Particles Mechanics Narrative

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Constants: CODATA-2022 (NIST SP 961, May 2024); PDG 2024 for cross-checks (masses/widths).

Locks: import a single dimensional scale $S_0 = \hbar$ (SI-locked). Speed of advance c is an acceptance lock. No new tunables are introduced.

Locks & Conventions

• Route/closure language: same as EM/Mechanics (display-area A_d; action S[path] ≡ ∫ A_d ds when we need phase).

• Data anchors: CODATA-2022 and PDG-2024; prefer ratios when tighter than absolutes.

• Notation sanity: new symbols are dimensionless unless stated; any absolute mass/width is PDG-anchored in Calibration.

• Single dimensional scale: $S_0 = \hbar$ (SI-locked). No other tunable scales.

Scope

Build particle classes (charges, spins, families) from closure harmonics and loop topology, derive mass/mixing/decay relations as **dimensionless ratios** using a single scale $S_0 = \hbar$, and recover standard limits where appropriate. This document sets the picture and the on-ramp to math; the detailed derivations live in the Math Walk-Through and the Pillar Math Appendix.

SM link: width/lifetime ratios compare directly to PDG without adding dimensional dials.

Definitions: $\Delta S \geq 0$ is the minimal action gap to any allowed open route. Q is a dimensionless quality factor (geometry/statistics). Ω is a dimensionless attempt-frequency ratio (combinatorics/phase-space).

SM link: the 3-state generalization yields a unitary rotation with one CP-phase; mapping to CKM/PMNS parameters appears in the Appendix (structure-level, ratio-first).

Coverage map

• Foundation — $S_0 = \hbar$; operators {E_κ, T, S, C}; route/closure language consistent with other pillars.

• Quantization — closed-route integers → charge steps and spin classes (boson/fermion).

SM limit: integer n labels reproduce charge steps and spin classes (boson/fermion) without importing gauge axioms; anomaly notes live in the Appendix.

• Gauge structure — route symmetries → group structure (U(1), SU(2), SU(3) analogs).

SM limit: stabilizers of the admissible route symmetries mirror U(1), SU(2), and SU(3); we read these from invariances rather than postulating a gauge set.

• Mass patterns — closure tension and coupling geometry → mass ratios (leptons; selected light-baryon bands).

• Mixing — overlap of near-patterns → unitary rotations (2- and 3-state cases).

• Decay & widths — escape map Π_esc with $\Delta S/S_0$; lifetime/width ratios as exponentials with dimensionless prefactors.

• Predictions & falsifiers — ratio-first targets with PDG anchors; no new dimensional knobs.

Example (widths): publish a pairwise width-ratio band using $\Delta S/S_0$ differences and Ω ratios; compare to PDG medians with no new knobs.

Example (ratios): publish a predicted ordering/band for m_μ/m_e and m_τ/m_μ from one $\mathcal{G}$ geometry; lock absolutes only when calibrated.

In-scope (this pillar)

• Charge quantization and spin classes from closed-route integers; anomaly-safe symmetry statements in the Appendix.

• Lepton mass ratios; selected light-baryon band structure (catalog level).

• Lifetime/width scaling from an escape map Π_esc with no new dimensional constants.

• Mixing angles/phases from route-overlap integrals; CKM/PMNS analogs at the level of structure and ratios.

Out-of-scope (here)

• Full nuclear structure; heavy-flavor phenomenology (dedicated branches).

• Material/device microphysics (thermo/material pillars).

• Beyond-SM numerics; we publish ratios/bands and compare to PDG without adding knobs.

What is a "particle" in VMS? (common-sense picture, same ontology)

We keep the same ontology you've seen in the other pillars: routes and closure. Nothing new is smuggled in. Here's the clean story of how a particle appears, stays around, and eventually ends, using only display-area, caustics, and closed harmonics.

1) Start: display-area expansion (an open route)

A void advancing at light speed hides a circular patch of space each step: the display-area $A\_d = \pi r^2$. Along a route we add those patches up: that running total is the display-area action $S[path] = \int A\_d\, ds$. When we need a phase label, we divide by the single scale $S_0=\hbar$.

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A_d = π r²

S[path] = ∫ A_d · ds

phase label:  φ = S / S₀   (with S₀ = ħ, SI-locked)
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At this stage we have an open propagation front. No particles yet—just a clean route with a phase counter we can read if we need it.

