The Vacuum.Net Theory: Foundational Paper

Sixth Edition — Leiden, 9 August 2026 J. Konstapel, Constable Research B.V.

Revision note (Edition 6)

Edition 5 closed the review cycle: four adversarial GPT reviews, all corrections absorbed, status "final pending O1". Edition 6 adds one new part and changes nothing in the theorem structure.

The addition is **Part II: The Ternary Ground**. It answers a question the earlier editions left implicit: why three? It gives three results. First, three symbols is the minimal alphabet in the sense of Leibniz and Chaitin. Second, the balanced form of that alphabet is the only notation whose operations close without external conventions. Third, this yields a new conditional theorem, **T7 (Unique Address)**, with two corollaries that clean up T3 and the epistemics section.

One number is corrected. P3 listed the solar winding edge as 5,350 AU. Recomputing from the stated formula with the stated inputs gives 7,400 AU. The formula stands; the arithmetic is fixed. Every step is now in the text.

New references: Leibniz (1686), Chaitin (2005, 2006), Stifel (1544), Knuth (1997), Euler via Andrews (2007), Brusentsov's Setun, Hayes (2001), Ma et al. (2024).

Part I — Axioms

The theory rests on five axioms. Everything else is derived, corresponded, identified, predicted, or declared open. The five statuses are defined in Part X.

N1 (Strand). There is one strand. It is oriented and continuous. Its only local act is self-crossing. A self-crossing has three states: over (+1), under (−1), or none (0).

N2 (Closure). Only configurations that close — that return in phase onto themselves — persist. What does not close, does not last. Closure is the selection rule. There is no external selector.

N3 (Memory). A closed configuration constrains the next rewrite. The net carries its history as its shape.

N4 (Context). The response of the medium is a state function, not a universal constant. Universality is the empirical limiting case $g(\chi) = g_0$ when the state variable χ does not vary across the sample.

N5 (Scale). The net repeats its own construction across depth. One winding step deeper multiplies the count of distinguishable states by three: each site adds one three-valued crossing. Identity over scale: the same winding, read at another depth.

Part II — The Ternary Ground (new in this edition)

II.1 Minimality: why three symbols

Leibniz states the design principle in the *Discours de métaphysique* (1686), §5–6: the best world maximizes the richness and diversity of phenomena while minimizing the ideas and laws used to build it. Comprehensibility is a consequence: a world built from few bricks can be grasped.

Chaitin translates this into a measurable criterion. A law is a compression. A theory is a program shorter than the data it produces. Comprehensibility equals compressibility. The quality of a foundation is its program length.

The principle has a numerical answer for alphabets. The cost of representing values in radix r is proportional to $r \cdot \log_r(N)$, hence to $r / \ln r$. Compute it:

- $r = 2$: $2 / \ln 2 = 2.885$
- $r = 3$: $3 / \ln 3 = 2.731$
- $r = 4$: $4 / \ln 4 = 2.885$
- continuous optimum: $r = e = 2.718$

Three is the integer closest to the optimum. Three beats two. The cheapest alphabet that expresses richness has three symbols. In the vocabulary of N1: over, under, none. The trinity is not one possible ground among many. It is the solution of Leibniz's minimization.

Note on the selector. In Leibniz the minimization is performed by God — an external builder. The net does not need one. By N2, only what closes persists. The optimum is not chosen; it is what remains. Selection by fit replaces the external optimizer. Chaitin secularizes Leibniz halfway; closure completes it.

II.2 Symmetry: the balanced notation

Base three has two notations. Unbalanced ternary uses $\{0, 1, 2\}$. Balanced ternary uses $\{-1, 0, 1\}$, written here as $\{T, 0, 1\}$. The balanced form is the notation of the strand: T is counterwinding, 0 is rest, 1 is winding.

Balanced ternary closes without external conventions. Four facts, each verifiable by direct computation:

(a) No minus sign. The sign of a number is the sign of its leading nonzero trit. Negation is trit-wise mirroring: swap $1 \leftrightarrow T$. Example: $8 = 10T$ $(9 - 1)$; $-8 = T01$ $(-9 + 1)$. No symbol is imported from outside the alphabet.

(b) Closed single-trit multiplication, no carry. The full table: $1\times1 = 1$, $1\times T = T$, $T\times T = 1$, anything $\times 0 = 0$. One trit in, one trit out. The addition table has two carries in nine entries. Binary-coded systems cannot match this economy.

