

The spacetime weave and its consequences

Theorems, mechanizations, and a falsifiable register

(focused extract of the TQNT V6 monograph — Topological Quantum Knot Theory — v2,
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Abstract

We present **the spacetime weave**: spacetime as the continuous undulation of a single field χ , graduated in action (the pitch is h), and we deduce its consequences — the birth of matter in the rails (nodal lines), gravitation by depletion, and a fully *mechanized* cosmology: the flat Friedmann law and $\Omega_{\text{tot}} = 1$ as theorems (expansion is the push of the weave paying for the wells it digs), local elasticity (why bound systems do not expand), the river theorem (the weave responds to density, not to motion), structure growth (σ_8 deduced) and $w = -1$ constant. The central thesis is epistemologically unusual: *the observational indistinguishability from $\Lambda\text{CDM}+GR$ is not an empirical finding of the framework, it is one of its theorems* — and its counterpart is a register of dated, falsifiable *absence* predictions (GRB dispersion, drift of the constants, curvature, $w(z)$, replication of the CMB anomalies, gravitational sirens, MOND, fourth family). Every statement carries its status (DERIVED, CONDITIONAL, CALIBRATED, HINT, MEASURED); the document closes with the *refutation register* of the programme — what it has abandoned, with dates and reasons — because a theory is also judged by what it knows how to reject.

Framework and notation. This document is a self-contained extract of the **Topological Quantum Knot Theory** (TQNT), the framework in which particles are knots and links of a single field χ (monograph [1]). The labels “Pn” refer to its numbered postulates; those used here: **P10** (the Chern–Simons action of the χ field — a first-order dynamics); **P15** (topological reconnection — strand exchange at a crossing, the mechanism of the weak interaction); **P20** (the quantum gravitational field — each particle’s depletion well); **P22** (topological nucleation at boundaries, $\Gamma = \Gamma_P e^{-2\pi/\xi}$ — the theory of entry). Their full statements are in the postulates chapter of the monograph [1]. The marginal tags on each result — [DERIVED], [CONDITIONAL], [CANDIDATE], [ORDER OF MAGNITUDE], [OBSERVED]... — give its epistemic status: proven within the framework, dependent on a declared identification, a named lead, an order of magnitude, or an external fact. *Version 2 (August 31, 2026): acronyms, postulate labels and the bibliographic apparatus introduced and wired; the physics content is unchanged.*

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Chapter 1

The spacetime weave : the single object

1.1 The existence argument

The starting point is not a postulate of empty space populated by fields: it is spacetime itself as a **wave medium** — the spacetime weave, the wave background of the χ field (level α^0), graduated in *action*: every tooth is worth exactly h . The right image is not a floor beneath things: it is a **three-dimensional ocean of which we are the waves**. We are not set upon the spacetime weave; we are *woven* of it — every proton, every electron of a falling feather is a knot of its undulation, and the fall itself is nothing but the refraction of the wave packet towards the region where the medium is more crushed (gravitation chapter). Figure 1.1 summarizes the object: the undulating profile (top panel) and its rails (bottom panel).

Why believe in this object? Because three facts, ordinarily laid down as separate axioms of physics, become *readings* of it:

1. **$E = hf$ is an identity.** If the graduation of the medium is action, the energy of a wave is *by definition* its frequency counted in teeth: the Planck relation ceases to be a quantum postulate — it is the reading of the graduation. [DERIVED]
2. **The c limit is mechanical.** The meshing of the spacetime weave fixes a single propagation speed; Lorentz kinematics is the symmetry group of the wave equation $\square\chi = 0$ (constructive Lorentz–Poincaré–Bell route declared): special relativity is *deduced*, not posited. [CONDITIONAL : (S) EVERYTHING IS χ ; (D) ZERO DISPERSION] (*detailed demonstration : ref. [1], §kinematics derived from the weave*)
3. **Zero dispersion, structurally.** The spacetime weave is not an ether: action is the only frame-free graduation. The GRB nulls ($E_{QG} > 9.3 E_P$ [6]) are *predictions* of protection, not suffered constraints. [DERIVED + VERIFIED]

1.2 The quartet of constants

Four constants, four roles, one ontology (*detailed demonstration : ref. [1], §the undulating spacetime weave and the Planck constant*): **h the tooth** (absolute invariant — never crushed); **c the meshing** (pre-exists, never a step: the topological lock $\alpha = 1/(k+2)$, with $k = 135$ integer — the level of the Chern–Simons action —, forbids any continuous drift — zero drift observed, clocks/Oklo/quasars/CMB); **M_{Pl} the clock-rigidity** (the transmutation anchor, pre-exists); **G the amplitude of the wave of the bare spacetime weave** — the response to deficits: where a particle confiscates undulation, it is the amplitude of the medium *without* it that fixes the strength of the compensation well; it is also the only one of the four to have a step (at $t_c \approx 1.6 \times 10^{-4}$ s: it depends on the wells, which form). The Planck frequency is *definitional*, never “derived”.

1.3 Dimension : a knot theorem

The dimension of the spacetime weave is not a choice: in $D=2$ there is neither above nor below (no crossing possible); in $D \geq 4$ every closed curve unknots (numerical demonstration: the trefoil $\rightarrow$ circle homotopy requires a collision in 3D and requires none in 4D); **$D = 3$ is the unique dimension where knotting and the lock coexist** — where matter is possible. Time is the local frequency ($1/f$): the spacetime weave is 3+1, graduated in action. Structural cascade: $D=3 \rightarrow$ the trefoil is the minimal knot $\rightarrow$ its C_3 symmetry $\rightarrow N_c = N_{\text{gen}} = 3$: *the “threes” of physics descend from the dimension of the spacetime weave.* [DERIVED]

1.4 Time : the local frequency of the spacetime weave

Time is not an external parameter: **proper time is the count of teeth along the worldline** — the inverse of the local frequency of the spacetime weave. Everything follows, with nothing added:

- **gravitational dilation is the crushing**: near a mass, the spacetime weave is depleted, the local frequency drops ($\delta f/f = \Phi/c^2$), clocks slow down — GPS comes out *exactly* ($45.7 \mu\text{s/day}$); [DERIVED, EXACT]
- **kinematic dilation is Lorentz’s**, already deduced from $\square\chi = 0$ (first chapter): a single origin for both dilations — the graduation in action;
- **the horizon is the stopping of the teeth**: the crushing $E_{\text{tooth}} = hf_{\text{local}}$ (h invariant, never “crushed”) ranges from 1.75×10^{-45} (electron) to **0.5** at a black-hole horizon — the teeth stop, the knots freeze: time ceases to beat there;
- **the arrow of time is the dance**: the bare spacetime weave is reversible ($\Gamma = 0$); irreversibility is born from the decoherence of interacting knot systems ($\dot{S} \geq 0 \Leftrightarrow \Gamma \geq 0$: the second law is a reading of the decoherence rate, and heat, of wells that vibrate); [DERIVED]
- **time has an operational beginning**: before t_c (the freeze-out, $\sim 1.6 \times 10^{-4}$ s), no well depletes the spacetime weave — G does not yet exist: gravitation has a birth date, while time-as-frequency has none (it is the spacetime weave itself).

