Particles Mechanics Math Walk-Through

We pick up directly from the canonical Foundation Math Walk-Through. We carry a single dimensional scale $S_0 = \hbar$ (SI-locked via the electron anchor) and introduce no new dimensional scales here. All particle structure follows from the same route/closure variational framework; base locks are not re-tuned.

Foundation Bridge (Display-Area → Phase → Closed Harmonics)

Display-area counts patches, action sums them, phase labels them. Closed harmonics are the only quantization rule we need.

$A\_d = \pi r^2$

$S[path] = \int A\_d \cdot ds$

$\varphi = S / S_0 \quad (S_0 = \hbar)$

$S\_loop / S_0 = 2\pi n \ (n \in \mathbb{Z})$

Particles Math Walk-Through (Picks up from Canonical Foundation)

What we build, VMS-first, with short classical/SM dictionaries only:

• Quantization ladder from closed harmonics (integer n labels the class: charge steps; spin classes).

• Family structure from route symmetries (stabilizers mirror U(1)/SU(2)/SU(3) without importing gauge furniture).

• Mass patterns as ratios from closure-tension × geometry (no new scales):

- $E_k \equiv \int_0^{\ell_k} \tau_k(s)\, ds$ (dimensionless)
- $m_i/m_j \approx (E_i/E_j)\, \mathcal{G}_{ij}$

• Mixing from overlap (2-state shown; 3-state skeleton in Appendix):

$\tan(2\theta) = 2\kappa / \Delta$

• Widths and lifetimes from an action-gap escape map (ratios first):

$\Gamma\_i / \Gamma\_j \approx (\Omega\_i / \Omega\_j) \cdot e\hat{}\{-(\Delta S\_i - \Delta S\_j)/S_0\}$

No new tunables. Ratios/bands are published first; calibrated absolutes live in the Appendix/Calibration.

0) Locks, Scope, and Dictionary Discipline

• Locks: $S_0 = \hbar$ (single dimensional scale). Speed of advance c is an acceptance lock. No other units-bearing knobs.

• Ontology: display-area $A\_d = \pi r^2$; route action $S[path] = \int A\_d\, ds$; phase label $\varphi = S/S_0$.

• Scope: particle classes (charge steps, spin classes), family structure, mass ratios, mixing, widths/lifetimes — all as dimensionless relations. Catalog details and calibrations live in the Pillar Math Appendix.

$$A\_d = \pi r^2$$

$$S[path] = \int A\_d\, ds$$

$$\varphi = S / S_0 \; (S_0 = \hbar)$$

1) Display-Area → Phase → Closed Harmonics (with stability checks)

Step 1 — Action bookkeeping. Along any route, sum the hidden display-area patches (A_d) to get $S[path]$. When we need a phase we divide by S_0 so ϕ is dimensionless.

$$S[path] = \int A\_d\, ds \Rightarrow \varphi[path] = S[path]/S_0$$

Step 2 — Caustic optionality. Real geometry creates folds/foci where multiple near-optimal routes exist. If the spread of near-ties is on the same scale as the accumulating display-area, the front oscillates between options instead of averaging out.

Step 3 — Harmonic closure. If the geometry feeds the front back to its starting facing after one lap, the loop is closed. Stability requires an exact hand-off of facing, i.e., an integer number of phase turns:

$S\_loop/S_0 = 2\pi\, n\, S_0.$ n is an integer.

Interpretation. The integer n labels the loop class. These integers are the source of charge steps and spin classes. No separate quantization postulate is imported.

2) Quantization Ladder (Charge Steps; Spin Classes)

Closed-loop integer n is the class label. At catalog level:

$$q = n\, q_0 \quad (\text{integer step } q_0)$$

spin class: n even → boson; n odd → fermion

Why this is enough. The loop can hand off its facing only at integers; parity of n tracks the symmetry under exchange (class-level statement; anomaly/symmetry constraints are carried in the Appendix).

3) Route Symmetries → Family Structure (Gauge Dictionary)

We identify the invariances of $S[path]$ and the boundary rules that preserve closure. The stabilizer of those invariances partitions couplings into families. Coarse-grained, the connected components mirror U(1), SU(2), SU(3). We do not assume gauge furniture a priori.

Let $\mathfrak{G} = \{g : S[g \cdot path] = S[path] \text{ and boundary rules preserved}\}$.

$\mathrm{Stab}(\mathfrak{G}) = \{h \in \mathfrak{G}: h \cdot \text{pattern} = \text{pattern}\}$.

$\mathrm{Stab}(\mathfrak{G})$ acts on couplings $\Rightarrow$ families of couplings (labels: $U(1), SU(2), SU(3)$).

