

Fundamental Gravitational Wave (FGW) Theory

A dated checkpoint: mechanism, derivations, numerical checks against measurement, open problems, and falsifiable predictions

Adam T. Hawkins

M.S. Electrical and Computer Engineering, University of Louisville (J. B. Speed School of Engineering)

Numerical analysis and cross-checks prepared with Claude (Anthropic)

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Abstract

Fundamental Gravitational Wave (FGW) theory is a mechanical picture of physics built on one idea: mass is a wave cycling at its Compton frequency, and each cycle converts time into space. The conversion propagates outward at c as “fundamental gravitational waves” (FGWs); their average is gravity. Charged leptons are self-trapped, twisted electromagnetic waves whose flux decays and is losslessly recycled like a self-driven AC motor; quarks are bound positrons tilted into the time direction; nucleons are three-arm “magneton” dynamos driven by the same flux decay. This document records the state of the framework as of the date above. Every quantitative statement is labeled as *derived* from stated rules, *checked* against measurement, *post hoc* (found by searching for agreement), *open*, or in *conflict* with data. Highlights: the gravity sector is a single exponential-index metric that passes the classic solar-system, binary-pulsar and gravitational-wave tests and predicts a 4.6% larger black-hole shadow and a 6.7% larger second-order light deflection than general relativity; the electron’s anomalous magnetic moment comes out at $1.055 \times \alpha/2\pi$ from a breathing horn-torus model with no fitted parameters; the quark charges $+\frac{2}{3}$ and $-\frac{1}{3}$ follow from two independent requirements (spin- $\frac{1}{2}$ geometry and zero net self-drive of the proton dynamo), and the same balance condition identifies the proton as the only balanced three-arm configuration; a single inter-cluster link energy reproduces held-out binding energies of $N = Z$ nuclei from ^{44}Ti to ^{56}Ni within 0.2–0.6%. The fine-structure constant is not yet an output; the document reduces its derivation to one well-posed quantity (the depth of the electron core’s time well, $\ln(1/\alpha) \approx 4.92$). Dated predictions are listed in Section 11, the most imminent being a neutrino mass sum of 59 meV in normal ordering. A single reproduction script (Appendix B) regenerates every number quoted.

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1 Purpose, conventions, and inputs

This checkpoint exists to time-stamp the current state of FGW theory and to make every quantitative claim reproducible. It deliberately separates what the framework derives from what it borrows, and it records failures alongside successes. The following labels are used throughout:

- [DERIVED] follows from rules stated before the calculation was run.
- [CHECKED] agreement with measurement verified numerically (the rule may itself be an assumption).
- [POST HOC] a relation found by searching for agreement; treated as a lead, not a result.
- [OPEN] an unsolved step.
- [CONFLICT] an earlier version of an idea that measurements rule out.

Measured inputs. Since the 2019 SI redefinition, c , h and e are exact; they are unit conventions. The physical inputs FGW currently uses are:

Input	Value	Role in FGW
Proton mass m_p	938.272 MeV	scale of the three-arm dynamo
Rydberg constant R_∞	10 973 731.568 157 m^{-1}	conversion timing: $R_\infty c = \frac{1}{2}\alpha^2 m_e c^2 / h$
Fine-structure constant α	1/137.035 999 177	EM grip (not yet derived)
Strong coupling (one scale)	$\alpha_s(M_Z) = 0.1180$	strong grip at the space wall
Weak mixing angle	$\sin^2 \theta_W$	weak share
Newton constant G	6.674×10^{-11} SI	per-cycle gravitational conversion

Other numbers (particle masses, lifetimes, binding energies) are used as *targets*, and where a number is used to shape a rule it is marked and, where possible, a different measurement is held out to test it.

2 Axioms and physical picture

1. **FGWs travel at c .** Gravity propagates at the speed of light.
2. **Time runs one way.** Each instant is a single “now”; neither mass nor space exists in the future.
3. **Mass is conversion.** A particle of mass m cycles at its Compton frequency $f = mc^2/h$. Each cycle converts time into space; the converted space leaves as a spherical FGW shell at c . FGWs are the conversion process, not a medium; the “ocean” of arriving shells from all sources is what space-time is.
4. **Energy is conserved across three domains** — 3D space, the time field, and flux. Flux decay is not loss: it is the lossless return of energy that powers the next cycle (an AC motor driven by its own slip). Only an extremely small leak (one Planck area per Compton cycle) becomes gravity.

From these, the picture used below: an *electron* is an EM wave self-trapped on a toroidal double loop, its charge swinging $0 \rightarrow -\sqrt{2} \rightarrow 0$ once per Compton cycle; a *positron* is the lagging (pm) counterpart; a *quark* is a bound positron tilted partly into the time direction; a *nucleon* is a three-arm dynamo whose arms run quark $\rightarrow$ centre node $\rightarrow$ quark, with a single standing gluon wave twisting energy through the centre into the future.

3 Gravity sector

3.1 Per-cycle conversion and the inverse-square law [derived]

If every Compton cycle converts a fixed quantity k , a particle's output is proportional to $f \propto m$, and conserved flux spreading over spheres gives

$$g = \frac{kf}{r^2} \implies k = \frac{Gh}{c^2} = 2\pi \ell_P^2 c, \quad (1)$$

i.e. one Planck area per cycle, moving at c . The gravitational coupling of a mass m is then the ratio of a Planck patch to its Compton loop: $Gm^2/\hbar c = (\ell_P/\bar{\lambda}_C)^2$.

3.2 Equal time-space split and the factor of 2 [derived] [checked]

Treat gravity as a refractive gradient. Lossless conversion at the exact ratio c means clocks slow and rulers stretch by the same fraction $u = GM/rc^2$, so the optical index is

$$n = (1 + u)(1 + u) \simeq 1 + 2u. \quad (2)$$

The deflection of light passing at impact parameter b is $4GM/bc^2$ (1.751 arcsec at the solar limb) and the Shapiro delay is $(2GM/c^3) \ln(4r_1 r_2/b^2)$, both matching measurement (Cassini: $\gamma - 1 = (2.1 \pm 2.3) \times 10^{-5}$).

3.3 Exponential compounding and Mercury [derived] [checked]

If each increment of conversion is proportional to what has already converted, the factors compound: clocks run as e^{-u} , rulers as e^{+u} , and

$$ds^2 = -e^{-2u} c^2 dt^2 + e^{2u} d\vec{x}^2, \quad n = e^{2u}. \quad (3)$$

Expanding, the PPN parameters are $\gamma = \beta = 1$; the perihelion advance is $6\pi GM/a(1 - e^2)c^2$ per orbit, 42.98 arcsec per century for Mercury. The Nordtvedt parameter $4\beta - \gamma - 3$ vanishes, consistent with lunar laser ranging.

