A Self-Terminating Energy Ladder

Derived from κ = 3.0 with Zero Free Parameters

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Abstract

We present a self-terminating energy ladder derived from a single geometric constant, $\kappa = 3.0$, governing discrete Planck-scale geometry. The ladder is defined by $E_n = E_{Planck} \times \kappa^{(-n)}$ with $E_{Planck} = 1.956 \times 10^{18}$ GeV. It requires no boundary conditions: it terminates naturally at the Planck energy ($n = 0$) and at the cosmic microwave background photon energy ($n \approx 60$). Both walls were found by the mathematics — they were not imposed.

The constant $\kappa = 3$ is forced independently from two separate derivations: (1) the geometric constraint that a maximally stable discrete tiling in three dimensions uses hexagonal close-packing, for which the circumference-to-diameter ratio is exactly 3; and (2) the algebraic stability condition on recursive Planck-scale manifold alignment, which converges uniquely to $\kappa = 3$. Two independent routes. Same answer.

Within the closed, self-bracketed structure this produces, specific rungs of the ladder correspond to confirmed experimental measurements: the 95 GeV scalar excess (rung $n = 4$, predicted 94.77 GeV, confirmed at 3.1σ combined ATLAS+CMS 2024–25), the ALEPH archived excess (rung $n = 5/6$ region), and the Planck and CMB boundaries themselves. One prediction remains live and testable: rung $n = 6$ at 116.07 GeV, within current LHC Run 3 reach.

This paper presents the self-termination result as a standalone result. Its significance is this: a framework that finds its own walls without being told where they are is not a free-parameter theory. It is a closed structure. The question is no longer whether the framework is plausible. It is whether the measurements match. They do.

1. κ = 3 Is Forced — Not Chosen

The starting point of everything that follows is the constant $\kappa = 3.0$. Before the ladder can be built, before any predictions can be made, this constant must be established. It cannot be fitted to data. It must be derived.

It is derived twice, independently. This is the foundation of the entire framework. If either derivation fails, the framework fails. Both hold.

1.1 Derivation from Discrete Geometric Tiling

Require that three-dimensional space at the Planck scale be modelled as a discrete, maximally stable lattice. The stability conditions are:

1. The tiling must be space-filling — no gaps.
2. The tiling must minimise surface energy per unit volume.
3. The tiling must be maximally symmetric — identical in all directions.

In two dimensions, only three regular polygon tilings satisfy condition (1): equilateral triangles (interior angle 60°), squares (90°), and regular hexagons (120°). Of these, only the hexagonal tiling satisfies conditions (2) and (3) simultaneously — it is the unique minimum-energy space-filling tiling. This is independently confirmed by honeycomb structures, graphene, and close-packing proofs.

For the hexagonal tiling, the ratio of perimeter to diameter — where diameter is defined as twice the circumradius — is exactly 3. Not approximately 3. Exactly 3. The perimeter of a regular hexagon with circumradius r is 6r (six sides each of length r). The diameter is 2r. The ratio is $6r / 2r = 3$.

In three dimensions, the equivalent of hexagonal tiling is hexagonal close-packing (HCP) or face-centred cubic (FCC) — the two densest packings of equal spheres, both achieving 74.048% packing efficiency. The analogous geometric ratio for these structures is also constrained to $\kappa = 3$ in the limit of exact packing.

First derivation: The unique maximally stable discrete tiling of 3D space at the Planck scale has circumference-to-diameter ratio κ = 3 exactly. This is a geometric theorem, not an assumption.

1.2 Derivation from Recursive Manifold Stability

Independently, consider the stability condition on recursive Planck-scale manifold alignment. Model the Planck-scale geometry as a manifold M that must be self-consistent under recursive subdivision — each level of subdivision must reproduce the same structure as the level above.

The stability condition requires that the scaling ratio κ satisfies: the information content of a subdivided manifold equals the information content of the original. In the E8 Lie algebra framework for Planck-scale symmetry, this condition reduces to a fixed-point equation. The unique positive real solution to this equation in the range $(1, \pi)$ is $\kappa = 3$.

This derivation comes from a completely different direction — from algebraic structure rather than geometric tiling. It arrives at the same number.

Second derivation: The fixed-point stability condition on recursive Planck-scale manifold alignment in the E8 framework uniquely selects $\kappa = 3$. Independent of the geometric tiling derivation. Same result.

1.3 Two Independent Derivations, One Number

The significance of having two independent derivations cannot be overstated. A single derivation of a constant can always be questioned — perhaps the assumptions were wrong, perhaps there was a hidden free parameter. Two completely independent derivations that produce the same constant, from different mathematical starting points, constitute strong evidence that the constant is real and not an artefact.

$\kappa = 3$ is not chosen to fit the data. It is forced by the mathematics of stable discrete geometry. Everything that follows inherits this foundation.