Let $\mathfrak{G}$ be the set of transformations that leave the action S and the boundary rules unchanged. The stabilizer Stab($\mathfrak{G}$) (the elements that keep a given closed pattern fixed) acts on couplings and partitions them into families; under coarse-graining those families mirror U(1), SU(2), SU(3).

Appendix: explicit generators and admissibility constraints; here we keep the derivation ladder and the dictionary only.

4) Mass Patterns — Closure Tension × Coupling Geometry (Ratios-First)

Idea — The closed pattern stores a dimensionless tension count along its length. Effective mass scales with that count and with how the pattern couples to its environment/other loops. Derive the ratio in three steps.

Step A — Define a dimensionless stored-tension along the loop. Let τ(s) be the (dimensionless) closure-tension density and ℓ the loop length (dimensionless).

$$E\_loop \equiv \int_0{}^\wedge \ell \; \tau(s)\, ds \;\; \approx \;\; \bar{\tau}\, \ell$$

Step B — Relate effective mass to the loop tension count. The SI lock enters only through S_0 when phases are read; the proportionality cancels in ratios:

$$m \propto E\_loop$$

Step C — Allow dimensionless geometry in couplings (overlaps, background structure) via $\mathcal{G}$. Then:

$$m\_i \,/\, m\_j \;\; \approx \;\; (\, \bar{\tau}\_i \, \ell\_i \,) \,/\, (\, \bar{\tau}\_j \, \ell\_j \,) \;\; \times \;\; \mathcal{G}\_\{ij\}$$

Notes — $\mathcal{G}$_{ij} is a pure number from coupling geometry; no new dimensional constants appear. The lepton ladder can be fit as one $\mathcal{G}$ map; details in the Appendix.

5) Mixing — Overlap Diagonalization (2-State and 3-State Skeleton)

Mixing here is derived from overlap of two closed VMS patterns that are nearly the same shape. We coarse-grain the route counting to a 2×2 effective energy map built from (detuning Δ) and (overlap κ). This is not an import of quantum postulates; it's the VMS overlap operator written in the smallest non-trivial basis. Numbers are reported as ratios (units absorbed).

Effective 2×2 model — define detuning and write the matrix:

$$H = [[E_1, \kappa], [\kappa, E_2]]$$

$$\Delta \equiv E_1 - E_2$$

Diagonalize by a rotation through angle θ (kill the off-diagonal):

$$R(\theta) = [[\cos\theta, -\sin\theta], [\sin\theta, \cos\theta]]$$

$$\tan(2\theta) = 2\kappa \,/\, \Delta$$

Eigenvalues after rotation:

$$\lambda_+ = \tfrac{1}{2}(\, E_1 + E_2 + \sqrt{(\Delta^2 + 4\kappa^2)}\,)$$

$$\lambda_- = \tfrac{1}{2}(E_1 + E_2 - \sqrt{(\Delta^2 + 4\kappa^2)})$$

3-state skeleton (dictionary only) — use a unitary with one CP-phase:

$$U = U(\theta_{12}, \theta_{23}, \theta_{13}, \delta)$$

Appendix note — The Appendix carries the explicit 3×3 parameterization and ratio-first maps to CKM/PMNS-style sets.

6) Decays & Widths — Escape Map from Action Gaps (Full Steps)

Mass Patterns — Closure Tension × Coupling Geometry (Ratios-First)

Idea — A closed VMS pattern stores a dimensionless "tension count" around the loop. Effective mass scales with that stored count and with how the pattern couples to its environment/other loops. We publish ratios so all global proportionalities cancel.

Step A — Define the dimensionless stored-tension along the loop. Let $\tau(s)$ be the closure-tension density and ℓ the loop length (both dimensionless under our normalization):

$$E\_loop \equiv \int_0^{\ell} \tau(s)\, ds \;\approx\; \bar{\tau} \cdot \ell$$

Step B — Relate effective mass to the tension count. The SI lock enters only through S_0 when phases are read; the proportionality cancels in ratios:

$$m \;\propto\; E\_loop$$

Step C — Include dimensionless coupling-geometry differences between patterns i and j via $\mathcal{G}_{ij}$:

$$m_i / m_j \;\approx\; (\bar{\tau}_i \cdot \ell_i) / (\bar{\tau}_j \cdot \ell_j) \;\times\; \mathcal{G}_{ij}$$

Why this is VMS-first — $\bar{\tau}$ and ℓ come from the closed-route geometry (no imported constitutive laws), and $\mathcal{G}_{ij}$ is a pure number from overlap/coupling geometry. No new dimensional scales appear; one global calibration (handled elsewhere) is sufficient.

7) Mixing — Overlap Diagonalization (VMS-First)

VMS framing — Two closed patterns that are nearly the same shape can overlap. Coarse-graining the route counting to the smallest non-trivial basis gives a 2×2 effective map built from detuning Δ and overlap κ. This is not an imported quantum axiom; it's the VMS overlap operator in a tiny basis. We report ratios so units do not matter.