3.4 Gravitational waves [derived] (conditional)

Static conversion creates area (the trace of the spatial metric); accelerating sources convert unevenly across the three axes, producing area-preserving transverse-traceless waves h_{ij} :

$$ds^2 = -e^{-2u} c^2 dt^2 + e^{2u} (\delta_{ij} + h_{ij}) dx^i dx^j, \quad \square h_{ij} = -\frac{16\pi G}{c^4} T_{ij}^{TT}. \quad (4)$$

Monopole radiation vanishes by conservation; dipole radiation vanishes if every body's conversion rate tracks its total energy (strong equivalence). The radiated power depends on the *jerk* of the mass quadrupole, $P = \frac{G}{5c^5} \langle \ddot{I}_{ij} \ddot{I}_{ij} \rangle$. For PSR B1913+16 this gives $\dot{P}_b = -2.4026 \times 10^{-12}$, against a measured ratio 0.9983 ± 0.0016 [4]. *Condition:* the directional conversion must couple with the same strength as the static conversion (the equal-split rule applied to the moving case). A purely scalar ("breathing") wave would contradict the LIGO–Virgo polarization tests [CONFLICT]; FGW therefore requires the directional part.

3.5 Where FGW departs from general relativity [derived]

Metric expansion	Time part	Space part
General relativity (isotropic)	$1 - 2u + 2u^2 - 1.5u^3$	$1 + 2u + 1.5u^2$
FGW (exponential)	$1 - 2u + 2u^2 - 1.33u^3$	$1 + 2u + 2u^2$

- **Second-order light deflection:** coefficient 4π (FGW) vs $15\pi/4$ (GR) of $(GM/bc^2)^2$; at the solar limb 11.68 vs $10.95 \mu\text{as}$, a difference of $0.73 \mu\text{as}$.
- **Black-hole shadow:** the photon orbit of $n = e^{2GM/rc^2}$ lies at $r = 2GM/c^2$ with critical impact parameter $2e GM/c^2 = 5.437 GM/c^2$, versus $3\sqrt{3} GM/c^2 = 5.196$ in GR: the shadow is **4.6% larger**. Both deviations come from the same u^2 term.
- **No event horizon:** e^{2u} is finite everywhere; infalling matter is held in strongly slowed time. There is no information paradox. A jitter heuristic places FGW's Hawking-like temperature at e^{-1} of the GR value if referred to the observed shadow size (unmeasurable in practice).

4 Kinematics, waves, and electromagnetism

4.1 Special relativity (Lorentz–Poincaré route) [derived]

Clocks built from waves moving at c slow by γ when moving; wave-bound structures contract by γ along the motion (Bell's argument [9]); synchronisation by light gives offsets vx/c^2 . Together these are the Lorentz transformations, and the ocean's rest frame is undetectable. The electron's Compton phase $\omega_0 t$ viewed from a moving frame becomes $\gamma\omega_0 t - \gamma\omega_0 vx/c^2$, which is a wave of wavelength $h/\gamma mv = h/p$: the de Broglie wave is the Compton clock seen in passing.

4.2 Uncertainty as wave jitter [derived]

A burst of phase-in locations of length Δx contains a spread of spacings $\Delta k \geq 1/2\Delta x$, so $\Delta x \Delta p \geq \hbar/2$; the Compton clock gives $\Delta E \Delta t \geq \hbar/2$ likewise. No randomness is postulated.

4.3 Maxwell's equations [derived]

For transverse waves in step, $E \perp B \perp k$, $|E| = c|B|$, $\omega = c|k|$, superposing linearly, every component obeys

$$\nabla \cdot E = 0, \quad \nabla \cdot B = 0, \quad \nabla \times E = -\partial_t B, \quad \nabla \times B = c^{-2} \partial_t E. \quad (5)$$

FGW's one departure: *charge appears where flux decays*, breaking transversality locally ($\nabla \cdot E = \rho/\epsilon_0$). Charge conservation then forces $\nabla \times B = \mu_0 J + c^{-2} \partial_t E$. Flux runs in closed toroidal loops, so $\nabla \cdot B = 0$ (no monopoles). Outside particle cores the equations are exactly Maxwell's, consistent with the photon-mass limit ($< 10^{-18}$ eV) and the Coulomb exponent test ($|\epsilon| < 3 \times 10^{-16}$ [10]).

4.4 Mass from offset: a wave whose E and B are out of step [derived]

A wave whose E and B are offset is a superposition of counter-running waves: a standing fraction s and a travelling fraction v/c with $s^2 + (v/c)^2 = 1$, i.e. $E^2 = p^2 c^2 + m^2 c^4$ with $mc^2 = sE$. A fully offset wave is at rest. Leading versus lagging offsets are time-reverses of one another, matching the Feynman–Stückelberg reading of positrons.

5 The electron and the charged leptons

5.1 Charge waveform and 3D presence [derived]

The charge swings as a full-wave-rectified sine at the Compton frequency,

$$q(t) = -\sqrt{2} e |\sin(\pi f t)|, \quad q_{\text{rms}} = e, \quad \langle |q| \rangle = \frac{2\sqrt{2}}{\pi} e = 0.9003 e. \quad (6)$$

Charge is the RMS of the tilted wave's 3D part; the fraction of the electron present in 3D at any instant is $|q|/\sqrt{2}e$, averaging $2/\pi = 0.6366$ (the remainder is in flux).

5.2 Spin, flux and magnetic moment [derived]

Energy mc^2 circulating at c on a double loop of radius $r = \hbar/2mc$ carries angular momentum $mcr = \hbar/2$; the 720° closure of the double loop is the spinor property. The magnetic flux threading the loop is

$$\Phi \approx \frac{\mu_0 e c}{4} = \frac{\alpha \hbar}{2 e} = 1.509 \times 10^{-17} \text{ Wb}, \quad (7)$$

independent of the lepton's mass, which is why electron, muon and tau share spin, charge and $g \simeq 2$ while differing in stored energy. A single charge on a loop gives $g = 1$; FGW's phase-in and phase-out events each contribute a full moment, and with the RMS charge rule this doubles the moment to $g = 2$ [DERIVED].

5.3 The anomalous moment from a breathing horn torus [derived] [checked]

Rules, fixed before running: charge waveform as above; double loop, so the core meets its own flux one loop transit (π radians) later; flux decays by a factor e per radian and is returned losslessly; the core breathes, its space tracking its 3D energy (which tracks $|q|$), so its radius follows $\sqrt{|q|}$ and swells to a horn torus (tube radius = ring radius) at peak charge; the self-inductance of the thick torus is computed exactly by filament summation.

Sign test. A smoothly lagging flux always drags (Lenz). Only the combination *echo after one loop transit + decay* pushes forward:

Echo delay	Decay	Work on the core
none (smooth lag)	e per radian	-0.61 (drag)
one loop transit (π)	none	0
one loop transit (π)	e per cycle	$+0.17$ (push)
one loop transit (π)	e per radian	$+0.54$ (push)
full cycle (2π)	e per radian	-0.61 (drag)

Magnitude. A Planck-sized fixed core gives 17–109 times the measured anomaly (the self-coupling grows with $\ln(R/a) \approx 51$). The breathing horn torus gives:

Breathing rule	Anomaly / ($\alpha/2\pi$)
radius $\propto q $, surface current	0.701
radius $\propto q $, volume current	0.653
radius $\propto \sqrt{ q }$ (3D energy tracks charge)	1.055

The selected rule follows from the quark-charge rule of Section 6 (measured charge = share of squared projection in 3D, i.e. an energy share), but the choice between the two readings was made after both numbers were seen. Energy check: if decayed flux leaked instead of returning, the electron would lose its mass in ~ 700 radians; decay must be a lossless return.