2) Optionality: a suitable caustic appears

Real space isn't flat everywhere. Geometry and background can fold routes together and create a caustic—a place where there are two (or more) nearby, equally clean ways to advance. The front doesn't 'pick once and forget'; it oscillates between those near-ties. Whether that oscillation matters is controlled by scale: if the caustic's size and spacing are comparable to the display-area scale being accumulated, the oscillation persists instead of averaging out.

3) Closure: the oscillation locks into a closed harmonic loop

Now the key step. If the caustic geometry feeds the front back onto itself with the same facing after one lap, the route closes. Closure is only stable when the accumulated action completes an integer number of turns—so the hand-off of facing is exact. That's a closed harmonic:

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harmonic closure condition:   S_loop / S₀ = 2π n    (n ∈ ℤ)
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Those integers n are not decoration—they label the loop class. In the EM bridge they show up as charge steps $q = n \cdot q_0$; in spin language, the parity of n tracks the boson/fermion split. The point is: nothing was postulated—we got integers because the loop must hand off perfectly each cycle.

4) Why some loops live (stability) and others don't

A closed loop persists when three simple checks pass:

• **Exact hand-off** (the harmonic above). If S_loop/S_0 drifts off an integer, the facing mis-hands and the loop degrades.

• **Boundary rules** (same as everywhere): no sideways pile-up across a boundary; no tearing of closure. These forbid leaks that would kill the loop immediately.

• **No cheap exit**: there isn't a nearby open route with a tiny action gap. If there is, the loop will eventually 'take it'—that's decay.

What varies across classes (and shows up as mass and other labels) is the loop's internal tension and geometry, and how it couples to the background and to other loops. That's why different closed patterns sit at different mass ratios and selection rules without inventing new dials.

5) How lifetimes fall out (no new constants)

Let ΔS be the minimal action gap from the loop to any allowed open route. With a dimensionless quality factor $\mathcal{Q}$ (geometry/statistics) and a dimensionless attempt ratio Ω (combinatorics/phase-space), escape per cycle and widths/lifetimes scale as:

$$\Pi\_esc \simeq \mathcal{Q} \cdot \exp(- \Delta S / S_0)$$

$$\Gamma\_i / \Gamma\_j \simeq (\Omega\_i / \Omega\_j) \cdot \exp[- (\Delta S\_i - \Delta S\_j) / S_0]$$

Big ΔS means long-lived; small ΔS means short-lived. Ratios are the point—we compare species cleanly without adding a new units-bearing constant.

6) Walking straight into this pillar's scope (what we work out next)

Once the loop exists, everything we publish in this pillar is a consequence of that same picture:

• **Quantization**: integers n from harmonic closure give charge steps and spin classes (no gauge axioms were assumed first).

• **Gauge structure**: the allowed symmetries of the route and its couplings pick out the interaction families—the stabilizers mirror the familiar U(1), SU(2), SU(3) sets.

• **Mass patterns (ratios)**: loop tension and coupling geometry set

$$m\_i / m\_j \simeq (\tau\_i \cdot \ell\_i) / (\tau\_j \cdot \ell\_j) \times \mathcal{G}\_\{ij\}$$

with $\tau \cdot \ell$ a geometric tension–length and $\mathcal{G}$ a dimensionless coupling geometry. One geometry can ladder the leptons; the Appendix shows the working.

• **Mixing**: near-patterns overlap; diagonalizing a small overlap κ against a detuning Δ gives the rotation angle (2-state sketch):

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

The 3-state generalization is a unitary rotation with one CP-phase; we map structure-level parameters to CKM/PMNS in the Appendix.

• **Decay/widths**: lifetimes and widths are just the $\Delta S/S_0$ story above; we publish width and lifetime **ratios** (and bands) first, then calibrated numbers when useful.

That's the whole arc: an open route with display-area expansion encounters a suitable caustic, locks into a closed harmonic, and—if there isn't a cheap exit—persists as a particle. Everything else in this pillar is bookkeeping on that loop: symmetries, ratios, and clean comparisons, all on one scale $S_0 = \hbar$.

7) Quantization from closed routes

Stable loops carry integer winding numbers. Those give discrete charge steps and spin classes.

$$q = n \cdot q_0 \quad (n \in \mathbb{Z})$$

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spin class:n even → boson, n odd → fermion(class-level statement)
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Charge quantization and allowed spins appear as topological integers of closure; the Appendix states symmetry/anomaly constraints explicitly.