Effective 2×2 model (define detuning and write the matrix):

$$H = [[E_1, \kappa], [\kappa, E_2]]$$

$$\Delta \equiv E_1 - E_2$$

Diagonalize by a real rotation $R(\theta)$ that kills the off-diagonal term:

$$R(\theta) = [[\cos\theta, -\sin\theta], [\sin\theta, \cos\theta]]$$

$\tan(2\theta) = 2\kappa / \Delta$

Eigenvalues after rotation (observed levels):

$$\lambda_+ = ½(E_1 + E_2 + \sqrt{(\Delta^2 + 4\kappa^2)})$$

$$\lambda_- = ½(E_1 + E_2 - \sqrt{(\Delta^2 + 4\kappa^2)})$$

Interpretation — Large overlap (κ) relative to detuning (Δ) gives a big rotation θ and a large level split; small κ/Δ gives a small rotation and a small split. Branching-ratio patterns and oscillations follow from the same rotation (see Appendix for the amplitude algebra).

3-state skeleton (dictionary only) — When three near-patterns mix, use a unitary with one CP-phase:

$$U = U(\theta_{12}, \theta_{23}, \theta_{13}, \delta)$$

We keep the 3×3 parameterization and CKM/PMNS-style dictionaries in the Appendix; here we only carry the VMS-first ladder and the minimal formula

8) Composites — Binding Algebra with 2-Loop and 3-Loop Examples

Idea — A composite is a bound set of closed VMS patterns (loops). Binding means the total route-action decreases when the loops couple admissibly (hand-offs allowed, no sideways pile-up). We stay ratio-first: global proportionalities cancel.

Definitions (what each symbol means)

• S_i — route-action of loop i when isolated (dimensionless under our normalization).

• S_int(i,j), S_int(1,2,3,…) — action changes from admissible couplings (geometry-only, dimensionless).

• E_loop,i ≡ $\int_0$^{ℓ_i} τ_i(s) ds ≈ τ̄_i ℓ_i — loop "tension count" (dimensionless).

• κ_ij — effective overlap/coupling between loops i and j (dimensionless, sign fixed by admissibility).

• Δ — detuning between uncoupled loop counts ($\Delta = E_1 - E_2$ in 2-loop case).

Binding condition and mass deficit (general)

$$S\_total\text{^}\{separate\} = \Sigma\_i\ S\_i$$

$$S\_total\text{^}\{bound\} = \Sigma\_i\ S\_i + \Sigma\_\{i<j\}\ S\_int(i,j) + S\_int(1,2,3,\ldots)$$

$$\Delta S\_bind \equiv S\_total\text{^}\{separate\} - S\_total\text{^}\{bound\}\ >\ 0 \quad \text{(bound if positive)}$$

In mass ratios (global proportionality cancels), the composite sits below the sum of the parts by a geometry factor $\mathcal{G}$_bind:

$$m\_\{comp\} / (\Sigma\_i\ m\_i)\ \approx\ 1\ -\ (\Delta S\_bind / \Sigma\_i\ E\_\{loop,i\}) \cdot \mathcal{G}\_\{bind\}$$

Two-Loop Composite — Bonding/Antibonding split (worked)

Coarse-grain the coupled pair to a 2×2 effective map built from uncoupled counts (E_1,E_2) and a coupling κ (>0 for admissible bonding).

$$H = [[E_1, -\kappa], \ [-\kappa, E_2]]$$

$$\Delta \equiv E_1 - E_2$$

Diagonalize with a real rotation R(θ) that kills the off-diagonal. Read both the mixing angle and the energy split directly:

$$R(\theta) = [[\cos\theta, -\sin\theta], \ [\sin\theta, \cos\theta]]$$

$$\tan(2\theta) = 2\kappa \,/\, \Delta$$

$$\lambda\_\pm = ½(E_1 + E_2 \ \pm \ \sqrt{(\Delta^2 + 4\kappa^2)} \,)$$

Binding shows up as the lower mode sitting below either part:

$$\lambda\_- \ < \ \min(E_1, E_2)$$

The composite's effective loop count tracks λ_−. The action gain (dimensionless) relative to separate parts is:

$$\Delta S\_bind \,/\, S_0 \ \approx \ (E_1 + E_2 - 2\lambda\_-) \,/\, S_0$$

Lifetime still follows the action-gap law but now from the bound pattern:

$$\Gamma\_\{comp\} \ \approx \ \nu \cdot \mathcal{Q} \cdot \Omega \cdot \exp(-\Delta S\_\{exit\}/S_0 \,)$$

Three-Loop Ring/Braid — Clear 3×3 form and special case

Write a symmetric 3×3 with admissible couplings κ_ij (sign chosen so that negative off-diagonals produce a bonding drop).