The two slopes of a rail (nodal line) oscillate in anti-phase: the transverse potential difference exists by construction and screens as $K_0(\pi y/a) \sim e^{-\pi y/a}$ — compensated at infinity, undetectable by construction. **The crushed energy never heats** (stationary structure, $\Gamma = 0$, protection): it is the zero point (physical and finite: Casimir $-\pi/24L$ verified to 6×10^{-9}) and becomes QGF where matter confiscates — and the uniform zero point *does not gravitate in bulk*: G reads deviations, not the absolute (the resolution of the 123 orders of ρ_Λ). [DERIVED]

1.5 Dirac and second quantization, deduced

On the spacetime weave: mass = confined frequency ($m/M_{\text{Pl}} = \omega_0/\omega$), $E^2 = (pc)^2 + (mc^2)^2$ emerges; the tube is ribboned (4π doublet) $\rightarrow$ spin-statistics derived, Dirac equation *forced* (blocks = mirror pair $K/\bar{K}$, first order inherited from the Chern–Simons action of the χ field (postulate P10 of [1]), first-order by definition); minimal U(1) coupling yields QED at $\alpha = 1/137$ and $g = 2$; the loops are *finite* (capture at the vertex: the spacetime weave is the UV completion). Second quantization has its germ in the nucleation postulate (P22 of [1], whose exponent $2\pi/\xi$ is the exact Schwinger exponent), its statistics in braid parity, and its sum over paths computed in the soluble 1+1D instance (exact transmutation to Dirac’s J_0 , unitarity 10^{-14}). [CONDITIONAL, CONSOLIDATED] (*detailed demonstration : ref. [1], §§kinematics ; second quantization*)

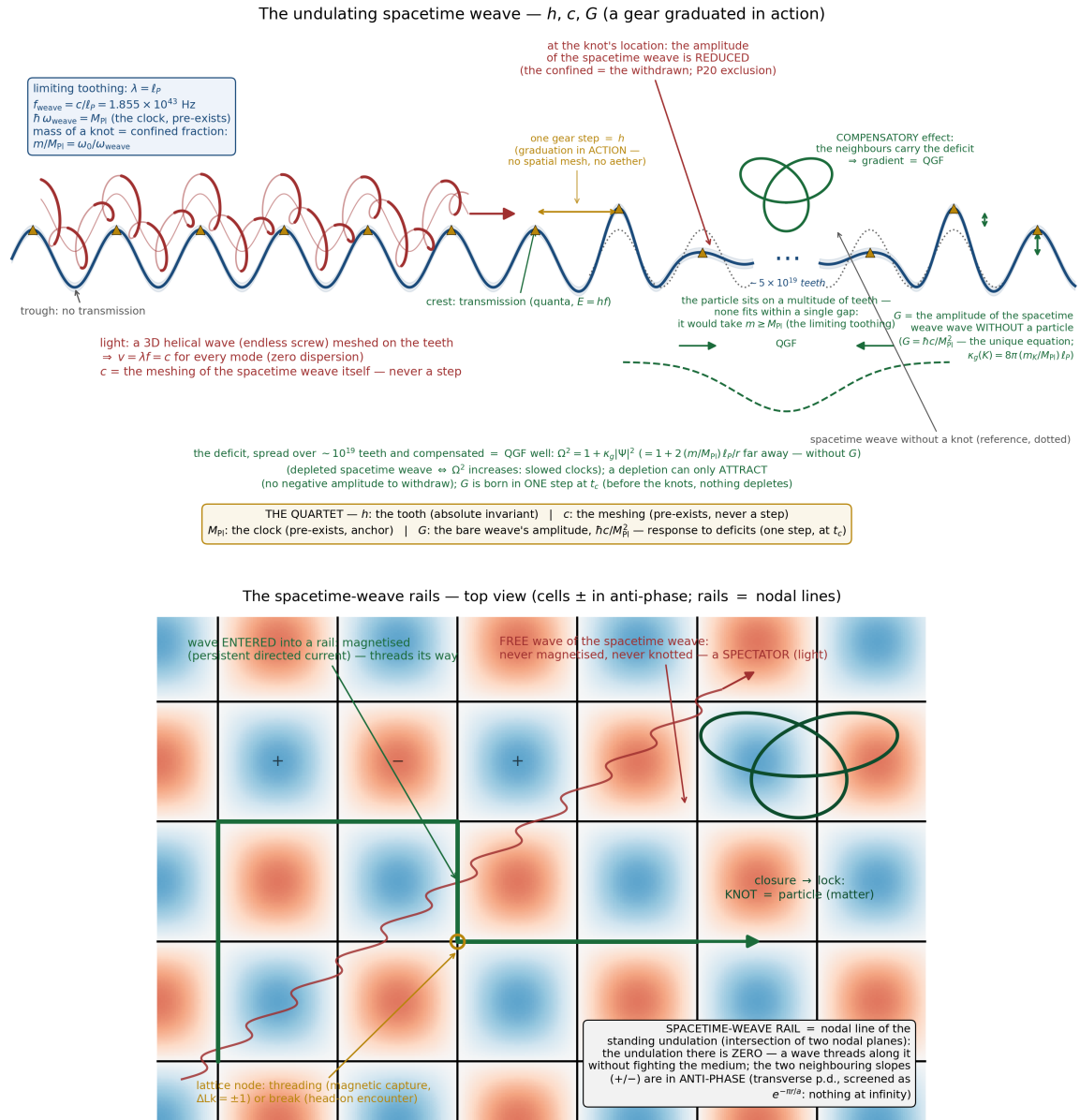


Figure 1.1: *Top*: the undulating spacetime weave — h the tooth (graduation in action), c the meshing (light as a meshed helix: zero dispersion), G the amplitude of the bare spacetime wave (at a knot: depletion over $\sim 5 \times 10^{19}$ teeth, compensation = the quantum gravitational field, QGF). *Bottom*: the **rails of the spacetime weave** — nodal lines of the standing undulation ($\pm$ cells in anti-phase); a wave *entered* into a rail magnetizes and threads through; a *free* wave is a spectator (light); closure locks the knot: *the particle*.

