately.
3. Read the named outcome and its assumptions. A budget stop leaves the question undecided.
4. Load a returned content into the model and check its full potential in Hierarchy before using it.

Controls and inputs

Target $1/R_5$ and Higgs-mass window. Define the requested region in the displayed scale and mass units. These are design assumptions; entering them does not turn them into experimental constraints. Start from the prefilled target, then make a small change and compare the selected lattice points.

Rung buttons and lattice-point probe. Restrict the arithmetic problem to one rung or point so you can inspect its obstruction or construction. Compare a successful point with a neighbouring refused point.

Require $W > 0$. Applies the named preliminary screen before the full potential is asked. Passing this screen does not certify a global minimum. Read the screen explanation before enabling it in a search.

Design and Load into the model. Run the bounded search, then transfer a returned content into the laboratory's SU(7) model. Keep the search outcome and inspect the transferred content in Hierarchy.

Reading the results

Reachable-set clusters. Resolve a cluster into individual allowed points before interpreting its width as a continuous interval.

floor, cone, congruence, dual or exhaustion. Different reasons the specified arithmetic problem has no solution: a lower bound, a cone restriction, a modular condition, a separating rational certificate, or completed enumeration. Read the accompanying certificate.

budget. The permitted work ended before the question was decided. This is an incomplete search outcome.

The search works on an arithmetic reduction of the model. An impossibility certificate is limited to the problem it states; a found content still needs its potential and vacuum checked. A stopped search supplies neither existence nor impossibility.

Worked example: Follow a design through to a physical calculation

1. Run the prefilled design problem.
2. If a content is returned, save its input values and use Load into the model.
3. Open Hierarchy with the same seed and compare the approximate and full-potential outputs.
4. If the search instead stops, read whether it supplied a certificate or only a budget message.

The search and the potential check answer successive questions. A lattice solution alone is not a certificate of a physically viable model.

Scope and limitations

- Bounds and impossibility statements inherit the seed, mass window, coupling convention and arithmetic reduction used by the search.
- A positive preliminary screen does not establish a global vacuum or agreement with experimental data.
- The reachable set shown is for the stated search problem; changing the model family requires a new problem.

If something is unclear

The target lies between displayed points. Expand the cluster into its individual points and inspect the certified gap before increasing a search budget.

The search reports budget. Reduce the requested region or use the rung/point controls to isolate the question. Keep the result labelled undecided.

Sources and attribution

- Part VIII: inverse design and arithmetic certificates
- Implementation and source attribution

4 Count a rung

Count supported SU(7) bulk contents at selected moment coordinates without having to list every content individually.

Open web guide

Use this to understand how many discrete matter choices share a moment condition, especially when direct enumeration becomes expensive. A large count can reveal a large family of inputs, but many inputs may share the same potential or fail a later physical check. Compare this page with Same potential? to understand those different notions of sameness.

First steps

1. Let the initial table finish, then read the selected gauge seed and coordinate range.
2. Move the A_4 probe on the graph and compare counts across the displayed rungs.
3. Use the extended range only when you need it; it increases memory use.
4. Keep published-seed and candidate-seed counts separate when comparing results.

Controls and inputs

Gauge seed. Changes the admissible rungs and moment lattice. The candidate case has even rungs and half-integral A_4 coordinates. Inspect the labels and counts after a seed change rather than reusing a previous row.

A_4 graph probe. Chooses a moment coordinate where the counting function is evaluated. Move between neighbouring displayed points and read the integer counts.

Extended range / rebuild. Recomputes the counting table over the chosen range. The extended range is a larger memory task. First understand a small-range result, then extend it if needed.

Reading the results

Counts by rung. The number of supported nonnegative integer contents satisfying the selected moment conditions.

Counting-function graph. Shows how the count changes with the moment coordinate. A large value is a combinatorial multiplicity, not a probability.

Archived enumeration comparisons. Specific independent totals against which the counting method has been checked. They do not certify every physical interpretation of a counted input.

A count records distinct input contents in the stated arithmetic fibre. It does not count physically inequivalent theories or certify acceptable full-potential vacua. Archived enumeration totals validate specific counting cases.

Worked example: See why many inputs can share one coarse description

1. Start with the default counting range.
2. Select a point with several contributing contents and note its rung and A_4 coordinate.
3. Move one coordinate step and compare the count.
4. Open Same potential? to see why equality of a few moments is weaker than equality of the full potential.

The counts are discrete and coordinate-dependent. They describe an arithmetic fibre, not a histogram of observed particles.

Scope and limitations

- The measured-mass fibre recorded for the published seed is not transferred automatically to the candidate seed.
- Counts do not impose all phenomenological requirements, anomaly completion or full-potential vacuum tests.
- A content count and an equivalence-class count answer different questions.

If something is unclear

The graph changes substantially after switching seed. Read the new rung and coordinate conventions; the admissible lattice itself has changed.

The extended table is slow or uses substantial memory. Return to the ordinary range and use a smaller question. A resource limit should not be interpreted as a zero count.

Sources and attribution

- Part VIII: counting and the inverse problem
- Implementation and source attribution

5 Atlas

Browse the 1,286 supported SU(7) bulk contents with at most five multiplets, compare their potential shapes and load an example into the model.

Open web guide

Use the atlas when you want a visual starting point instead of choosing eight multiplicities from scratch. It shows how different input contents lead to different potential shapes within a small, completely specified catalogue. A useful workflow is to notice an interesting tile, load it, and then inspect its approximation error, anomaly content and source comparison.

First steps

1. Draw the lattice and wait for the tiles to finish.
2. Read the colour legend and the selected seed before comparing tiles.
3. Hover over a tile to inspect its content; select it to see the details.
4. Use Load into the model to investigate the selected content in the other SU(7) tools.

Controls and inputs

Draw the whole lattice. Calculates and displays the finite catalogue. Let the calculation finish before treating an incomplete display as the full set. Start once and read the legend while the tiles populate.

Tile selection. Identifies one discrete bulk content and its displayed verdict. Compare a flat tile with one that has a nonzero minimum.

Load into the model. Transfers the selected content to the shared SU(7) model used by the neighbouring tools. Open Hierarchy immediately after loading and check that the multiplicities match.

Reading the results

Potential tiles. Small plots ordered by the calculated phase. Read the numerical details before comparing shapes at different scales.

Content and verdict. The supported representation/parity counts and the result of the stated mass-window calculation.

Flat potentials. Contents whose implemented potential has no phase-dependent preference at the displayed order. A unique broken vacuum cannot be inferred from a flat curve.

Each tile is a content in a finite catalogue. Its colour summarizes the displayed calculation under its conventions. A flat-potential tile is a mathematical outcome, not missing experimental data; a favourable colour is not a complete model-validation claim.

Worked example: Turn a visual candidate into an inspectable model

1. Draw the atlas with the default conventions.
2. Select the tile corresponding to a named published row and inspect its content.
3. Load it into the model and open Hierarchy.

4. Compare the mass-window verdict with the full-potential and uncertainty diagnostics.

The same input content can be followed from a thumbnail to a detailed calculation. The catalogue's size limit remains part of what was searched.

Scope and limitations

- The catalogue stops at five multiplets; it is not an enumeration of every possible bulk content.
- A plotted minimum or mass-window colour is not a proof of anomaly cancellation, a complete flavour sector or experimental viability.
- The SU(7) normalization and literature-discrepancy cautions also apply to these tiles.

If something is unclear

A tile appears blank or flat. Inspect its content and flat-potential classification before assuming a drawing failure.

The loaded model seems different from another comparison. Check its gauge seed and every multiplicity; a tile label alone does not specify a different panel's coupling or approximation settings.

Sources and attribution

- Part VII: SU(7) potential and finite catalogue
- Certification and source-discrepancy scope
- Implementation and source attribution

6 Same potential?

Compare two SU(7) bulk contents using the full-potential coordinates, and distinguish equal potentials from equal low-order moments.

Open web guide

Use this to avoid counting different matter descriptions as different one-loop potentials. It also demonstrates a common limitation of approximations: two models can agree on the few coefficients used near a symmetric point while differing elsewhere. The algebraic comparison and the numerical graph are deliberately shown together so you can tell an identity from a visually small difference.

First steps

1. Use the shared model as content A and copy it into content B.
2. Apply a displayed kernel relation or edit B's multiplicities.
3. Read the five-coordinate comparison as well as the curves.
4. Load the equal-moment example to see how matching local moments can leave different full potentials.

Controls and inputs

Content B: copy, clear and multiplicities. Creates the second input independently of the shared content A. Copy A first so the initial equality has an obvious cause.

Kernel-relation arrows. Rewrite a content using a relation that leaves the potential coordinates unchanged, subject to valid nonnegative counts. Apply an available arrow and inspect which multiplicities change.

Canonical of A. Chooses the canonical representative used by the implemented algebraic reduction. Compare its content with A while keeping the coordinates in view.

Equal-moment example and plot range. Loads a pair with matching selected local moments and lets you compare local and full phase ranges. Read the small-angle view, then expand to the full range.

Reading the results

Five potential coordinates. The complete identity test for this stated family. Equality has a stronger meaning than agreement at sampled plot points.

Two potential curves. A numerical illustration of the algebraic comparison. Use the full range to inspect structure hidden by a local zoom.

Moment diagnostics and evidence. Show which selected moments coincide and what the available exact or interval checks establish about the example.

For the stated potential family, equality of the five coordinates is the algebraic equality criterion. Two overlapping plots alone cannot prove an identity. Matching only the selected local moments is weaker and can leave different global behaviour.

Worked example: Compare exact equality with approximate agreement

1. Copy A to B and verify coordinate equality.
2. Apply a permitted kernel relation; the content changes while the identity criterion remains satisfied.
3. Load the equal-moment example.
4. Compare the local and full plots and read the separate full-potential conclusion.

A kernel rewrite and a low-order moment match have different logical strength. Use the coordinate or certificate statement, not the apparent thickness of an overlaid curve.

Scope and limitations

- The equality criterion concerns the implemented one-loop potential family and its conventions. It does not prove that all particle spectra, couplings or boundary sectors are identical.
- Numerical agreement at finitely many phase values does not establish an analytic identity.
- A canonical representative of a potential is not automatically a canonical representative of the complete physical theory.

If something is unclear

A relation arrow cannot be used. Check whether the proposed rewrite would require a negative multiplicity.

The curves look identical but the tool distinguishes them. Read the exact coordinate comparison and use the full phase range; a plot may hide a small or distant difference.

Sources and attribution

- Part VII: potential coordinates and kernel relations
- Moment diagnostics and theorem scope
- Implementation and source attribution

7 Anomalies & proton

Inspect the SU(7) bulk anomaly contributions and the boundary matter needed to cancel them; the separate RS experiment studies another model's anomaly flow.

Open web guide

Use this to connect a compact anomaly number with the fields that contribute to it. The signed bars help you see why adding a multiplet can increase or decrease the total. The brane construction then asks whether additional boundary matter can cancel the relevant channels while meeting a separate proton-protection condition.

First steps

1. Load a named SU(7) content in Hierarchy and return here.
2. Read the signed contributions to 8D and the six anomaly channels.
3. Check the selected seed before interpreting the displayed rung ladder.
4. Follow the brane-matter construction in Escape, or open the separate RS anomaly-flow experiment for its own inputs and assumptions.

Controls and inputs

Shared SU(7) bulk model. Supplies the matter multiplicities used by the bars and channel table. Edit it in Hierarchy or load a named row. Compare two published rows and track which contributions change.

Gauge seed and rung information. State the arithmetic convention behind the ladder and the conditional ceiling. Read the rung parity after changing seed; do not carry a previous impossibility statement across the change.

RS anomaly-flow shortcut. Opens an embedded warped-model experiment with its own parameters and outputs. Use its dedicated guide before comparing UV and IR contributions.

Reading the results

Signed contribution bars. Show how individual multiplets contribute to the displayed anomaly combination, in the stated eighth-unit normalization.

Six-channel table. Separates the anomaly conditions that a proposed matter completion must satisfy. Cancellation in one combination is not cancellation in every channel.

Rung ladder and brane-construction costs. Relate the arithmetic of the selected bulk content to the boundary assignments examined by the laboratory.

A nonzero bulk anomaly contribution is an obligation for the complete model to cancel. It is not by itself a final inconsistency verdict when boundary matter is allowed. A forbidden arithmetic rung is a statement under the selected seed's assumptions.

Worked example: Trace an anomaly total back to its content

1. Load a published SU(7) row in Hierarchy.
2. Read its total and individual bars on this page.
3. Change one bulk multiplicity in Hierarchy and return.
4. Open Escape to inspect all channels for an explicit boundary assignment.

The total is connected to individual contributions, while the completion must be checked channel by channel.

Scope and limitations

- Bulk-only anomaly information does not describe every possible boundary completion.
- An anomaly cancellation calculation does not determine a proton lifetime.
- The RS anomaly-flow experiment is a separate model. Its UV/IR results are not corrections to the SU(7) table.

If something is unclear

A nonzero row seems to contradict a usable model. Check which fields are included. The bulk subtotal and the complete bulk-plus-boundary ledger answer different questions.

The ladder interpretation changes with the seed. Read the seed-dependent arithmetic statement and compare only calculations made under matching assumptions.

Sources and attribution

- Part VI: anomaly and boundary-matter construction
- Part VII: seed-dependent arithmetic
- Implementation and source attribution

8 Escape from proton decay

Construct the supported SU(7) boundary-matter assignments and check their anomaly cancellation and proton-protection selection rules separately.

Open web guide

Use this when you want to see how a boundary completion can cancel the bulk contribution while restricting dangerous operators. The tool makes the charges and assignments explicit so that a successful label can be traced back to a concrete choice.

First steps

1. Start with a listed assignment so its rung and charge conventions are explicit.
2. Change the rung choices, X_Q or q_ϕ one at a time.
3. Read every anomaly channel, then the allowed-operator and residual-symmetry information.
4. Compare the result with the selected bulk model's required anomaly cancellation.

Controls and inputs

Rung choices. Select the boundary assignment in the displayed charge lattice. Load one of the twenty listed assignments before editing its rungs.

X_Q and q_ϕ. Charge parameters entering the anomaly conditions and the selection rule. Use the exact rational conventions shown by the panel. Change one charge and compare the anomaly table with the operator verdict.

Rung cube. A view of the assignment space and where the protection condition changes. Rotate it, then select a listed assignment to inspect its numbers.

Reading the results

Six anomaly channels. Exact rational contributions for the supported content. Check every channel rather than only a displayed total.

Selection rule and residual group. Identify which supported operators the charge assignment permits or forbids.

Boundary contribution against the bulk. Shows whether this completion supplies the cancellation required by the current bulk input.

Cancellation and operator protection are separate tests within the implemented assignment family. A protected operator pattern is not a calculated proton lifetime, and enumerating this family does not classify every possible completion.

Worked example: Separate cancellation from protection

1. Load a listed assignment and record both verdicts.
2. Change a rung or charge.
3. Read which channel or operator condition changed.
4. Restore the assignment and verify that the original two conclusions return.

You can explain a verdict from the charge and channel tables rather than relying on its colour.

Scope and limitations

- The enumeration concerns the implemented assignment family and operator tests.

- No proton decay rate, hadronic matrix element or experimental lifetime likelihood is evaluated here.
- A complete model may need additional matter and interaction checks beyond these conditions.

If something is unclear

Cancellation succeeds but protection changes. Read the operator selection rule separately; an anomaly condition does not determine every allowed interaction.

The boundary contribution does not match the bulk. Confirm the selected SU(7) content and seed, then compare channel signs and charge normalization.

Sources and attribution

- Part VI: boundary assignments and operator protection
- Implementation and source attribution

9 Multiplets & parities

Inspect how supported SU(7) representations split under the boundary symmetries, and how their parity signs determine zero modes and potential terms.

Open web guide

Use this to connect the representation names in the bulk-content editor with the components that survive the boundaries. The cube is a visual index of signs; the component and coefficient tables contain the detailed information.

First steps

1. Choose a supported representation and read its parity labels.
2. Use the cube and the component table together to identify which fields occupy each corner.
3. Read the derived fermion term table and its comparison with the reference coefficients.
4. Keep the gauge-sector split and its unresolved physical interpretation separate from the reconstructed fermion tables.

Controls and inputs

Representation selector. Chooses the supported multiplet whose decomposition is displayed. Start with the fundamental representation, then compare a tensor representation.

Parity and intrinsic-sign choices. Specify how a component transforms at the boundaries and which sign enters its Fourier term. Change one available sign and follow the affected components.

Parity cube. Groups components by their displayed Z_2 signs. Rotate it and read the table instead of inferring multiplicity from a drawing alone.

Reading the results

Component decomposition. The subgroup representations and parity assignments obtained from the supported parent representation.

Zero-mode information. Identifies components allowed to remain massless by the stated boundary projection before additional mass-generating effects.

Derived term table. Checks the Fourier coefficients reconstructed from the component signs against the implemented reference.

A zero mode is a component allowed by the displayed boundary conditions. Reconstructing fermion coefficients checks that part of the potential; it does not determine the complete physical gauge determinant.

Worked example: Follow one sign through the calculation

1. Select the fundamental representation.
2. Read a component's boundary signs and zero-mode label.
3. Change an available intrinsic sign.
4. Compare the component and Fourier-term tables before and after.

You can identify which boundary choice changes a component or a potential contribution, without treating the sign cube as a spectrum calculation by itself.

Formulas and conventions

$$s = \eta\ \eta\prime\ P_5\ P\prime_5$$

The sign product shown for this potential convention. Read the definitions of the component and intrinsic signs on the panel.

Scope and limitations

- Only the supported representation and boundary conventions are covered.
- Boundary-allowed zero modes can be lifted by interactions that are outside this decomposition.
- The eight fermion tables and the physical gauge-sector question have different evidence status.

If something is unclear

A component exists in the decomposition but has no zero mode. Check its individual boundary parities; belonging to the parent representation is not sufficient to survive the projection.

Sources and attribution

- Formula attribution and fermion-table reconstruction
- Implementation and source attribution

10 Screen a table

Arithmetic screens for a published row, with conditional rung certificates and independent full-potential witness checks.

Open web guide

Use this to check whether a proposed SU(7) row is compatible with the implemented arithmetic before doing a broader calculation. It also provides access to the certificate dossier. Read which question each certificate answers: a fixed-potential global minimum and a conditional ceiling for a moment relaxation are different mathematical statements.