Matrix form (readable layout):

$$H = [\,[\,E_1, \ -\kappa_{12}, \ -\kappa_{13}\,],$$

$$[\,-\kappa_{12}, \ E_2, \ -\kappa_{23}\,],$$

$$[\,-\kappa_{13}, \ -\kappa_{23}, \ E_3\,]\,]$$

Binding criterion — after diagonalization, the lowest eigenvalue lies below all three uncoupled counts:

$$\lambda\_min \ < \ \min(E_1, E_2, E_3)$$

Special analytic check (equal loops and equal couplings: $E_1=E_2=E_3=E$, $\kappa_{12}=\kappa_{23}=\kappa_{13}=\kappa>0$). Then the eigen-pattern is closed form:

$$\lambda\_bond = E - 2\kappa \qquad \text{(symmetric bonding mode)}$$

$$\lambda\_anti \ = E + \kappa \qquad \text{(twofold degenerate)}$$

A bound composite exists if $E - 2\kappa < E \Rightarrow \kappa > 0$ (with admissible hand-offs). The eigenvector for the bonding mode is proportional to [1, 1, 1] (all loops in-phase).

If couplings are unequal, numerically diagonalize the 3×3 above; the same binding criterion on λ_min applies.

Admissibility and stability (what to check)

• Integer locks across the layout — each loop's hand-off remains integer-clean and the composite symmetry is admissible.

• Exit hardness — the cheapest allowed escape from the bound pattern obeys $\Delta S_{exit}/S_0 \gtrsim \Lambda$ (Λ modest).

• Quasi-static background — keep the caustic/coupling geometry slow vs. the composite cycle time; otherwise expect drift.

Worked micro-check (numbers as a sanity test)

Take $E_1=1.00$, $E_2=1.10$, $\kappa=0.08$. Then $\Delta=-0.10$, $\tan(2\theta)=2\cdot0.08/-0.10=-1.6 \Rightarrow \theta\approx-0.688$ rad ($\approx-39.4°$).

Eigenvalues: $\lambda_\pm=½(2.10 \pm \sqrt{(0.01 + 0.0256)}) = ½(2.10 \pm \sqrt{0.0356}) = ½(2.10 \pm 0.1887) \Rightarrow \lambda_- \approx0.9557$, $\lambda_+\approx1.1443$.

Binding check: $\lambda_- < \min(1.00, 1.10) = 1.00$ ✓ (composite is bound).

Proton, Neutron, and "Apparent Size" from Prying (VMS predictions)

Three-loop composite picture — Model each baryon (proton or neutron) as a three-loop composite with uncoupled counts E_i and admissible couplings κ_{ij} determined by the layout/orientation. In the symmetric baseline ($E_i = E$ and $\kappa_{ij} = \kappa$), the bonding eigenvalue is $\lambda_{bond} = E - 2\kappa$. Small orientation-driven differences ($\Delta\kappa_{ij}$) shift the bonding level and set the mass split.

Baseline and first-order shift (Rayleigh quotient)

For small asymmetries around the symmetric bonding vector $v = [1,1,1]/\sqrt{3}$, the first-order shift of the bonding level is the average coupling change seen by v:

$$\lambda_{bond} \approx E - (2/3) \cdot (\kappa_{12} + \kappa_{23} + \kappa_{13})$$

Therefore the proton–neutron mass difference in this picture follows the **sum of couplings**:

$$\lambda_{bond}^{(n)} - \lambda_{bond}^{(p)} \approx (2/3) \cdot [(\kappa_{12} + \kappa_{23} + \kappa_{13})^{(p)} - (\kappa_{12} + \kappa_{23} + \kappa_{13})^{(n)}]$$

Interpretation — If the neutron's admissible couplings sum to a **smaller** value than the proton's (slightly less binding), then $\lambda_{bond}^{(n)} > \lambda_{bond}^{(p)}$ and the neutron is heavier, as observed.

Ratio-first prediction band (no new scales)

Use mass ∝ bonding level. With E as a shared scale (drops in ratios):

$$(m_n - m_p)/m_p \approx [\lambda_{bond}^{(n)} - \lambda_{bond}^{(p)}] / \lambda_{bond}^{(p)}$$

$$\approx (2/3) \cdot [(\Sigma \kappa)^{(p)} - (\Sigma \kappa)^{(n)}] / \lambda_{bond}^{(p)}$$

A tiny fractional difference in the **sum of couplings** (order 10^{-3}) produces the observed $O(10^{-3})$ neutron–proton mass ratio split. You can fit the single number $\Delta(\Sigma\kappa)$ once and carry it across related observables (decay/width bands).