(c) Truncation equals rounding (Knuth). Cut a balanced ternary expansion after position m. The discarded tail is at most $\Sigma_{i>m} 3^{-i} = 3^{-m}/2$ in absolute value — half the last kept unit. Cutting is therefore automatically rounding to nearest. No separate rounding rule exists or is needed.

(d) Shift equals scale step. Shifting the trit string one place left multiplies by 3; one place right divides by 3. Same string, other depth. This is N5 written as notation.

Decimal and binary need two external conventions: a minus sign and a rounding rule. Both are external standards in the sense of the assumptions inventory (*The Assumptions Nobody Declares*, 26 July 2026). Balanced ternary needs neither. It is the only positional notation in which the trinity closes on itself.

II.3 Theorem T7 (Unique Address) — conditional

Hypotheses. N1 (three local states per site) and N5 (scale step of factor three).

Statement. (i) Every finite net state at depth n corresponds to exactly one trit string of length n. (ii) Every integer winding sum has exactly one finite balanced ternary representation with nonzero leading trit.

Proof. *Existence*. Convert any integer via standard ternary, then replace every digit 2 by the pair (carry 1, digit T), since $2 \cdot 3^i = 3^{(i+1)} - 3^i$. The procedure terminates because each step strictly reduces the number of 2s at or below the current position.

Uniqueness. Suppose two distinct finite trit strings represent the same integer. Their trit-wise difference gives $\Sigma\, d_i 3^i = 0$ with all $d_i \in \{-2, -1, 0, 1, 2\}$, not all zero. Let k be the largest index with $d_k \neq 0$. Then $|d_k| 3^k \geq 3^k$. But the remaining terms satisfy $|\Sigma_{i<k} d_i 3^i| \leq 2 \Sigma_{i<k} 3^i = 3^k - 1 < 3^k$. The sum cannot vanish. Contradiction. ∎

Corollary T7.1 (Mirror charge). Q and −Q have the same address, mirrored trit-wise. The sign of the Hopf charge in T3 is a property of the string, not a label attached from outside. Winding and counterwinding are one strand, read in mirror.

Corollary T7.2 (Self-centering depth). By fact (c), the state read at finite winding depth m is automatically the nearest value at that depth. Description at a given depth needs no external rounding convention. Measurement at finite depth is well-defined from inside.

Corollary T7.3 (Capacity per depth). The maximal winding sum expressible at depth n is the all-ones string: $(3^n - 1)/2 = 1, 4, 13, 40, 121, \ldots$ Each depth has a hard capacity; exceeding it forces the next depth. This is the quantitative content of N5.

Precedent. The uniqueness in (ii) was used by Euler to prove an identity of formal power series (Andrews 2007). The notation runs on hardware: Brusentsov's Setun computer (Moscow, 1958) computed in balanced ternary. Current ternary-weight neural networks, including the 1.58-bit large-language-model line (Ma et al. 2024), use exactly the alphabet $\{-1, 0, 1\}$. The MAZE kernel can take it as its ground type.

Status. T7 is conditionally proved (on N1, N5). The identification of trit values with strand states is a correspondence (C6, Part IV), not a theorem.

Part III — Theorems (conditional)

Each theorem states its hypotheses and scope. None claims more than its conditions deliver.

T1 (First knot)

Hypotheses. Closed embedding (S^1 or fixed endpoints); crossings countable.

Statement. The trefoil is the simplest configuration that cannot be undone, at three crossings.

Proof. *Distinctness*. Color the arcs of a diagram with three colors such that at every crossing the three meeting arcs carry either one color or all three. The unknot admits only single-color colorings. The standard trefoil diagram admits a coloring using all three colors: assign each of its three arcs a different color; at each crossing all three colors meet, satisfying the rule. Tricolorability is invariant under all three Reidemeister moves (checked case by case on the finitely many local pictures). Hence the trefoil is not the unknot. *Minimality.* Diagrams with 0, 1, or 2 crossings are finitely many up to the moves; each reduces to the unknot (direct check). So no nontrivial knot exists below three crossings. ∎

Remark (new). The proof itself is ternary: three arcs, three colors, three crossings. The first stable form is certified by a three-coloring. The trinity appears in the first proof of the first knot.

T2 (Double cover)

Hypotheses. Orientation states form the unit quaternions; a strand is attached (has ends or environment).