SM limit: integer n labels reproduce charge steps and spin classes (boson/fermion) without importing gauge axioms; anomaly notes live in the Appendix.

8) Gauge structure from route symmetries

Route invariances generate the interaction families. At coarse-grain the admissible invariances form group structures that mirror U(1), SU(2), and SU(3) analogs. This fixes which couplings exist and which do not; we don't postulate gauge furniture first and explain later—we begin with route symmetries and read off the families.

SM limit: stabilizers of the admissible route symmetries mirror U(1), SU(2), and SU(3); we read these from invariances rather than postulating a gauge set.

9) Mass from closure tension and coupling geometry (ratios, no new scales)

Effective mass reflects stored tension in the closed pattern and how patterns couple to the background and to each other. The algebra is ratio-first:

$$m_i / m_j \simeq (\tau_i \cdot \ell_i) / (\tau_j \cdot \ell_j) \times \mathcal{G}_{ij}$$

Micro-example (in Appendix): show how a single $\mathcal{G}$ map produces a lepton ladder m_μ/m_e and m_τ/m_μ as ratios with one geometry.

Here $\tau \cdot \ell$ is a geometric tension-length product for the pattern, and $\mathcal{G}_{ij}$ is a **dimensionless** coupling geometry ratio (no new dimensional constants). The pillar keeps $S_0 = \hbar$ as the only units-bearing scale; absolute values are reported only when anchored to PDG references in Calibration.

10) Mixing as route overlap (2-state sketch)

When two patterns are similar enough to overlap, the observed states are rotated mixtures. A minimal 2-state model uses a symmetric overlap κ and a detuning Δ. Diagonalizing gives the mixing angle:

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

The Appendix carries the 3-state generalization and the mapping to CKM/PMNS-style parameterizations. SM link: the 3-state generalization yields a unitary rotation with one CP-phase; mapping to CKM/PMNS parameters appears in the Appendix (structure-level, ratio-first).

11) Decay and widths from an escape map (dimensionless, ratio-first)

Let ΔS be the minimal action gap to reach any allowed open route from a closed pattern. With an escape quality factor $\mathcal{Q}$ (dimensionless geometry/statistics), the escape probability per cycle scales as:

$$\Pi\_esc \simeq \mathcal{Q} \cdot \exp(- \Delta S / S_0)$$

Widths/lifetimes then scale as:

$$\Gamma\_i / \Gamma\_j \simeq (\Omega\_i / \Omega\_j) \cdot \exp[- (\Delta S\_i - \Delta S\_j) / S_0]$$

where Ω is a dimensionless attempt-frequency ratio that carries combinatorics and phase-space factors. This form makes clear what is predicted (ratios) without inventing new dimensional dials.

Definitions: $\Delta S \geq 0$ is the minimal action gap to any allowed open route. $\mathcal{Q}$ is a dimensionless quality factor (geometry/statistics). Ω is a dimensionless attempt-frequency ratio (combinatorics/phase-space).

SM link: width/lifetime ratios compare directly to PDG without adding dimensional dials.

12) Composites & Apparent Size — Narrative Insert (VMS-first)

Plain-English take: a composite particle is just several closed VMS loops that lock together in an admissible layout so the total route-action drops. No new stuff—same routes, same closure rules, same single scale $S_0 = \hbar$. Binding means the coupled pattern costs less to run per lap than the parts do separately; that's why a composite sits below the sum of its pieces in mass ratios.

What "binding" means in our language

We compare the action of the parts run separately to the action of the coupled layout. If the coupled layout wins (smaller action), it binds:

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

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

$$\Delta S\_bind \equiv S\_total^{separate} - S\_total^{bound} > 0$$

That ΔS_bind is dimensionless in our normalization. In ratios, the composite mass comes in lower than the sum of its parts; the exact drop depends on how the loops overlap and hand off (a geometry factor only, no new dimensional knobs).

13) Two-loop composites (bonding / antibonding)

For a pair of loops with counts E_1 and E_2 and an admissible coupling κ, the smallest faithful model is a 2×2 map. Diagonalizing that map is just the usual rotation: a lower 'bonding' level and a higher 'antibonding' level. If the lower level sits below either part, you've got a bound composite.

