PANTAREON GMBH

Emergent Graph Theory

A framework for emergent spacetime under strict energy conservation

"Structure is a configuration that has become invariant under the energy-conserving dynamics of its substrate."

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§ 01 — THE PROBLEM

Four open questions of the Standard Model

01

Fine-tuning

The constants of nature are highly specific. The standard models offer no mechanism for their selection other than the anthropic principle.

02

Black hole information paradox

The information-theoretic properties of black holes cannot be reconciled with geometric spacetime without contradiction.

03

Dark sector

Dark matter and dark energy are described as separate phenomenological patches, without a common cause.

04

Passive vacuum

Four forces are recognised, yet space remains a passive stage. Vacuum energy, the cosmological constant and QED polarisation remain unrelated.

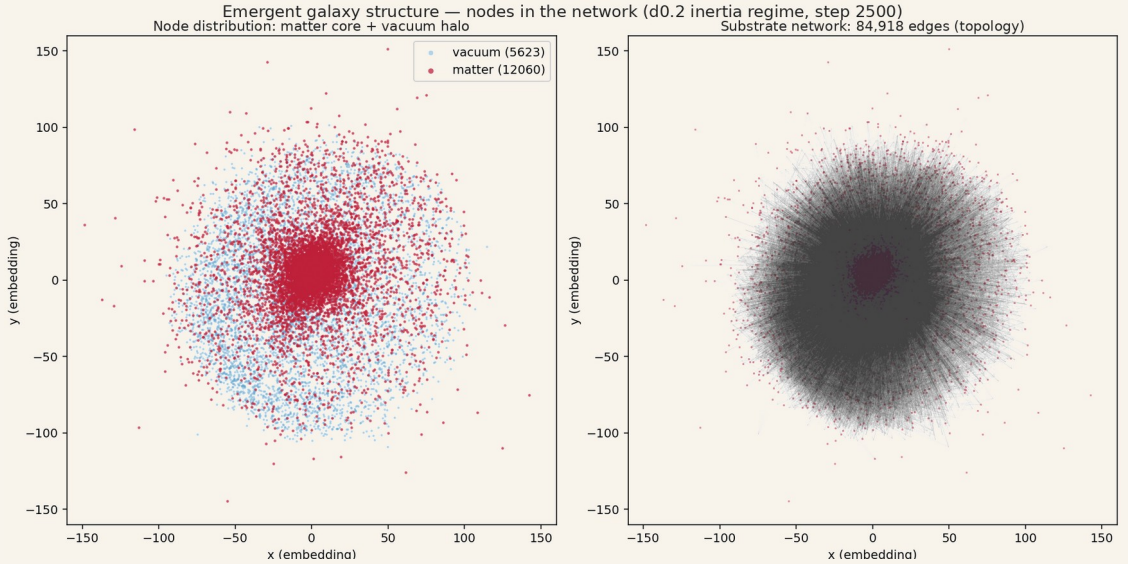
The EGT thesis: a single mechanism, the activity of the substrate, produces these phenomena together.

Reality is an energy-conserving graph.

The universe as a high-dimensional graph of relations through which energy flows. Physics is not a stage on which dynamics happens — it is the running execution of that dynamics.

Metric	= edge tension (energy)
Evolution	= interaction processes (Chronos)
Structure	= emergent (Quanta)

Stable structure is the answer to the question: which configuration of this graph is invariant under further evolution?



Emergent large-scale structure: matter core and vacuum halo form out of pure graph dynamics. No placed lattice.

Emergent Universe, d0.2 inertia regime, step 2,500: 12,060 matter nodes and 5,623 vacuum nodes, 84,918 edges.

The ECQ triad.

E — GROWS

Substrate sediment

Energy accumulates in the archive at the south pole through the activity of the fifth force.

C — ACCUMULATES

Chronos

Events stack up for as long as interaction takes place.

Q — SHRINKS

Matter energy

The matter sector loses energy to the substrate and grows progressively poorer.

COHERENCE STATE

$$\mathcal{K} = E \cdot C / Q$$

rises monotonically as the cycle ages (net $\times 10^3$ to $\times 10^4$ per generation)

The growing pressure E/Q forces structures into self-optimisation: the proposed thermodynamic mechanism of emergent complexity.

Measured in the runs as a strong, monotonic tendency. It is not proven to be a necessity.

Four postulates.