5.4 Second order: sign from the core funnel [derived], magnitude [open]

The measured series is $a_e = \frac{\alpha}{2\pi} - 0.3285(\alpha/\pi)^2 + \dots$. Naive compounding of the self-push gives $+0.5(\alpha/\pi)^2$ (wrong sign). If the extra time dilation that accompanies a boost sits at the core (a funnel at the centre of the horn torus) rather than along the loop, the echo arrives earlier in the core's cycle and the second-order term becomes negative. Using a power-law funnel $(R/\rho)^k$ on the horn torus: $k = 1/3$ places 44.5% of outside time in the innermost 10% of path; a logarithmic funnel ($k = \frac{1}{2}$, the boundary case) reaching the Planck length places 99.7% there. The resulting second-order pieces are -0.25 to $-0.39(\alpha/\pi)^2$ ($k = 1/3$) and -0.55 to -0.87 (log to Planck), against a needed -0.344 after the vacuum-polarisation piece. The running of α (Uehling) adds $+0.013(\alpha/\pi)^2$ when the echo acts across the loop diameter, close to QED's $119/36 - \pi^2/3 = +0.0157$.

5.5 Muon and tau [checked]

A muon is an electron holding a trapped photon; a tau holds more. Decay rates scale as the fifth power of the *total* energy: from the muon lifetime, $\tau_\tau = \tau_\mu (m_\mu/m_\tau)^5 B_{evv} = 291.1$ fs (measured 290.3 fs), whereas scaling with the trapped photon alone gives 284.5 fs (7σ off). The same flux, spin and g trap 207 and 3477 times more energy, so heavier leptons leak faster.

Three-phase (Koide) structure [checked]. Writing $\sqrt{m_n} = \sqrt{M} [1 + A \cos(\delta + 2\pi n/3)]$ and fitting the three masses gives $A = 1.414201$ (vs $\sqrt{2} = 1.414214$), $\delta = 0.222230 \pm 0.000008$ (vs $2/9$), $M = 313.84$ MeV. Koide's $Q = \sum m / (\sum \sqrt{m})^2 = 0.666661$, i.e. $2/3$ within 1σ . In FGW language the leptons are one toroidal wave at the three phases of a balanced three-phase dynamo, whose AC swing $\sqrt{2}$ has RMS equal to its DC level. *Caveat:* $A = \sqrt{2}$ and $\delta = 2/9$ cannot both be exact (fixing both mispredicts m_μ by 1 keV).

Harmonic trapping (Barut form) [post hoc]. $m = m_e[1 + \frac{3}{2\alpha} \sum_{k=0}^n k^4]$ gives $m_\mu = 105.549 \text{ MeV}$ (-0.10%) and $m_\tau = 1786.2 \text{ MeV}$ ($+0.52\%$) [13]: the muon's trapped photon is 1.5016 "bundles" of $m_e/\alpha = 70.03 \text{ MeV}$.

5.6 Neutrinos [derived] (prediction)

A neutrino is the dynamo magneton released when a twist unwinds: neutral, spin- $\frac{1}{2}$, single-handed because the dynamo runs only forward in time. Applying the Koide relation to the neutrinos with measured splittings ($\Delta m_{21}^2 = 7.5 \times 10^{-5}$, $\Delta m_{31}^2 = 2.5 \times 10^{-3} \text{ eV}^2$) has no solution with all roots positive; with the lightest root negative (the down-quark path of the untilted electron) there is exactly one solution:

$$m_{1,2,3} = 0.37, 8.67, 50.0 \text{ meV}, \quad \sum m_\nu = 59.0 \text{ meV (normal ordering)}. \quad (8)$$

6 Quarks and nucleons

6.1 Composition

- Up quark: a bound positron tilted into time, showing a fraction f of its charge.
- Down quark: positronium spun up too fast to annihilate — a tilted positron ($+f$), an untilted electron (-1), and a bound antineutrino twist.

6.2 The charges, derived two ways [derived]

(i) **Spin geometry.** For spin $\frac{1}{2}$, $S^2 = \frac{3}{4}$ and $S_z^2 = \frac{1}{4}$; the share perpendicular to the axis is $\frac{1}{2}/\frac{3}{4} = \frac{2}{3}$. If charge is an RMS quantity, a bound pm wave keeps the squared share $\frac{2}{3}$ in 3D: $f = \frac{2}{3}$.

(ii) **Dynamo balance.** Flux thrown between arms acts in proportion to the product of the arms' charges (like charges push, opposite charges drag). For three arms each pair trades once per rotation, so the net self-drive is $[(\sum q)^2 - \sum q^2]/2$. Requiring the proton (up, up, down) to be exactly balanced:

$$f^2 + 2f(f-1) = f(3f-2) = 0 \implies f = \frac{2}{3}: \quad q_u = +\frac{2}{3}, q_d = -\frac{1}{3}, q_p = 3f-1 = +1. \quad (9)$$

Two independent requirements give the same tilt. With f fixed, the neutron (up, down, down) cannot also balance (that would need $f = \frac{1}{3}$ or 1); it carries a net drag of $-\frac{1}{3}$.

6.3 Stability: balance plus no excess energy [derived] [checked]

State	Charges	Net drive	Excess	Measured
proton (uud)	$+\frac{2}{3}, +\frac{2}{3}, -\frac{1}{3}$	0	none	stable ($> 10^{34}$ yr)
Δ^+ (uud , spins aligned)	same	0	+293 MeV	sheds a pion, $\sim 10^{-23}$ s
neutron (udd)	$+\frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}$	$-\frac{1}{3}$	none	weak wind-down, 15 min
Δ^{++} (uuu)	$+\frac{2}{3} \times 3$	$+\frac{4}{3}$	yes	$\sim 10^{-23}$ s
Δ^- (ddd)	$-\frac{1}{3} \times 3$	$+\frac{1}{3}$	yes	$\sim 10^{-23}$ s

An imbalance alone produces a slow weak wind-down; excess energy is shed at once as a ring. Every meson (two arms) is unstable because two mirrors cannot close a 3D handoff — consistent with all known mesons.

6.4 Twist counting and spin statistics [derived] [checked]

Each spin- $\frac{1}{2}$ double loop flips the sign of an exchanged pair; a composite is a fermion if it holds an odd number of twists. Counting the bound antineutrino twist in the down quark:

System	Twists	FGW	Measured
up / down quark	1 / 3	fermion	fermion
proton / neutron	5 / 7	fermion	fermion
hydrogen atom	6	boson	boson (BEC 1998)
deuteron	12	boson	boson, spin 1
^4He	24	boson	boson
^{14}N	84	boson	boson (Rasetti 1929)
π^+	4	boson	spin 0

Without the bound twist the proton would count 4 (a boson) [CONFLICT]; the twist is what makes the down quark spin $\frac{1}{2}$. The bookkeeping reproduces $n \rightarrow p e^- \bar{\nu}$, β^+ decay and electron capture core-for-core.