Chapter 2

The rails : the birth of matter

2.1 The rails exist : definition

Definition (rail of the spacetime weave). *A rail of the spacetime weave is a nodal line of its standing undulation — the intersection of two nodal planes, where the undulation vanishes identically.* It is the only place where a wave can thread through *without fighting* the medium; the two slopes bordering a rail oscillate in **anti-phase** (the transverse potential difference exists by construction, maximal on the rail, and screens as $e^{-\pi r/a}$: nothing at infinity). Three orthogonal families of rails, connected at triple points, form **the edge network of a cubic lattice** (coordination 6, pitch = half-wavelength of the spacetime weave): a threading wave is a *path* on this lattice (fig. 1.1, bottom panel). [EXACT]

2.2 Magnetization is an entry property

Only waves *entered* into a rail magnetize: 1D confinement gives a *persistent* directed current (Biot-Savart-type field), whereas a free wave of the spacetime weave carries a current oscillating at every pitch — measured coupling 2×10^{-3} (spectator theorem). Hence the ontological dichotomy: **matter = waves entered into the rails ; light = free waves of the spacetime weave**: entry is *the* transition, and the photon never weighs because it never enters. [DERIVED (QUANTIFIED)]

2.3 The origin of entry : a threshold event

Why does a wave enter? *Never spontaneously*: the photons of the cosmic background cross the universe without loss, and a spontaneous entry in uniform motion would define an absolute frame — the rate is *exactly zero* (protection). Entry requires a **threshold event**: a quantum of action at the gate and a closable neutral topology $\rightarrow$ the minimal entry is a *knot + mirror pair* — the gate of the EM sector is $\gamma\gamma \rightarrow e^+e^-$ (Breit-Wheeler, 1.022 MeV, *observed* [5]), its field-assisted version is Schwinger. The primordial channel is an *anchoring*: the walls of the Z_3 domains of the freeze-out settle on the nodal surfaces (minimal cost, computed), their junctions on the rails — the condensate strings are born *in* the rails. Four channels (primordial freeze-out, collision, critical field, horizon), one mechanism: in each case an event supplies the wave with the action quantum $2\pi/\xi$ — the barrier of the nucleation postulate (P22 of [1]) in its semiclassical (WKB) form, $\Gamma = \Gamma_P e^{-2\pi/\xi}$. In other words, the postulate that governed nucleation at boundaries is re-read as *the theory of the entry of matter into the rails*: a wave becomes matter when an event pays the action price of its entry. [DERIVED/CANDIDATE ; EM GATE OBSERVED (BREIT-WHEELER)]

2.4 Threading, breaking, and the formation constant

In the rails, two counter-propagating waves meet with certainty (1D channel) and *break* (fission); a perpendicular rail wave, captured magnetically at the knot, *threads itself* — its linking number Lk , the number of mutual windings of two loops, jumps by one unit ($\Delta Lk = \pm 1$); the fragments re-thread: the cycle is the cascade. The branching is derived from the $k=2$ ribbon algebra: the fission carries the loop value $d = \sqrt{2}$ (the head-on collision *closes* the history loop — physical Markov closure), each winding sense carries the excess $d - 1$; whence

$$\alpha_{\text{cond}} = \ln \frac{d}{d-1} = \ln(2 + \sqrt{2}) = 1.2279 \quad (\text{closed-form candidate ; used : 1.1991})$$

at +0.7–2.4 % of the independent determinations. [CONDITIONAL THEOREM ; THE NUMERICAL CHAIN KEEPS ITS VALUES] (*detailed demonstration : ref. [1], §the rails of the spacetime weave*)

2.5 The knotting combinatorics : who can be born

Threading is *ghostly* (the wave superposes); the knot only *locks* at closure. Measurements: first knotting at ~ 24 rail steps (the minimal lattice trefoil, Diaio's theorem); $P(\text{knotted}) = 1 - e^{-(N-22)/126}$; **the trefoil dominates** (59 %): the universal core of matter is the most probable product of threading. And superposition is *necessary*: the self-avoiding subset practically never knots — the order wave $\rightarrow$ threading $\rightarrow$ closure $\rightarrow$ lock is *forced*. [MEASURED + THEOREM]

2.6 Electron, proton, neutron : the probabilities

$P(3_1) = 0.07\text{--}0.19$ per closure (the electron, generic product); $P(7_2) \approx 1.2 \times 10^{-3}$ with 50/50 chirality — the mirror pair $7_2 + \bar{7}_2$, companion of the nucleon, is *natural* (parity theorem); the complete proton assembly ($3_1 + \text{mirror pair} + Lk_{\text{tot}}=3$) costs $\sim 4 \times 10^{-9}$ — thirty million times the electron. **The funnel** established turns these raw rates into the observed hierarchy: cascade towards the floors (electron, proton), linking-potential step = $1.29 \text{ MeV} = \Delta m(n-p)$, conservation of Q forcing $n_e = n_p$. [MEASURED ; FUNNEL DERIVED]

2.7 The mathematical definition of a knot

Before defining the particle, the word “knot” must be taken in the strict mathematical sense:

Definition. A *knot* K is a smooth embedding of the circle S^1 into the space $\mathbb{R}^3$ (a closed curve without self-intersection), considered *up to ambient isotopy*: two knots are *the same* knot if one can be continuously deformed into the other without ever cutting the curve or letting it pass through itself. A *link* L is an embedding of several disjoint circles.