"Apparent size" from prying (compliance)

Define a small pry coordinate a that opens the three-loop layout (e.g., a symmetric radial separation). The bonding level responds as:

$$\lambda\_bond(a) \ \approx\ E \ -\ (2/3) \cdot [\ \kappa_{12}(a) + \kappa_{23}(a) + \kappa_{13}(a)\ ]$$

The effective stiffness against pry is the curvature:

$$k\_eff \ \equiv\ -\, d^2\lambda\_bond/da^2 \ \ =\ \ (2/3) \cdot [\, -\kappa_{12}''(a) \ -\kappa_{23}''(a) \ -\kappa_{13}''(a)\,]$$

Apparent size tracks compliance (larger compliance ⇒ larger apparent radius under small-q probes). As a dictionary to scattering form factors at small q:

$$r\_\{app\}^2 \ \ \propto\ \ 1\ /\ k\_eff \quad \text{(dictionary only: slope of form factor} \leftrightarrow \text{compliance)}$$

Prediction — If the neutron's couplings are slightly weaker (smaller Σκ), it should also be **softer** (larger compliance) under the same pry, giving a larger r_app in this sense.

Verification steps (how to test)

1) Sign of the mass split — Verify that any admissible orientation that reduces Σκ for the neutron predicts m_n > m_p (correct sign).

2) Magnitude band — Fit Δ(Σκ) from the mass ratio once; propagate to width-ratio bands where the exit map matches (Ω, ν common).

3) Prying compliance — Measure small-q slopes (dictionary) or direct pry response in a controlled setup; check C_n > C_p at low pry if Σκ^{(n)} < Σκ^{(p)}.

4) Stability — Ensure integer locks hold for the composite and $\Delta S\_exit/S_0$ sits in the long-lived band; otherwise, expect broadened widths.

Stability & Selection Rules (Quick)

• Integer locks must remain admissible across the coupled layout (no forbidden hand-offs).

• Exit hardness must be significant: $\Delta S\_exit/S_0 \ \gtrsim\ \Lambda$ (Λ modest).

• Background must be quasi-static on the composite cycle time to avoid wandering of n or θ.

9) Nuclear Binding, Strong/Weak, and Atomic

Locks and stance — VMS-first, ratio-first. Single dimensional scale $S_0 = \hbar$ (SI-locked). Binding and forces are gradients of the same route-action bookkeeping. No imported force laws; the shapes come from overlap kernels and admissibility (hand-off rules) on closed patterns.

9.a) A-Body Binding: VMS Liquid-Drop with Derivation Sketch

9.a.1 Smooth binding from geometry/tension budgets

We split smooth (bulk) contributions from shell oscillations. Smooth terms follow counting of loop patches (volume), their boundary (surface), orientation-charged overlap (Coulomb dictionary from EM), and proton-neutron imbalance (asymmetry). All coefficients are dimensionless composites of tension/geometry integrals; calibrated once.

$$\Delta S\_bind^{smooth}(A, Z) / S_0 = \alpha\_V A - \alpha\_S A^{2/3} - \alpha\_C [Z(Z-1)] A^{-1/3} - \alpha\_A (A-2Z)^2 / A + \alpha\_G \mathcal{G}(A, Z)$$

Why the exponents: in a roughly compact 3D layout, occupied loop patches scale like A (volume), boundary like A^{2/3} (area), and mean separation like A^{1/3}, giving A^{−1/3} in the Coulomb dictionary term. The asymmetry penalty is quadratic in proton–neutron imbalance divided by size. $\mathcal{G}$(A, Z) collects admissible layout effects (pure number).

$$R(A) \propto A^{1/3}$$

$$\text{Area} \propto A^{2/3} \quad ; \quad \text{Mean spacing} \propto A^{1/3}$$

9.a.2 Shell correction from discrete closure (magic numbers)

Closed integers in a mean field add extra binding near specific counts (magic numbers) for protons and neutrons. We use a smooth dip near each magic value; nearest shell dominates:

$$\Delta S\_shell(A, Z)/S_0 = -\Sigma_{x \in \{p, n\}} \beta\_x \cdot \max\_k \exp(-(N\_x - N_{magic, x}^{(k)})^2 / (2 \sigma\_x^2))$$

Nearest-shell approximation: the max_k picks the closest magic number; *for smooth gradients in fitting, replace max with a log-sum-exp over shells.*

Here N_p = Z, N_n = A − Z. Amplitudes β_x and widths σ_x are dimensionless, set once.

9.a.3 Total binding and mass dictionary (ratios)

Calibration set (fit once, carry across predictions): **{ α_V, α_S, α_C, α_A, α_G, α_P, β_p, β_n, σ_p, σ_n }**

$$\Delta S\_bind(A, Z)/S_0 = \Delta S\_bind^{smooth}/S_0 + \Delta S\_shell/S_0$$

$$m_{A, Z} / (\Sigma\_i\, m\_i) \approx 1 - [\Delta S\_bind(A, Z) / \Sigma\_i\, E_{loop, i}] \cdot \mathcal{G}_{bind}(A, Z)$$

We publish ratios (per-constituent or to a reference nucleus). Absolutes appear only after a one-time calibration.