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

$$\Delta \equiv E_1 - E_2$$

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

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

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

Binding check:

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

In words: enough admissible overlap (κ) relative to the mismatch (Δ) pulls a shared mode down and locks the pair as one object.

14) Three-loop rings/braids (what changes and what doesn't)

With three loops the picture is the same in spirit: write the symmetric 3×3 with admissible couplings and look at the lowest eigenvalue. Equal loops with equal couplings make the point transparent: one fully in-phase 'bonding' mode and two higher modes.

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

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

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

Equal-E, equal-κ special case (closed form):

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

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

The composite is bound when the lowest level lies below the individual loop counts:

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

If the κ's aren't all equal, you just diagonalize the 3×3 numerically; the binding criterion is the same.

Proton, neutron: what our 3-loop picture says

We model light baryons (proton, neutron) as three-loop composites with small orientation-driven differences in the admissible couplings κ_ij. At the symmetric baseline (all E_i equal, all κ_ij equal) the bonding level is λ_bond = E − 2κ. Small deviations around that baseline shift the bonding level by the average coupling change seen by the in-phase vector [1,1,1]/√3:

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

So the neutron–proton mass split tracks the **sum of couplings**. If the neutron's admissible couplings sum to a slightly smaller number than the proton's (a little less binding), the neutron sits higher in mass—correct sign, with no new scales. Ratio-first band:

$$(m\_n - m\_p)/m\_p \;\approx\; [\,\lambda\_bond\char`^\{(n)\} - \lambda\_bond\char`^\{(p)\}\,] \,/\, \lambda\_bond\char`^\{(p)\} \;\approx\; (2/3)\cdot[\,(\Sigma\,\kappa)\char`^\{(p)\} - (\Sigma\,\kappa)\char`^\{(n)\}\,] \,/\, \lambda\_bond\char`^\{(p)\}$$

A difference of order 10^{-3} in that coupling sum produces an order-10^{-3} mass split—right ballpark. We fit that single Δ(Σκ) once, then carry it across related observables (width bands where the exit map matches).

"Apparent size" from prying (compliance story)

'Size' here is not an ingredient we put in; it's the composite's compliance under a small, symmetric pry that opens the layout. Let a be the pry coordinate. The bonding level responds as the couplings change with a, and the 'stiffness' is the curvature:

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

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

Dictionary to measurement: a larger compliance (smaller k_eff) reads as a larger apparent radius in small-q probes. If the neutron's coupling sum is smaller, we also expect it to be slightly softer to pry—so a larger apparent size in this sense.

15) What to check (predictions you can actually test)

• Sign: from any admissible orientation that makes (Σκ)_n < (Σκ)_p, predict m_n > m_p (observed sign).

• Magnitude band: fit Δ(Σκ) from the mass ratio once; propagate to width-ratio bands via the same exit map (Ω, ν common), no new scales.

• Apparent size: compare low-q slopes (dictionary) or direct pry response; expect the neutron to be slightly more compliant than the proton if its Σκ is smaller.

• Stability: ensure the integer locks hold for the composite and that $\Delta S\_exit/S_0$ sits in the long-lived band; otherwise widths broaden and the simple picture breaks.

Bottom line: composites and apparent size drop straight out of the same closure-and-geometry story—one ontology, one scale. We keep it ratio-first, publish bands, and let data accept or reject without adding knobs.

16) Nuclear Binding, Strong/Weak, and Atomic

We don't import nuclear or weak force laws. We keep the same book-keeping we used everywhere else: closed patterns, admissible hand-offs, and one dimensional scale $S_0 = \hbar$. Binding is just "the coupled layout runs cheaper per lap than the parts." Forces are gradients of that same action. Everything below mirrors the math insert, step by step, in plain language.

1) A-Body Binding — What each term means and why the exponents look the way they do

We split binding into a smooth bulk piece and a shell piece. The smooth piece is geometry/tension counting; the shell piece is the extra dip you get when a count lands near a clean harmonic (a 'magic' number). The math wrote this as:

$$\Delta S_{bind}^{smooth}(A, Z) / S_0 = \alpha_V A - \alpha_S A^{2/3} - \alpha_C [Z(Z-1)] A^{-1/3} - \alpha_A (A-2Z)^2 / A + \alpha_G \mathcal{G}(A, Z)$$

How to read it:

- Volume term (+): more loops packed coherently → more binding.
- Surface term (−): boundary costs you; the fraction of loops sitting on a boundary scales like area.
- Coulomb opposition (−): protons repel via the EM dictionary, and the average spacing grows with size.
- Asymmetry (−): too many of one kind (proton vs neutron) frustrates admissible hand-offs.
- Geometry correction $\mathcal{G}(A,Z)$: layout effects (pure number).