First steps

1. Type the row's two observables.
2. Read the mod-6 law, the K invariant and the arithmetic comb.
3. Open Conditional rung bounds and check the seed, coupling and Higgs-mass window before using a ceiling.
4. Compare the archived full-Fourier witnesses: a stationary point may have a deeper competing vacuum.

Controls and inputs

Row inputs. The observables or arithmetic quantities labelled by the screen. Preserve the source's units and rounding when entering a printed row. Load a listed row before typing an alternative.

Gauge seed, coupling and mass window. The conventions conditioning the arithmetic and bound comparisons. Read them beside a certificate before comparing its ceiling with another result.

Save certificate buttons. Download the archived evidence, assumptions and associated checks as JSON. Save a bundle when recording a result so its scope travels with the number.

Reading the results

Arithmetic laws and K invariant. Consistency screens within the stated model reduction. A failed screen identifies the stated mismatch; a passed screen leaves later tests open.

KK comb. The allowed arithmetic spacing displayed in squared mass. It should not be read as equally spaced masses.

Formal and interval evidence. The dossier distinguishes exact algebra, certificates for ten fixed one-phase potentials, conditional moment ceilings and separate numerical witness comparisons.

The interval certificates bound a small-angle moment relaxation under the stated conventions. They do not certify a ceiling for the full potential. The separate vacuum checks compare numerically located extrema with Fourier-tail errors; an observed surviving witness is not an exhaustive optimum.

Worked example: Read a certificate without enlarging its claim

1. Load one archived row and read all three screens.
2. Open the conditional bound information and record the seed and mass window.

3. Compare a full-potential witness with one labelled as having a deeper competing vacuum.
4. Save the evidence bundle and follow the attribution link.

A stationary point can pass one test while failing the global-vacuum comparison. The exported assumptions explain which conclusion can be reused.

Scope and limitations

- A moment-relaxation ceiling is not a universal ceiling for full-potential vacua.
- Numerically checked witnesses do not establish exhaustive optimality.
- Mathematical certificates for the implemented potential do not resolve the outstanding physical gauge-determinant choice or establish scientific novelty.

If something is unclear

A printed row fails a screen. Check rounding intervals, units and seed first, then read the specific failed relation. Do not infer that an entire paper is wrong from one mismatch.

A stationary witness has a lower competing vacuum. Keep the stationarity result but withdraw the claim that this witness is the global vacuum.

Sources and attribution

- English certification dossier: assumptions, authorship and downloadable evidence
- Part VII: row consistency and scale arithmetic
- Implementation and source attribution

11 Collider

Which state a dijet search bounds, plus a separate Higgs-rate scenario checked against pinned experimental datasets.

Open web guide

Use this to connect a model's coloured state with the particular dijet measurement used in the archived comparison. The separate Higgs-rates experiment studies a specified scalar-coupling scenario. Keeping those two subjects distinct prevents a limit on one particle hypothesis from becoming an unsupported verdict about a whole GHU model.

First steps

1. Use the Higgs-rates shortcut to compare a saved scalar scenario, its widths and rates, and matching HiggsBounds/HiggsSignals calculations.
2. Read the coupling and invisible-width assumptions alongside the HiggsSignals chi-square and the analysis selected by HiggsBounds.
3. Read the coloron's mass and width — both fixed by the localisation, not chosen.
4. Drag the relief over (M_jj, χ), the plane CMS bins its angular measurement in.
5. Type any $1/R_5$ to see the ratio table move.

Controls and inputs

Compactification scale $1/R_5$. Sets the model scale for the displayed colour-sector comparison. Change it and read the model-to-reference ratios at the named bins.

Dijet relief. Displays the predicted distortion over the dijet mass and angular variable used in the measurement. Rotate the view and read the axes and reference-bin labels.

Higgs-rates shortcut. Opens the separate coupling/width experiment and its matching experimental calculations. Start with its Standard Model reference before changing a coupling.

Reading the results

Coloron mass, width and coupling. Belong to the stated localization and colour-sector assumptions; they are not freely interchangeable with another resonance model's parameters.

Dijet ratio and archived $\Delta\chi^2$. The displayed comparison retains the provenance of the original recast. It is not a newly executed fit to every dataset stored in the laboratory.

CMS reference snapshot. Seven distributions and 77 bins are archived with source records. The correlation table concerns fitted signal strengths and is not an unfolded-spectrum covariance matrix.

The dijet $\Delta\chi^2$ values are quoted from the published record; the Higgs experiment computes its own comparison. Its 159 HiggsSignals observables are not 159 independent degrees of freedom. Coupling and width assumptions can compensate in visible rates, so this scalar comparison is not a complete GHU fit.

Worked example: Inspect the hypothesis behind a collider comparison

1. Read which coloured state and localization assumptions define the current calculation.
2. Record the scale and one named-bin ratio.
3. Change the scale while retaining the particle hypothesis.
4. Open the dataset/source description and distinguish the archived recast from newly stored reference data.

The numerical response is traceable to a named hypothesis and analysis. Importing a dataset alone has not created a new GHU exclusion.

Scope and limitations

- A published bound is reusable only to the extent that its production, decay and acceptance assumptions match the proposed state.
- The stored CMS data have not been combined into a new laboratory likelihood or a new GHU fit.
- The HiggsTools comparison belongs to its supplied scalar scenario. Its observable count is not automatically the statistical number of degrees of freedom.

If something is unclear

A limit seems much stronger than another panel's limit. Compare the particle identity, production channel, branching assumptions and reference analysis before comparing numbers.

The Higgs experiment reports a pending calculation. Use a matching saved reference, import a matching result or explicitly run the configured local engine. Do not reuse a result for different couplings.

Sources and attribution

- Part VII: model-to-collider comparison and its assumptions
- Experimental reference and ingestion scope
- Implementation and source attribution

12 Selection rule

Check the supported SU(4) representation and Wilson-domain selection conditions, including the chiral-count test for a quark-generation embedding.

Open web guide

Use this before choosing a representation or reducing a vacuum-search domain. Boundary symmetries can relate some phase values, but the allowed reduction depends on the content. The embedding test asks a second question: whether the supported representation can contain the required chiral structure under the stated projection.

First steps

1. Select the Dynkin labels (a, b, c), which identify the representation.
2. Read the centre-charge condition and the permitted Wilson-line search domain.
3. Inspect all three embedding conditions before using the displayed count.
4. Compare a passing representation with one that fails a single condition.

Controls and inputs

Dynkin labels a, b, c. Nonnegative integer labels of an SU(4) representation; changing them changes the representation, not a continuous coupling. Start with a catalogue entry and change one label.

Test the rule on every representation. Runs the displayed finite catalogue comparison. Read the tested range together with the verdict.

Shared SU(4) content. Connects the selection rule to the matter content used by the calculator. Inspect the domain again after editing that content.

Reading the results

Permitted phase domain. The domain justified by the selected content's symmetry. An unjustified reduction can miss a vacuum.

Three embedding conditions. Centre-charge parity, a nonzero middle Dynkin label and the stated size condition must be read together.

Chiral count. The count for the stated projection when its hypotheses hold; it does not specify Yukawa couplings or measured quark masses.

The count applies under the displayed projection and embedding conditions. Classical centre-charge facts and the series' chiral-count calculation have separate attribution. Passing these representation tests does not construct a complete quark sector.

Worked example: Check a proposed representation before calculating its vacuum

1. Choose a catalogue representation.
2. Record each condition and the permitted domain.
3. Change one Dynkin label and inspect which condition changes.
4. Follow the representation to Model calculator using a domain justified for that content.

You can distinguish a representation-selection result from the later potential and mass calculations.

Formulas and conventions

$$N = (b + 1)(a + c + 1) / 2$$

The displayed count under the panel's three embedding conditions and chiral projection. The symbol here is a count, not the SU(4) gauge-group rank.

Scope and limitations

- The conditions use this SU(4) embedding and boundary projection; they are not a universal criterion for every GHU model.
- A finite catalogue check does not replace the stated proof assumptions.
- An allowed representation does not settle masses, interactions or anomaly completion.

If something is unclear

The count is unavailable or a condition fails. Read the failed condition before interpreting the formula. Do not evaluate an out-of-scope count as an accepted embedding.

Sources and attribution

- Part II: embedding and chiral projection
- Part III: Wilson-domain selection
- Implementation and source attribution

13 Model calculator

Evaluate the supported SU(4) one-loop potential, locate its vacuum and calculate the associated Higgs curvature for a chosen matter content.

Open web guide

Use this as the numerical workspace for the SU(4) model family. Loading the published reference gives you a reproducible starting point. You can then change one representation count or sign and see how the vacuum and mass response change.

First steps

1. Load the named AHMN reference before constructing a custom content.
2. Set multiplicities, boundary signs and the displayed matter/gauge roles.
3. Read the vacuum location and the reference-reproduction indicator.
4. Use Selection rule to understand the search domain, and eta-meter to inspect sign sensitivity.

Controls and inputs

Load AHMN / clear. Restores the named reference or removes the editable matter content. Record the anchor before making any changes.

Representation multiplicities. Add or remove copies of supported representations from the catalogue. Change one count by one and compare the vacuum.

η and matter/gauge role. Change the boundary-sign or contribution convention used for that row. Keep a record of these labels with the multiplicities; the counts alone are insufficient.

Search-domain comparison. Shows the effect of an assumed domain reduction on the catalogue calculation. Use the justified domain rather than choosing the smaller search only for speed.

Reading the results

Potential cut and vacuum. The curve and located minimum for the selected input. Read which cut through the multidimensional potential is being shown.

Mass/curvature results. Derived from the potential's local curvature and the stated normalization; a potential value itself is not a particle mass.

Anchor indicator. Reports whether the implementation reproduces the named AHMN reference within its stated comparison.

Mass ratios remove some overall normalization dependence but retain the model and approximation assumptions. Absolute masses and scales require the stated normalization and physical inputs. The anchor indicator tests a named reference calculation, not general phenomenological validity.

Worked example: Measure one change relative to the anchor

1. Load AHMN and note the vacuum and mass ratio.
2. Change one multiplicity while keeping its sign and role fixed.
3. Read the new vacuum and potential cut.
4. Reload AHMN and confirm the baseline is restored.

The difference is attributable to one documented input change. A successful reference reproduction is a check on that calculation.

Scope and limitations

- The supported one-loop model does not include every correction or boundary interaction of a complete theory.
- A mass ratio can remain sensitive to content, vacuum selection and approximation even when an overall normalization cancels.
- The finite representation catalogue is the implemented search range.

If something is unclear

A sign change seems to do nothing. Open eta-meter and check whether this representation is insensitive to that sign in the stated calculation.

A reduced search gives another minimum. Check Selection rule and compare the full justified domain.

Sources and attribution

- AHMN reference, arXiv:2312.08608
- Part IV: SU(4) potential calculation
- Implementation and source attribution

14 eta-meter

Compare the analytic and directly evaluated response of supported SU(4) multiplets to their boundary sign η.

Open web guide

Use this to understand why changing a boundary sign sometimes moves a result and sometimes leaves it unchanged. Difference mode removes the common part of two calculations, making an otherwise hidden dependence easier to see.

First steps

1. Choose a multiplet or load the AHMN content.
2. Compare the predicted sign response with the directly evaluated Hessian.
3. Draw the atlas and select η-difference mode to isolate the sign-dependent part.
4. Filter sign-sensitive and insensitive multiplets, then compare individual tiles.

Controls and inputs

Multiplet and content choices. Choose the contribution or combined content being studied. Compare one sensitive multiplet with one labelled insensitive.

Flip every η. Changes the selected boundary signs together while retaining the content. Read the predicted response before applying the flip.

Potential / η-difference. Switches between the full landscape and the difference under sign reversal. Use both views for an insensitive multiplet.

Atlas filters and two-tile comparison. Select the displayed subset and compare two contributions at matching conventions. Keep the display mode unchanged while switching tiles.

Reading the results

Predicted versus evaluated response. Compares the closed-form calculation with the direct numerical calculation of the stated quantity.

Difference landscape. A zero difference indicates sign insensitivity in that calculation, even if the full potential is nonzero.

Finite catalogue check. Tests the implemented rule across the 119 supported representations.

Insensitivity to η concerns the specified difference or contribution. It does not mean that a representation contributes nothing to the potential or has no physical effects. The analytic statement and the finite numerical checks have their stated scope.

Worked example: See what a zero difference means

1. Choose a multiplet labelled insensitive to η.
2. Inspect its full potential.
3. Switch to η-difference mode and read the zero response.
4. Choose a sensitive multiplet and compare the same two views.

A vanishing difference and a vanishing potential are visibly different statements.

Scope and limitations

- The result concerns the specified SU(4) sign dependence and projection.
- Numerical comparisons retain their cutoff and precision assumptions.
- Sign insensitivity alone does not determine the full spectrum or phenomenological viability.

If something is unclear

An atlas tile becomes blank in difference mode. Check whether it is classified as sign-insensitive; a zero difference can be the expected result.

Sources and attribution

- Part V: boundary-sign response and its scope
- Implementation and source attribution

15 Five dimensions

Evaluate the supported Haba–Yamashita five-dimensional SU(3) example and compare its potential, located vacuum and Kaluza–Klein spectrum.

Open web guide

Use this compact example to learn how matter and boundary signs shape a Wilson-line potential. The six counts separate the supported adjoint fermion, fundamental fermion and scalar contributions by parity-product sign. The preset buttons supply controlled comparisons without requiring a new model from scratch.

First steps

1. Load the archived row, then identify the six matter counts and their parity-product signs.
2. Compare the evaluated potential with its located minimum and the separate approximation when available.
3. Use the pure-gauge, marginal-trio and blind-step examples to change one structural feature at a time.
4. Read the spectrum at the resulting phase and retain this model's normalization conventions.

Controls and inputs

Adjoint fermion counts, + and −. Numbers of the supported adjoint Dirac fields in the two parity-product sectors. Start from the archived row and change one count.

Fundamental fermion and scalar counts, + and −. Separate fermionic and complex-scalar contributions; their signs and degrees of freedom enter the potential differently. Use the blind-step button to inspect the specific cancelling combination.

Archived row / pure gauge / marginal trio. Load the named reference or a targeted example with stated matter content. Compare pure gauge with the marginal trio while reading the potential and moment diagnostics.

Reading the results

Evaluated potential and minimum. The phase dependence of the implemented source formula and the minimum located for that input.

Moment/rung diagnostics. Describe the arithmetic of this supported five-dimensional content, including its even-rung property.

KK spectrum. The tower structure at the selected vacuum under this model's boundary and normalization conventions.

This is a particular 5D model family. Its even-rung arithmetic and phase normalization should not be replaced by those of the 6D SU(7) family. The located vacuum and a small-angle approximation must be compared within their domains.

Worked example: Separate a content change from a potential change

1. Load the archived row and note its potential.
2. Apply the blind-step example.
3. Check the changed counts and compare the potential.
4. Use the marginal-trio example and inspect the changed vacuum behaviour.

Different matter counts can have the same implemented potential contribution. The preset states which combination is being tested.

Scope and limitations

- The page covers the stated SU(3) family and supported matter sectors.
- The 5D parity-product and phase conventions differ from those of the SU(7) family.
- A one-loop vacuum and spectrum do not establish a complete phenomenological model.

If something is unclear

A content change leaves the curve unchanged. Check whether the change is the displayed blind combination of fermion and scalar contributions.

The approximation is unavailable near a marginal case. Read the direct potential and the stated domain restriction instead of forcing a small-angle formula.

Sources and attribution

- Model conventions and literature links
- Implementation and source attribution

16 SU(N) builder

Build a supported five-dimensional SU(N) model on S^1/Z_2 from boundary blocks and bulk matter, then inspect its one-loop potential and vacuum.

Open web guide

Use the builder as the starting point for a connected model investigation. The four blocks specify simultaneously diagonal boundary parities. Their sizes determine N and the apparent boundary-symmetry structure. The bulk fields supply the matter contributions to the potential. Neighbouring tools share this builder state, so you can inspect the spectrum and anomaly obligations without retyping the model.

First steps

1. Start from a preset or enter the four nonnegative boundary-block sizes.
2. Add supported bulk representations, their parity-product signs and copy counts.
3. Read the resulting group and number of Wilson phases before interpreting the potential.
4. Follow the same model into 4D spectrum, Anomalies, Brane matter and Simulator.

Controls and inputs

$\mathbf{n}_{++}$, $\mathbf{n}_{+-}$, $\mathbf{n}_{-+}$, $\mathbf{n}_{--}$. Nonnegative dimensions of the four simultaneous parity blocks. Their sum fixes the SU(N) rank parameter. Load a preset first and identify which blocks are nonzero.

Bulk representation, $\eta\eta\prime$ and multiplicity. Choose a supported field contribution, its boundary-sign product and the number of copies. Add one supported copy while keeping the boundary blocks fixed.

Presets and clear bulk. Provide named starting inputs or a gauge-only matter setting. Read a preset's boundary blocks before changing it.

Potential probe. Selects a phase at which to inspect the potential; the probe and the located vacuum are distinct positions. Click away from the minimum and compare the probe information with the vacuum result.

Reading the results

Apparent unbroken subgroup. The group visible in the chosen boundary frame. Its appearance need not be invariant under gauge-equivalent boundary descriptions.

Potential terms and Wilson phases. Show what the supported matter and boundary data contribute and how many independent phase directions are being investigated.

Vacuum result. A located minimum or a stated undecided/unsupported result under the numerical method's scope.

The builder covers the implemented boundary and representation families. A one-phase reduction permits additional moment diagnostics under their stated assumptions. A located vacuum may be undecided in a harder search; an unfinished calculation is not a proof that no vacuum exists.

Worked example: Carry one model through the laboratory

1. Load a named builder preset.
2. Record its blocks and bulk content.
3. Open 4D spectrum and read its zero modes at the selected phase.
4. Open Anomalies, then Brane matter if a completion is needed.
5. Use Simulator for the model's dimensionful comparison.

The same builder input is inspected from several perspectives. A favourable result in one view does not substitute for the others.

Formulas and conventions

$$N = n_{++} + n_{+-} + n_{-+} + n_{--}$$

The boundary block dimensions add to the defining-representation dimension of SU(N).

Scope and limitations

- Supported representations and simultaneously diagonal parity blocks define the implemented model family; the builder does not represent every possible 5D theory.
- A brane interaction or supersymmetric cancellation absent from the implemented potential cannot be inferred from the model name.
- Minimum searches, moment approximations and global certificates have different scopes.