9.b) How "Strong" Falls Out (Short-Range Attraction with Core)

In VMS, attraction between nucleons is a drop in total action from admissible overlap of closed loops; range is limited by caustic spread, and a very-short-range penalty prevents sideways pile-up (hard core). Write a two-body action kernel in separation r:

$$\Delta S_{NN}(r)/S_0 = -K_{att} \cdot \exp(-r / \ell\_s) + K_{core} \cdot \exp(-(r / r\_c)^p)$$

• ℓ_s is a short range set by caustic size; r_c is a core scale; p ≥ 2 is steep. K_att, K_core are dimensionless strengths from overlap geometry. The "force" profile is the gradient of this action w.r.t. r (dictionary to conventional force via acceptance locks):

$$F\_s(r) \propto -d[\Delta S_{NN}(r)/S_0] / dr = -(K_{att}/\ell\_s) \exp(-r/\ell\_s) + (K_{core}\, p / r\_c) (r / r\_c)^{p-1} \exp(-(r / r\_c)^p)$$

This produces an attractive well at 1–2 short-range units with a repulsive core at very small r, matching qualitative nucleon–nucleon phenomenology.

Many-body saturation follows because each loop only overlaps a finite neighborhood at short range; the net per-particle gain saturates, giving the volume term with a surface subtraction (α_V, α_S).

9.c) How "Weak" Falls Out (Class-Changing, Short-Range, Chiral Gate)

Amplitude-level transition probability (per attempt), with a short-range kernel and an action gap:

$$P_{trans} \approx \mathcal{Q}_w \cdot \int K_w(r)\,dr \cdot e^{-\Delta S_{trans} / S_0}$$

Width (rate) scales as amplitude squared times phase-space:

$$\Gamma \propto G_w^2 \cdot \Phi_{PS} \cdot e^{-2\,\Delta S_{trans} / S_0}$$

Contact strength (short-range integral):

$$G_w \equiv \int K_w(r)\,dr$$

Symbols & Notes

- $\mathcal{Q}_w$ — orientation/handedness acceptance (chiral gate; dimensionless).
- $K_w(r)$ — short-range overlap kernel (dimensionless; rapidly decays with r).
- ΔS_{trans} — action gap to the allowed class-changing exit (dimensionless).
- S_0 — the single dimensional scale; we lock $S_0 = \hbar$ (SI).
- G_w — contact strength from the short-range kernel (dimensionless in our units).
- Φ_{PS} — phase-space factor (dimensionless).
- Γ — partial width (rate); totals add as $\Gamma_{total} = \Sigma_i \Gamma_i$ across channels i.

Narrative link: amplitude $\propto e^{-\Delta S/S_0}$; squaring the amplitude yields the $e^{-2\Delta S/S_0}$ in widths. Chirality enters via $\mathcal{Q}_w$ (selection rule), not as an added force. Ratio-first reporting is preferred; absolute calibration is optional.

9.d) Admissibility + Pairing (Many-Loop Rules)

Admissible composites keep integer hand-offs per constituent and a composite symmetry that doesn't force sideways pile-up. Pairing is the even–even advantage from making hand-offs come in balanced pairs (dimensionless add-on):

$$\delta_{pair}(A, Z) = +\alpha_P \cdot A^{-3/4} \quad \text{(even Z, even N)}$$

$$\delta_{pair}(A, Z) = 0 \quad \text{(odd A)}$$

$$\delta_{pair}(A, Z) = -\alpha_P \cdot A^{-3/4} \quad \text{(odd Z, odd N)}$$

Add δ_{pair} to ΔS_{bind}^{smooth} before the shell term. α_P is dimensionless and calibrated once.

9.e) Worked Nuclear Examples (Ratios-First)

9.e.1 Deuteron (A = 2, Z = 1) — shallow bind

Use the two-body kernel ΔS_NN(r)/S_0 above. There is a shallow bound if the attraction overwhelms the core at some r = r_0:

$$d[\Delta S\_\{NN\}(r)/S_0]/dr\ |\_\{r=r_0\} = 0, \quad \Delta S\_\{NN\}(r_0)/S_0 > 0$$

$$(d/dr)\ \Delta S\_\{NN\}(r) = 0\ \Rightarrow\ (K\_att/\ell\_s)\cdot e\hat{}\{-r/\ell\_s\} = (2\ K\_core\ /\ r\_c\hat{}\{2\})\cdot r\cdot e\hat{}\{-(r/r\_c)\hat{}\{2\}\}$$

Solve this for r = r_0 (e.g., numerically for p = 2), then check that ΔS_{NN}(r_0) > 0 to confirm a shallow bound.

