How a Theory Is Built

One researcher. One postulate. One AI team.

The methodology behind Discrete Emergent Gravity — four years of AI-assisted research, ~80 specialist sessions, zero free parameters

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THE ORIGIN — INTUITIONS THAT PRECEDED ALL MATHEMATICS

"The starting point was an objection."

THE ASYMMETRY

In general relativity, spacetime is four-dimensional — three spatial and one temporal. But the three spatial dimensions behave consistently, while the fourth does not. Time curves differently, enters the metric with the opposite sign, flows in only one direction. In the standard framework, this asymmetry is treated as a foundational given. For Matteo Pinna, it was a signal that the description was incomplete — not the universe. A framework built on an unexplained asymmetry is not a foundation. It is a symptom. The correct response: remove time from the foundation entirely.

THE DICE

Time is not a dimension of nature. It is what you observe when entropy increases across a discrete substrate. The intuition came from watching dice: fill a container halfway, shake it, and they spontaneously stack into ordered columns — not because any force commands them, but because the statistics of expansion leave order as the highest-entropy configuration. Gravity belongs to the same class as centripetal force: real in its effects, fictitious in its foundations. Mass does not attract. An expanding discrete spacetime produces an apparent inward pull as a statistical consequence.

THE CONSTRAINT

The third conviction was the most constraining: nature does not use complex machinery to describe itself. Luciano Burderi — astrophysicist, teacher in Cagliari — once remarked, almost in passing, that elaborate mathematics could not be the true base of a nature that is actually simple. That sentence stayed. If a description requires fine-tuned parameters added by hand, it suggests we may be describing symptoms rather than causes — that the theory is not yet operating at the deepest level. Zero free parameters was therefore not a goal to aim for. It was a requirement to impose from the beginning. These three convictions preceded all mathematics by years.

FROM FIRST INTUITION TO FORMALISED THEORY

2017 – 2018
THESIS & FIRST CONVICTIONS

MSc thesis on Padmanabhan's entropic gravity. The asymmetry objection forms: time cannot be a peer dimension of space. An early conviction takes hold — that gravity is not a fundamental force, that dark energy as a separate entity feels unnecessary, and that something in the geometry of spacetime itself must carry the explanation.

All intuitions. No formalism. By hand, alone.

2018 – 2025
INDEPENDENT RESEARCH

Seven years of thought experiments, hand calculations, private notes. The dice analogy crystallises gravity as a fictitious force. The belief that complexity signals a wrong description deepens into a methodological constraint.

No institution. No collaborators. No formal output. The ideas wait for a formalism capable of carrying them.

2025 – 2026
THE AI PROGRAMME

AI deployed as structured research infrastructure. 11 phases, ~80 specialist sessions, five-role editorial pipeline. The intuitions of seven years meet the rigour of formal derivation.

Seven landmark results. Zero free parameters. DEG Manifest v3. GeomGravX Tartu 2026.

2017 PROGRAMME ORIGIN	**11** RESEARCH PHASES	**~80** SPECIALIST AI SESSIONS	**7** LANDMARK RESULTS	**0** FREE PARAMETERS

RESEARCH PHASES

PH. 1–2 · Ch. 1–6 — **Foundations — Time, Gravity, Λ**
Time emergence from entropy maximisation. Newton's law and Einstein equations derived. Λ predicted to within 1.4σ of Planck 2018.
[Λ predicted ✓]

PH. 3 · Ch. 7–9B — **Astrophysics — Galaxies, GW Speed**
MOND-like acceleration. GW170817 forced conformal coupling discovery — an observational falsifier produced a theoretical result.
[Conformal coupling ✓] [Course correction 7→7B]

PH. 4 · Ch. 10–14 — **QG — BH Entropy, CMB, RG**
Black hole entropy S = N ln 442 derived. Wheeler-DeWitt cosmology. First renormalisation group analysis.
[BH entropy exact ✓]

PH. 5–6 · Ch. 15–21C — **Standard Model Embedding**
SU(21)→SM. Three generations from $SU(3)_{fam}$. Fermion masses, CKM, CP violation, leptogenesis, sterile neutrino DM candidate.
[SM embedding ✓]

PH. 7–9 · Ch. 22–43 — **Higgs Sector, Fine-Tuning**
φ_{DEG} = 0.598 rad pinned by seven independent constraints. Higgs mass predicted: 124.8 ± 2.4 GeV — 0.19σ from PDG, no fitting.
[m_H = 124.8 GeV ✓] [Δ_{min} = 7.3 certified]

PH. 10–11 · Ch. 44–57 — **QG Completion — Page Curve, WdW**
Area spectrum derived. Page curve exact at leading order. Wheeler-DeWitt unitarity proved exactly. Analytic ceiling: 99%.
[WdW unitarity exact ✓] [Page curve ✓]

> *"The AI never said 'what if time isn't fundamental.' That came in 2018, by hand, alone."*
> — Matteo Pinna

THE VIRTUAL TEAM — ALL AI SPECIALISTS

PRINCIPAL INVESTIGATOR
Matteo Pinna
Directed all sessions. Provided all founding intuitions. Assessed every result. Sole author of all work. The human who held the full picture across all 80 sessions simultaneously.