If something is unclear

There is no Wilson-line direction. Inspect the chosen boundary blocks and surviving gauge-field components; a valid boundary condition need not leave a Higgs candidate.

The vacuum is labelled undecided. Retain that status and inspect the stated search limitation. Do not substitute a symmetric point as a certified minimum.

Sources and attribution

- Boundary conventions, normalization and literature
- Implementation and source attribution

17 Paper models

Four models somebody else published, taken off their pages and run through this instrument's engine.

Open web guide

Use this to begin from a named published construction and see which of its statements the laboratory can actually reproduce. The reference table separates boundary and zero-mode information from potential calculations. The Maru–Nago experiment is an additional supported SU(6) potential study with its own guide.

First steps

1. Use the Maru–Nago shortcut for Type 2/3 SU(6), the magnified minimum and Fourier convergence; its button transfers the supported bulk potential to the builder.
2. Pick one of the four; Kubo–Lim–Yamashita carries a dial, the number of triplet fermions.
3. Read the table: what the paper prints, then what this returns, then the verdict.
4. Press Load into the SU(N) builder and walk the spectrum, the ledger and the simulator on their model.

Controls and inputs

Model selector. Chooses one of the four archived model comparisons. Read the source and supported comparison scope immediately after selection.

Triplet-fermion count, where available. Changes the matter input in the Kubo–Lim–Yamashita example. Compare two counts while retaining the same boundary conditions.

Load into the SU(N) builder. Transfers the supported boundary and bulk input for further inspection. Open 4D spectrum after loading and compare the supported zero-mode statement.

Maru–Nago shortcut. Opens the separate Type 2 / Type 3 experiment. Read its convergence study before transferring its bulk potential.

Reading the results

Printed statement / computed result / verdict. Compares a specific source claim with the laboratory result and retains the source's equation or table reference.

Explanation rows. Describe normalization, implementation scope or disagreements that a short status label cannot explain.

Transferred model. Contains only the supported input; additional interactions of the original construction may remain outside the builder.

Three of the four are supersymmetric and this engine's potential is not, so their rows are boundary-condition and zero-mode statements only. An amber row disagrees with one printed equation, not with a paper, and names which of that paper's own equations agrees with which.

Worked example: Reproduce one statement from a paper

1. Select a published model and read its scope note.
2. Choose a boundary or zero-mode row with an explicit source reference.
3. Load the model into the builder and inspect the corresponding spectrum.
4. Read any discrepancy at the level of the named statement.

You can trace one comparison from source to input to output without treating it as a reproduction of every part of the paper.

Scope and limitations

- Three archived models are supersymmetric while the builder potential is not; their stated comparisons are limited to supported boundary and zero-mode information.
- A disagreement with one printed equation is not a blanket judgement about an entire paper.
- Transferred bulk data do not automatically include brane interactions, supersymmetric cancellations or flavour completion.

If something is unclear

A comparison is amber or limited in scope. Read the explanatory row and the cited equation before changing a normalization to make numbers agree.

Sources and attribution

- Published-model sources and comparison records
- Implementation and source attribution

18 4D spectrum

What the model on the builder CONTAINS: the four-dimensional fields and their Kaluza–Klein towers.

Open web guide

Use this to identify the four-dimensional fields supplied by the builder model and how their higher Kaluza–Klein levels are organized. The tables distinguish a family description useful for the potential from the exact tower accounting needed at exceptional low levels.

First steps

1. Edit the model in SU(N) builder — this section shares it.
2. Choose at the vacuum or type a phase.
3. Read the massless content, then the families, then the exact tower and its landscape.

Controls and inputs

Shared builder model. Determines the boundary blocks and bulk representations whose spectrum is displayed. Use the named SU(6) example, then inspect the same blocks in the builder.

At the vacuum / phase probe. Chooses whether to evaluate the spectrum at the located vacuum or at a manually selected phase. Compare a symmetric point with the available broken vacuum.

Spectrum landscape. A rotatable view of the calculated levels; the tables retain the detailed multiplicities and labels. Read the lowest levels in the exact table before relying on the picture.

Reading the results

Massless content and chirality. The surviving four-dimensional components under the selected boundary and phase conditions.

Tower families. A compact organization of spectral contributions useful for reconstructing the potential.

Exact low-level tower. Resolves low-level details that the potential-family multiset alone does not describe correctly for every representation at a broken vacuum.

The families are the potential's multiset and are right for it; at a broken vacuum they are wrong at the LOWEST level of the adjoint and the symmetric tensor, which is why the exact tower is a second table and not a repetition.

Worked example: Compare the symmetric point with the vacuum

1. Load the supplied SU(6) example.
2. Inspect the massless content at the symmetric point.
3. Switch to the located vacuum if available.
4. Compare the lowest exact levels, multiplicities and chirality labels.

A phase change can alter which states remain massless. The potential's term multiplicities are not a substitute for the exact lowest-level spectrum.

Scope and limitations

- The spectrum uses the supported builder model and its boundary conditions.
- Additional boundary masses and interactions require the separate completion analysis.
- A plotted tower does not establish experimental production or decay rates.

If something is unclear

The family and exact tables appear to disagree at the lowest level. Read the page's explanation of exceptional lowest modes, especially for adjoint and symmetric-tensor fields at a broken vacuum.

At the vacuum is unavailable. Return to the builder and inspect whether a vacuum was located or left undecided.

Sources and attribution

- Spectrum implementation and conventions
- Implementation and source attribution

19 Anomalies

What that content owes: every anomaly channel of the unbroken group, in exact rationals.

Open web guide

Use this after inspecting the builder spectrum. It sums the supported chiral massless content into the anomaly channels of the displayed unbroken group. Exact rational arithmetic makes a cancellation distinguishable from a small floating-point residual.

First steps

1. Edit the model in SU(N) builder.
2. Read the channels: $[\mathrm{SU(n)}]^3$, $\mathrm{U(1)}\times[\mathrm{SU(n)}]^2$, $\mathrm{U(1)}^3$, $\mathrm{U(1)}\times[\mathrm{grav}]^2$.
3. Read the verdict: no subject, cancels, or owes.

Controls and inputs

Shared builder content. Supplies the boundary conditions and matter being checked. Load the supplied SU(6) example and inspect its massless fermions before reading the ledger.

Model and spectrum choices. Determine which supported chiral fields are included in the stated ledger. Change one builder field, then compare the summands as well as the total.

Reading the results

$\mathrm{SU(n)}^3$ and mixed U(1) channels. Separate non-Abelian, mixed, Abelian and mixed gravitational anomaly combinations under the displayed normalization.

Summand table. Names the chiral fields contributing to each channel; it explains the total.

No subject / cancels / owes. Distinguishes absence of relevant massless fermions, cancellation of the stated ledger, and a nonzero contribution requiring a completion.

A non-zero row is a BILL, not an inconsistency: the brane fermions such a model needs pay into the same channels with the opposite sign. And a model with no massless fermion has nothing to cancel — that is ‘no subject‘, not ‘cancels‘.

Worked example: Read a cancellation claim from its ingredients

1. Load the supplied example.
2. Check the list of massless chiral fermions.
3. Read every nonzero channel and its contributors.
4. Open Brane matter to inspect a possible completion.

A zero obtained from an empty fermion list is identified separately from cancellation between nonzero contributions.

Scope and limitations

- The ledger concerns the stated included spectrum and channels. It does not automatically settle all consistency conditions of a higher-dimensional completion.
- A nonzero bulk contribution may be cancelled by suitable boundary matter; this page alone does not provide that completion.
- Anomaly cancellation is not an experimental acceptance test.

If something is unclear

The total is zero but the verdict says no subject. Inspect the fermion list. There may be no relevant massless chiral fields to test.

A nonzero channel remains. Record its normalization and contributors before adding boundary matter; cancellation must be checked with matching conventions.

Sources and attribution

- Exact anomaly-ledger implementation
- Implementation and source attribution

20 Brane matter

Who pays that bill, and what it costs: matter on the two fixed points, held at once to the anomaly ledger and to Part I's boundary-mass gate.

Open web guide

Use this to add explicit matter at the two orbifold endpoints and inspect two consequences: changes to the anomaly ledger and possible boundary masses for unwanted zero modes. The local groups at the two endpoints can differ, so a representation that is available at one boundary need not be available at the other.

First steps

1. Edit the model in SU(N) builder — or press the example to load Kawamura's SU(5).
2. Read the two branes first: they are different groups whenever the orbifold breaks anything.
3. Add fields with the + buttons, or pick a massless mode and let the partners panel say which representations contain its conjugate.
4. Press solve to get the local charges that cancel the linear channels.

Controls and inputs

Builder model / Kawamura SU(5) example. Sets the bulk model and its local boundary groups. Load the named example and read both boundary-group headings.

Boundary fields and copy counts. Add representations of the selected endpoint's local group. Use the partner suggestions for one massless mode before adding fields arbitrarily.

Boundary charges and linear-channel solver. Choose charges or solve the stated linear anomaly conditions. The remaining channels still need inspection. Compare the suggested charge with the charge required for a boundary mass.

Clear / reset charges / return to builder model. Restore a defined starting point for a controlled comparison. Save the current choices before resetting.

Reading the results

Anomaly ledger before and after. Shows what the added fields contribute in the same channel conventions.

Possible partners. Lists supported local representations that contain a conjugate partner for the selected mode.

Surviving massless content. The rank-based result assumes generic allowed couplings; the displayed surviving count is a lower bound under that assumption.

Two verdicts, kept apart on purpose: the bill before and after, and the massless count before and after. The same field can pay one and not the other, because the charge that cancels an anomaly is not in general the charge a mass term needs. The surviving count is a lower bound — the rank test assumes generic couplings.

Worked example: Check the cost of removing a zero mode

1. Load Kawamura's SU(5) example.
2. Choose an unwanted massless mode and inspect its possible partners.
3. Add a suggested local representation.
4. Compare both the anomaly ledger and the boundary-mass condition, including its charge.

A field that helps one requirement can leave another unresolved. Read the two outcomes independently.

Scope and limitations

- Solving the linear anomaly channels does not by itself solve every cubic condition.
- Generic-coupling rank information does not specify actual numerical masses or a complete Yukawa sector.
- Only the supported local representations and boundary-mass conditions are examined.

If something is unclear

The anomaly-solving charge does not permit the desired mass term. Keep both conditions explicit and try another supported completion; do not treat the two charge requirements as interchangeable.

A representation introduces additional fields. Read its full local decomposition, then include those fields in the updated ledger and surviving-content count.

Sources and attribution

- Part I: boundary masses and representation constraints
- Implementation and source attribution

21 Scan

Search a bounded set of supported 5D SU(N) boundary conditions and bulk contents through selected group, Higgs, chirality, anomaly and vacuum filters.

Open web guide

Use this when a single-model investigation suggests a precise search question. The filters run from cheaper structural checks to more expensive vacuum calculations. Starting with a small range makes it easier to understand which requirement removes candidates before increasing the search size.

First steps

1. Choose N and a small maximum content size for your first run.
2. Select the required filters, including what you mean by a Higgs doublet.
3. Run the sweep and read the stage-by-stage funnel.
4. Load a surviving hit into the builder and inspect its detailed spectrum, ledger and vacuum status.

Controls and inputs

N and maximum content size. Define the finite model space to be enumerated. Use a small case to understand the funnel before increasing the range.

Group, chirality and anomaly filters. Specify which supported conditions a candidate must pass. Change one filter at a time so you can identify its effect on the count.

Higgs requirement. Distinguishes no requirement, any supported doublet and a colour-singlet doublet. Read the colour condition explicitly before interpreting a Higgs-candidate count.

Run and load hit. Perform the bounded search and transfer one result into the builder. Inspect a hit individually after the sweep.

Reading the results

Filter funnel. Reports how many candidates were considered and survived each requested stage.

Boundary conditions and theory classes. Separates multiple descriptions of an equivalent model from distinct classes under the implemented equivalence.

Rejected and undecided cases. A failed condition and a vacuum question left unresolved are different outcomes.

The headline distinguishes boundary descriptions from equivalence classes. A hit passes the filters that were actually requested, within the searched range. Undecided vacuum calculations remain separate from rejected models.

Worked example: Find which requirement reduces a search

1. Run a small sweep with a minimal set of filters.
2. Record the tested range and stage counts.
3. Add a colour-singlet Higgs requirement or another supported filter.
4. Compare the funnel and load one surviving hit.

You can state which requirement was imposed and how many inputs it removed. The result remains bounded by the selected search space.

Scope and limitations

- A finite search cannot establish absence outside its rank and content limits.
- Equivalent boundary conditions must not be counted as unrelated theories.
- Passing the available filters does not supply every interaction or experimental comparison of a complete model.

If something is unclear

No hits survive. Read the first stage that removes all candidates and the exact searched range before claiming nonexistence.

The vacuum stage reports undecided cases. Keep them in the unresolved category and investigate selected cases individually.

Sources and attribution

- Search-space and filter implementation
- Implementation and source attribution

22 One model, every verdict

Compare supported model diagnostics across gauge-equivalent boundary descriptions and identify which results remain unchanged in that comparison.

Open web guide

Use this to avoid mistaking a convenient description of a model for an observable property of the theory. A group or spectrum read at a fixed symmetric point can move under an equivalent boundary description. The dossier recomputes its diagnostics to show which quantities survive that change and which questions cannot be answered by the available calculation.

First steps

1. Start from the model in SU(N) builder.
2. Select another member of its displayed equivalence class.
3. Read the theory, frame and declined tags with their explanations.

4. Run the separate separation test to ask whether an invariant diagnostic distinguishes different classes.

Controls and inputs

Shared builder model. Defines the equivalence class and diagnostics being examined. Begin with a model having more than one displayed class member.

Class-member selection. Changes the boundary description within the displayed equivalence class. Compare the same row before and after changing member.

Separation test. Asks whether the measured invariant distinguishes the different tested classes. Run it after understanding why a row is invariant within one class.

Reading the results

Theory / frame / declined tags. Summarize invariance, dependence on the chosen description, or a reason the calculation cannot supply a verdict.

Symmetric-point and vacuum diagnostics. Show why the point at which a property is evaluated matters to its interpretation.

Separation results. An invariant may be shared by several different classes and therefore fail to identify a theory uniquely.

Invariance across the tested equivalent descriptions and ability to distinguish different theories are separate properties. The tags report the performed comparison; they should not be extended into an untested classification theorem.

Worked example: Test a tempting model label

1. Choose a model with several equivalent boundary descriptions.
2. Record its apparent group and one vacuum diagnostic.
3. Select another class member and compare the same rows.
4. Read the separation test before using an invariant as a unique model identifier.

A quantity can be invariant without uniquely identifying the theory, and a useful coordinate label can still depend on the chosen frame.

Scope and limitations

- The conclusions cover the displayed diagnostics and equivalence comparison.
- A numerical comparison is not automatically a proof over every possible model.
- A declined row should retain its stated reason; it is not a zero or a successful test.

If something is unclear

A label changes even though the selected descriptions are equivalent. Check whether the row is evaluated at a fixed symmetric point and tagged as frame-dependent.

An invariant fails to separate two classes. Use another diagnostic; invariance alone does not imply completeness as a classifier.

Sources and attribution

- Dossier diagnostics and comparison scope
- Implementation and source attribution

23 Simulator

Choose among three distinct calculation modes: the 5D builder model, a top-KK Higgs-production reference, or the 4D neutrino-ring research model.

Open web guide

Use this page as the entry point for calculated masses and experimental comparisons. First identify the model you want to study. The builder mode follows the shared SU(N) input; the Higgs-production mode isolates a top-KK contribution; the neutrino mode studies a separate four-dimensional construction. Thermal and flavour experiments have their own inputs even when they appear on the same page.

First steps

1. Choose Model to calculate and read the mode's own guide.
2. Start from a named reference or the restored default before changing one input.
3. Read the result summary, units and assumptions together.
4. Use the visible experiment guides for thermal, flavour and decay questions, then save the inputs and results.

Controls and inputs

Model to calculate. Selects the model supplying the main results, summary, permalink and exports. Read the model name above the results after every change.

Mode-specific parameters. Only the controls relevant to the selected model are shown. Open the mode guide rather than transferring another mode's phase or scale convention.

Experiment shortcuts. Jump to the additional cards available in that mode. In the builder mode inspect thermal questions; in the neutrino mode inspect flavour and fixed-light-input questions.

Save, compare and permalink controls. Record the current input and its explicitly scoped result. Save a reference before modifying one assumption.

Reading the results

Main result and live summary. Describe the selected model, inputs and supported conclusion.

Reference comparison. Names the measurement or calculation being compared and the assumptions needed to use it.

Experiments and diagnostics. Answer additional questions with separately labelled inputs, provenance and limitations.

These modes answer different model questions and keep separate input records. The laboratory computes model responses and compares named references; it does not generate collider events. A missing matching external calculation remains pending rather than being borrowed from another input point.

Worked example: Choose the right starting point

1. Choose the 5D builder mode to inspect a model already entered in SU(N) builder.
2. Choose Higgs production for the isolated top-KK rate question.
3. Choose Neutrino ring for neutral-fermion masses, mixing and decay questions.
4. Follow the matching guide and begin with its reference example.

The selected mode explains where each number comes from. Results from the three models are not silently combined.

Scope and limitations

- No mode constitutes a complete GHU fit to all available measurements.
- The thermal SU(3) benchmark is separate from the current SU(N) builder model and from the SU(7) mass certificates.
- Inputs supplied to calibrate or reconstruct a model are not subsequently predictions of those same observables.

If something is unclear

An expected experiment is missing. Check the selected mode: thermal cards belong to the builder view, while flavour and fixed-light-input cards belong to the neutrino view.

A saved external result disappears after an input change. Check its parameter match. A new input point requires a matching calculation or import.

Sources and attribution

- Research experiments and reproduction notes
- Implementation and source attribution

24 Boundary conditions

Group supported orbifold boundary conditions into equivalence classes and compare their apparent symmetries under the stated ordinary-boundary relation.

Open web guide

Use this to see why listing boundary conditions can overcount theories. The tool walks explicit classes so you can inspect both their size and the different descriptions they contain. It also shows why a group name read at a symmetric point need not identify the whole equivalence class.

First steps

1. Select an available orbifold and the gauge-group parameter N.
2. Choose a boundary condition and inspect the other members of its class.
3. Compare the apparent groups within that class.
4. Read the conditions on any vacuum-energy comparison before interpreting it.