Statement. A strand returns to its initial state after a rotation of 4π, not 2π.

Proof. Unit quaternions $q = a + bi + cj + dk$ with $i^2 = j^2 = k^2 = -1$ represent rotations by $v \to q\, v\, q^*$. Both q and $-q$ give the same rotation: the representation is a double cover. A continuous rotation by 2π carries q to $-q$; only 4π returns q to q. For a free frame the sign is unobservable. For an attached strand the sign is stored in the strand's configuration relative to its attachment, hence observable. ∎ (C2 identifies spin-½ as this rotation label.)

T3 (Charge conservation)

Hypotheses. Field configurations map into the target space of closed windings; the strand is continuous (N1); no boundary is crossed.

Statement. The Hopf charge $Q \in \pi_3(S^2) = \mathbb{Z}$ is conserved under all continuous rewrites.

Proof. Q is an integer-valued homotopy invariant. A continuous deformation cannot change an integer continuously. Q can change only through discontinuity: cutting the strand, leaving the target space, or crossing a boundary. All three are excluded by hypothesis. Conservation follows from strand continuity alone — no symmetry argument (Noether) is invoked. ∎ By T7.1, Q and $-Q$ are mirror addresses of one string.

T4 (Constitutive equation)

Hypotheses. The energy density of the medium admits the expansion $e(n) = (g_2/2)\, n^2 + (g_3/6)\, n^3$ around a reference density $\bar{n}$, with $g_3 \neq 0$. Scope: one explicit realization of N4.

Statement. $g\_eff = \bar{g}\,(1 + \gamma\delta)$, with $\bar{g} \equiv g_2 + g_3\, \bar{n}$, $\gamma \equiv g_3\, \bar{n} / \bar{g}$, and $\delta \equiv (n - \bar{n})/\bar{n}$.

Proof. Two derivatives: $g\_eff = d^2e/dn^2 = g_2 + g_3\, n$. Insert $n = \bar{n}(1 + \delta)$: $g\_eff = (g_2 + g_3\, \bar{n}) + g_3\, \bar{n}\, \delta = \bar{g}\,(1 + \gamma\delta)$. ∎ The stiffness of the medium is a state function of its density. This is N4 made explicit.

T5 (Sign theorem)

Hypotheses. T4 holds; at the reference state $\gamma = 2\pi$ (correspondence C5, not proved here).

Statement. $g_2 < 0$, and the attractive quadratic term cancels 84.1% of the cubic term at reference density.

Proof. From $\gamma = g_3\,\bar{n} / \bar{g}$ and $\bar{g} = g_2 + g_3\,\bar{n}$: $g_2 = \bar{g}\,(1 - \gamma)$. With $\gamma = 2\pi > 1$, $g_2 = \bar{g}\,(1 - 2\pi) < 0$ for $\bar{g} > 0$. The cancellation fraction is $|g_2| / (g_3\,\bar{n}) = (2\pi - 1)/2\pi = 1 - 1/2\pi = 0.8408 \rightarrow$ **84.1%**. The residual stiffness is $\bar{g} = g_3\,\bar{n} / 2\pi$. ∎ The vacuum sits near criticality: two large contributions, nearly balanced, one small net stiffness. This is the formal version of the weather picture.

T6 (Loss has an address)

Hypotheses. Local balance equations hold; fluxes J and forces X are defined per mesh; channels may couple.

Statement. Entropy production is $\sigma = \Sigma\, J\cdot X \geq 0$ for the total, per location. Individual terms are sign-definite only in diagonalized channels. $\sigma = 0$ does not force every J and X to zero, only the coupled total.

Proof sketch. Clausius inequality per control volume plus the flux-force decomposition of de Groot–Mazur. Positivity binds the sum, not the parts. ∎ Consequence: every irreversible discharge occurs at a mesh with an address. Loss is bookkeeping on the net, not a leak out of it.

T7 (Unique Address)

Stated and proved in Part II.3.

Part IV — Correspondences

Correspondences identify model elements with observed structures. They are neither proved nor predicted; they are declared, and they can fail.

C1 (Mark). Spencer-Brown's mark of distinction = the self-touching of the strand. Absorbed into N1.

C2 (Rotor). The local state is a quaternion rotor; spin-½ is the rotation label of T2.

C3 (Nilpotence). Rowlands' nilpotent condition $Q^2\psi = 0$ with $Q^2 = E^2 - p^2 - m^2$ corresponds to closure: a configuration closes exactly when its rotor squares to zero in the Cl(1,2) fragment.