STRATEGY
Architecture chats
Phase mapping, dependency graphs, branching protocols before each session

PHYSICS
~57 specialist sessions
Each assigned one domain, one objective, explicit success/failure criteria

CONTINGENCY
~25 branch sessions
Pre-planned fallbacks triggered when a main session hit a wall

SYNTHESIS
Phase synthesis chats
Cross-verified all results. Hostile reviewer mode. Open problems stated explicitly.

REVIEW & CROSS-CHECKING

Epistemic tagging
Every result carries a precision tag. No untagged claim enters any document.

Phase synthesis
After each phase: cross-verification matrix, assessment written for a hostile reviewer.

Branching protocol
If a derivation failed, the pre-planned branch was triggered — not the result modified to fit.

Negative results recorded
n_s = 4, κ_V tension, MOND gap: all stated openly in the Manifest. Not papered over.

EDITORIAL PIPELINE — FIVE ROLES PER PAPER

PI	A	B	C	D	E	P
DIRECTION	PRIMARY AUTHOR	CLARITY EDITOR	CRITICAL REVIEWER	STYLE ENFORCER	FINAL POLISH	JOURNAL FORMATTER
Sets scope, reviews every checkpoint, final authority.	→ Research output → full technical draft.	→ Readability without touching technical content.	→ Hostile-but-fair. Triggers revision loop back to A.	→ Trained on author's work. Consistent voice and notation.	→ LaTeX, grammar, figures, references.	→ Journal style, cover letter, reviewer suggestions.

EPISTEMIC TAG SYSTEM

[DERIVED] [EXACT] [SEMI-DERIVED] [APPROXIMATE] [OPEN] [NOT DERIVED] [RULED OUT] [SPECULATIVE] [COINCIDENCE]

Every result in the Manifest carries one of these tags — making the epistemic status of every claim explicit and machine-readable. Designed before the first session and applied without exception throughout.

WORKING WITH AI — SEVEN CHALLENGES NAVIGATED

AI BIAS
Minimum viable result
At every stage the AI recommended proceeding as soon as a result was defensible. Correct academic practice — wrong for DEG, where internal consistency mattered more than speed.
→ Higgs mass pushed through Chats 28–30 until κ_{FN} derived from group theory at 0.2% precision.

AI BIAS
Canon over intuition
When intuitions pushed against established physics, the AI defaulted to trusting the canon. Each override required stating the intuition as a hard constraint, not a suggestion.
→ Chat 7→7B: forced the hybrid sterile neutrino model with a genuine geometric component.

METHODOLOGY
Category error, not physics failure
30+ attempts to reproduce n_s ≈ 0.963 all failed. The AI kept treating this as a DEG physics problem — using canonical physics that presupposes already-formed spacetime.
→ T_{reheat} identified as DEG's geometric origin. n_s = 4 is a structural boundary, not a gap.

METHODOLOGY
Silent errors across sessions
Individual sessions were unreliable in isolation. Unstated assumptions and skipped steps accumulated silently. The multi-layer review was not optional — it was load-bearing.
→ 4π convention error: Δ = 71 sat unchallenged. True value 18.2. Would have propagated without review.

METHODOLOGY
Stopping at "good enough"
The AI consistently stopped at minimum acceptable error. Numerical closeness as sufficient rather than necessary-but-not-sufficient was a constant tension to manage.
→ Δ_{min} = 7.3 certified in Chats 41–43 after AI was satisfied at Δ = 18.2.

ARCHITECTURE
No persistent memory
AI has no memory between sessions. Results and corrections accumulated across 80 sessions with no automatic reconciliation. Early results could be silently contradicted by later ones.
→ Project folder + Master Assessment + epistemic tags: every value traces to a specific session and verdict.

COMPUTATIONAL LIMIT
The boundary where AI stops — DEG-L lattice
One open problem cannot be resolved by AI at all: the DEG-L lattice computation. Resolving κ_V, K_{fam}, and the cosmological constant precision requires a full $SU(3)_{fam}$ lattice simulation — months of HPC time on a supercomputer cluster, human physicists, real infrastructure. The AI team wrote the complete simulation specification (Chat 38) and stopped there. This is the honest boundary of what an AI research team can do. The computation remains open.
→ HPC collaboration welcome. This is an open co-authorship opportunity. Contact: matteo@deg-gravity.com

FROM RESEARCH SESSION TO FINALISED RESULT — ONE EXAMPLE

RESEARCH CHAT OUTPUT
"Chat 27: Φ_{DEG} = 0.252 rad satisfies 7/7 constraints. m_H = 124.8 GeV. Verdict: PASS. Recommend proceeding to paper assembly."
AI recommendation: proceed now.