POSTULATE I

The spectral vector

Energy is fundamentally spectral: not a scalar quantity but a distribution over frequencies that carries the causal history of every interaction.

POSTULATE II

Resonant conductivity

Information routes itself. Energy propagates preferentially along spectrally resonant paths; the graph acts as a spectral filter.

POSTULATE III

Time as events

Time is not an external parameter but the cumulative number of interactions. A system at rest accumulates no time.

POSTULATE IV

The fifth force

The activity of the substrate itself. It unifies vacuum energy, dark energy, the cosmological constant and vacuum polarisation as one interaction.

Together they yield the ECQ triad, the thermodynamic engine of self-organisation.

§ 05 — THE INSTRUMENT

Emergent Universe, the physics engine.

A scale-invariant Rust engine: the laws hold identically, independent of graph size. Configurations are not sought by gradient descent, they emerge from physical dynamics.

CONSERVATION

Energy is only moved, never created. Across complete multi-generation runs including collapse and re-seed, the global drift stays on the 10^{-10} scale; the most event-rich of the fourteen cells sits at 1.3×10^{-9}.

ONE CALIBRATED SCALE

A binary search on the string tension σ of the Y-junction hadron until the minimised hadron energy hits the proton mass: 938.27 MeV. Genuinely sensitive ($E \sim \sqrt{\sigma}$) and bracket-independent.

TWO DECLARED ANCHORS

$\alpha^{-1} = 137.036$ is a CODATA input, not an emergent measurement; an earlier circular derivation was removed. The neutron–proton splitting (+1.293 MeV) is likewise declared, because the string model alone yields the wrong sign.

DETERMINISM

Bitwise reproducible, all draw sites through one seeded stream. This is what makes the campaign on the next slide possible: frozen declaration, deterministic replays, per-operator audits.

In the hot phase the substrate is an energy and interaction network. The route to spacetime is open.

Fourteen cells, frozen declaration.

Ten ensemble cells, three full-detail cells at 2×10^5 steps, one triple-scale cell. Every census mass-based, every criterion frozen before the run.

10^{-10}

Global energy drift across complete multi-generation runs, including collapse and re-seed. The most event-rich cell sits at 1.3×10^{-9}, and its accumulation follows the activity.

The conservation claim of this deck rests on fourteen cells.

exactly zero

How the charge census closes in all fourteen cells — through all 121 stellar collapses, that is, precisely in the regime whose latent leak the audit had found.

4×10^{-13}

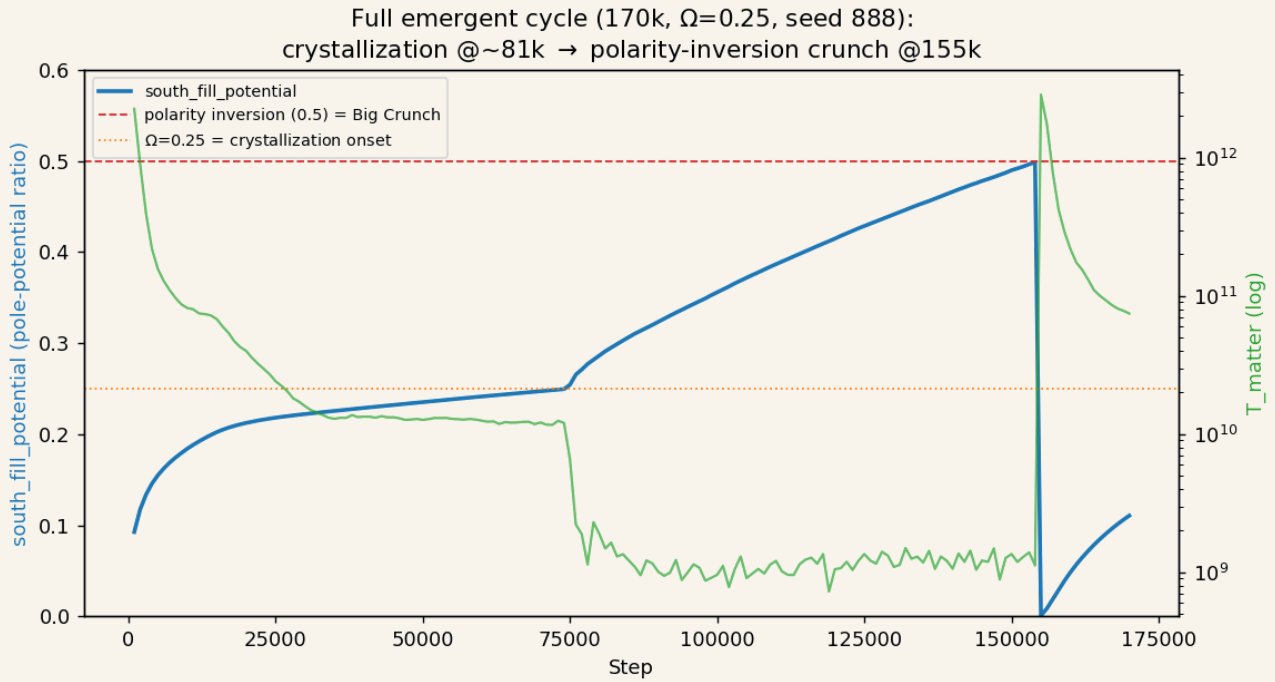
How tightly the four-sector partition of the ECQ balance closes.