What distinguishes knots are their **invariants** — the quantities isotopy cannot change, and it is precisely these that the physics of this book reads:

- the **crossing number** $c(K)$ (minimum over all diagrams): the trefoil 3_1 is the minimal knot, $c = 3$ — and the only one at $c = 3$ (the origin of the Z_3 triality);
- the **polynomials** of Jones $V_K(t)$ and Alexander $\Delta_K(t)$ (and the determinant $|\Delta_K(-1)|$, used for identification in our simulations);
- the **mirror** $\bar{K}$ ($V_{\bar{K}}(t) = V_K(t^{-1})$): a *chiral* knot differs from its mirror (matter/antimatter), an *amphichiral* one ($4_1, 6_3, 8_3$) is identical to it;

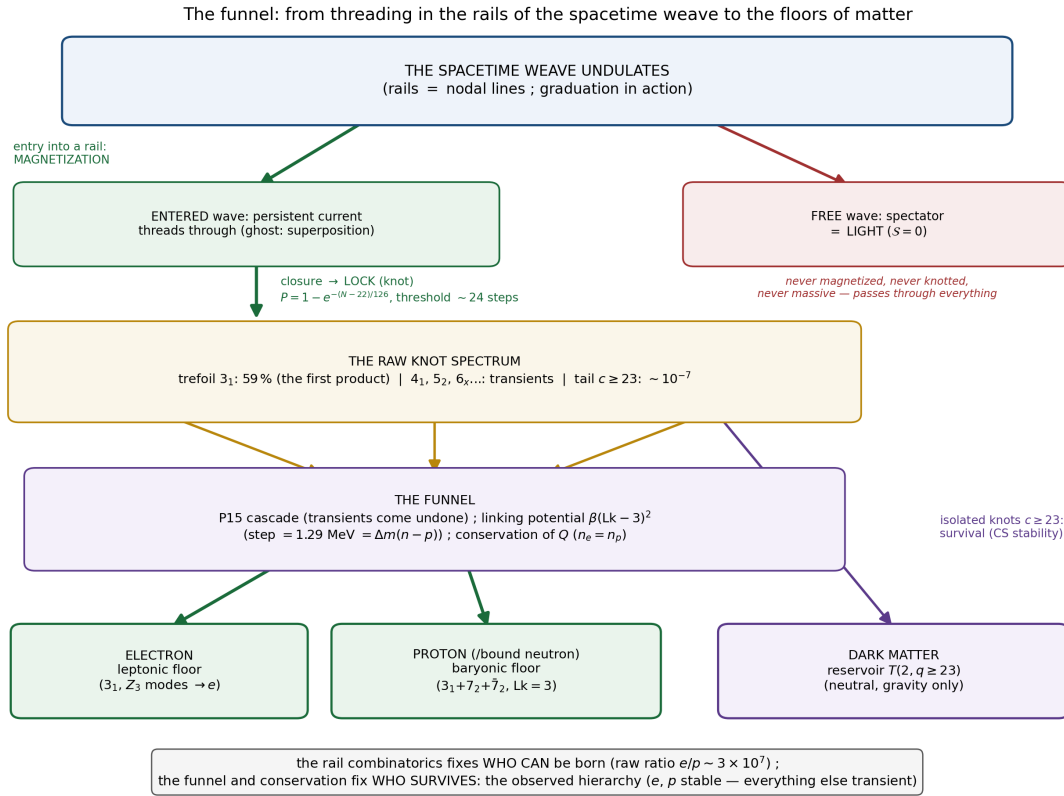


Figure 2.1: The funnel: the spacetime weave undulates; the waves that enter the rails magnetize, thread through and lock into knots (the trefoil first); the cascade of reconnections (postulate P15 of [1]), the linking potential (step = 1.29 MeV = $\Delta m(n-p)$) and the conservation of Q channel everything towards the floors — electron and proton — while the isolated knots at $c \geq 23$ survive as the dark reservoir and light, never entered, passes through everything.

- the **linking number** Lk between components (Gauss integer) and the Călugăreanu theorem $Lk = Tw + Wr$ (twist + writhe of the ribbon: the mechanics of spin and of the strange offset);
- the **ropelength** $\ell(K)$ (minimal length of a unit-radius tube realizing K): the *geometric* invariant that carries the mass of the light plateau — and whose minimal rail length $N_{\min}(K)$ is the combinatorial precursor;
- the **braid index** $b(K)$ (the minimal number of strands of a braid whose closure is K): the spin.

The dimension theorem of the first chapter takes on its full weight here: these invariants only exist in $D = 3$ — in higher dimension every closed curve is isotopic to the trivial circle, and there is *nothing to read*. [STANDARD MATHEMATICS ; PHYSICAL READINGS DERIVED]

2.8 What is a particle ?

The chapter can now answer the question every physics must pose — and the answer fits in one definition:

A particle is a locked knot of the spacetime weave: a wave that *entered* the

rails, *magnetized* there (persistent directed current), *threaded* through, then *closed* on itself — and the lock (condensation into an impenetrable tube) froze its topology.

Everything else follows as *readings* of the knot:

- **its mass** is the undulation it confiscates (the total deficit of the spacetime weave at its location — the depletion charge);
- **its spin** is the arity of its braid, carried by the ribbon of the tube (the 4π object);
- **its charge** is $\Sigma\chi + \text{Lk}$ (chiral writing + linking), integer through the fluxoid;
- **its lifetime** is its topological stability (the floors — electron, proton — are the states whose conservation forbids any descent);
- **its antiparticle** is its mirror ($V_K(t) \rightarrow V_K(t^{-1})$).

Three clarifications delimit the definition. *(i)* A particle is **not a point**: it extends over $\sim 5 \times 10^{19}$ teeth (fitting in a single tooth would require $m \geq M_{\text{Pl}}$); the “pointlikeness” of colliders is that of the *knot*, not of a grain. *(ii)* There are three families of objects: the **simple knots** (the trefoil and its Z_3 modes: the leptons); the **links** (several knots linked together: baryons, mesons, the electroweak sector — and the dark reservoir, isolated knots of high complexity); and the **free waves** of the spacetime weave (photon, neutrino): the latter are *not* particles in the knotted sense — never entered the rails, never magnetized, never massive ($\mathcal{S} = 0$) — they are the *spectators*. *(iii)* The particle carries its **identity card** readable on the spacetime weave (mass = compensation amplitude ; J = frequency, Regge ; parity = 4π ; the rotation rate ω is hidden by theorem): it is this card that all the laws of this book read. [DEFINITION ; READINGS DERIVED]