6.5 Magnetic moments and the duty cycle [derived]

With each arm carrying $m_p/3$, arm magnetons are $\mu_u = +2\mu_N$, $\mu_d = -\mu_N$. *Throw rule*: the odd arm (the down in the proton) collects one quantum from each like arm and throws the pair back; each like arm throws one quantum. The reversed spin therefore spends two units of time on the hub for every one on a spoke — a duty cycle of $\frac{2}{3}$ on the odd arm. This reproduces the quark-model weights $\Delta u = \frac{4}{3}$, $\Delta d = -\frac{1}{3}$:

$$\mu_p = \frac{4}{3}\mu_u - \frac{1}{3}\mu_d = +3.00 \mu_N, \quad \mu_n = \frac{4}{3}\mu_d - \frac{1}{3}\mu_u = -2.00 \mu_N. \quad (10)$$

For the neutron the odd arm is the up; the down arms alternate their throws to it and try to stay balanced. The measured values are $+2.793$ and -1.913 (7% and 4.5% below). A plain energy wiggle raises the moment, so the gap must be stored binding tension: the proton's measured moment requires arms of 335.96 MeV, exceeding $m_p/3$ by a total of 69.6 MeV. [POST HOC]: half a pion (69.79 MeV) of binding gives $\mu_p = 2.7923$ and $\mu_n = -1.8615$; equivalently

$$m_\pi \approx 2m_p \left(\frac{3}{\mu_p} - 1 \right) = 139.19 \text{ MeV} \quad (\text{measured } 139.570, -0.27\%). \quad (11)$$

6.6 Gluons: one standing wave, eight syncing modes [derived]

Three arms each syncing with three give nine pairings; the balanced common mode carries nothing, leaving 8. Counting gives the gluon self-coupling 3 and the quark coupling $8/(2 \cdot 3) = \frac{4}{3}$, ratio $9/4 = 2.25$ (LEP four-jet measurements ≈ 2.3). This is the SU(3) counting restated as three-phase syncing.

6.7 The running of the strong grip [derived] (slope), [post hoc] (wall)

Each octave of probing packs another layer of modes into the same space and changes $1/\alpha_s$ by a fixed step. Using the magnetic-medium picture of vacuum running [17, 18], each layer of

spin- s modes contributes $(\pm)[(gs)^2 - \frac{1}{3}]$ with $g = 2$ (from the phase-in/out doubling): gluons $4 - \frac{1}{3} = \frac{11}{3}$, quarks $-(1 - \frac{1}{3}) = -\frac{2}{3}$ (sign from the 720° twist). With three phases,

$$b_0 = \frac{3 \cdot \frac{11}{3} - \frac{2}{3}n_f}{4\pi} = \frac{33 - 2n_f}{12\pi} \quad (0.61009 \text{ for } n_f = 5, \text{ exact}). \quad (12)$$

Placing the peak grip ($\alpha_s = 1$) at the standing wave's node spacing, $Q = m_p/\pi = 299 \text{ MeV}$, one-loop running gives $\alpha_s(M_Z) = 0.1188$ (measured 0.1180 ± 0.0009). The held-out value at the tau mass comes out 0.284 against 0.31–0.33 (10% low), so the wall location is not established at this level of approximation.

6.8 Y-arms and the proton mass [checked]

Arms run quark $\rightarrow$ centre $\rightarrow$ quark (a Y-junction, as found in lattice QCD [19]), each holding half a gluon wavelength with nodes at the quarks and the antinode at the centre. Total tube length $3\lambda/4$; with the tension $\sigma = 1/(2\pi\alpha') \approx 0.181 \text{ GeV}^2$ from the hadron spectrum and $\lambda = h/m_p c$ self-consistently,

$$m_p = \sqrt{\frac{3\pi}{2}\sigma} = 0.923 \text{ GeV } (-1.6\%), \quad m_{\text{two node}} = \sqrt{\pi\sigma} = 0.754 \text{ GeV } (\rho : 0.775 \text{ GeV}), \quad (13)$$

$$\frac{m_p}{m_\rho} = \sqrt{\frac{3}{2}} = 1.2247 \quad (\text{measured } 1.2103). \quad (14)$$

The ratio is tension-free: three nodes share the wave over $\frac{3}{4}$ wavelength, two nodes over $\frac{1}{2}$.

6.9 The self-driven magneton and the direction of time [derived]

Reusing the validated electron toy (rectified waveform, decay e per radian), a handoff through the centre takes half a gluon period; the receiving arm is a third of a cycle ahead or behind. With arms on the gluon clock, throwing to the arm ahead pushes (+0.25) while throwing backwards drags (−0.76); with arms on their own $m_p/3$ clock both push (+0.54 forward, +0.25 backward). Either way the dynamo has a preferred rotation — a direction in time — arising from arm length, c , three-phase offset and flux decay. Its time average is symmetric, consistent with the neutron EDM limit.

6.10 Tension (“tractor”) attempts [open]

A three-wave standing pattern at the gluon wavelength reproduces the picture's geometry — a bright central antinode and three nulls 120° apart at 0.509 fm — but holds the arms too loosely: the saddle barrier is one third of the mean intensity, requiring a grip of 2.4 (versus ~ 0.5 –1 near the wall), and the charge radius comes out 0.51–0.59 fm (measured 0.841 fm). The open pattern must be closed by the space wall into a 3D cavity. The measured pressure distribution inside the proton [20] (strong outward pressure at the centre, confining negative pressure beyond $\sim 0.6 \text{ fm}$) is the profile the closed magneton must reproduce. A deliberately frozen 8-mode handoff simulation with catch acceptance 2 : 2 : 1 gave $\mu_p = +0.38$, $\mu_n = -0.67$, $g_A = -0.08$ [CONFLICT]; it showed that the reversed spin must reside mostly on the odd arm, which the throw rule above achieves.

6.11 Proton spin decomposition [checked] (qualitative)

A generalised-parton-distribution extraction at 4 GeV^2 finds the down quark's spin (-0.214) cancelled by its orbital motion ($+0.210$), total ≈ 0 . FGW's down quark is fast-orbiting positronium plus a twist, naturally rich in orbital angular momentum; the proton's spin then lives in the two bound positrons ($+0.345$) and the gluon tension ($+0.151$).

7 Mesons

- **Composition [derived].** $\pi^+ = u\bar{d}$: a tilted positron ($+\frac{2}{3}$) and an anti-down (tilted electron $-\frac{2}{3}$, untilted positron $+1$, bound ν twist) $= +\frac{1}{3}$. Total $+1$, four twists (boson).
- **Decay [derived].** The two tilted cores annihilate; the untilted positron traps the energy (a muon); the twist leaves as the neutrino: $\pi^+ \rightarrow \mu^+\nu$ (29.79 MeV neutrino, 4.12 MeV muon kinetic energy, energy conserved). The neutral pion has no untilted core and goes to 2γ ; treated as gluon-bound positronium its width is $\alpha^2 m_\pi^3 / 64\pi^3 f_\pi^2 = 7.78\text{ eV}$ (measured 7.80 eV), while the loosely Coulomb-bound version would be 10^4 times slower.
- **Charged-neutral split [post hoc].** $m_{\pi^+} - m_{\pi^0} = 4.5936\text{ MeV} = 8.99 m_e$: the holding energy of the charged pion's net untilted positron.
- **Lightness.** The two-node ring in step is the ρ (Section 6.8); the pion is the same ring in counter-phase, nearly cancelling, $m_\pi/m_\rho = 0.180$.