10.7 M

Fusion events, booked transaction-exact.

Fourteen of fourteen cells complete the full cycle, and all fourteen successor generations run structurally healthy.

The tipping point has no button.



Showcase run: 170,000 steps, Ω = 0.25, seed 888. Crystallisation at ~81k, polarity-inversion crunch at 155k. The cycle length is emergent.

THE ERA SEQUENCE, INSTRUMENTED

One detail cell reads: recombination at step 12,000, first nuclei with Z ≥ 2 at 44,800, Z ≥ 3 at 46,300, deuteron-safe cold window from 52,000, crunch at 97,200.

THE CRUNCH IS THE INVERSION

Ω is the crystallisation onset. The crunch itself is the polarity inversion at a south fill level of 0.5 — literally EGT § 8.2, not a parameter.

THE GENERATIONS AFTER

All fourteen run structurally healthy. Two seeds close second full cycles within the window, one a healthy third generation.

The bimodality finding after the re-seed was a race condition: six of six affected seeds healed, three of three healthy ones unchanged, flipped bit-exact into the canon.

The ladder does not fade, it is harvested.

63 SPECIES UP TO A = 49

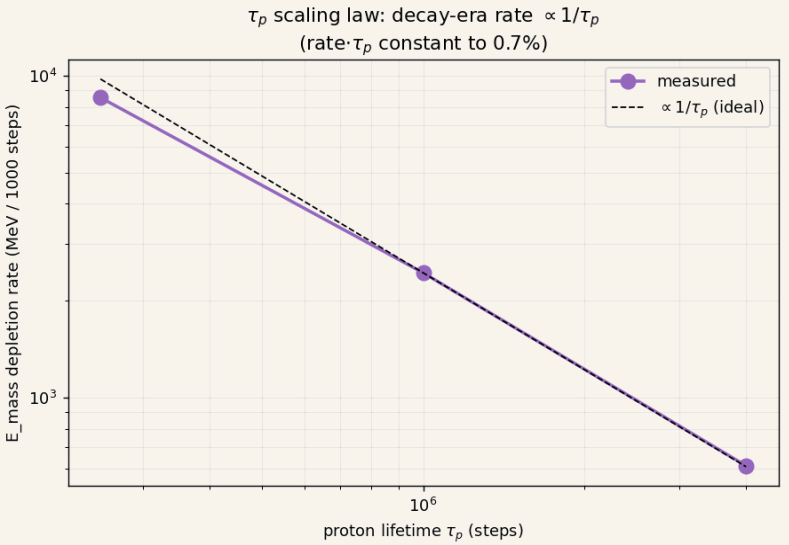
In the cold window the mass-based ladder stands at 255 deuterons, 141 ^{3}He, 153 ^{4}He and 147 nuclei with A ≥ 5; the triple-scale cell carries 63 distinct species up to A = 49, Z = 13.

121 COLLAPSES − 120 + 1

Above that the ladder ends physically: 121 collapse events resolve, via a three-pressure cascade — electron degeneracy, neutron degeneracy or neither — into 120 neutron stars and one white dwarf. Progenitors: A ≈ 40 to 64.

NO Z ≥ 26

In none of the fourteen cells. The iron edge is the next mapped distance on the scale axis, not a failure of fusion.