Chapter 3

Matter : mass, spin, charge (summary)

The detail of the spectrum belongs to the monograph (and to a dedicated publication); we keep here only what the spacetime weave imposes. **Mass** follows $m = \sqrt{\sigma_\chi} \mathcal{S}$ — a single scale ($\sqrt{\sigma_\chi} = 418.47$ MeV, the tension of the χ string) and a topological-class factor: 89 states at median 0.13 %, 226-state extension at 1.43 %, heavy spectroscopic sector at *zero read number* (peripheral torsion: half a ribbon turn $= \pi\sigma_\chi$, the universal hyperfine quantum). [10 GLOBAL CALIBRATED PARAMETERS ; CLOSED FORMS DERIVED] **Spin** is the braid arity (the rotation rate is structurally hidden: all mass laws use J , never ω); the 4π doublet of the ribbon forces the spinor. [DERIVED] **Charge** is $Q = \Sigma\chi + \text{Lk}$ (sum of the knots' chiralities + linking number): topological, quantized, and the framing neutrality of the dark reservoir follows from it. [DERIVED] (*detailed demonstration : ref. [1], mass, spin, charge chapters*)

Chapter 4

Gravitation

4.1 The mechanism : depletion and compensation

A particle extends over $\sim 5 \times 10^{19}$ teeth; at its location the amplitude of the spacetime weave is strongly reduced (the confined *is* the withdrawn — total deficit = mass) and the neighbours carry the deficit by compensation: **the gradient is the quantum gravitational field (QGF)**. Gravity is weak because the spacetime weave is rich; depletion only attracts (no negative mass). To fall is to refract towards the more crushed region — where time beats more slowly. [DERIVED (THE DEPLETION WELL — POSTULATE P20 OF [1] — MECHANIZED)]

4.2 G derived, and its single step

Before the formula, the reading: G is the **amplitude of the wave of the spacetime weave without particle** — the constant that converts an undulation deficit into curvature of the medium (κ_g is its deficit $\rightarrow$ metric conversion); gravity is weak because the spacetime weave is rich. Its quantification is the equation of G — *unique*:

$$G = \frac{\hbar c}{M_{\text{Pl}}^2}; \quad m_{\text{base}} = M_{\text{Pl}} \sqrt{\frac{12}{7} \alpha^{18}} \implies G = \frac{12}{7} \alpha^{18} \frac{\hbar c}{m_{\text{base}}^2} \rightarrow -0.05\% \text{ vs CODATA [11]}$$

(the second writing is the *reading* of the rigidity M_{Pl} by the nucleon — the scale of the 18 crossings —, not a second equation; $m_{\text{base}} = 938.24$ MeV, the nucleon link before Lk selection; the residual -4.9×10^{-4} is *significant*: attached prediction — metrology must converge downwards). The per-crossing ladder (α^0 background, α^1 interface, α^{18} nucleon) is an exchange theorem with M_{Pl} (the rigidity, non-derivable: the counterpart of Λ_{QCD}); κ_g is exact; G is *invariant* across particles (equivalence = uniqueness of the spacetime weave) and is born in *one* step at t_c . Classical tests: Newton, Schwarzschild, Mercury, GPS exact, GW150914 [9] (exact M_{chirp}). [DERIVED]

4.3 Mechanized cosmology : Friedmann, flatness, elasticity, river, growth

The dynamical reading of depletion (2026-07-24) closes the cosmology of the framework in five mechanizations:

(1) *Friedmann mechanized*. The undulation displaced by the crushing must go somewhere: it pushes the weave outwards. The energy balance (the weave *pays* for the wells it digs: $v^2/2 = GM/R$) gives $v = \sqrt{8\pi G\rho/3} R$ — **the flat Friedmann law**: expansion is no longer an initial condition, and $\Omega_{\text{tot}} = 1$ is a *theorem* (push and attraction are the same depletion field;

any detected curvature would refute). Strictly global scope: only the whole universe has no exterior; perturbations ride this background as in GR (Birkhoff). [DERIVED]

(2) *Scale elasticity*. When the mass withdraws, the pushed weave *returns*; and our rulers being made of the same weave, one cannot measure one's own scale. Hence: bound systems do not expand (static crushing pattern — “why the atom does not expand” receives its mechanism); zero local drift (Oklo [12], clocks, GPS); redshift is *cumulative*, visible only at a distance. The push is global *because* only the whole universe never withdraws. [DERIVED]

(3) *The river theorem*. The weave responds to *density* $\rho(x, t)$, not to individual masses: a stationary rotation is a *constant* crushing (the water flows, the level is fixed) — bound systems and orbital rotation are the same case. Corollary: no “weave MOND” — flat rotation curves remain the business of the dark reservoir. [DERIVED]

(4) *Growth deduced*. The friction term $2H\dot{\delta}$ of the growth equation *is* the push that disperses: without it, free fall (~ 590 kyr at recombination — a single clump); with it, $D \propto a$: the push is what maintains $\sigma_8 \sim 0.8$, and the apparent clumpiness grows by dilution of the background (contrast $\propto a^3$, halos held by elasticity). By Birkhoff, this braked growth *is* the Λ CDM growth: $\sigma_8 = \sigma_8^{\text{Planck}}$, *deduced*. [DERIVED]

(5) $w = -1$ *as a theorem*. The vacuum residual does not *dilute* (it is the zero-point deficit of the weave, not of matter) and never *withdraws*: by the river, its push is constant — $dw/dz = 0$ *by construction*. The DESI $w_0 w_a$ preference must regress. [DERIVED]

Epistemological consequence: with expansion, flatness, bound systems, rotation and growth, *the indistinguishability from Λ CDM+GR is no longer an empirical finding: it is a theorem of the weave* — and every “anomaly” opposing it receives a mechanized, dated absence prediction (falsifiability chapter). Two recorded safeguards: the *instantaneous local* sourcing of H is refuted (wrong sign for a void, freezes structure formation); isotropy is structural (no preferred axis possible). [REFUTATIONS RECORDED]

Chapter 5

Emergent thermodynamics

5.1 Temperature : a parameter of the wave content

Temperature is not fundamental: it *emerges* from the wave content of the spacetime weave. The established chain: a background of χ waves + equiprobability of configurations $\rightarrow$ the *dance* (the self-consistent agitation of knots in their wells) + an emergent temperature — it is the derived Boltzmann weight of formation that governs all the way to the dark-matter abundance. Equilibration is a *friction on the content*: the present background (photons, χ waves) defines a licit frame — like the CMB — and the fluctuation-dissipation relation ($D/\mu = kT$) locks *one* temperature between drag and kicks. [DERIVED]