Triplet admissibility (aligned facings) opens the gate (κ_att > 0); singlet can be near-threshold (small effective κ_att). This reproduces the pattern: one shallow bound channel and one unbound/marginal.

9.e.2 Helium-4 (A = 4, Z = 2) — tight bind, even–even pairing

Plug A = 4, Z = 2 into the smooth binding with pairing (and a small shell bump near closed sub-structures). Even–even pairing adds binding; short range and saturation explain why extra loops beyond the first shell gain little per particle.

9.g) Atomic Attachment (EM Bridge) — with Hydrogen Example

Electrons attach via the EM orientation/Coulomb dictionary. Bound routes follow closure, fermion parity fills shells; no new scales are introduced. The circular closure for Hydrogen:

$$S\_loop\ =\ \oint p\cdot dl\ =\ 2\pi\ n\ S_0, \quad n\in\mathbb{Z}\hat{}+$$

$$p\cdot r\ =\ n\ S_0$$

$$p\hat{}2\ /\ \mu\ =\ k\_C\cdot q\_0\hat{}2\ /\ r \qquad (\mu = \text{reduced mass})$$

$$r\_n\ =\ n\hat{}2\ S_0\hat{}2\ /\ (\ \mu\ k\_C\ q\_0\hat{}2\ )$$

$$E\_n\ =\ -\ \tfrac{1}{2}\ \mu\ (\ k\_C\ q\_0\hat{}2\ )\hat{}2\ /\ (\ n\hat{}2\ S_0\hat{}2\ ) \quad \Rightarrow \quad E\_n\ /\ E\_1 = 1\ /\ n\hat{}2$$

This is the same closure story; the EM pillar carries the full periodicity via screening + shell parity.

9.f) Validity & Falsifiers

Holds when composites are integer-locked and backgrounds vary slowly. Strong kernel short-range must be small vs composite size; weak transitions must be dominated by a single ΔS_trans channel.

Falsifiers: width or mass-ratio patterns that cannot be fitted with a single calibration of {α_V, α_S, α_C, α_A, α_G, α_P, β_x, σ_x}; nucleon–nucleon shapes inconsistent with any short-range attractive + core grammar; weak decays demanding non-chiral gates at leading order.

10) Elemental Table (VMS Taxonomy Schema)

We catalog **primes** (single closed patterns) and **composites** (admissibly bound sets). Each row is a **pattern class**, not a classical species. The table is ratio-first and dimensionless; calibrated anchors appear in a side band.

Recommended columns (minimal set):

• Class label (integer n and parity) | Charge step ($q = n\ q_0$) | Spin class (even→boson, odd→fermion)

• Family tag (by stabilizer dictionary: U(1)/SU(2)/SU(3)) | Loop count E_loop ($\bar{\tau}\ \ell$) | Geometry tag $\mathcal{G}$

• Mixing links (neighbors, angles) | Width band from ΔS_exit | Validity strip (integer lock; Λ)

• For composites: constituent set {i}, coupling map κ_{ij}, predicted binding $\Delta S\_bind/S_0$, admissibility notes (hand-off rules).

Usage — Fill **primes** first (n, q, spin, E_loop, $\mathcal{G}$). Then add **composites** with κ_{ij} and ΔS_bind estimates. Worked ratios go in the rightmost columns; absolutes are added only after Calibration locks are applied.

Build Checklist (fast)

1) Prime rows — fit (n, q, spin), E_loop, and $\mathcal{G}$ from clean single-pattern data.

2) Candidate composites — propose κ_{ij} from overlap geometry; check λ_min < min(E_i).

3) Stability — verify integer locks and $\Delta S\_exit/S_0$ bands.

4) Mixing — record θ and (if 3-state) $\{\theta_{12}, \theta_{23}, \theta_{13}, \delta\}$; ensure unitarity.

5) Ratios first — publish m_comp/Σ m_i, Γ ratios, and band plots; defer absolutes to Calibration.

11) Validity, Limits, and Falsifiers

This walk-through is meant for the regime where closed patterns are well-formed and the environment is gentle enough that the integer hand-off and the coarse-grained overlap picture both make sense. Below are the exact checks we use.

When it holds (green zone)

• Clean harmonic closure (integer lock). The loop hands off its facing exactly after a lap:

$$S\_loop\ /\ S_0 = 2\pi\ n\ \pm\ \varepsilon\_int \quad (n \text{ is an integer},\ \varepsilon\_int \ll 1)$$

• Stationarity at the solution. Small admissible distortions do not change the integer:

$$\delta\ S\_loop = 0 \quad (\text{at fixed } n)$$

• No cheap exits. The minimal action gap to any allowed open route is comfortably above the noise floor:

$$\Delta S\_min\ /\ S_0\ \gtrsim\ \Lambda \quad (\Lambda \text{ is a modest constant; large values} \Rightarrow \text{long lifetimes})$$

• Admissible symmetry locks. The pattern's symmetry lies in the stabilizer (no anomaly flags at this level).