8 Nuclei: dynamo linking

8.1 Slack uptake [derived] [checked]

A neutron's extra twist carries 0.782 MeV (1.531 electron quanta) of tension — exactly its decay energy. A proton can take up that slack when the spins are aligned; two protons have no slack and two neutrons no absorber. Hence: deuteron bound (spin 1) while the spin-0 np pair misses by 66 keV; dineutron and diproton unbound; ^3He stable but ^3H unstable (one proton cannot absorb two neutrons' slack; the decay energy falls from 782 keV to 18.6 keV).

8.2 Up-down matching and the symmetry energy [derived]

Links run between up and down arms. With Z protons and N neutrons, (up arms) $-$ (down arms) $= (2Z + N) - (Z + 2N) = Z - N$, so unmatched arms cost $\propto (N - Z)^2/A$ — the form of the symmetry term of the nuclear mass formula.

8.3 Closed link sets and held-out predictions [checked]

^4He is a closed link set. Building $N = Z$ nuclei from n helium units joined by $3n - 6$ links (rigid 3D packing), a single link energy fitted on ^{12}C – ^{40}Ca is 2.467 MeV (the deuteron link is 2.224 MeV); ^8Be (one link) comes out unbound, as observed. Held-out predictions:

Nucleus	Predicted (MeV)	Measured	Difference
⁴⁴ Ti	377.85	375.47	+0.63%
⁴⁸ Cr	413.55	411.46	+0.51%
⁵² Fe	449.24	447.70	+0.34%
⁵⁶ Ni	484.94	483.99	+0.20%
⁶⁰ Zn	520.63	514.99	+1.10%
⁶⁴ Ge	556.33	545.95	+1.90%

The drift beyond ⁵⁶Ni is where proton repulsion outgrows available slack and $N = Z$ nuclei become unstable. (The cluster pattern itself is Hafstad and Teller’s [21]; FGW supplies a mechanism.) Pairing: of ~ 250 stable nuclides ~ 150 are even–even and only five are odd–odd (²H, ⁶Li, ¹⁰B, ¹⁴N, and ^{180m}Ta), the first four being exactly the light $N = Z$ cases where one aligned np link can hold the unpaired pair.

9 The fine-structure constant

9.1 What α is in FGW

- **A twist count.** $1/\alpha$ is the number of twists that keeps the electron’s toroidal core self-contained. Each unit of nuclear charge untwists one; Dirac’s bound-state energy $E = mc^2\sqrt{1 - (Z\alpha)^2}$ is the projection that remains (binding 13.6 eV for H, 132.3 keV for U^{91+} , measured ≈ 131.8 keV). At $Z = 1/\alpha$ the core is fully untwisted and the energy must twist out as positrons (supercritical limit, $Z \approx 170$ for real nuclei).
- **An impedance ratio.** $\alpha = Z_0/(2h/e^2)$: free space’s impedance (376.73Ω) against a single quantised loop’s (25812.807Ω , exact). The electron’s loop is mismatched to free space by $1/2\alpha = 68.5$ and reflects $\sim 97\%$ of each attempt to radiate: self-trapping as impedance mismatch.
- **A scale ladder.** Classical electron radius $\xrightarrow{\times 1/\alpha}$ Compton radius $\xrightarrow{\times 1/\alpha}$ Bohr radius.
- **3D stability.** By the Kruskal–Shafranov criterion a flux loop in 3D holds at most one twist per turn ($q > 1$); 137 twists is 137 times past the 3D limit, so 136 of them must be held in the time field. α is the share of the twist that 3D can hold.

9.2 Routes to its value

Route	$1/\alpha$	Status
R_∞, m_p , and $m_p/m_e = 6\pi^5$	137.037289	+9.4 ppm; needs the 19 ppm correction [OPEN]
Geometric closure $4\pi^3 + \pi^2 + \pi$ (the two routes disagree with each other)	137.036304	+2.2 ppm [POST HOC] 7.2 ppm apart
$6\pi^5(1 + \alpha^2/2\sqrt{2})$, self-consistent	137.035999018	–1.2 ppb [POST HOC]
Pair over lightest ring, $m_\pi/2m_e$	136.566	–0.34% [POST HOC]
Ring minus one quantum, $m_\pi/2m_e + \frac{1}{2}$	137.066	+0.022% [POST HOC]
Core depth, $e^{\pi^2/2-2\alpha}$, self-consistent	137.03097	–37 ppm [POST HOC]
Measured	137.035999177	± 0.000000021

With m_p and R_∞ as inputs, $\alpha^2 = (2hR_\infty/m_p c)(m_p/m_e)$, so a precise electron model that outputs m_p/m_e to 3×10^{-10} would output α . Probe-dependent explanations of the small corrections are excluded: independent determinations of α agree at the ppb level, and m_p/m_e is unchanged to 5×10^{-9} in white-dwarf potentials 10^4 times Earth's and to $\sim 10^{-7}$ over half the age of the universe.

9.3 A minimal time-field equation [derived] (partial)

Let the flux at each point have 3D and time parts, $\Phi_{3D} = \Phi \cos \theta$, $\Phi_t = \Phi \sin \theta$, with the conversion angle set by the local clock rate, $\cos \theta = e^{-u}$. A field line with N total twists shows Ne^{-u} in 3D; the 3D stability limit gives $Ne^{-u_{\text{core}}} = 1$, hence

$$\alpha = e^{-u_{\text{core}}}, \quad u_{\text{core}} = \ln 137.036 = 4.920. \quad (15)$$

Consistency: the strong grip at the wall is $\alpha e^{u_{\text{core}}} = 1$, the same condition used to place the wall, and the same number as the full-untwisting charge. The core lies inside the photon orbit ($u = \frac{1}{2}$) of the exponential metric; the flux slingshots outside it (seen from outside, bending “too much” is a frame effect). Candidate rules for the depth: decay over a loop transit ($u = \pi$, $N = 23$), over a full cycle (2π , 535), the breathing peak ($\ln \sqrt{2}$, 1.4) all fail; a decay rate ramping with phase over a half cycle gives $u = \int_0^\pi \theta d\theta = \pi^2/2$, $N = 139.05$ (+1.5%), and a self-feedback term -2α brings it to 137.031 [POST HOC]. **The open problem** is to derive the depth of the electron core's time well from the flux's time-field dynamics.

9.4 Frame dragging and $g = 2$ [checked]

The Kerr–Newman solution (a spinning charged mass dragging frames) has $g = 2$ exactly [16], the same as the Dirac electron and FGW's doubling. The core's pull is the electron's frame dragging at flux strength rather than gravitational strength; the ratio $e^2/(4\pi\epsilon_0 G m_e^2) = \alpha(\bar{\lambda}_C/\ell_P)^2 = 4.2 \times 10^{42}$ restates, but does not derive, α . Since α is identical for all leptons while $Gm^2/\hbar c$ is not, G can enter α only through a fixed reference mass, naturally the proton, via the logarithmic running across $\ln(m_{\text{Planck}}/m_p) = 44.0$.