C4 (Knot = matter). Stable particles are closed windings. The electron corresponds to the Williamson–van der Mark toroidal configuration: a photon closed on itself in a double loop.

C5 (Crossover). $\gamma = 2\pi$: the leading nonlinearity of the collective net dynamics is one full phase winding. Crossover rule $\gamma\,\chi\_a = 1$ gives $a_0 = cH_0/\gamma$.

C5a (Bridge B1, observable–state). $\delta = k\,\chi\_a$ near the reference point, with $k \equiv d\delta/d\chi\_a$. Measurement fixes the product $\gamma k \approx 2\pi$; $k = 1$ is an additional choice, not a result. Validity: near the reference point only.

C6 (Trit = strand state, new). The trit values {1, 0, T} correspond to {winding, rest, counterwinding} at a site. This identification carries T7 from arithmetic onto the net. It is a correspondence: the arithmetic is proved, the mapping is declared.

Part V — Identifications

I1. Electron = Williamson–van der Mark double-loop photon. **I2.** State variable $\chi\_a = a/(cH_0)$: the only independent dimensionless ratio of local acceleration to background. **I3.** $a_0 = cH_0/2\pi$. With $H_0 = 70$ km s^{-1} $Mpc^{-1} = 2.27 \times 10^{-18}$ s^{-1}: $a_0 = (3.00 \times 10^8 \times 2.27 \times 10^{-18})/2\pi =$ **1.08×10^{-10} m s^{-2}**. Measured threshold (rotation-curve fits): 1.2×10^{-10} m s^{-2}. Agreement within 10%. **I4.** $g = g(\alpha(\chi))$: context sets α, α sets interaction. $\Delta\alpha/\alpha = \beta\cdot\Delta\chi$ is the inner function in the weak-field tail.

Part VI — Units

The model is dimensionless. Its native quantities are ratios: winding sums, densities relative to reference, χ_a. There is no ħ in the model. c is a state function of the medium, not a universal input. SI numbers are conversions performed after the fact, for comparison with instruments. By T7.2, finite-depth readout is self-centering: the notation needs no unit convention to be well-defined internally.

Part VII — Predictions

Each prediction carries its pre-commitments. A prediction without a pre-registered map is not a prediction.

P1 (Clock–spectroscopy benchmark, conditional). In potential form: $\Delta\alpha/\alpha \approx +3 \times 10^{-8}$ at the white dwarf G191-B2B, conditional on the pair (χ_Φ, β). A null result refutes that pair, not the theory. Pre-commitment: the χ-map of the line of sight, fixed before analysis.

P2 (Overdetermination). $\gamma k = \beta\cdot p\_\alpha$, with $p\_\alpha \equiv d \ln g / d \ln \alpha$. Two independent routes — rotation curves (SPARC) and α-spectroscopy — must return the same product $\gamma k \approx 2\pi$. Sign conditions stated; preregistration required.

P3 (Solar winding edge). The edge lies where internal acceleration meets the background: $GM/r^2 = a_0$, hence $r\_edge = \sqrt{(GM/a_0)}$. Every input is in this text: $GM_\odot = 1.327 \times 10^{20}$ m^3 s^{-2}, $a_0 = 1.08 \times 10^{-10}$ m s^{-2} (I3). Then $r\_edge = \sqrt{(1.23 \times 10^{30})} =$ **1.11×10^{15} m = 7,400 AU**. (Edition 5 printed 5,350 AU; the formula was right, the arithmetic was not.) Scaling: $r\_edge \propto \sqrt{M}$. Honest label: the scaling follows from the threshold identification; the theory's own contribution is the value of the threshold (I3).

P4 (No dark-matter particle). Operational form: no context-independent particle will ever be detected. Pre-registered function: $\Delta m\_eff/m\_eff = s\_m \cdot \gamma k \cdot \Delta\chi\_a$, with susceptibility $s\_m \equiv d \ln m\_eff / d \ln g\_eff$, to be computed in O1. A collective excitation that tracks χ does not count as a particle. Only refutable in this operational form.

P5 (Forbidden outcomes). (i) A quantized spin-2 graviton. (ii) Any measured α-variation must survive the χ-regression; a residual dipole after regression refutes the model. Four pre-commitments fixed in Edition 5 apply unchanged.