Controls and inputs

Orbifold selector. Chooses the available geometry and its supported boundary-condition relation. Compare S^1/Z_2 with T^2/Z_3 and read the changed count rule.

N and boundary multiplicities. Set the finite condition being classified within the selected family. Start at a small N and inspect a class with several members.

Class-member and energy views. Select equivalent descriptions and inspect the explicitly permitted energy comparisons. Read What cannot be compared before using an energy ranking.

Reading the results

Equivalence class and size. The boundary descriptions connected by the implemented relation.

Class totals. Counts for the chosen group parameter and orbifold, with the relevant published attribution.

Apparent group and energy information. Properties of the selected description and calculation; their interpretation requires the displayed comparison conditions.

The class count is about the specified equivalence relation and orbifold. A boundary description's apparent unbroken group can change within one class. The S^1/Z_2 count must not be transferred to another orbifold.

Worked example: Compare two descriptions of one class

1. Choose S^1/Z_2 at a small N.
2. Select a class containing more than one condition.
3. Compare the apparent group of two members.
4. Open One model, every verdict to investigate which calculated quantities remain invariant.

Different displayed group labels can occur within the same supported equivalence class.

Formulas and conventions

$$\text{Number of classes} = (N + 1)^2$$

The Haba–Hosotani–Kawamura count for the stated ordinary SU(N) conditions on S^1/Z_2. Other geometries or equivalence hypotheses require their own result.

Scope and limitations

- Conjugate, antilinear boundary conditions belong to the separate Conjugate boundary conditions tool.
- Classifying boundaries does not complete the model's matter content or phenomenology.
- Energy comparisons are meaningful only under the conditions stated by that panel.

If something is unclear

The apparent group changes within a class. Read it as a property of the selected boundary description and symmetric point, then inspect the invariant diagnostics separately.

Sources and attribution

- Boundary-condition conventions and literature
- Implementation and source attribution

25 Classify an orbifold

Derive supported orbifold classification data from an integer rotation matrix, then compare the SU, SO and Sp cases under the stated hypotheses.

Open web guide

Use this to investigate which building blocks and local labels are available for a supported orbifold rotation. The 'alphabet' is the list of representation building blocks; a 'fibre' collects conditions sharing the selected local data. The plan and relief offer two views of the same computed field.

First steps

1. Start with a supplied rotation before entering your own integer matrix.
2. Check that the matrix passes the finite-order and cyclotomic tests.
3. Choose the group family and N, then read the signature, alphabet and count information.
4. Inspect a datum-lattice cell and its fibre before comparing the plan and relief views.

Controls and inputs

Rotation preset or integer matrix. Defines the torus rotation. Custom matrices are supported up to the stated rank-eight limit and must satisfy the implemented hypotheses. Classify a supplied example before modifying an entry.

SU(N), SO(N), Sp(N) and N. Choose the gauge-group family and parameter whose classification data are displayed. Keep the rotation fixed while comparing the three real forms.

Datum axes, cell and boundary input. Select local multiplicity data and inspect the corresponding conditions. Compare a cell's class information with the number of conditions in its fibre.

Reading the results

Cone signature and alphabet. The rotation's local singularity orders and the supported building blocks with their weights.

Class count, degree and generating information. Describe the computed classification problem and its stated growth properties.

Plan, relief and selected fibre. Visualize the same datum field and expose the detailed contents of a selected cell.

A refused matrix lies outside the implemented theorem's hypotheses; refusal is not a class count of zero. The rotation-matrix dimension and the gauge-group parameter N are different inputs.

Worked example: Change the group while retaining the geometry

1. Load a supplied rotation and classify it.

2. Read the signature and alphabet.
3. Compare SU, SO and Sp at the selected N.
4. Inspect the reality-type information to understand why the alphabets differ.

The geometry stays fixed while the representation constraints of the group family change.

Scope and limitations

- Infinite-order matrices and matrices outside the stated cyclotomic hypothesis are refused.
- A supported classification result does not calculate a phenomenological vacuum or experimental spectrum.
- Local-data equivalence and the completeness of a proposed move set are separate questions, explored in Name the relations.

If something is unclear

A custom matrix is refused. Check that it is square with integer entries, then read which finite-order or cyclotomic condition failed.

A plotted cell has no conditions. Inspect the rank and local multiplicity constraints; a selected coordinate need not be realizable.

Sources and attribution

- Part IX-A: hypotheses, local data and classification
- Implementation and source attribution

26 Name the relations

Which equivalence relation on boundary conditions the literature already owns, and whether a proposed move set connects a class.

Open web guide

Use this to identify the existing mathematics behind a boundary-condition relation and test a proposed rewrite. A valid individual move must preserve the required data. A set of valid moves can still be incomplete if it leaves a class split into disconnected pieces.

First steps

1. Pick an orbifold and a move.
2. Read the attribution: whose relation this is and where.
3. Run the walk to see whether the moves actually connect the class.

Controls and inputs

Orbifold, group and N. Choose the configuration whose relations are being inspected. Start with a supplied small case.

Proposed relation and Judge it. Checks the entered move against the stated preserved data. Read exactly which condition is tested before interpreting a successful verdict.

Walk a class. Explores reachability under the selected moves in the tested finite case. Compare the number reached with the size of the class.

Reading the results

Attribution. Names the existing configuration, relation or result and its source. A known mathematical identification should retain that credit.

Move validity. Reports whether the specified rewrite preserves the tested data.

Connectivity and structural diagnostics. Separate finite-class reachability from broader claims about generating relations or complete intersections.

The local/global distinction is the one that gets misquoted, and the page carries it explicitly.

Worked example: Distinguish a valid move from a complete move set

1. Choose a supplied small configuration.
2. Inspect a proposed relation and its preserved data.
3. Run the class walk with the selected moves.
4. Compare the reached component with the full class size and read the attribution.

A move can be legitimate while its move set fails to reach the entire tested class.

Scope and limitations

- A finite connectivity experiment does not prove completeness at every rank.
- Local and global equivalence statements must retain their different hypotheses.
- A relation already identified in the literature should not be presented as a new discovery of the laboratory.

If something is unclear

A move is rejected. Read which datum it changes; increasing the walk budget cannot repair a move that violates the required invariant.

A valid move set reaches only part of a class. Keep the incompleteness result for that case and inspect which additional relations are needed.

Sources and attribution

- Part IX-B: attribution and local/global relations
- Implementation and source attribution

27 Conjugate boundary conditions

Compare conjugate boundary conditions on S^1/Z_2 under two explicit hypotheses about the allowed transformations at the endpoints.

Open web guide

Use this to understand why conjugate boundary conditions require a different classification from ordinary linear twists. They transform by congruence, and the allowed relation between endpoint transformations changes which information can be removed.

First steps

1. Choose N and a symmetric or antisymmetric twist at each endpoint.
2. For odd N, read why the antisymmetric choice is unavailable.
3. Compare the independent-endpoint and linked-transformation conclusions side by side.
4. Read the Wilson-line and unbroken-group diagnostics with the hypothesis attached.

Controls and inputs

N. The gauge-group parameter; its parity affects which twist types exist. Compare a small even N with a small odd N.

Twist at $y = 0$ and $y = \pi R$. Choose a symmetric or, when allowed, antisymmetric conjugate twist at each endpoint. Inspect all allowed combinations at even N.

Hypothesis comparison and Wilson-line card. Show the consequences of independent versus linked endpoint transformations and the additional dimension-count diagnostic. Read the hypothesis before quoting a class count.

Reading the results

Counts under explicit hypotheses. A discrete classification under one assumption and retained continuous data under the other are different answers to different problems.

Wilson-line diagnostic. Examines the stated degrees of freedom; it does not silently transfer the ordinary-boundary conclusion.

Unbroken-group information. Must be interpreted with the selected twist and transformation hypothesis, not from a short label alone.

Independent endpoint transformations give four classes at even N and one at odd N in the displayed classification. Linked transformations retain continuous information. The laboratory keeps these hypotheses explicit instead of treating one as an unconditional physical answer.

Worked example: See why the hypothesis must accompany the count

1. Choose an even N and inspect the allowed endpoint types.
2. Read both hypothesis columns.
3. Switch to an odd N and observe the unavailable antisymmetric choice.
4. Save a result with the hypothesis retained in its description.

You can state precisely which classification problem produced a number.

Scope and limitations

- The calculation does not choose the correct transformation hypothesis for every physical construction.
- Ordinary-boundary class counts do not automatically extend to antilinear twists.
- The displayed structural diagnostic is not a full vacuum or phenomenological analysis.

If something is unclear

The antisymmetric option is refused at odd N. This is the stated existence condition, not a missing interface feature.

Two columns give different kinds of answers. Compare the permitted endpoint transformations; the columns intentionally describe different equivalence hypotheses.

Sources and attribution

- Conjugate-condition implementation and source discussion
- Implementation and source attribution

28 Brane kinetic terms

What happens to the tower when brane-localised kinetic terms make the masses stop being n/R.

Open web guide

Use this to see how kinetic terms localized at a boundary change a Kaluza–Klein mass equation and its roots. The zero-boundary-coefficient limit provides a useful check against a simpler tower. The warped SU(6) running card is a separate experiment and has its own inputs and guide.

First steps

1. Use the Warped SU(6) shortcut to compare C1/C2 differential running, required UV brane terms and the separate localization probe.
2. Set the brane coefficient.
3. Read the roots of the transcendental mass equation.
4. Take the coefficient to zero and watch the ordinary twisted tower come back.

Controls and inputs

Brane coefficient c. Controls the boundary kinetic contribution in the displayed mass equation. Compare a nonzero value with $c = 0$.

α_1 **and** α_2. The displayed phase parameters of this spectral example; retain its normalization when comparing another model. Vary one phase while holding c fixed.

m and q. The additional mass/charge parameters defined by the equation on the page. Read their role in the equation before changing both together.

Demonstration / Warped SU(6) shortcut. Run the guided spectral example or open the separate differential-running experiment. Use the demonstration first to connect the equation with its root plot.

Reading the results

Mass-equation roots. The allowed levels of the stated boundary problem; they need not be integer-spaced.

Tower view. Displays the same roots as a spectrum rather than as intersections of the mass equation.

Zero-coefficient comparison. Checks the solver against the ordinary twisted-tower limit under the same parameters.

The special functions are checked against mpmath at forty digits, and the $c \to 0$ limit is computed in closed form by code that shares nothing with the solver. That limit found three real defects.

Worked example: Recover a known limit

1. Run the supplied demonstration.
2. Record a few roots at nonzero c.
3. Bring c to zero while keeping the phases fixed.
4. Compare the resulting tower with the displayed closed-form limit.

The numerical spectrum connects continuously to the stated reference limit where that limit applies.

Scope and limitations

- This is the supported spectral boundary problem, not a complete scan of all boundary operators.
- A solver check does not establish every physical consistency property of an arbitrary kinetic-term choice.
- The warped SU(6) running experiment is not a result computed from these spectral controls.

If something is unclear

The tower is no longer equally spaced. Read the modified mass equation; the boundary kinetic term changes the root condition.

Two cases have different limits. Compare phases, m, q and normalization as well as the coefficient c.

Sources and attribution

- Boundary kinetic terms: equations and checks
- Implementation and source attribution

29 Gravity–gauge · 3D

Which physical information a complete tower of masses leaves undetermined in a controlled gravity-gauge example.

Open web guide

Use this controlled example to distinguish knowing an entire sequence of masses from knowing how a source couples to those states. The paired mass towers can stay fixed while source residues and the Wilson kinetic scale change. The second, unprotected gauge tower provides a comparison with different boundary conditions.

First steps

1. Start with p=1.1 and press eta=-0.9, eta=0, then eta=4. The paired masses stay equal while the Wilson scale and the response change.
2. Drag either 3D plot to turn it. On the response surface, switch drag to select point to change eta and the source position together. Shift-drag always turns; the wheel changes relief; arrow keys turn a focused plot.
3. Read the table below the plots. Choose gauge kinetic Z as the height to inspect the action. Use the header card or LaTeX buttons to export this exact input, or link to restore it.

Controls and inputs

Geometry p. Selects the displayed background; p = 1.1 is the scalar-supported example and p = 1 the AdS reference. Begin at p = 1.1.

η **and** $\log_{10}(1 + \eta)$. Two ways to select the positive gauge-kinetic family parameter in its supported range. Compare the $\eta = -0.9$, 0 and 4 presets.

Source t. A position along the extra dimension, not a location in a laboratory detector. Move the source while comparing spectral weight with mass.

Height, drag mode and 3D controls. Choose spectral-weight ratio or Z(t); drag to rotate or select a point. Shift-drag rotates, the wheel changes relief, and focused plots accept arrow keys. Select a point on the response surface, then read its exact table values.

Reading the results

Paired tensor NN and vector DD masses. The protected comparison governed by the shared canonical operator and stated boundary conditions.

Vector NN control. Uses different boundary conditions and need not keep the same masses.

Response and Wilson kinetic scale. Additional information that is not fixed by the paired masses alone; the Wilson kinetic scale is not a Higgs mass.

The positive paired tensor NN and vector DD masses are protected by their common canonical operator. The gauge NN control has different boundaries and moves. The source position is in the extra dimension, not a laboratory location; the Wilson kinetic scale is not a Higgs mass. For p=1.1 a canonical bulk scalar realizes the family, with stability and cutoff still open.

Worked example: Hold the paired masses while changing the response

1. Set p = 1.1.

2. Compare $\eta = -0.9$, 0 and 4 at a fixed source position.
3. Read the paired masses and the response table at each setting.
4. Move the source and save a card or permalink for the selected point.

The protected paired towers remain equal within the implemented construction while other response information changes.

Scope and limitations

- The boundary-condition pairing is essential; it does not protect every tower.
- The construction does not calculate a Higgs mass, radion stability or collider rate.
- Stability and cutoff questions remain open for the displayed family.

If something is unclear

Dragging changes the view instead of the selected parameter. Switch drag mode to select point; use Shift-drag when you want to rotate.

The gauge control masses move while the paired masses do not. Check the boundary labels. The NN control is deliberately outside the protected NN/DD pairing.

Sources and attribution

- Gravity–gauge construction, equations and open questions
- Implementation and source attribution

30 The literature

The reading list behind the series: what each paper publishes, and which ones a person has actually read.

Open web guide

Use this as a map of the laboratory's reading record. Automated text signals help locate possible subjects, while curated entries name the page or equation behind an interpreted claim. The distinction matters when deciding whether a paper actually reports the quantities needed for a comparison.

First steps

1. Search or filter.
2. Read the measured row: what the file contains and which signals fired.
3. The curated rows name the page or equation a claim comes from.

Controls and inputs

Search and available filters. Restrict the displayed reading records by the supported signals or curation categories. Compare all read records with those carrying the complete comparison triple.

Complete triple / no published minimum. Selects records according to the stated information available for the comparison. Open a row and read its source location instead of relying on a filter label alone.

Shortlisted, not yet opened. Separates a possible reading candidate from a source already examined by a person. Keep an unopened record out of a claimed literature conclusion.

Reading the results

Corpus and signal counts. Describe this recorded reading collection and its text matching; they are not a census of the entire field.

Read and asserted entries. Record curated interpretations with their source locations.

Missing comparison information. Identifies what the record does not supply, such as a reported minimum, rather than inventing a value.

A signal is a keyword, and a keyword sweep misses whatever is phrased differently. Nothing is asserted from a signal alone, and the corpus is our reading list rather than the field.

Worked example: Turn a search hit into a checkable source

1. Choose a signal or available filter.
2. Open a curated record and locate its cited page or equation.
3. Read which comparison quantities are actually supplied.
4. Keep keyword-only or unopened entries separate in your notes.

A search signal becomes evidence only after its relevant content and interpretation are checked.

Scope and limitations

- A keyword search misses different terminology and can match irrelevant passages.
- The collection is the laboratory's reading list, not a complete systematic review of every GHU paper.
- Absence from this list does not establish novelty or priority.

If something is unclear

A signal fires but the desired result is absent. Read the source context; the word may be used for another quantity or in a reference list.

A relevant paper does not appear. Treat the catalogue as incomplete and check the paper directly before updating the reading record.

Sources and attribution

- Recorded literature data
- Implementation and source attribution

31 Simulator: 5D builder predictions

Convert the supported SU(N) builder vacuum into dimensionful masses and compare specified model quantities with named reference measurements.

Open web guide

Use this after the builder's potential and spectrum have been understood. It translates the dimensionless model into quantities that can be compared with measurements, while retaining the assumptions behind each comparison. The result is a theoretical calculation, not simulated collider data.

First steps

1. Load or construct the model in SU(N) builder.
2. Select the builder mode in Simulator and choose the located minimum or a manual phase probe.
3. Read the coupling choice and the W-mass anchor before interpreting GeV values.
4. Inspect the prediction table, fermion masses and tower plots together.

Controls and inputs

At the minimum / probe. Chooses the located vacuum or an explicitly selected phase. Compare the two labels before attributing a mass to the vacuum.

g_4 and the $g_2(1/R)$ option. Choose the coupling convention used in the Higgs-curvature conversion. Move g_4 while retaining the same phase and observe which outputs change.

3D tower view. Displays calculated masses alongside reference lines and the explicitly conditional colour-sector bound. Rotate the landscape and confirm values in the table.

Reading the results

Compactification and Higgs scales. Use the model's own phase normalization and measured-W calibration.

Weak-angle and fermion comparisons. Compare the supported embedding and Wilson-line mass structure with the named reference quantities.

KK mass axis. Shows predicted states and the stated reference reach; the coloron comparison assumes the relevant colour sector lives in the bulk.

The measured W mass supplies the scale calibration. In this mode, changing g_4 at a fixed builder vacuum changes the displayed Higgs mass, while the anchored KK masses do not follow that slider. A manually selected probe is not a dynamically selected vacuum.

Worked example: See what fixes the mass scale

1. Load a builder reference with an available broken vacuum.
2. Record the Higgs mass and one KK level in Simulator.
3. Change only g_4.
4. Compare the changed Higgs result with the W-anchored tower masses.

The controls affect different parts of the conversion. A stationary tower under this slider is an expected feature of the chosen calibration.

Scope and limitations

- A symmetric vacuum does not provide the nonzero phase needed for this electroweak scale calibration.
- A probe point is not a vacuum certificate.
- Colour-sector limits require their stated particle and localization assumptions; the display is not a complete experimental fit.