The era sequence reproduces Adams–Laughlin with no design target. Rate · τ_p is constant to 0.7%: what is measured is the role of τ_p as the clock of the decay era; its numerical value remains declared.

Most stellar activity lies in the successor generations: 24 collapses before the repair, 121 after. In this cosmology, generation two is the stellar era.

§ 09 — THE DARK SECTOR

A Λ slot without Λ.

The vacuum substrate carries energy in the same ledger as matter and gravitates in the Friedmann source density. It has no radiative export channel: it holds energy and curves, and it does not shine.

DARK MATTER, MEASURED

Share of the total density, read directly from the ledger partition: 39 to 59% at boot, 45 to 100% before collapse. With no dark component inserted.

DARK ENERGY, STRUCTURAL

ρ = (E_matter + E_vacuum) / n_space. The matter term dilutes with volume, the vacuum term does not — more space brings its own energy with it. No Λ exists in the code.

A PARAMETER-FREE PREDICTION

Late in the cycle H becomes vacuum-dominated and lands on the prediction $H_0 \cdot \sqrt{(\bar{e}_{vac}/\rho_0)}$, at a ratio of 1.10 to 1.20. There is no de Sitter phase: the crunch closes the cycle first.

BLACK HOLES

120 horizon observations at 27 nodes. Boundary growth correlates weakly positively with swallowed mass ($\rho = 0.22$). The area law for information is a characterised negative.

The FRW vocabulary is a reading; EGT has no Einstein tensor. On the detail scale the measured ratio falls below one — declared openly.

Pre-registered testing: passed and refuted.

Criteria, seeds and verdicts are frozen before every run and stand unchanged afterwards, whether they come out for or against the theory.

PASSED

- Scale criterion: frozen in advance, Kendall $\tau_b = -0.867$ across all three seeds, one-sided $P = 0.0083$ per seed.
- Helium prediction: declared before the measurement. Charge conservation as canon doubles the yield in the slow regime, 0.013 → 0.028, with no tuning.
- Export efficiency wager: $+0.058 \pm 0.003$, within the pre-registered band.
- E_{bind} falsification test: with both SED gates off, E/N goes to 1.00 instead of 141.5.

FALSIFIED AND REPLACED

- Virial crunch trigger: refuted by a proxy-free test. The trigger is the south fill level, not the pressure balance.
- Sakharov dilution: still compatible across two scales, excluded across the pre-registered third.
- "α deviation ~0%": withdrawn once it was recognised as true by construction.
- Two accounting defects: a beta-decay counter and a fusion gate that leaked an elementary charge. Both found by per-operator audit, campaign re-run from scratch afterwards.

EGT resolves the conflict between quantum mechanics and relativity through emergence rather than quantisation — in the tradition of Sakharov, Jacobson, Verlinde and the causal sets.

§ 11 — WHERE IT STANDS

What does not emerge.

Two declared anchors

α^{-1} is a CODATA input, the neutron–proton splitting likewise. Neither is an emergent measurement.

26, or 70 to 80

Counted narrowly — canon-active, continuous, not empirically anchored — around 26 free constants. Counted the way a hostile referee counts, with thirteen cadences and roughly forty hard-coded coefficients: 70 to 80.

Primordial nucleosynthesis

Off in both accessible regimes, in opposite directions: fast 0.10 helium at 0.3 metals, slow 0.013 at 0.03. Observed are 0.245 and near zero.

Isotropy

Hot 0.01 to 0.03, cold 0.25 to 0.31 with falling spread of the signal velocity. An equilibration trend, far from an emergent Lorentz symmetry.

Over-compact large-scale structure

The two-point correlation follows a power law with $R^2 = 0.98$, but with index 4 to 5 instead of the observed 1.8.

The strength of gravity

Present and measured, but four to five decades too strong. The declared central open problem of the theory, developed on the next slide.

The external discriminator is outstanding — the central open commitment. That holds for the whole field: no established approach has passed a confirmed, unambiguous external test.

Gravity is there. It is too strong.

Nowhere is it a force arrow between particles. Mass curves the metric operationally: where two massive nodes share a neighbour, a new edge is financed out of the tension of the parent edges. Attraction is the densification of space around mass.

READ OFF, NOT PLACED

The mean edge density on mass concentrations sits at eight times the vacuum baseline and falls to background within two to three hops. A gravitational potential, read directly off the substrate.