5.2 Heat and the second law

Heat is wells that vibrate. The master formula of dissipation: $\dot{q} = (m^*/ne^2) \Gamma J^2 = \rho J^2$ — the heat of a conductor is a reading of the decoherence rate Γ of the dance. There follows the **second law as a theorem**: $\dot{S} \geq 0 \Leftrightarrow \Gamma \geq 0$ — irreversibility is the decoherence of interacting knots, and the limit $\Gamma = 0$ (perfect coherence: the superconducting state) is exactly the reversible limit. The *bare* spacetime weave, for its part, never dissipates (stationary structure, zero-dispersion protection): the arrow of time belongs to matter, not to the medium. [DERIVED]

5.3 Weave friction : Unruh and Hawking

Friction on the *bare* spacetime weave is forbidden in uniform motion (it would be an absolute frame — protection verified by the GRB non-detections). It exists only under *proper* acceleration (absolute, frame-free), and its temperature is Unruh's: $kT_U = \hbar a/(2\pi c)$ — the identity $4\pi/\xi = mc^2/kT_U$ is exact within the framework (verified to 10^{-9}); the extreme case is the horizon (stopped teeth) and its Hawking temperature. *The framework thus already contains two temperatures that are pure weave friction.* In everyday life, nothing of the sort: $T_U(g) \approx 4 \times 10^{-20}$ K — ordinary heat comes from collisions (from the wells), not from the bare spacetime weave. [DERIVED]

5.4 The zero point : finite, and it does not weigh

The structural energy of the spacetime weave (the screened potential difference of its rails, its modes) *is* its zero point — physical and **finite** (the Casimir effect comes out at $-\pi/24L$, verified to 6×10^{-9} in the soluble instance: renormalization is a reorganization, executed). And this uniform zero point **does not gravitate**: G reads the *deviations* of the level of the spacetime

weave, not the absolute — this is the structural resolution of the 123 orders of magnitude of the cosmological-constant problem, and the bridge to the next chapter. [DERIVED]

Chapter 6

The interactions

6.1 Electromagnetism : $\alpha = 1/137$

A single integer fixes the theory: the level $k = 135$, whence $\alpha_{\text{EM}} = 1/(k+2) = 1/137$. Minimal coupling is *forced* by the $U(1)$ of χ ; $g = 2$ comes out of the Gordon reduction; the loops are finite (the spacetime weave is the UV completion). [DERIVED ; FINE CANDIDATE $\cos(\pi/137)/137$ IN RESERVE]

6.2 The weak force : a reconnection, not a fundamental boson

The “weak” is **topological reconnection** (postulate P15 of [1]): strand exchange at a crossing. The Fermi structure is *derived*: the impenetrability of the tube forces the fusion/fission pair (the “second order” is a theorem), the amplitude is scale-free ($g_{\text{topo}} = 1$ exactly: there exists *no* weak coupling constant, only the barrier), phase space yields Sargent’s m^5 (itself deduced from the kinematics of the spacetime weave). The $N = 2+3$ counting of the τ and the “families” of the W are derived (Z_3 saturation: *never* a fourth family). The electroweak condensate value (the VEV, *vacuum expectation value*) is *derived*: $v = \sqrt{7\pi/6}(k+2)m_{\text{base}}(1 + \alpha/4\pi) = 246.227 \text{ GeV}$, +28 ppm. The $K/D/B/B_s$ oscillations close at $\Sigma|\log| = 0.0008 \text{ dex}$. [DERIVED (CONDITIONAL DECLARED)]

6.3 The strong force : junctions, cables, Steiner

Confinement is the χ string itself (the tension of the Cornell quarkonium potential is that of the string, $\sigma_{\text{Cornell}} = \sigma_\chi$: Cornell adds nothing). Baryons are Y-junctions (Steiner: every internal vertex is 3-valent at 120°); identical pairs form *cables* whose exchange is worth $d = \sqrt{2}$ (quantum-dimension theorem — the same $\sqrt{2}$ as Koide [4, 2]); compact dibaryons are double-Y + bridge ($\ell = D$ derived by the contact theorem). $N_c = 3$ is not a postulate: it is the C_3 of the trefoil — and the trefoil, the minimal knot of $D = 3$. [DERIVED]

Chapter 7

Dark matter

7.1 The reservoir : isolated knots of high complexity

Dark matter is made of *isolated* prime knots at $c \geq 23$ (families $T(2, q \geq 23)$, $T(3, q \geq 12)$): $c_{\min} = 23$ is *derived* (kinetic decoupling + cosmological survival), dark links $n \geq 2$ are unstable (theorem), and the toric sorting is a *survival* selection (Chern-Simons stability, $\tau > 10^{347}$ s — magnetic selection at formation is cleanly refuted). The rails feed the tail ($P(c=23) \sim 10^{-7}$ per closure, spectrum at $r \approx 0.48/\text{crossing}$, bracketed by $e^{-\alpha_{\text{cond}}}$ and the established net rate): production is *entirely primordial* (creating a high- c afterwards is Vassiliev-suppressed as $\alpha^{\Delta c}$).
[DERIVED]

7.2 The abundance : a closed chain

$\Omega_{\text{DM}}/\Omega_b$ is reconstructed *without free parameters*: the visible side annihilates down to the CP crumb (η_B), the dark side is a symmetric relic (Vassiliev-crushed annihilation); the string supply 8/9 is exact (Z_3 piercing counted) *and its geometry is the nodal anchoring*: the walls of the Z_3 domains of the freeze-out settle on the nodal surfaces (minimal cost, computed), their junctions on the nodal lines — **the condensate strings are born in the rails of the spacetime weave**: the substrate of cosmological formation and that of the knotting combinatorics (rails chapter) are *one and the same geometry*, the chain is welded end to end with no new factor; the knotted fraction and the cascade are derived, the count is measured ($n_{\text{knot}}/L = 0.304/\xi$), and $T_c = 62 \pm 3$ MeV is *derived* (topological tightening). Result: $\Omega \approx 0.6$ [0.2, 1.3] — the order of magnitude of Planck (5.45), the gap within the declared $O(1)$ s (3.9 ± 0.4 at the formerly adopted T_c).
[DERIVED CHAIN ; ORDER OF MAGNITUDE]