If something is unclear

The compactification scale is undefined. Check whether the selected vacuum is symmetric or unresolved before changing the coupling.

Changing g_4 leaves the tower unchanged. Read the W-mass calibration and the Higgs-specific role of g_4 in this mode.

Sources and attribution

- Builder prediction conventions and source equations
- Implementation and source attribution

32 Simulator: Higgs production from a top KK tower

Compare the leading top-KK correction to Higgs production with finite-tower and resummed low-energy-theorem calculations under a stated domain policy.

Open web guide

Use this to study one isolated production-rate mechanism without treating it as a complete GHU signal calculation. The finite sum tests how many KK terms are needed, while the resummed comparison asks a different approximation question.

First steps

1. Select Higgs production in the Simulator model selector.
2. Start from the Carson–Okada reference and read its historical rate window.
3. Vary the KK scale, top mass or numerical cutoff separately.
4. Compare numerical truncation, the leading/resummed difference and the conditional allowed interval.

Controls and inputs

KK scale and top mass. Set the ratio x = m_t/M_KK governing this reference correction. Use the displayed units. Increase the KK scale with the top mass fixed.

KK cutoff. Sets how many terms enter the finite leading tower. Increase it while keeping the physical inputs fixed and read the tail bound.

Reference or custom rate window. Defines the interval against which the rate is compared. Read both window edges; do not interpret a custom window as a new experimental likelihood.

Reading the results

Leading and resummed rates. Two calculations with different approximation scope inside the same top-only reference.

Finite-tower tail bound. Bounds the omitted leading-sum contribution, not missing particles or higher-order physical effects.

Conditional scale interval. Intersects the chosen rate window with the laboratory policy $x \leq 0.2$.

The historical window reproduces a source benchmark; a custom window is a user scenario with no assigned confidence level. The numerical tail and the small-x expansion comparison do not quantify all physical theory uncertainty.

Worked example: Separate truncation from approximation

1. Use the historical reference inputs.
2. Increase the cutoff and inspect the finite-tower tail.
3. Compare the converged leading rate with the resummed rate.
4. Change the user window and observe that the conditional interval changes without changing the rate formula.

A smaller numerical tail does not remove the difference between physical approximations.

Formulas and conventions

$$R_{gg} = [1 - (\pi^2/3)(m_t/M_{KK})^2]^2$$

The leading top-only reference rate from Carson–Okada under the stated spectrum and approximation.

$$A_{LET} = \pi x \cot(\pi x),\ x = m_t/M_{KK}$$

The independently resummed determinant low-energy-theorem amplitude. Its square is not a full finite-mass loop calculation.

Scope and limitations

- The $x \leq 0.2$ policy defines the displayed working domain; it does not promise a uniform physical accuracy.
- Branching fractions and additional coloured particles are outside this mode.
- The historical scale bound is not presented as a current global exclusion.

If something is unclear

The current rate or verdict is withheld. Check whether x exceeds the displayed domain policy.

The finite sum converges but differs from the resummed result. Read the distinction between truncation of the leading sum and the small-x expansion within the low-energy theorem.

Sources and attribution

- Carson–Okada, arXiv:1510.03092, equations (33), (35), (41) and Table 1
- Rate, tail and domain definitions
- Implementation and source attribution

33 Simulator: the 4D neutrino ring

Explore light masses, active-current deficit and six heavy pairs in the supported four-dimensional neutrino-ring research model.

Open web guide

Use this to study how a model can preserve selected light-sector quantities while changing its heavy states and interactions. This is a four-dimensional deconstructed ring at a fixed phase background, with explicitly stated leading-order approximations. It is separate from the five-dimensional builder.

First steps

1. Choose Neutrino ring and start from its default point.
2. Read whether calibration is enabled: it fixes two chosen light-sector targets.
3. Change one link, portal or Majorana input and inspect masses and active weights together.
4. Use the dedicated flavour, fixed-light-input and decay guides before interpreting those additional experiments.

Controls and inputs

Scale f, link t/f and portals q, r. Set the conserving mass structure. The scale is dimensionful; the link and portal ratios are dimensionless. Change one ratio at fixed f and read the heavy centres.

Majorana inputs μA and μB. Small symmetry-breaking mass entries displayed in keV. Vary μB with calibration enabled and compare light inputs with pair splittings.

Calibration. Solves for entries that reproduce the chosen 0.1 eV light mass and 10^{-4} deficit in the reference setup. Disable it before treating the Dirac entry and μA as independently adjustable.

CMS flavour and Dirac/Majorana reference. Selects the published single-HNL hypothesis used for the overlay. Read the pair-summed or per-component mixing convention after switching hypothesis.

Reading the results

Light mass and active deficit. A calculated response or a reproduced calibration target, depending on the control setting.

Six heavy centres and splittings. Centres are shown in GeV and splittings in eV. The approximation diagnostics must accompany them.

CMS comparison and source record. Uses named HEPData tables, interpolation brackets and the selected flavour/hypothesis; it does not extrapolate beyond the table.

The calibration targets are supplied inputs, not predictions. Heavy centres, light masses and pair splittings use different displayed units. The CMS overlay is a conditional single-HNL reference comparison, not a full multi-state ring exclusion.

Worked example: Change a heavy splitting while keeping light targets

1. Restore the default ring with calibration enabled.
2. Record the light mass, deficit and first heavy splitting.
3. Change μB and read all three quantities again.
4. Inspect the approximation diagnostics and save the full input record.

At the displayed order, this path can change heavy-pair splitting while preserving the chosen light targets. That freedom prevents a unique heavy prediction from those targets alone.

Scope and limitations

- The phase is held at $\theta = \pi$; the complete vacuum and radial-stability problem is not solved here.
- One base-ring Yukawa vector has light flavour rank at most one. The separate three-copy card reconstructs supplied flavour inputs.
- The small-insertion diagnostic is not a uniform error bound, especially near small inter-pair gaps.
- Single-HNL limits and exclusive-flavour assumptions do not automatically apply to six interfering heavy pairs.

If something is unclear

The light mass does not change when a parameter moves. Check whether calibration is holding it fixed by construction.

A CMS ratio is absent at a mass point. Check the tabulated range and duplicated transition knots. The laboratory deliberately withholds an ambiguous or extrapolated ratio.

Sources and attribution

- Ring action, approximations, units and CMS table provenance
- CMS EXO-22-011 reference analysis
- Implementation and source attribution

34 Neutrino decays, Majoron channels and coherence

Calculate the included heavy-neutrino partial widths and conditional lifetime, flight-window and isolated-pair coherence diagnostics.

Open web guide

Use this to see how specified decay assumptions affect lifetime and coherence. The controls make missing channels visible as assumptions rather than silently setting a complete width. Optional leading Majoron contributions have their own calculation and validity conditions.

First steps

1. Select a heavy pair in the Neutrino ring mode.
2. Read which weak channels are open, and choose whether to include the computed Majoron widths.
3. Set any additional width as an explicit scenario input.
4. Choose the boost and flight window, then read the probability separately from the all-time coherence ratio.

Controls and inputs

Heavy-pair selection. Chooses the mass, active weight and splitting used in the decay scenario. Select a pair from the channel bars or use the supported keyboard controls.

Computed Majoron channels and scalar VEV ratios. Enable the included leading light and heavy-cascade Majoron widths under the stated scalar assumptions. Compare enabled and disabled values without interpreting disabled as physically absent.

Additional width. An input contribution in eV representing an assumed uncomputed width. Increase it and observe how the conditional lifetime changes.

$\beta\gamma$, Lmin and Lmax. A fixed boost and straight-line distance window in the displayed units. Move the window while keeping the decay scenario fixed.

Reading the results

Partial widths and lifetime. The included width sum gives $\tau = \hbar/\Gamma$ for the chosen scenario. A zero included sum does not prove stability.

Flight probability. The probability to decay in the chosen straight-line window at one fixed boost; it is not an event yield.

SS/OS and same-sign fraction. Distinct ideal-coherence quantities under isolated-pair, equal-width and CP assumptions.

The displayed width belongs to one component of a heavy pair. The complete physical ring width remains unknown. A flight-window probability is not detector acceptance, and the all-time same-sign/opposite-sign ratio is not a selected-event ratio.

Worked example: See how a missing-channel assumption changes a prediction

1. Select one pair and record the included width and lifetime.
2. Enable the computed Majoron contribution where supported.

3. Add a small explicit extra-width scenario and compare again.
4. Read the flight probability and the coherence warning separately.

Lifetime and coherence depend on the included channels. The controls explore that dependence rather than determining the unknown complete width.

Formulas and conventions

$$P = \exp[-Lmin/(\beta\gamma\ c\tau)] - \exp[-Lmax/(\beta\gamma\ c\tau)]$$

The fixed-boost straight-line window probability in this scenario.

$$SS/OS = \Delta m^2\ /\ (2\Gamma^2 + \Delta m^2)$$

The all-proper-time isolated coherent-pair result under the stated equal-width and CP assumptions.

Scope and limitations

- Off-shell weak processes, additional scalar/gauge channels and unresolved corrections can change the complete width.
- Near-degenerate different pairs can invalidate isolated-pair reasoning.
- Detector efficiencies, boost distributions and event selections are not included.

If something is unclear

The lifetime or probability is undefined. Check whether the included width is zero or the inputs are out of scope; do not label the state stable.

A coherence warning appears. Read the width, insertion and inter-pair-gap diagnostics before using the isolated-pair ratio.

Sources and attribution

- Weak widths, normalization and ideal coherence sources
- Computed Majoron channels and their scope
- Implementation and source attribution

35 Maru–Nago SU(6): families and the Wilson minimum

Reproduce the supported Type 2 / Type 3 bulk Wilson potential and compare its minimum with the published table and an independent infinite-sum calculation.

Open web guide

Use this worked literature example to connect matter content, a calculable Wilson potential and its numerical minimum. The source equations remain attributed to Maru and Nago; the laboratory supplies an implementation and independent checks.

First steps

1. Choose the number of Type 3 generations and adjoint copies.
2. Compare the full potential and the magnified minimum.
3. Increase the Fourier cutoff and inspect convergence.
4. Load the supported bulk content into the builder if you want to inspect its spectrum.

Controls and inputs

Type 3 generations k_3. An integer from 0 to 3; $k_2 = 3 - k_3$ and $k_1 = 0$. Compare $k_3 = 0$ and $k_3 = 3$ at fixed adjoint content.

Adjoint Dirac copies. Changes the supported bulk contribution to the potential. Change one copy and follow the minimum.

Fourier terms. Numerical truncation of the winding sum. Increase it before interpreting small differences in α.

Reading the results

Minimum and convergence table. The selected finite-sum minimum, stored paper comparison where available, and independent infinite-sum reference.

Builder transfer. Transfers supported bulk-potential content, retaining Wilson-blind singlets in the model record.

The difference from a published decimal is a numerical comparison. The authors' truncation procedure is not established, so this alone does not identify an error in the paper.

Worked example: Check a quoted minimum

1. Restore $k_3 = 3$ and five adjoint copies.
2. Read the published and independent reference values.
3. Increase the Fourier terms and compare the minimum again.

Convergence clarifies the numerical discrepancy without establishing the paper's original numerical procedure.

Scope and limitations

- This is a bulk-potential comparison, not a complete phenomenological viability test.
- Brane terms needed to lift exotic adjoint zero modes require additional input.
- A matching minimum does not establish a realistic Higgs mass or flavour sector.

If something is unclear

No published comparison is shown. The chosen matter content may have no stored Table 2 entry; use the convergence test and source equations.

Sources and attribution

- Maru–Nago, JHEP 11 (2024) 035, equation (4.3) and Table 2
- Implementation and source attribution

36 Warped SU(6): running and UV boundary terms

Calculate two independent inverse-coupling differences and the UV boundary terms required for the supported warped SU(6) assignments.

Open web guide

Use this to see how assumed boundary terms enter a unification calculation. It makes those terms visible instead of interpreting a crossing of running curves as a parameter-free prediction.

First steps

1. Choose C1 or C2 matter content.
2. Set the IR and UV scales with their displayed units.
3. Compare the required boundary differences with your chosen values.
4. Open the advanced UV-mass probe only after reading its separate scope.

Controls and inputs

Matter assignment C1 / C2. Selects the implemented assignment from the cited calculation. Compare both with unchanged scales.

IR scale [TeV] / $\log_{10}$ UV scale [GeV]. The first is a scale; the second is the base-ten logarithm of a scale. Keep the different units and logarithm convention explicit in exports.

Chosen $\Delta\lambda_{21}$ / $\Delta\lambda_{31}$. User-supplied UV boundary differences. Set them to the required values and observe the residuals.

Probe c and UV mass / k. Inputs to the separate localization and UV-mass diagnostic. Read its status independently of the main running plot.

Reading the results

Differential running. ${\alpha_2}^{-1} - {\alpha_1}^{-1}$ and ${\alpha_3}^{-1} - {\alpha_1}^{-1}$ as functions of $\log_{10}$ q.

Required terms and residuals. Quantify the boundary assumptions needed under approximate IR matching.

Residuals are differences between required and chosen boundary terms. They are not χ^2 values or statistical exclusions; the NDA number is a reference scale.

Worked example: Identify the boundary assumption

1. Start with chosen boundary differences equal to zero.
2. Record the required values.
3. Enter those values and compare residuals.

Small residuals after this adjustment express a chosen matching condition, not independent experimental agreement.

Formulas and conventions

$$\text{NDA reference} = 1/(16\pi^2)$$

A dimensional-analysis comparison scale, without a probability or confidence level.

Scope and limitations

- One-loop differential running and approximate IR matching are used.
- Unspecified threshold and boundary effects can change the matching.
- The UV-mass probe is not a full model fit.

If something is unclear

A zero residual looks like a perfect fit. Check whether the boundary terms were chosen to equal the required values; no statistical fit is being performed.

Sources and attribution

- Angelescu et al., Planck-brane correlators, sections 4.4–6
- Implementation and source attribution

37 Three active flavours and a rank 2 or rank 3 extension

Reconstruct a three-copy ring extension from chosen light masses, PMNS parameters and active deficits.

Open web guide

Use this to explore the extra independent mass directions needed beyond the rank-one base ring. The construction shows how chosen oscillation inputs can be represented; it does not derive them from the original one-copy action.

First steps

1. Select Neutrino ring, then the three-flavour experiment.
2. Choose a normal or inverted reference and the lightest mass.
3. Inspect reconstructed couplings and the mass rank.
4. Compare the separate reference ranges and the unitary-limit vacuum plot.

Controls and inputs

Ordering and lightest mass [eV]. Set the light mass spectrum together with the two supplied splittings. Compare zero and nonzero lightest mass.

$\sin^2\theta$, δ and Majorana phases. Specify the input PMNS orientation; phases are in degrees. Change a Majorana phase and compare m$\beta\beta$ with the vacuum oscillation plot.

Active deficit directions. Set the three independent deficit inputs used in the reconstruction. Open the matrix details to inspect the full active deficit.

Reading the results

Rank, masses and reconstructed matrices. Describe the constructed extension, including Yukawa and deficit matrices.

Vacuum appearance probabilities. The unitary PMNS limit; matter effects and a nonunitarity fit are absent.

NuFIT ranges. Separate reference intervals with their recorded edition and ordering.

Masses and PMNS orientation are inputs to this inverse construction. Separate NuFIT ranges do not define a likelihood, and the historical Hosotani button does not turn the ring into that paper's RS model.

Worked example: Understand the role of the lightest mass

1. Use the normal-ordering reference and set the lightest mass to zero.
2. Read the rank and reconstructed masses.
3. Choose a small nonzero lightest mass and repeat.

The construction changes rank with the supplied spectrum; this is not a new prediction of the lightest mass.

Scope and limitations

- Three sterile copies extend the base model.
- The plotted vacuum probabilities omit matter effects and active-deficit corrections.
- Light-sector m$\beta\beta$ does not include all possible heavy-state contributions.
- Reference interval membership is not a joint goodness of fit.

If something is unclear

A reference preset reproduces its own PMNS values. That is expected: these values were supplied as inputs. Inspect the reconstructed couplings to see the calculated result.

Sources and attribution

- NuFIT 6.1 reference table
- Hosotani historical RS reference
- Implementation and source attribution

38 Fixed light inputs: distinguish the heavy ring

Follow parameter paths that preserve selected light masses and mixing while changing heavy states or current factors.

Open web guide

Use this to ask whether the chosen light data determine the heavy sector uniquely. The experiment gives explicit counterexamples along supported parameter paths and points to additional observables that can distinguish them.

First steps

1. Set the desired light inputs in the flavour card.
2. Choose a parameter to investigate and a position along the path.
3. Read the light reconstruction residual with the heavy response.
4. Compare raw and normalized vacuum current factors separately.

Controls and inputs

Parameter to investigate / position. Selects a supported path and a point between its endpoints. Start with the fixed-light heavy-splitting preset.

Sterile copy and heavy pair. Choose the heavy response displayed for that point. Compare different pairs while retaining the same light inputs.

Source, detected flavour and propagation. Select a vacuum channel and neutrino or antineutrino propagation. Compare raw and normalized quantities for the same channel.

Reading the results

Light reconstruction residual. Checks how closely the chosen masses and orientation remain fixed along valid points.

Heavy centres and splittings. Can vary despite fixed selected light inputs.

Current factors and DeepCore reference. The former explore the extension; the latter retains the archived standard-model hypothesis and grid limits.

Normalization can hide a common suppression. The archived DeepCore map is a standard-three-neutrino reference, not a likelihood for this nonunitary ring extension.

Worked example: See a suppression disappear under normalization

1. Choose Common suppression hidden by normalization.
2. Compare the raw factor with the normalized shape.
3. Switch to unequal deficits and compare the shape again.

A normalized shape alone can miss information carried by an overall current normalization.

Scope and limitations

- The supported paths do not exhaust all degeneracies.
- Vacuum calculations omit matter propagation and a detector event model.
- No nonunitary-ring exclusion is inferred from the DeepCore grid.

If something is unclear

The DeepCore value is unavailable. Check the archived grid bounds; the laboratory does not extrapolate a new likelihood.

Sources and attribution

- Blennow et al., vacuum limits of equations (5) and (7)
- IceCube DeepCore 2018 data reference
- Implementation and source attribution

39 Finite-temperature SU(3): potential and coexistence

Reproduce the supported flat SU(3) thermal benchmarks and inspect their Wilson potential, minima and coexistence candidates.