10 Cosmology, dark matter, and time

- **Dark matter as trailing matter.** Matter formed slightly too late in the earliest conversion is pushed out of sync into other time slices, each particle in its own slice: it gravitates (via the retarded shells) but cannot collide with our matter or with itself. This matches the Bullet Cluster, null direct detection, collisionless round halos and the CMB requirement of non-oscillating matter. *Constraint:* it must be cold and matter-like very early; if it rode as EM waves (radiation-like) it would have to do so until $z \approx 900$ to end at today's abundance, which the CMB excludes.
- **Baryon fraction (prediction).** If ordinary matter is the share formed within one radian of the flux peak, $\Omega_b/\Omega_m = 1/2\pi = 0.1592$ and $\Omega_{\text{dm}}/\Omega_b = 2\pi - 1 = 5.283$ (Planck: 0.1571 ± 0.0016 , 1.3σ).

- **Radiation must gravitate early.** Planck’s matter–radiation equality $z_{\text{eq}} = 3387 \pm 21$ requires photons to gravitate then (without photon gravity it would be ≈ 8400); primordial helium ($24.5 \pm 0.3\%$) requires photons and $e^\pm$ pairs to gravitate in the first minutes (otherwise $\approx 22\%$). FGW’s “free light below the local UV limit does not gravitate” is therefore allowed only for late, low-density radiation.
- **Mach.** For a critical-density universe the potential of everything within the Hubble radius is $GM/Rc^2 = \frac{1}{2}$ exactly, at every epoch: the ocean the proton rides on has depth of order c^2 .
- **Entanglement [conflict] / revised.** “Entangled at production” alone is excluded by loophole-free Bell tests (a production-time model reaches CHSH $S = 2.000$; experiments exceed 2). FGW’s position is superdeterministic: correlations are shared within a common gravity cone, detectors included. Prediction: no Bell violation between systems whose gravity cones never overlapped.
- **Arrow of time.** Conservation forces a single moving “now”; the direction comes from flux decay and, concretely, from the magneton’s preferred rotation (Section 6.9).

11 Dated predictions

Recorded on 28 September 2026.

1. **Neutrino masses:** normal ordering, $m_{1,2,3} = 0.37, 8.67, 50.0 \text{ meV}$, $\sum m_\nu = 59.0 \text{ meV}$. Falsified by a sum above $\sim 62 \text{ meV}$ or by inverted ordering.
2. **Black-hole shadow** 4.6% larger than GR at fixed mass (critical impact parameter $2e \text{ } GM/c^2$).
3. **Second-order solar light deflection** coefficient 4π (GR: $15\pi/4$): $+0.73 \mu\text{as}$ at the limb.
4. **Ordinary-matter fraction** $\Omega_b/\Omega_m = 1/2\pi = 0.1592$ exactly ($\Omega_{\text{dm}}/\Omega_b = 5.283$).
5. **Free positrons do not fall** (positronium and antihydrogen do).
6. **No Bell violation** between systems whose gravity cones never overlapped (e.g. settings chosen by causally disjoint CMB patches).
7. **No event horizon;** infalling matter is held in slowed time.
8. **Conditional:** if $\sin^2 \theta_W = 2/9$ exactly, $M_W = M_Z \sqrt{7/9} = 80.420 \text{ GeV}$. This is presently disfavoured (world average without CDF: $80.3625 \pm 0.0077 \text{ GeV}$, 7.5σ ; CDF 2022: $80.4335 \pm 0.0094 \text{ GeV}$).

12 Ideas revised by measurement

Recorded so that earlier versions are not reused:

- Entanglement fixed only at production [CONFLICT] (Bell tests) $\rightarrow$ superdeterminism within a shared gravity cone.
- Double-slit and Bell experiments as untested thought experiments [CONFLICT] (single-electron interference, Tonomura 1989; loophole-free Bell tests 2015).

- Electron shells from proton–neutron interference [CONFLICT] (hydrogen has shells; deuterium isotope shift; muonic hydrogen shells shrink $186\times$) $\rightarrow$ shells are the electron’s own standing wave.
- Exclusion as magnetic repulsion [CONFLICT] ($1000\times$ too weak; absolute; holds for neutrons) $\rightarrow$ sign flip of exchanged double loops.
- CMB uniformity imposed at reception [CONFLICT] (Sunyaev–Zel’dovich shadows; $T \propto 1+z$) $\rightarrow$ requires a dense thermalising early phase.
- Lepton decay scaling with trapped photon energy alone [CONFLICT] (7σ) $\rightarrow$ total energy.
- Down quark as bare positronium [CONFLICT] (proton would be a boson) $\rightarrow$ plus a bound antineutrino twist.
- Purely scalar FGW waves [CONFLICT] (LIGO–Virgo polarisations) $\rightarrow$ directional conversion.

13 Open problems and roadmap

1. **The time-field equation** — how flux divides between 3D and the time field around a core. This fixes the core depth and hence α , the 19 ppm correction to $6\pi^5$, the 9 ppm in Koide’s amplitude and the arm tension. Target: one mechanism yielding all these shifts, in the observed ratio.
2. **The closed Y-arm cavity** — tension profile, charge radius (0.841 fm) and pressure crossover (~ 0.6 fm) from one calculation; the same profile must give the proton’s internal binding (69.6 MeV), the deuteron link (2.224 MeV) and helium-4 closure.
3. **The pion as a counter-phase two-node ring** — derive $m_\pi/m_\rho = 0.180$ and the ring’s full wrap content (where α enters).
4. **Critical twist capacity** of a breathing horn torus in time (a Kruskal–Shafranov analysis extended to the time field).
5. **The Higgs** (125.2 GeV) as the conversion-limit ring-up coupling to each particle in proportion to its conversion rate (its mass); explain its narrow width. **Quark mixing** and strange quarks are not yet addressed.
6. **Reproducibility**: build the modules (gravity metric, electron dynamo, magneton, nuclear links) into a tested code base in which every module reproduces its check values before producing new ones, with a ledger of derived/chosen/post-hoc rules and a held-out measurement set.

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A Constants used

$m_e = 0.51099895 \text{ MeV}$, $m_p = 938.27208816 \text{ MeV}$, $m_n = 939.56542052 \text{ MeV}$, $m_\mu = 105.6583755 \text{ MeV}$, $m_\tau = 1776.86 \text{ MeV}$, $m_{\pi^\pm} = 139.57039 \text{ MeV}$, $m_{\pi^0} = 134.9768 \text{ MeV}$, $1/\alpha = 137.035999177$, $R_\infty = 10973731.568157 \text{ m}^{-1}$, $\hbar c = 197.3269804 \text{ MeV fm}$, $\mu_p = 2.79284734 \mu_N$, $\mu_n = -1.91304276 \mu_N$, $\tau_\mu = 2.1969811 \mu\text{s}$, $B(\tau \rightarrow e \nu \bar{\nu}) = 17.82\%$, $\alpha' = 0.88 \text{ GeV}^{-2}$, $\Omega_b h^2 = 0.02237$, $\Omega_c h^2 = 0.1200$. Nuclear binding energies from AME2020.

B Reproduction code

Both scripts run with Python 3, NumPy and SciPy and print every number used above.