Why those exponents are not hand-wavy: in a compact 3-D layout radius grows like $A^{1/3}$. That makes area ~ $A^{2/3}$, and average spacing ~ $A^{1/3}$.

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

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

So the surface penalty naturally scales with area ($A^{2/3}$), and the Coulomb dictionary brings in an $A^{-1/3}$. Nothing was invented for effect.

2) Shell correction — Why magic numbers happen (in our language)

Closed harmonics in the mean field are simply layouts where the hand-off is perfectly integer-clean. You get an extra dip (more binding) when a count lands near one of those integers—both for protons and for neutrons. The compact formula uses a nearest-shell dip; if you want smooth gradients for fitting, swap in a log-sum-exp.

$$\Delta S_{shell}(A, Z)/S_0 = - \Sigma_{x\in\{p,n\}} \beta_x \cdot \max_k \exp\left(- (N_x - N_{magic,x}^{(k)})^2 / (2 \sigma_x^2) \right)$$

3) Total binding and masses — Why we stay ratio-first

We add the smooth and shell parts and then talk in ratios so the global proportionality drops out. That's why we can publish bands without adding knobs:

$$\Delta S_{bind}(A, Z)/S_0 = \Delta S_{bind}^{smooth}/S_0 + \Delta S_{shell}/S_0$$

$$m_{A, Z} / (\Sigma m_i) \approx 1 - [\Delta S_{bind}(A, Z) / \Sigma E_{loop}] \cdot \mathcal{G}_{bind}(A, Z)$$

Read: positive binding makes the composite lighter than its pieces—exactly what you expect, and it's the same logic we used for simpler composites.

4) Where the "strong" comes from — short-range attraction with a hard core

Two nucleons 'like' each other when the admissible overlap lowers the total action; they 'don't like' getting smashed together side-by-side. That grammar is just a short-range attraction with a very-short-range core. You saw it as:

$$\Delta S_{NN}(r)/S_0 = -K_{att}\, e^{-r/\ell_s} + K_{core}\, e^{-(r/r_c)^p}$$

The "force" shape (if you insist on that language) is just the gradient of ΔS with respect to r. That gives an attractive region at ~1–2 short-range units and a stiff core at tiny r.

$$F_s(r) \propto -d[\Delta S_{NN}(r)/S_0]/dr = -(K_{att}/\ell_s)\, e^{-r/\ell_s} + (K_{core}\, p / r_c)\,(r/r_c)^{p-1}\, e^{-(r/r_c)^p}$$

Saturation (why nuclei don't just keep getting more bound per particle) falls straight out: each loop only overlaps a few neighbors at short range. That's your volume term with a surface subtraction in the smooth binding.

5) Where the "weak" comes from — class-changing, short-range, chiral gate

Weak processes are hand-offs that change the integer/handedness class. They need a special overlap (short-range) and they pay an action gap. That's why the widths fall with an exponential of the gap; the contact-like strength is just the short-range kernel integrated.

$$P_{trans} \approx \mathcal{Q}_w \cdot \int K_w(r)\, dr \cdot e^{-\Delta S_{trans}/S_0} \propto G_w^2 \cdot \Phi_{PS} \cdot e^{-2\,\Delta S_{trans}/S_0}$$

One crucial point: the chiral behavior (parity violation) isn't bolted on. It's a selection rule from the orientation gate:

- Chiral selection rule — the orientation gate $\mathcal{Q}_w$ suppresses one handedness of admissible hand-offs; parity violation shows up as a selection, not as a new force.

6) Admissibility + pairing — why even–even wins a little

Admissible composites keep everyone's integer locks and avoid sideways pile-up. Pairing is just "make the hand-offs come in balanced pairs." It's a small dimensionless add-on that favors even Z and even N at fixed A (the effect shrinks with size):

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

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

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

7) Worked nuclear pictures — what to look for

Deuteron (A=2): one shallow well if the attraction beats the core at some separation r_0. In the math that was the derivative-equals-zero line and the "value positive" check:

$$(d/dr)\, \Delta S_{NN}(r)\,|_{r=r_0} = 0 \;,\; \Delta S_{NN}(r_0)/S_0 > 0$$

For the p=2 case you can even write the well location condition explicitly (solve this for r_0):

$$(K_{att}/\ell_s)\, e^{-r/\ell_s} = (2\, K_{core}/r_c^2) \cdot r \cdot e^{-(r/r_c)^2}$$

Helium-4 (A=4): tight bind because (i) short-range saturation gives a strong volume term for small A and (ii) even–even pairing adds a little extra. You also get a small shell bump from closed sub-structures.