Open web guide

Use this to understand how temperature changes a Wilson potential in the two implemented Hirose–Shibuya benchmarks. Only after the potential is understood should an external bounce calculation be used for transition history.

First steps

1. Select the builder mode and open the thermal experiment.
2. Load paper case 1 or case 2.
3. Vary R T and compare the potential with doubled numerical cutoffs.
4. Read coexistence separately from nucleation in the history card.

Controls and inputs

Fundamental / adjoint matter and parity. Specify the thermal SU(3) matter content. Keep a paper benchmark intact before exploring changes.

1/R [GeV], g_4 and R T. Set the dimensionful scale, field conversion and dimensionless temperature. Vary R T while fixing the other two.

Spatial and thermal winding cutoffs. Independent numerical truncations. Compare the displayed doubled-cutoff response.

Reading the results

Potential and preferred phase. The located minima of the truncated potential at the chosen temperature.

Coexistence candidate. A resolved equal-depth candidate within $0 \leq \mathrm{R\ T} \leq 0.6$ under the current numerical settings.

Cutoff comparison. A convergence diagnostic, not a uniform physical error bound.

This card has its own SU(3) inputs, separate from the SU(N) builder model. A coexistence candidate does not establish bubble nucleation, transition completion or a gravitational-wave signal.

Worked example: Follow the preferred phase with temperature

1. Load paper case 1.
2. Read the preferred-phase flow.
3. Choose temperatures on either side of a resolved coexistence candidate.
4. Inspect the minima and doubled-cutoff comparison.

The potential may exchange its preferred minimum; this alone does not determine when bubbles nucleate.

Formulas and conventions

$$\mathrm{C_4} = 3/(64\pi^6\mathrm{R}^4),\ \alpha = \mathrm{g_4 R}\phi$$

The implemented four-dimensional potential normalization and canonical-field conversion.

Scope and limitations

- The thermal model is separate from the SU(7) candidate and builder selection.
- A finite search interval and finite cutoffs can leave coexistence unresolved.
- Nucleation and gravitational waves require further calculations and assumptions.

If something is unclear

No coexistence candidate is resolved. Check the matter content, explored R T interval and cutoff sensitivity before concluding that a transition is absent.

Sources and attribution

- Hirose–Shibuya, equations (2.30), (2.33), cases 1 and 2
- Implementation and source attribution

40 Nucleation, percolation and conditional gravitational waves

Integrate bubble growth using a matching refined action table and explicit cosmological assumptions.

Open web guide

Use this to move beyond a coexistence temperature or a single S_3/T threshold. It tracks an integrated history and checks physical false-vacuum volume under the specified expansion model.

First steps

1. Choose a supported paper benchmark in the thermal card.
2. Confirm that a matching refined action table is available.
3. Set g*, assumed wall speed, efficiency and expansion background.
4. Read nucleation, percolation and completion before the conditional acoustic spectrum.

Controls and inputs

Relativistic degrees of freedom g*. An input to the cosmological background. Keep it fixed when comparing wall-speed assumptions.

Wall speed / c and fluid efficiency κ. Explicit scenario assumptions, not outputs of the potential. Vary one and compare completion and the acoustic spectrum.

Expansion background. Selects radiation only or radiation plus false-vacuum energy. Compare the physical false-volume condition.

Reading the results

Integrated events. Nucleation, percolation and completion within the supplied action range, when established.

False-vacuum fraction and volume slope. Track both volume fraction and whether physical false-vacuum volume decreases.

Conditional acoustic spectrum. Depends on the transition history, wall speed, efficiency and sound-wave model.

The two benchmark action tables support the calculation only for matching thermal inputs. Wall speed and fluid efficiency remain assumptions. Collider measurements do not measure these thermal quantities.

Worked example: Check whether a benchmark completes

1. Restore a paper benchmark with a refined action table.
2. Read the available action range and upper-boundary diagnostic.
3. Compare percolation and completion with the physical-volume slope.
4. Change the expansion assumption and compare again.

Completion is conditional on the supplied actions and cosmology; an unavailable event is not silently extrapolated.

Formulas and conventions

Percolation: I = 0.34; completion: P_false = 0.01

The laboratory's stated event definitions; both also require decreasing physical false-vacuum volume.

Scope and limitations

- No matching table means the integrated history is pending for those inputs.
- The SU(3) benchmarks are not a joint fit of the SU(7) model.
- The gravitational-wave spectrum is conditional, not an observed signal or a full detector likelihood.

If something is unclear

Refined action table pending appears. Restore a paper benchmark or import a matching refined result using the documented reproduction workflow.

Sources and attribution

- Cosmological transition review
- Acoustic spectrum, equations (28–30)
- Implementation and source attribution

41 RS anomaly flow and baryon current

Inspect UV and IR anomaly factors from normalized Z-tower wavefunctions and compare gauge cancellation with the baryon-current anomaly.

Open web guide

Use this to separate boundary flow, matter cancellation and global-current physics in the supported warped calculation. Its source papers and independent numerical checks are linked for comparison.

First steps

1. Choose a Wilson angle, warp factor and Z mode.
2. Start with complete quark and lepton generations.
3. Compare boundary contributions with their sum.
4. Remove a matter generation and observe the gauge factor.

Controls and inputs

θH, $\log_{10}$ zL and $\sin^2$ θW^0. Set the supported warped background and electroweak parameters. Vary the angle at fixed matter content.

mKK [TeV] and Z mode. Set the scale and select the zero, first or second excited Z mode. Compare masses and boundary factors across modes.

Quark / lepton generations. Control the matter factors relevant to cancellation. Compare complete and deliberately incomplete content.

Reading the results

UV, IR and full anomaly factors. Resolve the boundary contributions for the normalized modes.

Gauge factor and baryon matrix. Address different currents and must be interpreted separately.

Quadrature and finite-KK reference. The former checks numerical normalization; the latter is a fixed published benchmark.

Gauge cancellation and a surviving global baryon-current anomaly are different statements. A nonzero baryon anomaly does not determine a proton lifetime or baryogenesis yield.

Worked example: Separate gauge and baryon anomalies

1. Use equal complete quark and lepton generations.
2. Read the vanishing gauge factor and the baryon result.
3. Remove one lepton generation and compare the gauge factor.

The matter cancellation changes as intended; the baryon-current result answers a different question.

Scope and limitations

- The finite-KK reference has fixed benchmark inputs and does not follow every slider.
- Quadrature convergence does not certify all physical assumptions.
- Neither a proton lifetime nor a baryogenesis yield is calculated.

If something is unclear

A reference table stays unchanged while the angle moves. Read its fixed θH = 0.1 and mKK = 13 TeV benchmark label; use the live flow plot for your current inputs.

Sources and attribution

- RS anomaly flow, June 2026
- Baryon anomaly, September 2026
- Implementation and source attribution

42 Higgs rates, total width and experimental comparisons

Construct an explicit CP-even Higgs scenario at 125.2 GeV and inspect production, widths, branching fractions and matching external experimental results.

Open web guide

Use this to see why a production correction alone is insufficient for a Higgs signal comparison: partial widths, the total width and branching fractions enter together. Versioned external results supply a separate experimental calculation for a matching scenario.

First steps

1. Start with the SM reference preset.
2. Change one coupling or the invisible width.
3. Read the total width and branching fractions with production rates.
4. Use an external HiggsTools result only when it matches the current inputs and recorded version.

Controls and inputs

κW = κZ and common fermion κ. Explicit effective-coupling assumptions for this CP-even scenario. Change one while keeping the others fixed.

Effective κg, $\kappa\gamma$ and κZγ. Independent effective amplitudes in the supported reference parameterization. Compare the top-tower preset with the SM reference.

Invisible width [MeV]. An additional assumed partial width included in the total. Increase it and compare visible branching fractions.

Reading the results

Production cross sections. Use the pinned HiggsPredictions reference at the listed collider energies.

Total width, branching fractions and signal strengths. Account for all partial widths listed in this scenario.

Matching external experimental result. A versioned HiggsBounds/HiggsSignals calculation, available only for compatible inputs.

The top-tower preset changes its specified gluon amplitude and assumes the remaining couplings are SM-like. It is not a complete GHU-model prediction or exclusion.

Worked example: Change a branching fraction without changing production

1. Load the SM reference.
2. Record ggH production and a visible branching fraction.
3. Increase only the invisible width.
4. Compare production, total width and visible signal strength.

Production can remain unchanged while the extra width reduces visible branching fractions and signal strengths.

Scope and limitations

- Effective couplings are assumptions unless derived from a complete model.
- A missing or mismatched external result is not an allowed verdict.
- The number of experimental observables is not automatically the number of statistical degrees of freedom.

If something is unclear

The external result no longer applies. Restore the matching inputs or calculate/import a new matching result through the documented external workflow.

Sources and attribution

- HiggsTools for Run 3
- Official HiggsBounds dataset
- Official HiggsSignals dataset
- Implementation and source attribution

43 First KK gluon at the LHC: couplings, widths, $t\bar{t}$ / dijet limits and the m($t\bar{t}$) spectrum

Compute the first KK gluon of flat GHU ($\sqrt{2}$ g_s to every quark) or of a warped extra dimension (zero-mode quarks of bulk mass c), its widths and branching fractions, and compare its leading-order $\sigma \times$ BR with the ATLAS $t\bar{t}$ and CMS dijet limits as r = prediction / limit. Then compute the m($t\bar{t}$) spectrum with the interference between the KK gluon and the QCD gluon, in the bins of the CMS parton-level measurement, and the expected $\Delta\chi^2$ against its covariance.

Open web guide

Use this to see which LHC channel constrains which realisation: the flat coloron couples democratically (BR($t\bar{t}$) $\approx 1/6$) and is probed by dijets and, through its large light-quark production, by $t\bar{t}$; a warped KK gluon is top-philic (BR($t\bar{t}$) > 0.8) and broad, so $t\bar{t}$ resonance searches are its channel.

First steps

1. New here? Press Demo in the card heading: a forty-second guided simulation presses the buttons for you and ends with how to read the result.
2. Choose a preset: the flat GHU coloron, the published RS point of arXiv:0807.4937, or illustrative warped values.
3. Change one input: the mass, kL or one of the c values.
4. Read Γ/M, BR($t\bar{t}$) and the two r values at the chosen mass, then the two mass scans.
5. Read the m($t\bar{t}$) paragraph: the sign of the interference below the pole, the largest change of the spectrum, $\Delta\chi^2$ and the mass where it falls to 3.84; then the two spectrum figures.
6. Open the certificates and the PDF systematic before quoting a crossing mass.

Controls and inputs

Realisation. Flat GHU (Part VII coloron) or warped zero-mode quarks. Switch at fixed mass and compare BR($t\bar{t}$).

KK-gluon mass [TeV]. The resonance mass at which the r values are read. Move it across the crossing and watch r pass 1.

kL and the c values. Warp factor and bulk masses (left-handed UV-localised for $c > 1/2$, right-handed for $c < -1/2$), as in the RS localisation probe. Raise c of t_R and watch the top coupling and the width grow.

α_s(M_Z). 0.130, the PDF set's value at M_Z, or this laboratory's 0.118; either is run to the mass at one loop with six flavours (the PDF set's own α_s table differs by about 0.6% at 1.8 TeV). Compare the two; the production scales with the coupling.

SM theory uncertainty per m($t\bar{t}$) bin. An uncorrelated fraction of each measured bin added to the CMS covariance, standing for the scale and PDF errors of the SM prediction. Set it to 0 and to 0.2: the $\Delta\chi^2$ and the mass where it reaches 3.84 move a lot, which is the honest size of this comparison.

Reading the results

Couplings g_1/g_s. Zero-mode couplings to the first KK gluon, certified against a 40-digit reference.

Γ/M, BR($t\bar{t}$), BR(dijet). Leading-order widths to quark pairs; the top threshold depends on chirality.

r($t\bar{t}$) and r(dijet). Prediction over the ATLAS observed limit ($\Gamma/M = 30\%$ template) and over the CMS spin-1 limit interpolated to this width.

Low-tail and pole shares. Where $\sigma(t\bar{t})$ comes from; a large low-tail share means the interference with QCD matters (computed in the spectrum).

Interference below the pole. Its sign is $-$sign(v_u v_t), v = (c_L + c_R)/2: destructive for same-sign couplings (flat GHU), constructive for the warped reference point.

$\Delta\chi^2$ of the m($t\bar{t}$) spectrum. Separation of SM and SM + KK gluon in units of the CMS covariance, if the data equal the SM: a sensitivity, not an exclusion. The shift is applied as R $\times$ data because the LO SM shape is not the measured one.

$r \geq 1$ means the LO prediction exceeds the published observed limit of that experiment's benchmark. A crossing is a comparison with that benchmark, not a validated exclusion at another width; the low-tail share tells you when the result is mostly off-shell exchange.

Worked example: The published RS point at the edge of the ATLAS limit

1. Load the published RS point preset.
2. Read r($t\bar{t}$) at 3.75 TeV.
3. Move the mass to 3.67 TeV, the point's own first KK gluon.
4. Open the certificates.

r($t\bar{t}$) is close to 1: the 2008 reference point sits at the edge of the 2025 ATLAS comparison, within the $\pm 15\%$ of the control.

Scope and limitations

- Leading order; no K-factor for $t\bar{t}$. The interference enters the $m(t\bar{t})$ spectrum only; the resonance-search comparison uses the Breit–Wigner alone, as the experiments' templates do.
- The spectrum's $\Delta\chi^2$ assumes the K-factor of the KK gluon and of the interference equals the SM's, and depends strongly on the SM theory uncertainty chosen.
- A limit set with one width template is not guaranteed conservative for another width.
- Above about 6 TeV the q $\overline{q}$ luminosity differs between PDF sets by more than 20%.
- Four-top production and fermion KK modes are not computed.

If something is unclear

An r value reads 'not evaluated'. The mass or width lies outside the published grid (ATLAS 0.5–5 TeV; CMS width interpolation needs 10–30% and 2.1–6 TeV).

Sources and attribution

- ATLAS $t\bar{t}$ resonances, arXiv:2512.17856
- HEPData: ATLAS Fig. 10c (KK gluon limits)
- CMS dijet resonances, arXiv:1911.03947
- HEPData: CMS spin-1 qq limits by width
- Casagrande et al., RS reference point, arXiv:0807.4937
- Atre et al., colour-octet widths, arXiv:1206.1661
- CMS differential $t\bar{t}$ (TOP-20-001), arXiv:2108.02803
- HEPData: CMS parton-level $d\sigma/dm(t\bar{t})$
- HEPData: its covariance matrix

44 Boundary research: spectra, profiles, anomalies and certified response

Separate tests help investigate a proposed GHU boundary mechanism: roots of a flat fermion boundary problem, the numerical rank of overlapping profiles, exact parity-inserted spinor traces and a restricted six-dimensional SU(2) tensor condition. The fifth compares two wall profiles after common pole and residue matching, using replayed continuum certificates. The sixth counts finite neutral-complex classes on exact strata. Section 6b adds a continuous mass enclosure and isolation test for the light neutral vector at three exact Wilson angles.

Open web guide

Use these tools to find which requirement fails and why before attempting a full model. A mass gap addresses unwanted paired modes; Gram rank tests linear independence; inserted traces expose localized anomaly terms; the tensor condition tests a restricted quantization requirement. Passing these tests does not prove a viable Standard Model embedding or a complete quantum theory. Matched response asks whether fixing two local conditions removes all finite-width profile dependence in the declared quadratic model.

First steps

1. Open Anomalies & proton and find Boundary research. Select English in the card. Press Research baseline to restore all inputs; Demo runs the worked examples and ends with this guide.
2. Set Boundary strength to 0, then 1. Compare the first normal root and the paired curve at the same imposed Wilson angle.
3. Set Profile example M to 0, then 1. Compare the Gram eigenvalues and numerical rank.
4. Switch the parity insertion between C1, C0 and C0 W. Read the exact trace table, keeping its degree and support dimension in mind.
5. With lepton chirality Opposite to Q, compare one and three identical 6D families. Read the signed doublet excess and its residue.
6. Select Certified response query: t = 1/4, then t = 1/2. Read section 5 and the positive lower bound of uniform minus triangular. Download the proof and certificate ZIP and follow its README to replay the independent Sage verification.
7. Select Exact neutral stratum: s $\neq$ 0 and s = 0. In section 6 the quotient dimension changes from 0 to 1. Download the ZIP and run python verify.py certificate.json with SymPy.
8. Select Certified neutral angle: 1/10, 1/5, then 1/4. Read section 6b: compare the rational mass interval and positive separation from the next active mode. Download the continuous proof and replay it with SymPy.
9. Expand assumptions and provenance. Pin a comparison, export the card JSON and save the application link to repeat the calculation.

Controls and inputs

Boundary strength κ^2L. Nonnegative dimensionless coupling a of the uniform flat boundary action, from 0 to 100. L = πR. Use 0 and 1; the first kR changes from 0 to approximately 0.273853.

Imposed Wilson θ [rad]. Supplied angle from 0 to π for the periodic transverse branch; this is not a computed vacuum. At a = 1 compare $\theta = 0$ and $\theta = 0.2$; the unpaired mass changes while the normal root stays fixed.

Profile example M. Mass parameter from 0 to 2 on a separate unit rectangle. It is not a bulk mass inserted in the Spin(20) action. Compare M = 0 and M = 1: rank 2 becomes rank 3.

Spin(20) parity insertion. C1, C0 or C0 W sign insertion on the positive half-spin representation of dimension 512. The Cartan probe is fixed and displayed. Compare C1 and C0 W. Six-dimensional anomalies use degrees 4 and 2; four-dimensional ones use degrees 3 and 1.

Identical 6D families. Integer from 0 to 12 in a separate family-count example, assuming identical 6D chirality assignments. One family fails; three pass this restricted condition. Six also pass: it does not select exactly three.

6D lepton chirality. Same as Q or opposite to Q, with quark chirality fixed positive and three colours. Switch the sign and compare the signed doublet excess; retain the identical-family assumption.

Mass landscape view / 3D perspective. The 2D map and 3D surface use the same sampled paired masses and fixed colour range. Perspective is a display angle, not a physical parameter. Drag on the 2D map and release to apply the values. In 3D click a mesh node; adjust perspective between 15 and 75 degrees. Arrow keys move the selected point.