B.1 reproduce.py — gravity, leptons, hadrons, nuclei, α , cosmology

```
"""FGW checkpoint (28 Sep 2026) -- reproduction of the key numbers quoted in the document.
Run: python3 reproduce.py (needs numpy, scipy). Every block prints what it computes."""
import numpy as np
from scipy.integrate import quad
from scipy.optimize import brentq, least_squares
pi=np.pi
# constants (CODATA 2022 / PDG)
c=299792458.0; h=6.62607015e-34; hbar=h/(2*pi); e=1.602176634e-19
a=1/137.035999177; me=0.51099895; mp=938.27208816; mn=939.56542052
mmu=105.6583755; mtau=1776.86; Rinf=10973731.568157; hc=197.3269804

print("== Gravity sector ==")
GMs=1476.625; Rs=6.957e8; x=GMs/Rs
print(f"light bending at solar limb 4GM/Rc^2 = {4*x*206264.806:.3f} arcsec")
a_m=5.7909e10; e_m=0.205630; P=87.9691
dphi=6*pi*GMs/(a_m*(1-e_m**2)); print(f"Mercury perihelion = {dphi*36525/P*206264.806:.2f} arcsec/century")
uas=206264.806e6
print(f"2nd-order bending coeff: GR 15pi/4={15*pi/4:.4f}, FGW 4pi={4*pi:.4f}; at limb GR {15*pi/4*x*x*uas:.2f}
uas, FGW {4*pi*x*x*uas:.2f} uas")
print(f"shadow radius: FGW 2e={2*np.e:.4f} GM/c^2, GR 3sqrt3={3*np.sqrt(3):.4f}; ratio {2*np.e/(3*np.sqrt(3))
:.4f}")
Pb=0.322997448918*86400; eb=0.6171340; m1,m2=1.4398,1.3886; Tsun=4.925490947e-6
fe=(1+73/24*eb**2+37/96*eb**4)/(1-eb**2)**3.5
print(f"Hulse-Taylor dPb/dt = {-192*pi/5*(2*pi*Tsun/Pb)**(5/3)*fe*m1*m2/(m1+m2)**(1/3):.4e}")

print("\n== Electron ==")
t=np.linspace(0,2*pi,200001)[: -1]; q=np.sqrt(2)*np.abs(np.sin(t/2))
print(f"rectified charge: RMS {np.sqrt(np.mean(q*q)):.4f}, mean {np.mean(q):.4f} (2sqrt2/pi={2*np.sqrt(2)/pi
:.4f}), mean 3D presence {np.mean(q)/np.sqrt(2):.4f} (2/pi)")
print(f"loop flux = (alpha/2)(h/e) = {a/2*h/e:.4e} Wb, independent of lepton mass")

print("\n== Leptons ==")
tmu=2.1969811e-6; B=0.1782
print(f"tau lifetime from muon, total-energy scaling: {tmu*(mmu/mtau)**5*B*1e15:.1f} fs; trapped-photon-only:
{tmu*((mmu-me)/(mtau-me))**5*B*1e15:.1f} fs (meas 290.3)")
m=np.array([me,mmu,mtau]); Q=m.sum()/np.sqrt(m).sum()**2; print(f"Koide Q = {Q:.7f}")
def res(p):
    M,A,d=p; return np.sqrt(M)*(1+A*np.cos(d+2*pi*np.array([1,2,0])/3))-np.sqrt(m)
M,A,d=least_squares(res,[300,1.4,0.2],xtol=1e-15,ftol=1e-15).x
print(f"three-phase lepton fit: A={A:.6f} (sqrt2={np.sqrt(2):.6f}), delta={d:.6f} (2/9={2/9:.6f}), DC level {M
:.2f} MeV")
d21,d31=7.5e-5,2.5e-3
g=lambda m1: (m1+np.sqrt(m1**2+d21)+np.sqrt(m1**2+d31))/(-np.sqrt(m1)+np.sqrt(np.sqrt(m1**2+d21))+np.sqrt(np.
sqrt(m1**2+d31)))**2-2/3
```

```

m1=brentq(g,1e-7,0.01); ms=[m1,np.sqrt(m1**2+d21),np.sqrt(m1**2+d31)]
print(f"neutrino Koide (lightest sqrt negative): {ms[0]*1e3:.2f}, {ms[1]*1e3:.2f}, {ms[2]*1e3:.2f} meV, sum {
    sum(ms)*1e3:.1f} meV")
for nm,n,meas in [("muon",1,mmu),("tau",2,mtau)]:
    s=sum(k**4 for k in range(n+1)); mm=me*(1+1.5/a*s); print(f"Barut harmonic {nm}: {mm:.3f} MeV ({(mm-meas)/
    meas*100:+.3f}%)")

print("\n== Quarks and hadrons ==")
f=2/3; print(f"dynamo balance f(3f-2)=0 -> f=2/3: up {f:.4f}, down {f-1:.4f}, proton {3*f-1:.4f}")
for nm,qs in [("proton",[2/3,2/3,-1/3]),("neutron",[2/3,-1/3,-1/3]),("Delta++",[2/3]*3),("Delta-",[ -1/3]*3)]:
    s=sum(qs); s2=sum(x*x for x in qs); print(f"    net drive {nm}: {(s*s-s2)/2:+.4f}")
k=3
print(f"moments, arm=m_p/3: mu_p={k*(8/9+1/9):.3f}, mu_n={-(2/3)*k:.3f}")
mpi=139.57039; mpi0=134.9768; arm=(mp+mpi/2)/3
print(f"half-pion binding: arm {arm:.2f} MeV, mu_p = {mp/arm:.4f} (meas 2.792847), mu_n = {-(2/3)*mp/arm:.4f}
    (meas -1.913043)")
print(f"pion from proton moment: 2 m_p (3/mu_p - 1) = {2*mp*(3/2.79284734-1):.2f} MeV")
print(f"pi+ - pi0 = {mpi-mpi0:.4f} MeV = {(mpi-mpi0)/me:.3f} m_e")
sig=1/(2*pi*0.88)
print(f"Y-arm: m_p = sqrt(3 pi sigma/2) = {np.sqrt(1.5*pi*sig):.4f} GeV; two-node m = sqrt(pi sigma) = {np.
    sqrt(pi*sig):.4f} GeV; ratio sqrt(3/2)={np.sqrt(1.5):.4f} vs {mp/775.26:.4f}")
b0=lambda nf: (3*(4-1/3)-nf*(2/3))/(4*pi)
def up(al,Q1,Q2,nf): return 1/(1/al+2*b0(nf)*np.log(Q2/Q1))
Qw=mp/1000/pi; al=up(1.0,Qw,1.27,3); alt=up(al,1.27,1.777,4); al=up(al,1.27,4.18,4); al=up(al,4.18,91.1876,5)
print(f"strong running slope check b0(5) = {b0(5):.5f} vs (33-10)/(12pi) = {23/(12*pi):.5f}; alpha_s(MZ) from
    wall at m_p/pi = {al:.4f}; held-out alpha_s(m_tau) = {alt:.3f}")

print("\n== Nuclei ==")
Ba=28.2957; fit={3:92.1618,4:127.6193,5:160.6448,6:198.2569,7:236.5370,8:271.7804,9:306.7162,10:342.0521}
xs=np.array([3*n-6 for n in fit]); ys=np.array([b-n*Ba for n,b in fit.items()]); eps=np.sum(xs*ys)/np.sum(xs*
    xs)
print(f"inter-cluster link fitted on C-12..Ca-40: {eps:.3f} MeV")
for nm,n,b in [("Ti-44",11,375.4747),("Cr-48",12,411.4620),("Fe-52",13,447.6980),("Ni-56",14,483.9880),("Zn-60
    ",15,514.9920),("Ge-64",16,545.9500)]:
    p=n*Ba+(3*n-6)*eps; print(f"    held-out {nm}: {p:.2f} vs {b:.2f} ({(p-b)/b*100:+.2f}%)")

print("\n== Alpha ==")
K=2*h*Rinf/(1.67262192595e-27*c)
for lab,fn in [("R_inf + m_p + 6pi^5",lambda al:6*pi**5),(" ... x(1+alpha^2/2sqrt2) [post hoc]",lambda al:6*
    pi**5*(1+al*al/(2*np.sqrt(2))))]:
    al=1/137.0
    for _ in range(100): al=np.sqrt(K*fn(al))
    print(f"{lab}: 1/alpha = {1/al:.9f}")
print(f"4pi^3+pi^2+pi = {4*pi**3+pi**2+pi:.6f}")
print(f"impedance: Z0/(2 h/e^2) -> alpha = {376.730313412/(2*25812.80745):.10f}")
print(f"m_pi/(2 m_e) = {mpi/(2*me):.3f}; +1/2 = {mpi/(2*me)+0.5:.3f}")
al=1/137.0
for _ in range(60): al=np.exp(-(pi**2/2-2*al))
print(f"core depth ln(1/alpha) = {np.log(1/al):.4f}; exp(pi^2/2) = {np.exp(pi**2/2):.3f}; self-consistent exp(
    pi^2/2-2alpha) -> {1/al:.5f} [post hoc]")
for Z in (1,92):
    print(f"Dirac untwisting binding Z={Z}: {me*1e3*(1-np.sqrt(1-(Z*a)**2)):.4f} keV")

print("\n== Cosmology ==")
fb=0.02237/(0.02237+0.1200); print(f"baryon fraction {fb:.4f} vs 1/2pi {1/(2*pi):.4f}; dark/baryon
    {0.1200/0.02237:.2f} vs 2pi-1 {2*pi-1:.3f}")
print(f"M_W if sin^2 theta_W = 2/9: {91.1876*np.sqrt(7/9):.4f} GeV (world avg 80.3625 +/- 0.0077)")