→

AFTER CHATS 28–30 (PI OVERRIDE)
κ_{FN} = 1.369 from SU(21) A_2 root lattice, 0.2% match. Φ_{DEG} = 0.598 rad [APPROXIMATE]. m_H = 124.8 ± 2.4 GeV [SEMI-DERIVED]. Seven constraints satisfied.
Structurally complete. Ready to proceed.

GEOMGRAVX AI SESSION — FRIDAY 3 JULY 2026

"When do you expect AI to make a sufficiently novel intellectual contribution in deriving a physics result that it would merit co-authorship?"

GeomGravX 2026 AI session survey — Friday 3 July. This poster is one data point. The founding intuitions came from years of solitary thought experiments. The formalisation and rigour came from a structured AI team. Where exactly is the line? Come find us at the poster.

WHAT AI MADE POSSIBLE

DEG spans six distinct domains of physics simultaneously: quantum gravity, cosmology, particle physics, astrophysics, statistical mechanics, and information theory. In a traditional collaborative setting, a programme of equivalent scope would typically require 10–15 people — domain specialists, a principal investigator, reviewers, and editorial staff — working across multiple institutions.

In terms of time, a well-funded group covering quantum gravity, Standard Model embedding, and cosmology at this depth would represent a 15–20 year research programme. The AI-assisted phase of DEG reached analytic completion in under two years. In terms of cost, a research group of that size over five years in Europe — salaries, overhead, conferences, computing — would run €3–5 million at minimum. The AI programme cost a fraction of a per cent of that.

For a single independent researcher, this breadth was only possible because the AI team could be redirected to any domain in the next session — without the constraints of academic specialisation. Not being embedded in one specialised field was a structural advantage: it allowed the physics to be seen as a whole rather than as isolated sectors.

This is perhaps the clearest demonstration of what AI enables for independent research: not just speed, but *breadth without dilution*. The order-of-magnitude estimates above are rough — but the direction is not.

DEG ACROSS PHYSICS — COVERAGE COMPARED TO STRING THEORY AND LQG

The table below shows which physical phenomena each framework currently addresses and how.

PHENOMENON / PROBLEM	DEG	STRING THEORY	LQG
Cosmological constant Λ	Derived from atom statistics. Λ_{pred} within 1.4σ of observation. No fitting.	Landscape of ~10^{500} vacua. No unique prediction.	Not addressed.
Higgs mass	Predicted: 124.8 ± 2.4 GeV from CP-violating observables. 0.19σ from PDG. No fitting.	No prediction from first principles.	Not addressed.
SM gauge group	Derived: SU(21)×U(1) → SM via group branching. No fitting.	Requires choice of compactification. Many possible gauge groups.	Not addressed.
Three generations	Derived from $SU(3)_{fam}$ weight lattice geometry.	Not derived. Accommodated.	Not addressed.
Black hole entropy	Derived: S = N ln 442 from internal states.	Derived via D-brane state counting for extremal BH.	Derived: $S = A/4l_P^2$ from spin network.
Black hole information	Exact: finite-dimensional Hilbert space forces unitarity. Page curve derived.	Partial: ER=EPR conjecture. No complete derivation.	Not addressed.
Singularity resolution	*Discrete structure prevents r→0. Not rigorously derived.*	Not addressed in perturbative limit.	Derived: loop quantisation removes singularity.
Free parameters	Zero. All coefficients derived from g = 442.	Many. Compactification moduli unfixed.	Few. Barbero-Immirzi parameter and others.
Lorentz invariance	Derived: RG irrelevance of Lorentz-violating operators at low energy.	Preserved by construction.	Tension: some formulations predict Lorentz violation at Planck scale.
Spectral index n_s	*Open: DEG gives n_s = 4. Pre-geometric phase not yet modelled.*	Accommodated in many inflationary models.	Not addressed.
MOND / galaxy dynamics	*Semi-derived: a_0 27% below observed. Coarse-graining gap open.*	Not addressed.	Not addressed.
Hierarchy problem	Δ_{min} = 7.3 certified. Technically natural without SUSY.	Addressed via SUSY. Experimentally unconfirmed.	Not addressed.

DEG open problems are shown explicitly — n_s and MOND remain unsolved. String theory and LQG statuses reflect mainstream consensus as of 2026. This table makes no claim about the correctness of any framework.

Full manuscript · all derivations · 17 falsifiable predictions
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