7.3 Detection : a predicted absence, six lines

The reservoir knots are neutral (framing) and their persistent circulation — the rail current locked in the closed tube — leaves only a polarizability: $\sigma^{\text{eq}}(c=23) = 1.1 \times 10^{-48} \text{ cm}^2$, seven decades below the direct-detection frontiers [14]: **the absence in direct detection is a robust prediction** (any detection at 1.7–2 GeV would refute). The six strict amphichiral states give **six narrow lines at 1.07–1.64 GeV** (Fermi-LAT), $\times 8$ –13 below the 2015 limits [13]. The probes of the reservoir are gravitational (the compact objects of the catalogue [3] — the pearls) and cosmological.
[DERIVED ; FALSIFIABLE]

Chapter 8

Dark energy and cosmology

Dark energy: the zero point of the spacetime weave does not gravitate in bulk (G reads deviations — the G line of the quartet): the 123 orders of magnitude of the cosmological-constant problem are resolved *structurally*, and ρ_Λ is predicted to the order of magnitude (the residual gap falls within the band of the H_0 tension: there is no residual to explain). **Inflation:** $n_s = 0.965$ (Starobinsky sector; F1 — the first of the programme’s three recorded falsifications — closed), $A_s = 1.89 \times 10^{-9}$ without free parameters, reheating above primordial nucleosynthesis (BBN) — F2 closed; Ω_b/Ω_m and D_M/r_s (DESI) reproduced; baryogenesis provides the CP crumb that fixes the dark dominance. The nulls (GRB dispersion, BBN, drift of the constants) are *protection predictions* of the spacetime weave. [DERIVED/ORDER ; HONEST AUDITS MAINTAINED]

Chapter 9

Predictions and falsifiability

9.1 Already verified (2026)

Ω_{cc} observed by LHCb [19] at $\sim 3\,727$ MeV *within* the predicted range $[3\,715, 3\,788]$; $\Sigma_b(6097) = j1$ at $+0.02\%$; $B_J(5970)$ identified with the bottom 1D top ($+0.02\%$) and $B_{sJ}(6064)$ with the strange 1D top; the forty years of H-dibaryon non-detection *postdicted*; the strange baryonic offset confirmed in sign and order.

9.2 Observational check: H_0 , S_8 and flatness (Planck PR3 maps, DESI BAO)

The weave’s cosmological theorems ($\Omega_{\text{tot}} = 1$, constant $w = -1$, growth = Λ CDM via Birkhoff) were confronted with the *public* Planck PR3 maps [7] through an independent chain (July 2026, open scripts):

H_0 . The acoustic scale is re-measured on the SMICA map under the common mask (pseudo- C_ℓ , template stretch with a noise term): $100\,\theta_* = 1.0417$, within 0.06% of the official value. Under the flatness *theorem*, this θ_* fixes $H_0 = 67.2$ km/s/Mpc (Planck: 67.36 ± 0.54) — with no geometric freedom. The attached demonstration: *without* the theorem, the same θ_* accepts $H_0 = 73.2$ (the local SH0ES value) with $\Omega_k = +0.011$; the weave *forbids* that escape — it is the weave that makes the local value an inherited tension, not a solution.

Flatness certified. The geometric degeneracy is broken by reading the same standard ruler at two epochs: our θ_* ($z \simeq 1090$) + the public DESI DR1 BAO distances [8] ($z = 0.30\text{--}2.33$), background at $w = -1$ (internal consistency of the theorem):

$$\Omega_k = +0.0023 \pm 0.0016 \quad (|\Omega_k| < 0.0056 \text{ at } 95\%),$$

consistent with the theorem at 1.4σ . The theorem will always remain stronger than any measurement (cosmic-variance floor $\sim 10^{-4}$): it can be refuted, never proven.

S_8 . The official PR3 lensing bandpowers (MV, $L \in [8, 400]$, debiased) give $A = 0.987 \pm 0.025$ relative to the fiducial, i.e. under the growth theorem $S_8 = 0.826 \pm 0.011$ (Planck: 0.832 ± 0.013). The $2\text{--}3\sigma$ gap with galaxy weak lensing ($\sim 0.76\text{--}0.79$) is *inherited*: the weave cannot absorb it (the river theorem — no weave MOND), and it stands exposed — *confirmed* modified growth would refute it.

[CONSISTENCY CHECK; TWO REFUTATIONS OFFERED]

9.3 To be settled (2026–2032)

LHCb: H_{cc}^{++} at 4497 ± 10 MeV (displaced vertex $30 \mu\text{m}$, $0^+/1^+$ doublet of 75 MeV, never a peak above 4573); $\Xi_{cc}^* = 3659$ (vs ~ 3690 QCD); B_0^*/B_1' centroid 5665; $\Omega_b(1P)$ 6297–6304; $\Omega_{ccc} = 4782$ strict; Σ_c/Σ_b quintets; $J^P(5970) = 3^-$. Astroparticles: direct-DM absence (DS-20k/XLZD), six Fermi-LAT lines, $0\nu\beta\beta = 0$ exactly, $\Sigma m_\nu \approx 66$ meV, finite τ_p , r (LiteBIRD 2032). And the **ten falsifiable prohibitions** (never a Λ_{ss} , a fourth family, a sterile, a stable $c = 19$ –22 band, a free fractional charge, a TQNT-only state at a collider...): a single contrary observation would refute the corresponding rule.