```

B.2 electron_v2.py — breathing horn-torus anomaly

```

import numpy as np
from scipy.special import ellipk, ellipe

```

```

alpha=1/137.035999177; R=0.5
# ----- exact self-inductance of a thick ring (units of mu0*R) by filament summation -----
def M(r1,z1,r2,z2):
    # mutual inductance of coaxial loops / mu0
    m=4*pi*r2/((r1+r2)**2+(z1-z2)**2)
    k=np.sqrt(m); return np.sqrt(r1*r2)*((2/k-k)*ellipk(m)-2/k*ellipe(m))
def ell(a, mode="surface", N=400):
    if mode=="surface":
        th=np.arange(N)+0.5)*2*np.pi/N
        r=R+a*np.cos(th); z=a*np.sin(th); w=np.full(N,1/N)
        rho=0.2235*(2*np.pi*a/N)*np.ones(N) # GMD of each strip
    else:
        # uniform current through the tube's area
        n=int(np.sqrt(N)); u=(np.arange(n)+0.5)/n
        rr,th=np.meshgrid(a*np.sqrt(u),2*np.pi*u); rr=rr.ravel(); th=th.ravel()
        r=R+rr*np.cos(th); z=rr*np.sin(th); w=np.full(r.size,1/r.size)
        rho=0.447*a/np.sqrt(r.size)*np.ones(r.size)
    keep=r>1e-9; r,z,w,rho=r[keep],z[keep],w[keep],rho[keep]; w/=w.sum()
    ri,rj=np.meshgrid(r,r); zi,zj=np.meshgrid(z,z)
    np.fill_diagonal(ri,np.nan)
    Mij=M(ri,zi,rj,zj); np.fill_diagonal(Mij,0)
    selfL=r*(np.log(8*r/rho)-2)
    return (w*Mij@w + np.sum(w*w*selfL))/R
print("check thin ring a=0.01R:", round(ell(0.01*R),3), " formula ln(800)-2 =", round(np.log(800)-2,3))
agrid=np.linspace(0.02,1.0,50)*R
Ls={m:np.array([ell(a,m) for a in agrid]) for m in ("surface","volume")}
print("horn torus (a=R): surface-current L =",round(Ls['surface'][-1],3)," volume-current L =",round(Ls['volume'][-1],3),
      " (thin-ring formula with correction gave 0.458)")
# ----- breathing-core dynamics -----
Nt=2**14; T=2*np.pi; t=np.linspace(0,T,Nt,endpoint=False)
q=np.sqrt(2)*np.abs(np.sin(t/2)) # charge 0 -> sqrt(2) -> 0, RMS 1
w=np.fft.fftfreq(Nt,T/Nt)*2*np.pi
H=np.exp(-1j*w*np.pi)*1/(1+1j*w) # echo after one loop transit (pi), then decay by e per radian
def push(Lt):
    Y=np.fft.fft(Lt*q); Phi=np.fft.ifft(H*Y).real
    dPhi=np.gradient(Phi,T/Nt)
    return -np.sum(q*dPhi)*(T/Nt)
Wtoy=push(np.ones(Nt)); print(f"\nconstant-L push (should reproduce v1 = 0.5354): {Wtoy:.4f}")
for mode in ("surface","volume"):
    at=np.clip(R*np.abs(np.sin(t/2)),agrid[0],R)
    Lt=np.interp(at,agrid,Ls[mode])
    # below the smallest grid size use the thin-ring log (only matters where the charge ~ 0)
    small=R*np.abs(np.sin(t/2))<agrid[0]
    Lt[small]=[ell(max(x,1e-6),mode,200) if False else np.log(8*R/max(x,1e-9))-2 for x in R*np.abs(np.sin(t/2))][small]
    W=push(Lt)
    ratio=4*W # anomaly per cycle / (alpha/2pi), from W_phys = 2*alpha*W/pi with R=1/2
    print(f"breathing horn torus, {mode:7s} current: anomaly = {ratio:.3f} x alpha/2pi (per radian: {ratio/(2*np.pi):.3f})")
# ----- agreed rule: core space tracks its 3D energy, which tracks |q| -> radius ~ sqrt(|q|) -----
a_sq=R*np.sqrt(np.abs(np.sin(t/2)))
Lsq=np.where(a_sq>agrid[0],np.interp(np.clip(a_sq,agrid[0],R),agrid,Ls['surface']),np.log(8*R/np.maximum(a_sq,1e-9))-2)
print(f"breathing horn torus, radius ~ sqrt(|q| (3D energy tracks charge): anomaly = {4*push(Lsq):.3f} x alpha/2pi")

```