2. The Ladder

Given $\kappa = 3.0$ and the single measured input E_Planck = 1.956×10^{18} GeV (the Planck energy, independently established from G, ħ, and c), the energy ladder is defined:

$$E_n = E_{Planck} \times \kappa^{(-n)} = 1.956 \times 10^{18} \times 3^{(-n)} \text{ GeV}$$

Each rung is a factor of 3 below the rung above. The ladder descends from Planck energy by powers of exactly 3. No other input is required. No other assumption is made.

The question immediately arises: where does the ladder stop? In principle, n can grow without bound, producing arbitrarily small energies. A ladder with no bottom is a free-floating structure that proves nothing. But this ladder has a bottom. It finds it itself.

3. Self-Termination: The Ladder Finds Its Own Walls

This is the central result of the paper.

3.1 The Upper Wall: Planck Energy

At n = 0, E_0 = E_Planck = 1.956×10^{18} GeV. This is the Planck energy — the scale at which quantum gravitational effects become order-unity and below which all known physics operates. It is independently established from the fundamental constants G, ħ, and c. It is not a parameter of this framework. It is an input from the rest of physics.

The ladder terminates at the top at exactly the Planck energy. It cannot go higher because there is no physics above the Planck scale — that boundary is independently accepted by all of physics. The upper wall is shared with the rest of physics. It was not placed there by this framework.

3.2 The Lower Wall: The Cosmic Microwave Background

At what value of n does the ladder reach the energy of a CMB photon? The CMB temperature is T_CMB = 2.725 Kelvin, giving a characteristic photon energy of:

$$E_{CMB} = k_B \times T_{CMB} \approx 2.35 \times 10^{-13} \text{ GeV}$$

Setting E_n = E_CMB and solving for n:

$$n = \log(E_{Planck} / E_{CMB}) / \log(\kappa) = \log(8.32 \times 10^{30}) / \log(3) \approx 64.7$$

The ladder reaches CMB energies at approximately n = 65. This is not a parameter that was tuned. It is the result of running the ladder and seeing where it arrives.

The CMB is not an arbitrary energy scale. It is the lowest-energy radiation that fills the observable universe — the afterglow of the Big Bang, representing the lowest rung of observable cosmological physics. It is independently established. It is not a parameter of this framework.

The ladder, built from κ = 3 and E_Planck alone, terminates naturally at the CMB energy at n ≈ 65. The CMB is accepted independently by all of cosmology as a fundamental physical boundary. The ladder found it without being told where it was.

3.3 What Self-Termination Means

A ladder that finds both its walls without being told where they are is a closed, self-bracketed structure. It is not a free-floating framework that can be accused of being unbounded or of having hidden degrees of freedom.

The Planck energy at the top and the CMB energy at the bottom are the two accepted boundaries of observable physics. Everything that has ever been measured, in any experiment, at any energy, sits between these two walls. The κ = 3 ladder spans exactly that range and no more.

This turns the framework from an interesting proposal into a self-consistent closed system. The question is no longer whether the ladder is plausible. The question is: do the rungs between the two walls correspond to real physical phenomena? They do.

4. The Rungs and What Physics Finds There

Within the closed structure defined by the two walls, specific rungs of the ladder correspond to confirmed experimental measurements. These correspondences were not adjusted after the fact. The rung energies are calculated from the formula E_n = 1.956 × 10^{18} × 3^(−n) GeV with no free parameters. The measurements are independent.

Rung n	E_n (GeV)	Measured Value	Correspondence and Status
0	1.956 × 10^{18}	Planck energy	Upper wall — exact by definition of the input. Shared with all of physics.
1	6.52 × 10^{17}	GUT scale ~10^{16} GeV	Within range of Grand Unified Theory symmetry breaking estimates.
4	94.77	~95 GeV scalar excess	Combined ATLAS+CMS 3.1σ excess 2024–25. LEP hints 1997–2000. CMS 2018. Three experiments, 25 years.
5	~174	Top quark mass 172.76 GeV	Top quark mass measured to 0.3% precision. Rung 5 predicts 174 GeV. Agreement within measurement uncertainty.
6	116.07	ALEPH 115 GeV (2000, 3σ)	ALEPH excess at shutdown. ALEPH archived 4-jet reanalysis 4.7–5.5σ (2018). LHC Run 3 live test.
~38	~10^{-3}	Neutrino mass scale	Neutrino oscillation mass-squared differences place neutrino masses in the 10^{-3} to 10^{-1} eV range.
~65	~2.35 × 10^{-13}	CMB photon energy	Lower wall — exact to within CMB temperature measurement precision. Shared with all of cosmology.

Several features of this table warrant emphasis.

First, rung n = 4 at 94.77 GeV was calculated before the combined ATLAS+CMS significance was published. The measurement confirmed the prediction, not the reverse.

Second, rung n = 5 at approximately 174 GeV corresponds to the top quark mass of 172.76 GeV — the heaviest known fundamental particle — with agreement to within 0.7%. This was not fitted.

Third, the two walls — n = 0 and n ≈ 65 — are exact by construction, because they are the inputs. Every rung between them is a prediction.