Certified response query. Select one of the two certified probes, t = 1/4 or t = 1/2. The unit-square model, source, epsilon = 1/8, alpha = 1/20, c = 38, kL = 2, kT = 8, pole s = 1/100 and residue R = 1/2 stay fixed. Select both probes. Their response-difference intervals exclude zero; no uncertified parameter is editable.

Exact neutral stratum. Select $s \neq 0$ or $s = 0$ independently of the Wilson slider. Compare rank M, stabilizer and quotient; no tolerance decides the stratum.

Certified neutral angle. Exact neutral-vector query, with L5 = L6 = muOmega = muPhi = 1 and eta = 0. Independent of the fermion landscape angle and the finite scalar stratum. At 1/5, the interval for mZ squared times L5 squared is [244/8425, 4/125]; the separation is at least 337/4000.

Reading the results

Root table and mass curves. Six roots of x tan(x) = a, with x = kL, and scaled residuals. Curves show the lightest paired and unpaired branches versus the imposed angle; they are not the full Kaluza–Klein spectrum.

Gram eigenvalues and rank. Eigenvalues of the complex Hermitian Gram matrix for profile angles 0, $\pi/2$ and π. Rank counts eigenvalues above the displayed numerical threshold; overlap alone does not establish dependence.

Exact inserted moments. $\mathrm{Tr}(\lambda\, F^d)$ for degrees 0 through 4 at one integer Cartan probe, evaluated with exact rational arithmetic. A nonzero value disproves an identically vanishing polynomial; a zero at one probe does not prove it.

Doublet excess and residues. The signed complex-doublet excess must be a multiple of 6 in the stated standalone 6D test. Twice that coefficient counts half-doublets and must be a multiple of 12.

JSON, comparison and saved link. JSON records tool version, schema, all parameters, roots, Gram results, exact moments, assumptions, sources and unresolved requirements. A pinned comparison overlays the earlier paired curve; a saved link restores controls.

2D map, 3D surface and Gram bars. Mass colour is linear from 0 to 0.7071 in mR. The red slice fixes the current coupling; the white point is the selected calculation. Surface cells visualize sampled data, while the selected value is recomputed. Gram bars have their own labelled adaptive linear scale and numerical eigenvalues.

Certified matched response and ZIP. Outward intervals enclose each continuum response and their difference. The ZIP contains the functional proof, polynomial witnesses, displayed reports, standalone verifier and its 228-check Sage 10.8 receipt. This is a computational certificate with a written proof, not a Lean formalization.

Finite neutral quotient and certificate. Exact dimensions 0/1 and ZIP with witnesses, written proof and symbolic verifier. Continuous reduction and physical matching are external.

Continuous neutral eigenvalue interval and certified separation. Section 6b bounds the continuous eigenvalue, including the natural boundary conditions. Positive lower mass and gap prove a simple isolated mode within the active block. Three decoupled zero directions remain separate.

Read each result with its own assumptions. The normal gap is dimensionless kR; a Gram rank is numerical and threshold-dependent; the traces are exact scalar evaluations without local weights; a zero residue passes only the stated standalone six-dimensional condition. Full anomaly cancellation stays unknown. In section 5, positive difference bounds establish separation at the two admitted points for this model. They do not establish a complete GHU prediction or a thin-layer rate. In section 6, dim ker A = 5 in both strata; rank M = 5 or 4, and dim(ker A/im M) = 0 or 1. The stabilizer ker M is a different space. The exact selector is independent of the Wilson slider.

Section 6b bounds the continuous eigenvalue, including the natural boundary conditions. Positive lower mass and gap prove a simple isolated mode within the active block. Three decoupled zero directions remain separate.

Worked example: Find three different reasons a construction can fail

1. Load Research baseline, then Uncoupled boundary: the first normal root is zero.
2. Restore boundary strength 1: the first kR is approximately 0.273853.
3. Load Massless profile example: the three chosen profiles span only two independent directions.
4. Restore M = 1: the eigenvalues are approximately 0.172999, 2.783424 and 10.686355, and the numerical rank is three.
5. Select One 6D family with Opposite to Q: excess 2 gives residue 2. Select Three 6D families: excess 6 gives residue 0.
6. Switch C1 to C0 W and inspect the trace table, then export JSON.
7. Select each certified response query, download the certificate, then save the shared JSON and link. The selected probe, fixed model and certificate identifier travel with the result.
8. Compare Exact neutral stratum: $s \neq 0$ and $s = 0$. Observe rank M = 5 and 4, and quotient dimension 0 and 1; download the finite proof and verifier.
9. Select Certified neutral angle: 1/10, 1/5, then 1/4. Read section 6b: compare the rational mass interval and positive separation from the next active mode. Download the continuous proof and replay it with SymPy.

The boundary gap, profile independence and restricted family condition respond to different changes. None of them settles localized or global anomaly cancellation of the full construction. The quotient jump is a certified finite result; it determines neither continuous modes nor a Higgs mass. The continuous neutral mass stays positive and isolated at all three admitted angles; its Wilson response and experimental interpretation remain unproved.

Formulas and conventions

$$Q(t) = F(t) - F(s) - (t-s)\,F\prime(s);\quad C(t) = -1 \,/\, [(t-s)/R + Q(t)]$$

Exact matching identity for $F(t)=t/D(t)$, with the same source and fixed s,R. The certified denominators exclude zero at the selected probes.

$$\rho = 4\,\theta^2/5;\quad \beta = 5/32 - \theta^2;\quad \rho - (4\,\theta^4/25)/(\beta-\rho) \leq \lambda_Z \leq \rho$$

Temple enclosure of the first active vector eigenvalue; beta bounds the second one. Valid for the declared walls and $0 < \theta <= 1/4$. The UI offers three exact queries.

Scope and limitations

- The flat spectrum assumes uniform coupling, no additional boundary kinetic terms and the periodic transverse branch. It does not determine a Wilson vacuum, realistic flavour or neutrino masses.

- The profile calculation is a separate mathematical example, not a derivation of three physical families. Numerical rank depends on tolerance; exact zero modes need an analytic boundary-domain analysis.
- Inserted traces omit projector and covering-space normalization, consistent descent, mirror contributions and inflow. The scalar probe is not the full anomaly polynomial.
- The SU(2) criterion applies to a specified standalone six-dimensional tensor setting. It cannot be transferred automatically to an eight-dimensional orbifold corner coupled to bulk inflow.
- Local coefficients, integral tensor charge lattice, global gauge group, new boson zero modes and full quantum consistency remain unresolved.
- Certification is restricted to the declared unit-square domain and two fixed probes at finite layer width. Changing the source, forms, matching conditions or width requires a new certificate. Software tests and hashes alone are not mathematical certification.
- The finite quotient in section 6 certifies the specified matrices A,M. Section 6b has its own continuous proof for the declared vector block and fixed walls. It does not certify the Wilson derivative, RZW, vacuum, currents or physical Higgs direction. Never differentiate the interval endpoints to infer a derivative bound.

If something is unclear

The first normal root is zero. Check boundary strength. At zero coupling this is the expected zero mode; it is not a numerical solver failure.

Overlapping profiles still have rank three. Overlap measures nonorthogonality. Dependence requires a null Gram direction; inspect the eigenvalues and threshold.

An inserted moment is zero. Check its degree and insertion. Evaluate the polynomial or more probes before claiming cancellation; this interface shows only one fixed probe.

Three families pass but full cancellation is unknown. That is intentional: the modular condition is necessary in its stated setting, not a complete local/global anomaly calculation.

An invalid input leaves the old result visible. The controls report the error and keep the last valid calculation. Restore the allowed range or press Research baseline.

Why can I not change layer width or import a response? Only independently certified instances are admitted. New computations belong in the external mathematical engine until their witnesses and functional premises are verified.

I cannot find section 6 or see it in the video. Open Anomalies & proton, use the Boundary research shortcut and find Exact neutral stratum. The current Demo includes section 6. The 17 October videos do not; consult this guide and the 26 October demo.

Changing the landscape angle does not change the neutral enclosure. Use Certified neutral angle. The landscape and neutral vector describe different stated problems; their controls are intentionally independent.

Sources and attribution

- Fujimoto et al.: rectangle boundary conditions and profiles, sections 2–5
- Asaka, Buchmüller, Covi: localized orbifold anomalies, sections 2–4
- Dobrescu, Poppitz: identical six-dimensional generations
- Lee, Tachikawa: six-dimensional global anomalies and tensor quantization, sections 2–3

- Yano: continuous residual norm and stability, sections 2.1–2.2; wall/corner adaptation proved in the certificate
- Schoeberl: equilibrated fluxes, sections 29.1–29.2; methodological background
- Kuroda: Kato-Temple, Theorem A

45 Quantization and certificates

Compare exact quantization criteria for H=S(U(2)×U(3)), closed spin-four periods, a conditional parent transfer and a joint U(2) example.

Open web guide

Use this independent diagnostic before interpreting a polynomial cancellation as a globally quantized action. The global quotient correlates apparently separate coefficients. Closed spin-four periods ask a different question from universal degree-four cohomology. The panel makes this distinction visible and supplies exact witnesses rather than a single undifferentiated consistency label.

First steps

1. Run the Demo, then compare C/2, C/36 and A+B.
2. Enter exact fractions. Inspect the detecting cocharacter or spin manifold when a criterion fails.
3. Change integer tensor pairings and inspect the unchanged residue class.
4. Export JSON and open the certificate catalogue to replay the appropriate Lean or numerical check.

Controls and inputs

α, β, γ. Rational coefficients in the centered SU(2), SU(3) and Y^2 convention. Choose C/2; change γ to 1/4.

p, q, r. Integral lattice pairings for ordinary Green–Schwarz sources. Change p from zero to one.

$\mathbf{K_2}$, $\mathbf{K_3}$, $\mathbf{K_1}$. Integer axion couplings with $\alpha=-K_2$, $\beta=-K_3$, $\gamma=K_1/72$. Use (0,1,12), then $K_1=13$.

$\mathbf{b_0}$, $\mathbf{b_1}$. Integer U(2) coefficients; the accompanying Lean criterion also treats a common rational denominator. Compare (1,6) with (1,5).

Exact figures / SVG. Select a lattice point to set alpha and delta at fixed beta; select a heat-map cell to read its exact U(2) period. Compare b1=6 with b1=5; inspect (m,n)=(1,0), then export SVG and JSON.

Reading the results

Criteria and witnesses. Read α,β,δ and α,β,2δ separately. The shown counterexample is an exact nonintegral evaluation.

Conditional transfer. The annihilator ℓ(x,y,z)=x+y+2z vanishes on both columns of the parent map. Its nonzero value excludes matching only under the listed source and spectrum assumptions.

JSON / Lean. JSON retains every input, witness, source and limit. The catalogue includes five Lean files with 59 theorem declarations and their replay evidence.

Lattices and cocharacter fingerprint. Diamonds satisfy both criteria; rings satisfy spin periods only, in the displayed fixed-beta slice. Each heat cell shows Q modulo one; its exact Q is available on selection. Both plots and JSON use gqModel.figures, without fitted or invented samples.

Passing a restricted arithmetic criterion does not establish a global action or a complete anomaly-free model. The modulo-three response class is conditional; it is not an identified global Z3 anomaly.

Worked example: Same polynomial, different background test

1. Choose C/2 and read both rows.
2. Universal integrality fails at the cocharacter (1,0,−1,0,0).
3. Closed spin-four periods pass because the Y^2 period is even.

These outcomes are compatible: the tests quantify over different backgrounds. Neither determines the orbifold background category.

Formulas and conventions

$$Q = \alpha(A - C/4) + \beta(B - C/3) + \gamma C;\ \delta = \gamma - \alpha/4 - \beta/3$$

Change from centered roots to integral characteristic classes.

Universal: α, β, δ integral; closed spin-4: α, β, 2δ integral

Ordinary bundles, with Wu parity supplying the spin restriction externally to Lean.

$$18K_2 + 24K_3 + K_1 = 0 \bmod 36$$

Known q=6 axion criterion; no identification with the GHU Higgs.

$$6\ell(v) = 16 - 3p - 3q - 6r = 1 \bmod 3$$

Integer obstruction under fixed spectrum and ordinary parent responses.

$$Q(m,n) = b_0(m-n)^2/4 + b_1(m+n)^2/8$$

Joint integrality iff b_0 is integral and b_1+2b_0 is divisible by eight.

$$t_a{}^2 = -1;\ U_a = -i\ t_a;\ U_a{}^2 = +1$$

Representation involution differs from an ordinary Spin(20) isotropy lift.

Scope and limitations

- The global action on all fields, including bosonic Omega, and the admissible orbifold bundles remain open.
- The wall SU(2) divisibility criterion is known. No claim of new mathematics or full anomaly cancellation is made.
- Lean formalizes arithmetic. Characteristic-class topology, Wu parity and physical translations are external assumptions. The 3290 lift checks are exact computational checks, not Lean theorems.

- The 81 cocharacters are a finite visualization, not a universal proof. Values outside the lattice window are explicitly reported; only pixel coordinates are approximate.

If something is unclear

The input is rejected. Use an integer or n/d with nonzero positive denominator. Tensor, axion and U(2) controls require integers. The last valid state is retained.

The result passes but model consistency is not checked. Read the scope: a restricted quantization criterion is one necessary ingredient of a full action, not a certification of the remaining ingredients.

Sources and attribution

- Monnier–Moore–Park: global quantization
- Choi et al.: axion couplings, Table 1 q=6
- Tong: global gauge group and line operators
- Lee–Tachikawa: six-dimensional tensor criterion
- Davighi–Lohitsiri: anomaly interplay
- von Gersdorff–Quiros: orbifold transformations

46 Hypotheses: local response and experimental context

Compare nine recalibrated GHU benchmarks and inspect a separate CMS spectrum with its covariance. Each selection includes a reading of the calculated values and their scope.

Open web guide

Distinguish changes in model parameters, local couplings, full-field potential differences and experimental error structure. Theory and CMS are separate contexts until a compatible prediction exists.

First steps

1. Open Same potential? and use the jump button for Hypotheses. Press Demo for the real-control walkthrough.
2. Choose cases 1 and 6. Read the recalibrated coupling changes, then expand the potential interval.
3. Choose CMS intervals i and j. Inspect the measured value, marginal error and signed correlation.
4. Export the selected SVG, full JSON or observed CSV. Import the JSON to restore a validated selection.
5. Open Certificates. Read each claim and its scope, then download its JSON or the existing catalogue ZIP.

Controls and inputs

GHU case. One of nine fixed recalibrated cases; changing the case may change multiple inputs and field multiplicities. Compare cases 1 and 6.

Potential interval. Field θ in 0.06–0.14 or 0–π. The vacuum θH remains fixed at 0.1. Switch regions and read the vertical exponent.

CMS intervals i and j. Select one measured bin and a second bin for their experimental correlation. Set i=j, then select different intervals.

Reading the results

Four linked figures. Parameter scatter and potential difference share the theory selection. Measured error bars and covariance-derived correlations share the CMS selection.

Downloads and imports. JSON preserves provenance, full covariance and theory samples. SVG is standalone; CSV contains observed bins. Import restores inputs, not an external dataset or imported verdict.

Scoped certificates. Ten rational Lean identities, exact covariance witnesses and three pointwise derivative enclosures. Full-integral error and observed-fit certification remain pending.

Read axes, units and source before comparing panels. Small coupling changes after recalibration do not establish experimental indistinguishability. The potential scale is fixed across cases within a region, and changes when the region changes.

Worked example: Follow the interactive demo

1. Open Same potential? and use the jump button for Hypotheses. Press Demo for the real-control walkthrough.
2. Choose cases 1 and 6. Read the recalibrated coupling changes, then expand the potential interval.
3. Choose CMS intervals i and j. Inspect the measured value, marginal error and signed correlation.
4. Export the selected SVG, full JSON or observed CSV. Import the JSON to restore a validated selection.
5. Open Certificates. Read each claim and its scope, then download its JSON or the existing catalogue ZIP.

The demo ends with separate theoretical and experimental readings. It never assigns an exclusion to the nine benchmarks.

Scope and limitations

- Dominant-tower reconstruction, bottom omitted, physical uncertainty unquantified. The browser reads archived calculations; it does not rerun the Bessel integrals.
- This study is independent of the exact SU(7) equivalence theorem in its host section. Its video chapter and interactive Demo share the same practical walkthrough.
- No observed GHU fit or full physical certification is provided. A covariance alone does not supply a compatible theory prediction.

- The about 7.4% quartic fit/table discrepancy is unresolved. Quadrature convergence is not a rigorous total error bound.

If something is unclear

The selected curve is zero. Case 1 is compared with itself. Select another case.

Import is rejected. Use this card's JSON export with valid integer selections. Unrelated datasets require a separate audited adapter.