Part VIII — Open calculations

O1. Coarse-graining of the knot network: derive $\gamma = 2\pi$, the sign of g_2, and "why four". The decisive step. T5 and P4 wait on it. **O2.** Closure dynamics (Rosen): not "which action does the net minimize" but "which rewrite dynamics is its own fixed point". The action principle is an inherited external mover; the fixed-point form replaces it. **O3.** The mass spectrum from the winding alphabet. **O4.** One χ: unify $\chi\_a = a/(cH_0)$ and $\chi\_\Phi = |\Phi|/c^2$, now including k (C5a).

Part IX — Position

Wolfram/Gorard. Rule selection by the criterion that known physics emerges; the ruliad is an external standard. Program length now gives a neutral comparison (Part II.1): richness produced per axiom. Five axioms here; the challenge to any rival is to produce the same richness from fewer. **Verlinde.** Moves the foundation one floor (holography, de Sitter) but keeps it external. **Loop quantum gravity, CDT, causal sets.** Keep causal ordering or a background condition as primitive. N4 treats universality as an empirical limiting case; T3 supplies one topological conservation law independently of Noether. **Chaitin (new).** Supplies the metric on which all of the above can be compared without an external judge: comprehensibility = compressibility. The comparison is internal to the programs themselves.

Part X — Epistemic statuses

Every statement in this paper carries exactly one of five statuses:

1. **Assumed** — the axioms N1–N5.
2. **Conditionally proved** — T1–T7, valid under their stated hypotheses.
3. **Corresponded** — C1–C6, declared identifications that can fail.
4. **Predicted** — P1–P5, with pre-commitments.
5. **Open** — O1–O4, prioritized; the reduction claim remains a working conjecture.

By T7.2 the status system itself gains a small foundation: readout at finite depth is well-defined without external convention. The paper's honesty rule — say at which depth you are reading — is now backed by arithmetic.

Annotated references

Leibniz, G.W. (1686), *Discours de métaphysique*, §5–6. The design principle: maximal richness from minimal means; comprehensibility as consequence. The starting point of Part II.

Chaitin, G. (2005), *Meta Math! The Quest for Omega*; (2006), "The Limits of Reason", *Scientific American* 294(3). Reads Leibniz as proto–algorithmic information theory: a theory is a program shorter than its data. Supplies the comparison metric of Part IX.

Stifel, M. (1544), *Arithmetica Integra*, p. 38. Earliest appearance of balanced ternary. The notation predates the theory by five centuries.

Knuth, D. (1997), *The Art of Computer Programming*, Vol. 2, pp. 195–213. Balanced ternary arithmetic; truncation–rounding equivalence; "perhaps the symmetric properties … will prove to be quite important some day."

Andrews, G.E. (2007), "Euler's De Partitio numerorum", *Bull. AMS* 44(4). Euler's use of the unique-representation theorem behind T7(ii).

Hayes, B. (2001), "Third Base", *American Scientist* 89(6). Accessible survey of ternary systems, radix economy, and the balance-scale reading.

Krinitsky, Mironov & Frolov (1963), "Program-controlled machine Setun". The balanced-ternary computer of Brusentsov and Sobolev. Hardware precedent for the MAZE kernel.

Ma, S. et al. (2024), "The era of 1-bit LLMs: all large language models are in 1.58 bits", arXiv:2402.17764. Modern neural networks on the alphabet $\{-1, 0, 1\}$. The trinity alphabet is current engineering practice.

Spencer-Brown, G. (1969), *Laws of Form*; Kauffman, L. The mark of distinction and knot-theoretic self-reference behind N1 and C1.

Williamson, J. & van der Mark, M. (1997). The toroidal electron: a photon closed on itself. Basis of C4 and I1.

Rowlands, P. Nilpotent quantum mechanics; the closure reading C3.

Maxwell, J.C. The original quaternion form of electrodynamics; background of T2/C2.

McGaugh, S. et al., SPARC; Milgrom, M. (1983); Chae, K.-H. (2020). The measured acceleration threshold, the radial-acceleration relation, and the external-field effect: the data side of C5, C5a, I3, and P2.

Konstapel, J. (2026), working papers of 9 July 2026 and *The Assumptions Nobody Declares* (26 July 2026). The strand programme and the assumptions inventory that Part II.2 draws on.

Edition 6 status: final pending O1. The review cycle for the new Part II and T7 follows the established procedure.