9.4 The dated table

prediction	instrument / deadline	what a contradiction would refute
$H_{cc}^{++} = 4497 \pm 10$ MeV (displaced vertex), 75 MeV doublet	LHCb Run 3	the dibaryon map (Steiner+bridge)
$\Xi_{cc}^* = 3659$ vs ~ 3690 (QCD)	LHCb [18]	the recoupling ladder
B_0^*/B_1' centroid 5665 MeV	LHCb	the monotonicity of the bands
$\Omega_b(1P) = 6297$ – 6304 ; $\Omega_{ccc} = 4782$	LHCb	the multiplet rule
direct-DM absence 1.7–2 GeV	DS-20k / XLZD	the derived polarizability channel
six narrow lines 1.07–1.64 GeV	Fermi-LAT 15+ yr	the strict states
$0\nu\beta\beta = 0$ exactly ; $\Sigma m_\nu \approx 66$ meV	tonne-scale experiments (LEGEND, nEXO) ; KATRIN	the free-wave neutrino
zero GRB dispersion ; zero drift of the constants	continuous	the protection of the weave
$\Omega_{\text{tot}} = 1$ exact	CMB-S4 [17], Euclid	the flatness theorem
$w = -1$ constant (the $w_0 w_a$ preference regresses)	DESI DR3+, Euclid	the static vacuum residual
local GW sirens [10] $\rightarrow H_0 = 67.4$	LIGO O5 / ET (~ 2030)	the elimination position
non-replication of the large-scale CMB anomalies	LiteBIRD (E modes), lensing, 21 cm	structural isotropy
no JWST $z > 10$ population beyond ΛCDM	JWST (systematics) [15]	the growth theorem
never MOND (flat curves = reservoir)	dwarf/LSB rotation	the river theorem
never a 4 th family, a sterile, an axion, a Λ_{ss} , a TQNT-only collider state	continuous	the spectrum theorems
$r \leq 0.01$	LiteBIRD 2032 [16]	the Starobinsky sector

Table 9.1: The dated falsifiable register. Each line is *one* sufficient contrary observation.

9.5 The epistemological position

TQNT [1] is a *topological cartography* of the spectrum at $\sim 1\%$ (not a precision theory): ~ 25 load-bearing results pass the assignment null test, the rest is compatibility; in the regimes tested 2024–2026 it is observationally indistinguishable from $\Lambda\text{CDM}+\text{GR}$; past falsifications are dealt with (F1 closed, F2 closed, F3 lifted); the distinctive tests are *future* and *dated*.

Chapter 10

The register of refutations and requalifications

A theory is also judged by what it knows how to reject. The programme keeps a register of its own abandonments — here are its main entries, with dates and reasons; none was silently withdrawn.

abandoned object	date	reason
F1 : pure inflation (n_s)	2026	closed by the Starobinsky sector
F2 : reheating T_{reh}	2026-07-17	closed by insensitivities (the “V5.17” route of the programme’s history, carried through)
F3 : Class-E lines at the Ω_{ts} energies	2026-07-15	lifted: artefact of the Ω_{ts} masses; canonical lines $\times 8$ –13 below the limits
Ω_{ts} mass operator (V5)	2026-07	archived: wrong curves 14/19, assignment freedom (null test)
“writhe doublet of the 8_3 ”	2026-07-22	dead at the true ideal ($W_r = 0$ converged)
nucleation (P22 [1]) amplification	2026-07-14	computation without free parameters: null (81 decades)
(JWST, dark energy, halo)		
“ $m=3$ signal” Planck (internal)	2026-07-23	audit executed: generic low- m anisotropy, no $\mathbb{Z}_3$ signature (m -spectrum + anisotropic-noise controls)
instantaneous local sourcing of H_0	2026-07-24	wrong sign for a void; would freeze structure formation
Li-7 mechanism “ashes of the freeze-out”	2026-07-24	refuted <i>the day of its consolidation</i> at the efficiency wall (3×10^{-13} /photon computed: $\times 10^4$ deficit); the first-pass efficiency error is recorded
magnetic selection of the dark families	2026-07-23	cleanly refuted (survival sorting confirmed)
“419 tests < 5 %” as an argument	2026-07	reread through the null test: ~ 25 load-bearing results + compatibilities

Table 10.1: The refutation register (extract; full list in the monograph [1]). The four *inherited* mysteries — H_0 , S_8 , lithium-7, the shower muon puzzle — are declared as such: where the framework has no mechanism, it says so.

Chapter 11

Conclusion : one object, ten numbers

The path fits in one sentence: **the spacetime weave undulates; its nodal lines form rails; the waves that enter magnetize, thread, break and lock into knots; these knots are matter — their length is mass, their braid is spin, their linking is charge; their undulation deficit is gravitation; the knots too complex to interact are dark matter; the zero point that does not gravitate is dark energy resolved; and light is the population that never entered the rails.**

THE TEN CALIBRATED NUMBERS (nothing per particle)		
1	$\sqrt{\sigma_\chi} = 418.47 \text{ MeV}$	the tension of the χ string — the single scale; Regge, Λ_χ , E_{Z_3} , Cornell all derive from it
2	$m_\ell = 310 \text{ MeV}$	the trefoil knot — the <i>transmutation</i> constant (non-derivable in principle: scale invariance)
3	$m_s = 494.8 \text{ MeV}$	the 5_2 knot (geometric hint; rails: $3/2$ exact; +5.6 % dressing open)
4–5	$m_c = 1\,557, m_b = 4\,952 \text{ MeV}$	the heavy knots (the geometric ceiling is refuted: they remain calibrated)
6	f_π	the Goldstone sector (Gell-Mann–Oakes–Renner relation)
7	radial ratio 1.38	the radial excitations of the functional
8	$\tau_\perp$	the N– Δ hyperfine (Y-junction)
9	heavy hyperfine	the J/ψ – η_c pair
10	$\beta_\otimes = 0.210 \text{ MeV}$	the linking potential (mechanism identified: fluxoid)
<i>two hints</i> : $A = \sqrt{2}$ ($= d_{1/2}(k=2)$, the same as the excess $d-1$) ; $\delta_{\text{Koidé}} = 2/9$ <i>and one integer</i> : $k = 135$ (identified by $\alpha_{\text{EM}} = 1/137$ — it also fixes the cosmology)		

Table 11.1: The complete count. Derived (do not count): v (+28 ppm), G , T_c , $c_{\min}$, α_{cond} (closed-form candidate), the integer recoupling ladder, the bands at every $L \dots$

All of it with **ten calibrated global parameters** (against nineteen in the Standard Model, zero per particle — table 11.1) and **two hints** ($\sqrt{2}$, $2/9$); a single integer ($k = 135$) fixing α and the cosmology; and an honest work list: the Ω_c^* residual (-0.7%), the m_s dressing (+5.6 %, neither geometric nor combinatorial), the m_ℓ transmutation (non-derivable in principle), the heavy numbers m_c , m_b , the decimal of the baryonic offset, and the fine pinning of α_{cond} . Every statement of the framework is falsifiable; several will be soon.

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