8) Atomic attachment — why Hydrogen falls into a $1/n^2$ ladder without importing quantum postulates

We attach electrons with the EM dictionary for the central 1/r well. The same closure condition drives the result; we only change to the reduced mass μ.

$$S_{loop} = \oint p \cdot dl = 2\pi\, n\, S_0 \quad , \quad n \in \mathbb{Z}^+$$

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

$$p^2 / \mu = k_C \cdot q_0^2 / r$$

$$r_n = n^2 S_0^2 / (\mu\, k_C\, q_0^2) \quad , \quad E_n = -\tfrac{1}{2} \mu (k_C\, q_0^2)^2 / (n^2 S_0^2) \;\Rightarrow\; E_n / E_1 = 1 / n^2$$

Same closure story as everywhere else; no new scale, no wavefunction postulate sneaking in the back door.

9) Calibration and guardrails

We fit the dimensionless set once and carry it across predictions:

• Calibration set: { α_V, α_S, α_C, α_A, α_G, α_P, β_p, β_n, σ_p, σ_n }

• Valid when the composite is integer-locked and backgrounds vary slowly; strong kernel must remain short compared to the composite size; weak channels dominated by a single ΔS_{trans}.

• Falsifiers: mass/width patterns that cannot be fit with one calibration; NN shapes with no short-range well + core grammar; weak data that force non-chiral leading behavior.

Bottom line: same ontology, one scale, no borrowed force laws. The math insert tells you how to punch the numbers; this narrative is the why-it-means-what-it-means version you can hand to readers.

17) Bridges to Electromagnetism and Mechanics

• Same ontology and lock: $S_0 = \hbar$ once; no retuning by pillar.
• EM bridge: orientation-gated couplings here act as selection rules seen as polarization/interaction channels in EM's coarse-grain (Maxwell-limit box lives in EM docs).
• Mechanics/GR bridge: particle clocks obey the same timing kernels (no extra scale); closed-loop inertia/timing align with the cost-map picture.

18) Calibration capsule (how numbers get compared)

• Stamp constants (CODATA-2022, PDG 2024), record versions.
• Prefer **ratios** when they beat absolute calibration: m_p/m_e, m_μ/m_e, selected width ratios, magnetic-moment ratios (where used).
• Publish both ratio-only and calibrated values; recommend the tighter band and state why.
• Adopt **falsifiers**: sustained ≥3σ disagreement across independent ratios after systematics control is a fail; no rescue by adding knobs.

19) Predictions & falsifiers (high-level)

• Lepton mass ratio ladder with dimensionless geometry factors $\mathcal{G}$_{ij}.

• Selected baryon band tightening (catalog class positions, not per-isotope rows).

• Lifetime/width ratios from $\Delta S/S_0$ differences; publish predicted ordering and bands.

• Mixing angle/magnitude patterns constrained by overlap integrals; publish allowed regions.

• Falsifier: incoherent ratio shifts that would require introducing new dimensional scales (disallowed).

20) Reader map (where to go next)

• Math Walk-Through — proofs and skeletons for the relations above; minimal algebra for overlap models and escape maps.

• Pillar Math Appendix — readable, line-by-line derivations; symbol legend up front; anomaly cancellation and symmetry statements.

• Calibration — constants stamp, PDG anchors, ratio-vs-calibrated inserts.

• Verification & Falsification — pass/fail tables with DOIs; pre-registered tests where possible.

• Student Workbook — pedagogy and worked problems (same notation as Appendix).

• VMS Laws (Pilot) — concise value cards for immediate use, with classical/SM limit boxes.

Bottom line

One ontology, one scale ($S_0 = \hbar$), no new tunables. Quantization, gauge structure, mass/mixing/decay relations all drop out of closure and symmetry. We publish ratios and tight bands first, then calibrated numbers. Where data refuse the bands, we call it—no extra knobs.