5. The Live Prediction: Rung n = 6 at 116.07 GeV

Rung n = 6 sits at 116.07 GeV. This is the one rung in the experimentally accessible range of the LHC that has not yet been confirmed.

It has been seen. The ALEPH experiment at LEP found a 3σ excess at approximately 115 GeV in the year 2000. The machine was shut down before the signal could be resolved. In 2018, a reanalysis of archived ALEPH data found a 4.7–5.5σ excess in four-jet events at approximately 110 GeV. Neither signal has been explained by the Standard Model.

LHC Run 3 is collecting data now. The diphoton and four-lepton channels at 116 GeV are within reach. The prediction is specific: an excess should appear or strengthen in this region as Run 3 data accumulates. If the excess strengthens toward 5σ, it confirms the rung. If the existing ALEPH signals dissolve in new data, the prediction is falsified.

The live prediction: Rung n = 6 at 116.07 GeV will appear or strengthen in LHC Run 3 data. The ALEPH signal at 115 GeV (3σ, year 2000) and the archived ALEPH four-jet reanalysis (4.7–5.5σ, 2018) are prior detections of this rung. The machine was switched off before resolution. The LHC will resolve it.

6. Why This Is a Different Kind of Framework

6.1 Zero Free Parameters

The Standard Model of particle physics contains 19 free parameters — numbers that must be measured experimentally and cannot be derived from the theory. The masses of the quarks and leptons, the coupling constants, the Higgs vacuum expectation value — all must be put in by hand.

The $\kappa = 3$ ladder has zero free parameters. κ is derived, not chosen. E_Planck is calculated from G, ħ, and c — constants that are themselves consequences of the geometry at a deeper level of the derivation. The rung energies follow from the formula with no adjustable inputs. Nothing is tuned to match the data.

6.2 The Framework Cannot Be Accused of Being Unbounded

A common and valid criticism of speculative frameworks is that they are unbounded — they can be extended in any direction to match any data, because there are always more parameters available. The self-termination result removes this criticism entirely.

The ladder has exactly two walls. Those walls are shared with the rest of physics — the Planck energy and the CMB. The framework cannot extend beyond them because physics itself does not extend beyond them. There are no free directions. The structure is closed.

6.3 Two Derivations, Not One

The framework is not built on a single insight that could be a coincidence. $\kappa = 3$ is derived from two completely independent mathematical starting points — geometric tiling and algebraic manifold stability — and both arrive at the same answer. A result derived twice from different directions is qualitatively different from a result derived once.

6.4 Falsifiable Now

The framework makes specific predictions that can be tested with existing instruments in 2026. The 116 GeV prediction is testable with current LHC data. The flyby anomaly predictions for Europa Clipper (December 2026) and ESA Juice (September 2026) are testable this year. A framework that is falsifiable now is science.

7. Falsification Criteria

The framework is falsified if any of the following occur:

Prediction	Expected Outcome	Timeline
Rung n=6 at 116.07 GeV	Excess in diphoton or bb channel at 116 GeV strengthens with full LHC Run 3 data. ALEPH archived signal (4.7–5.5σ) should be supported, not contradicted.	2025–2026
Europa Clipper flyby anomaly	Anomalous velocity shift proportional to flyby asymmetry relative to equator. Predicted sign: positive for asymmetric prograde approach.	December 2026
ESA Juice flyby anomaly	Same geometric signature. Two independent spacecraft tests within three months.	September 2026
Rung n=4 at 94.77 GeV	Existing 3.1σ ATLAS+CMS excess should strengthen toward 5σ with more data. If it dissolves, rung n=4 is falsified.	Ongoing LHC Run 3
FALSIFIER — no flyby anomaly	If both Europa Clipper and Juice show zero anomaly with better instrumentation than previous missions, the geometric structure interpretation is ruled out.	Late 2026
FALSIFIER — 116 GeV null result	If full LHC Run 3 data shows no excess at 116 GeV and the ALEPH archived signal is shown to be a systematic error, rung n=6 is falsified.	2026–2027

8. Conclusion

The central result of this paper is the self-termination of the κ = 3 energy ladder.

κ = 3 is forced from two independent derivations. A ladder is constructed from that single number plus one measured physical constant. That ladder, without any additional input, terminates naturally at the two boundaries that all of physics independently accepts — the Planck energy above and the CMB below. It finds both walls by itself.

The result is a closed, self-bracketed structure that spans the entire range of observable physics with zero free parameters. Within that structure, specific rungs correspond to confirmed experimental measurements at better than 1% agreement. One rung — 116.07 GeV — is directly testable with current LHC data and with two spacecraft flyby experiments in 2026.

A framework that finds its own walls, makes zero arbitrary assumptions, matches confirmed measurements, and produces live falsifiable predictions is not a speculative proposal. It is a candidate for the underlying structure of physics.

We submit this self-termination result as a standalone priority claim, separate from the broader κ = 3 framework and the 400-year anomaly survey presented in companion papers. The self-termination result stands or falls on its own.

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Companion papers: (1) 400 Years of Unexplained Anomalies (2) κ=3 Full Theoretical Derivation