THE MASS COUPLING HOLDS

Measured passively on natural pairs in the cold window, nuclei against electrons at equal charge. Heavy pairs approach faster than their matched light twins: 8 of 9 cells, 167 of 217 pairs.

AND IT IS TOO STRONG

Every scale of the engine is hadronic, 156 MeV to 1 GeV. On the invariant $H \cdot \tau_n$ the coupling sits four to five decades above the physical value. The engine has no Planck hierarchy.

The only route compatible with the postulates is an emergent scale far above the proton mass, generated dynamically by scale-invariant running across many decades. That is precisely why the scale measurement on the next slide is more than a robustness check.

Sakharov dilution is excluded as the mechanism: across the pre-registered third scale the exponent collapses to $\alpha = 0.14 \pm 0.29$.

§ 13 — SCALE INVARIANCE

One grammar, from hadron to cosmos.

The postulates refer to no scale. The same energy-carrying edge grammar supports the bound hadron and cosmological structure, in one engine, under one calibration.

HADRONIC SCALE

Edges as QCD flux tubes

The EGT edge, an energy-carrying tension relation, follows the same effective grammar as the QCD flux tube: an exactly linear Regge trajectory, lattice-consistent Y-junction topology, constituent inertia from localisation alone.

COSMOLOGICAL SCALE

The clock runs with the scale

Measured across a full energy decade, against a criterion frozen in advance: Kendall $\tau_b = -0.867$ across all three seeds, one-sided $P = 0.0083$ per seed. The mean crunch time falls by 24% per energy decade.

The first quantity of the engine to pass a scale criterion declared in advance.

A result that the same formalism reproduces across different scales is stronger evidence than the same result from separate methods. Unification is operationalised rather than asserted.

§ 14 — POSITIONING

EGT in the field of quantum gravity.

Without recognition, tradition or budget: four candidates, compared structurally.

	EGT	STRING THEORY	LQG	CDT
Method	simulative (Emergent Universe)	analytical	analytical	simulative
Foundation	info & thermo postulates	symmetry principles	diffeo invariance	causal order
Continuum limit → GR	open	perturbative ✓	open	partly ✓ (4D)
Quantum formalism	none yet	✓	✓	✓ (path integral)
Confirmed external prediction	none	none	none	none
Maturity · attention	young · solo	very high	high	established

No approach has a confirmed external prediction; the causal sets come closest, with a rough Λ order of magnitude. The difference lies in maturity, tradition and budget. EGT's profile resembles that of CDT — simulative, discrete — plus frozen falsification discipline and a single calibration anchor.

§ 15 — THE PLATFORM

AEON COSMOS: the engine as a cloud platform.

The engine runs on Google Cloud. Reviewers operate it directly in the browser, with no Rust build and no HPC of their own.

graphdynamics.org

Playable universe

A run in the browser, steerable live. Emergent structure, cycles and metrics are displayed continuously.

Guided tour of the paper run

The reference run from the paper, 40,000 steps, visualised and annotated chapter by chapter.

The paper for download

EGT_Results v0.3 sits there next to the runs it refers to.

Run management

Frontend, configuration and storage. Every run is repeatable and shareable.

Diagnostics

Ledger, conservation and regime diagnostics built in. Energy conservation is checked before every run.

Scalable to cluster

Architecturally laid out up to compute clusters, not yet run there for cost reasons.

This is what makes the results of this paper reproducible, and the scaling is the infrastructure for the open questions of scale.

§ 16 — WHAT WE ARE LOOKING FOR

Where we are seeking support.

01

Funding

Means to continue the research: seed ensembles, event-driven scheduling, the single-action derivation of the couplings, a scale axis beyond one decade, and the route to an external discriminator.

02

Scientific stewardship

An advocate with standing, for visibility and peer embedding: someone who follows the programme critically and carries its results into the research community.

WHAT ALREADY EXISTS

- A running engine (Emergent Universe, Rust)
- Reproducible, documented results
- A frozen falsification record
- Code under NDA for qualified reviewers

PANTAREON GMBH

Spacetime and quantum, from one substrate.

Gravity is present and measured in this substrate, on three levels and without a single force arrow. What is missing is its order of magnitude and a quantum formalism. A running instrument in the tradition of Sakharov, Jacobson, Verlinde and the causal sets — developed far enough to be examined.

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Code available under NDA for qualified reviewers.