• Quasi-static background. Caustic structure and coupling geometry vary slowly compared to the loop cycle time τ_loop.

$$|d/dt|\_env \ll 1/\tau\_loop$$

Use caution (yellow zone)

• Background coupling shreds closure. Strong external coupling lowers ΔS_min; the loop becomes leaky and widths blow up.

• Rapidly varying caustics. If the fold/focus pattern changes on the loop timescale, the integer lock can wander.

$$\tau\_caus \lesssim O(\tau\_loop) \Rightarrow \text{expect drift in n and effective parameters}$$

• Strong degeneracy. When more than two near-patterns have comparable detuning, the 2×2 model is insufficient—use the full 3-state (or higher) unitary.

$$\Delta \approx 0 \text{ across} >2 \text{ patterns} \Rightarrow \text{require } U(\theta_{12}, \theta_{23}, \theta_{13}, \delta)$$

Out-of-scope (red flags)

• Non-adiabatic disruptions that break the integer lock (S_loop/S_0 ceases to sit near 2πn).
• Backgrounds that force non-unitary mixing at leading order (lossy, non-reversible channel wiring).
• Evidence that a new dimensional scale (beyond $S_0 = \hbar$ and acceptance locks) is needed to align independent ratios.

What would falsify this treatment (practical tests)

• Cross-ratio inconsistency that demands a new scale. Independent mass-ratio bands cannot be reconciled with a single geometry map $\mathcal{G}$ (within uncertainty).

• Width-ratio patterns not following the action-gap law, even after phase-space corrections Ω. A simple linear check over channels i, j:

$$\ln(\Gamma\_i/\Gamma\_j) \approx \ln(\Omega\_i/\Omega\_j) - (\Delta S\_i - \Delta S\_j)/S_0$$

If the slope $-1/S_0$ or intercept ln(Ω_i/Ω_j) systematically fail across clean channels, the model is wrong in this regime.

• Mixing that requires a non-unitary map ($U^\dagger U \neq I$) or cannot be captured by a single real rotation for a 2-state sector:

$$\tan(2\theta) \neq 2\kappa/\Delta \quad \text{(after consistent extraction of } \kappa, \Delta \text{ from independent observables)}$$

• Integer-closure failure. Direct probes of phase accumulation around the loop do not land at 2πn within the expected ε_int.

How to check in practice (quick checklist)

1) Closure lock — fit S_loop/S_0 from the harmonic; verify $|S\_loop/S_0 - 2\pi n| \leq \varepsilon\_int$.
2) Exit hardness — estimate ΔS_min from the cheapest allowed channel; check $\Delta S\_min/S_0$ against Λ (long-lived if large).
3) Mixing sanity — extract κ and Δ from independent observables; confirm $\tan(2\theta) = 2\kappa/\Delta$ and that U is unitary in the 3-state case.
4) Widths — compute $\ln(\Gamma\_i/\Gamma\_j) + (\Delta S\_i - \Delta S\_j)/S_0 - \ln(\Omega\_i/\Omega\_j)$ across channels; residuals should be small and structureless.
5) Stability — ensure $\tau\_caus \gg \tau\_loop$ and track drift over time; large drift flags out-of-regime behavior.

Classical/SM Bridge — Dictionary Only

Quantization and spin: integer winding constraints (not imported axioms).

Families: stabilizers of admissible route symmetries (U(1)/SU(2)/SU(3) dictionary).

Mass/mixing/width relations: dimensionless and ratio-first; absolutes anchored in Calibration.

Appendix — Cheat Sheet (Particles, VMS)

Lock: $S_0 = \hbar$ (single dimensional scale; SI-locked).

Harmonic closure: $S\_loop/S_0 = 2\pi\, n$ ($n \in \mathbb{Z}$).

Quantization: $q = n \cdot q_0$; spin class: n even → boson, n odd → fermion (class-level).

Mass ratios: $m\_i/m\_j \approx (\bar{\tau}\_i\ \ell\_i)/(\bar{\tau}\_j\ \ell\_j) \times \mathcal{G}\_\{ij\}$.

Mixing (2-state): $\tan 2\theta = 2\kappa/\Delta$; eigenvalues: $\lambda\pm = ½[(E1+E2) \pm \sqrt{(\Delta^2+4\kappa^2)}]$.

Widths: $\Gamma\_i/\Gamma\_j \approx (\Omega\_i/\Omega\_j)\exp[-(\Delta S\_i - \Delta S\_j)/S_0]$.

Validity strip: clean closure; stable symmetry locks; no cheap ΔS exits.