Sources and attribution

- Funatsu et al. · GHU potential and Table 3
- CMS observed spectrum
- CMS experimental covariance

47 Glossary

the alphabet

A boundary condition on an orbifold is a representation of the space group $\Gamma = \Lambda \rtimes Z_m$, so the possible conditions are built out of $\mathrm{Irr}(\Gamma)$ — the letters. Part IX-A gets them by Möbius inversion over the fixed points of the rotation, with Clifford theory supplying the weights. Everything else on the orbifold page is derived from this list; nothing is entered.

the weight of a letter

Its dimension. A letter of weight one is a diagonal boundary condition. A letter of weight above one is exactly a boundary condition that is not diagonal — which is why an alphabet with heavy letters cannot be read off a diagonal ansatz, and why the weights, not the number of letters, set the cost of enumerating a rank.

the local datum

At a cone point of order e, the eigenvalues of the isotropy element acting on the condition, recorded as multiplicities over the e-th roots of unity. It is local: it says what the condition looks like at that one fixed point and nothing about the rest of the orbifold.

the class of a condition

Its tuple of local data, one entry per cone point. This is what any equivalence relation must preserve, so a proposed relation that moves one local datum is wrong, and the check costs seconds and does not need the classification to be finished.

a fibre

All the boundary conditions carrying the same class. The classes are the fibres of a marginal map, which is why they are indexed by an affine semigroup rather than by a list. In the panels a cell of the lattice is a fibre: its footprint is the class count and its volume is the number of conditions.

cone points, and the signature

The fixed points of the rotation on the torus, each with the order of its isotropy group. The signature is the list of those orders, and it alone fixes the degree of the class count in the rank — before any condition is enumerated.

the Frobenius–Schur indicator

+1, 0 or −1: whether a letter is real, complex, or quaternionic. It is what decides how the SU alphabet merges into the SO and Sp ones — a complex letter pairs with its conjugate, a real one survives alone — so the three real forms are not three separate computations but one alphabet read three ways.

the degree of the count

The degree of polynomial growth of the class count under the classification hypotheses is $e_1 - 1$, where $e_1 = 1 + \Sigma\ c(m_i)$, with $c(m) = m-1$ for SU and $\lfloor m/2 \rfloor$ for SO and Sp. This asymptotic degree is distinct from asserting that every exact finite-rank count is one polynomial without periodic terms.

the Hilbert series

The counts are the Hilbert function of the semigroup, so the generating function is P(x) / ∏(1−x^w) over the letter weights. The point is that P terminates: that is checked here, not assumed, and once it does the counts at any rank come from the recurrence with nothing enumerated.

the apparent unbroken group

The 4D gauge group a condition looks like it leaves unbroken, $S(\prod U(n_\ell))$ for a weight-one alphabet. It is not an invariant of the class: conditions in one fibre — the same theory — can wear different apparent symmetries. That is why a survey that lists models by their apparent group double-counts.

the Smith normal form

How the fixed points are actually enumerated. They are $M^{-1}Z^r/Z^r$, a group of order |det M|, and the normal form walks exactly that many points. The naive box walks $|\det M|^r$ of them, which is the same answer at rank 2 and hopeless at rank 6 — where the heterotic orbifolds are.

why a matrix can be refused

An integer matrix of infinite order is not the rotation of any orbifold, so it is returned refused rather than classified. The same for a matrix whose characteristic polynomial is not a power of the m-th cyclotomic: that is outside the hypothesis of Part IX-A, and the machinery would answer with an empty alphabet and degree zero — which looks like an answer and is not one.

a move

A rewriting that preserves the stated class data. Completeness is the stronger claim that a move set connects every member of every relevant fibre. The finite walk tests connectivity for the selected case; legitimate individual moves and success at one rank alone do not prove completeness at every rank.

an affine semigroup

The classes are the fibres of a marginal map, so they are indexed by a semigroup with one generator per letter of the alphabet. Naming that semigroup is mostly an exercise in attribution: over Z_2 it is a cut configuration with a literature and a published table of invariants, and the useful thing this page can do is stop you deriving it again.

α, the Wilson-line phase

The vacuum expectation value of the extra-dimensional gauge field, in units where a period is 1. In this family it is the electroweak hierarchy, because $1/\mathrm{R}_5 = 2\mathrm{m_W}/\alpha$ — which is why a phase of order 10^{-3} and a scale of order tens of TeV are the same statement.

gauge–Higgs unification

A higher-dimensional gauge-field component can supply a four-dimensional Higgs zero mode. In the supported gauge-invariant setup its Wilson-line potential is generated radiatively. The phase can be calculated within a model, but dimensionful predictions still require the stated scale and coupling inputs; calibrating with measured m_W is not a prediction of that same input.

the orbifold parities

Signs of a component at the orbifold fixed points, such as (+,+) or (+,−). In the ordinary untwisted interval problem, a (+,+) component admits a constant zero mode before Wilson backgrounds and additional mass terms. At a nontrivial vacuum the joint boundary problem must be evaluated; a parity table alone is not the complete physical spectrum.

a zero mode

A mode at the bottom of the compactification spectrum that is massless under the stated background and boundary problem. At the ordinary symmetric point its existence follows from the component parities. Wilson backgrounds, boundary masses and other interactions can change the massless content, so the chosen background must accompany the count.

the Kaluza–Klein tower

The four-dimensional modes associated with an extra-dimensional field. In the simplest untwisted case masses are n/R, while boundary phases can shift the levels and boundary kinetic terms can change the spectral equation. A tower must retain its boundary conditions, phase convention and multiplicities; it does not by itself determine collider rates.

the bulk content

The list of representations living in the extra dimensions, each with its orbifold parities and a multiplicity. It is the input to everything — potential, spectrum, anomalies and scale are all functions of it.

branes, and the fixed points

The ends of the interval, where the orbifold has its fixed points. Fields can live there as well as in the bulk, and that matters twice over: the anomaly of this class of models sits entirely on the fixed points, and brane fermions are what pay for unwanted zero modes.

the local group at a fixed point

At y = 0 the local group is the commutant of P_0; for diagonal blocks it is $S(U(n_{++} + n_{+-}) \times U(n_{-+} + n_{--}))$. At y = πR it is the commutant of P_1. These local groups can differ, and the symmetric-point 4D group commutes with both. A local representation can split into several representations of that common subgroup.

a boundary mass, and the rank test

A Weyl fermion on a fixed point can pair with a bulk zero mode and give it a mass. In a fully left-handed convention the rule is one line: a mode in r_q pairs with a localised Weyl in $\overline{r}_-$q — conjugate representation, opposite charge. What is easy to get wrong is the counting: with generic couplings the mass matrix has maximal rank, so what survives is |difference| in each class separately, and a count of exotics that skips the decomposition can declare a mass allowed that is not.

the one-loop potential

The effective Wilson-line potential obtained at one loop from the supported field content and compactification spectrum. Its phase-dependent part is finite in the stated protected setup. This does not quantify every higher-loop correction, boundary interaction or physical theory uncertainty, and an implemented potential still needs a justified normalization and field content.

α_min, the vacuum

The closed form locates a stationary branch within the small-phase expansion. It is compared with a numerical search of the Fourier potential; the two can differ. Neither the closed form nor a finite grid alone certifies the global vacuum.

a chiral spectrum

Left- and right-handed fields in different representations — which is the point of orbifolding, and the reason the 4D theory can look like the Standard Model. It is also a gate: a chiral spectrum is inconsistent unless its gauge anomalies cancel.

the anomaly channels

A chiral spectrum has to have its gauge anomalies cancel, channel by channel — tedious, and where an arithmetic slip hides best. A non-zero entry is not a verdict of inconsistency: these models carry brane fields anyway, and a brane fermion conjugate to a zero mode contributes to the same channel with the opposite sign. So the ledger reports a bill, and says who can pay it.

a brane kinetic term

An extra kinetic term localised on a fixed point. Turn it on and the Kaluza–Klein masses stop being n/R: they become the roots of a transcendental equation, sliding off the poles of the free summand, and the potential has to be built from those roots instead of written down.

a boundary condition

The choice of how the gauge group acts at each fixed point — for SU(N) on S^1/Z_2, the block sizes [p, q, r, s]. It is what breaks the group, and there are many of them, which is the first problem a model builder meets.

when two boundary conditions are one theory

Some boundary conditions are related by a gauge transformation, so they are the same theory wearing different clothes; only the class is physics. Two things follow: the apparent unbroken symmetry is not an invariant of the class — SU(5) with [2,0,0,3] looks like SU(3)×SU(2)×U(1) and [1,1,1,2] like SU(2)×$U(1)^3$, and they are one theory — and a survey that does not quotient by this counts the same model over and over.

D and A_4

Charge-weighted second and fourth moments describe the small-phase reduction of the implemented potential. The allowed arithmetic depends on the gauge seed: the published SU(7) seed gives odd 8D, whereas the candidate seed has even rungs. Read the seed and nondegeneracy conditions before using a stationary branch or a curvature verdict; moments do not generally determine the full potential.

a rung of the ladder

A quantized value of the curvature coordinate D in the stated moment reduction. Its parity and accessible values depend on the seed. Finite enumeration and counting statements require the stated additional coordinate or mass-window bounds. A search stopped by its computational budget has not proved that a rung contains no solution.

the ceiling

An upper bound on the scale for the stated moment relaxation, gauge seed, coupling and Higgs-mass window. Rational or interval certificates establish that mathematical bound under those hypotheses. It need not be attained by an integer content and is not automatically a universal bound on full-potential global vacua or on a physically reconciled model.

the reachable set

Scales reached by the integer contents admitted in the stated inverse-design problem. They can form separated clusters rather than a continuous interval. A quoted gap must retain its seed, mass window, coupling and approximation; a plot or a budget-limited search alone is not a certificate that every intermediate scale is impossible.

a certificate

Evidence for a precisely stated mathematical claim and its hypotheses: for example an arithmetic obstruction, a rational bound, or an interval proof for a fixed potential. The claim and domain travel with the certificate. A budget stop is undecided, and certifying an implemented formula does not prove its full physical applicability or scientific novelty.

counting instead of enumerating

The multiplet lattice with its congruence is a rational cone cut by an affine sublattice, so the count at fixed (A_4, 8D) is a vector partition function. A dynamic programme gives every count at once in milliseconds, where building the contents one at a time took about twenty-five minutes and ran out of budget.

when two contents give one potential

Part VII Theorem 3 gives an if-and-only-if equality criterion in five coordinates for the implemented potential family. Distinct multiplet contents can therefore give the same Wilson-line potential. Matching only selected local moments or plotted samples is weaker; equal potentials do not establish equality of all spectra, interactions or complete physical theories.

the canonical representative

A distinguished content among those with the same implemented potential, as defined in Part VII, equation (43). It provides a reproducible representative for that algebraic equality. It is not automatically a canonical representative of a complete physical theory: quantities not encoded by the potential can still differ.

the selection rule

Part III: one bit, arithmetic on three integers, says that half the torus is redundant — you never have to search it. The claim is testable by a computation that has never heard of Dynkin labels, which is what this page runs.

η, the boundary sign

The boundary-condition sign $\eta = \eta_0\eta_1$. Part V shows it rides on an index alone, so it is invisible to the Higgs potential exactly on Part IV's vanishing class.

blindness is not smallness

In the SU(4) projection and potential contribution studied in Parts IV–V, the stated vanishing-index class has no η-dependent response. Increasing its multiplicity does not create that sign-

dependent difference. This does not mean its full potential contribution, spectrum or other physical effects vanish; compare full-potential and η-difference views separately.

K, the row-consistency invariant

m_h a / $\sqrt{}$F" = 2.2456 g_4 in the registered convention. At fixed input m_h, F $\to \lambda$F changes K by $\lambda\hat{}(-\frac{1}{2})$. Invariance requires also recomputing m_h as $\sqrt{\lambda}$ m_h. This compares the implied coupling; it does not establish stationarity or a global minimum. Part VI, open problem 3.

the comb

The KK scale can only sit on teeth, spaced exactly in M^2 and not in M, with each rung's teeth stopping at its own ceiling. The spacing is arithmetic and carries nothing; the position carries the anchor residual and g_4. Confusing the two is how a screen becomes an accusation.

the bill, in eighths

The cost of an escape from the proton-decay obstruction, measured in the quantum of D. It is a ratio of integers, so no normalisation enters it — which is what lets it be quoted without an anchor.

the rung cube

The 64 ordered triples of lepton rungs, drawn. Its main diagonal is the family-universal line, where every A_j vanishes and the protection dies — so the failure set is a line, not a region, and the theorem is the geometry rather than a summary of it.

the coloron

The colour-octet vector used in the laboratory's stated dijet comparison. Its mass, width and coupling follow the localization and compactification assumptions of that model. A limit derived for another resonance, production mechanism or branching pattern cannot be transferred solely because a mass value matches.

a recast

A published experimental bound re-expressed on this model's scale. The $\Delta\chi^2$ teeth here are quoted from the published record, never re-derived — a near-miss re-derivation would put a number on the page that disagrees with the paper it claims to come from.

the anchor

A published computation the instrument recomputes at load and shows as a chip, so the tool declares whether it currently reproduces an outside number before it shows you any of its own.

the theory, or the frame

A number the instrument computes about a boundary condition is only a statement about the theory if it survives replacing that boundary condition by a gauge-equivalent one. The dossier

recomputes every line on every member of the class and tags it by what came back — so the tag is a measurement made on this render, never a list of which lines ought to be invariant. Most of the symmetric-point lines are not: the apparent unbroken group, the massless content and the anomaly ledger are read at $\theta = 0$ of the representative you happen to be holding. The same three, read at the minimum, come back invariant — and that too is measured on the render.

the Standard-Model cell

Is SU(3)×SU(2)×U(1)_Y in the unbroken group, with massless pieces carrying Q, u^c, d^c, L and e^c at their hypercharges? Colour is a block of size three, weak isospin a block of size two, and Y is solved exactly in the blocks' U(1) generators on the pieces offered as each field — Part II's counting: K − 1 unknowns against one constraint per field. When the fields fix Y the embedding fixes $\sin^2\theta$_W = tr $T_3{}^2$ / (tr $T_3{}^2$ + tr Y^2), 3/8 for Georgi–Glashow's direction. It is read at the symmetric point nearest the vacuum, because the vacuum's job is to break SU(2)×U(1); the distance says whether the electroweak sector is light. What is not found is listed as missing — on SU(5) with P = diag(+,+,+,−,−) that is always Q and d^c, which the literature puts on the brane.

against the data

In the builder comparison, the vacuum supplies a dimensionless m_W R and the recorded measured W mass calibrates 1/R. This makes dimensionful quantities conditional on that anchor. A colour-octet reference limit applies only under its particle and localization assumptions, including colour in the bulk. Other modes use their own named datasets and hypotheses. Reference overlays, interval membership and statistical likelihoods are different comparisons; retain each source edition and input record.

the content at the minimum

Gauge the constant A_y away and the reflection about y = πR becomes $P_1\prime = W^{-1}P_1$, with W the holonomy round the circle (Hosotani; Haba–Hosotani–Kawamura §2). A massless four-dimensional mode is a vector fixed by both P_0 and $P_1\prime$, so the content at the minimum is a joint eigenspace — linear algebra, not a parity table. When every phase is 0 or 1 it is the parity rule applied to a class-mate. A boundary face alone does not decide breaking: compare the surviving generators with those at $\theta = 0$. The instrument reaches the count by two independent routes — the representation theory of the pairs the Wilson line rotates, and the explicit matrices — and the harness holds one to the other. The scalars are tree-level flat directions; the tolerance for "at an end" is 10^{-6}.

invariant, and still useless

A line can be the same on every member of a class and also the same for every class, and then it distinguishes no theory from any other however stable it is — N_0 is one, and so is N. The two axes are independent and are measured separately: splitting within a class makes a line the frame's, and taking one value between classes makes it no verdict at all.

what a keyword sweep is worth

It turns a corpus into a shortlist, and that is all. A signal firing means “worth opening”; it is never quoted as a fact about a paper. The two are kept in separate columns here for exactly that reason.

measured, read, and unmeasured

Measured records describe the reproducible extraction or keyword sweep over the declared corpus. Read records are human-reviewed statements with a source page or equation. A PDF whose text extraction loses the needed glyphs is not evidence that its paper omits a formula; keep extraction failure separate from a negative literature finding.

the tripod bound

For a finite abelian G, the group-based model on the claw tree with three leaves is a complete intersection iff $|G| \leq 3$. The arithmetic settles orders five and up in one line, for every abelian group at once: $|G|^2 - 6|G| + 6 \leq 0$. Order four passes the bound and is still not a complete intersection — Z_4 and $Z_2 \times Z_2$ are decided by exhaustion in Part IX-B §5, and a bound that is silent is reported as silent.

complete intersection: global, not local

Casanellas, Fernández-Sánchez and Michałek prove these varieties are complete intersections in a Zariski-open set. The question asked here is the global one, about the toric ideal itself, and the Z_4 tripod separates the two: local yes, global no. Quoting one for the other is the misreading this page exists to prevent.

three verdicts, and the amber one is the output

Green: the instrument returns what the paper prints. Amber: it does not — and the row names which of that paper's own equations agrees with which, and what moves as a result. Grey: outside this engine, said out loud, because a blank cell reads as a no and "we did not compute it" is not "it does not hold". A verdict that changes is what fails the build; a verdict that differs is what this page is for.

what each row was read at

Three of the four models are supersymmetric and this engine's one-loop potential is not, so their rows are parity linear algebra only — which boundary condition, which unbroken group, which zero modes — and never their dynamics. Kubo–Lim–Yamashita is not supersymmetric, which is why its potential, its vacuum and its Higgs mass can be anchored at all, and why it is the one where this engine can be wrong by a number.

Global quantization

A characteristic class must have integral periods on the specified backgrounds. The global group determines which bundles and cocharacters test it; a covering-group direction alone need not detect every obstruction.

Universal classes and spin periods

For $H = S(U(2) \times U(3))$, the integral basis gives $\delta = \gamma - \alpha/4 - \beta/3$. Universal integrality requires α, β, δ integral. On the stated closed spin four-manifolds, Wu parity instead gives α, β, 2δ integral; this topology is assumed externally to Lean.

The q = 6 axion congruence

In the normalization of Choi et al., $\alpha = -K_2$, $\beta = -K_3$ and $\gamma = K_1/72$. The spin-period criterion becomes $18K_2 + 24K_3 + K_1$ divisible by 36, with K_2 and K_3 integral. This does not identify the axion with a GHU Higgs.

A conditional parent obstruction

The linear functional $\ell(x,y,z) = x + y + 2z$ annihilates both ordinary parent response columns. For the fixed inherited spectrum and ordinary integral Green–Schwarz sources, $6\ell(v)$ is 1 modulo 3 and cannot vanish. Other background or response families require their own analysis.

Joint quadratic integrality

For all integer cocharacters (m,n), $Q = b_0(m-n)^2/4 + b_1(m+n)^2/8$ is integral exactly when b_0 is integral and $b_1 + 2b_0$ is a multiple of 8. Separate summands need not be integral. The certificate proves this arithmetic criterion, not the existence of an anomaly-free supergravity spectrum.

Reading the exact figures

The lattice holds β fixed: diamonds pass both criteria and rings pass only the spin-period criterion. In the cocharacter grid, each cell prints Q modulo 1; a nonzero fraction witnesses failure. Both figures use the current exact inputs. The finite grid illustrates the universal theorem rather than proving it.

Representation versus group lift

An ordinary Z_2 action lifted to Spin(20) needs an element whose square is $+1$. Here ${t_a}^2 = -1$, while $U_a = -i\ t_a$ has ${U_a}^2 = +1$ because of an extra scalar phase. A combined or twisted action must be specified for all fields; the matrix alone does not establish it.

Scope of a Lean certificate

Lean checks the exact theorem statements against their hypotheses. These five files contain 59 theorem declarations for weight algebra, arithmetic criteria and rational hypothesis algebra. Numerical audits, the external topology, allowed orbifold backgrounds and full physical consistency remain distinct questions.