Epistemic Status of the Two-Planck Derivation of the Cosmological Constant

A Critical Dialogue on Foundational Commitments, Scheme Dependence, and Falsifiability

Keith Taylor VERSF Theoretical Physics Program, Companion Paper Series

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This Paper's Role: The Two-Planck framework is developed across four companion papers: *Two-Planck Principle* (quantitative predictions and experimental signatures), *Relational Geometry* (foundational arguments and constraint universality), *Structural Closure* (independent verification of K = 7 and the CSS attractor theorem), and *Microphysical Foundations* (referee-standard derivations of all Route M parameters). Together, these papers construct a complete derivation of the cosmological constant from relational geometry without tunable parameters (and without fitting Λ itself), with Routes A/B using the measured expansion history H(z) only to evaluate the horizon scale.

This fifth paper serves a different and complementary function. It does not extend the derivation or introduce new results. Instead, it subjects the completed framework to a structured critical examination — a formal dialogue that identifies the strongest available objections, traces their resolution, and arrives at a precise characterization of what the derivation establishes and what it assumes. Its purpose is to make the epistemic status of the framework fully explicit: to distinguish the claims that are rigorously established from those that remain conditional, to delineate the foundational commitments from the derived consequences, and to specify the concrete steps (numerical and experimental) that would elevate the current result from order-unity consistency to quantitative confirmation or falsification. The paper is intended both as an honest self-assessment and as a roadmap for referees engaging with the companion papers for the first time.

Abstract

The Two-Planck framework derives the cosmological constant $\Lambda \approx 1.1 \times 10^{-52}\ m^{-2}$ from relational geometry without adjustable parameters, through three convergent routes: an infrared cosmological route (A), a mesoscopic force-emergence route (B), and an ultraviolet microphysical route (M). This paper presents a structured critical dialogue examining the epistemic status of this derivation. Five principal concerns are addressed: whether the foundational commitments are independently motivated or implicitly selected, whether scheme dependence of the blocking prescription undermines the prediction, whether three-route convergence constitutes a nontrivial consistency check, the role of percolation threshold uncertainty in the error budget, and whether the framework is genuinely falsifiable.

We argue that the derivation is **conditional but non-retrofitted**: given a small set of independently motivated structural commitments, the cosmological constant is fixed without adjustable parameters. The agreement of Route M (which uses no cosmological input) with Routes A and B constrains residual scheme dependence to an O(1) multiplicative factor, consistent with standard behavior of dimensional-transmutation scales. The framework is maximally predictive and explicitly falsifiable, with improved numerical precision serving only to sharpen tests rather than rescue the theory.

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1. Introduction

The cosmological constant problem — the enormous discrepancy between quantum field theory predictions and the observed vacuum energy density — has resisted resolution for decades. The Two-Planck framework, developed across a suite of four companion papers, claims to resolve this problem by deriving Λ from pure relational geometry. The derivation proceeds through three convergent routes, with genuine structural independence between the microphysical Route M and the cosmological Routes A/B, yielding overlapping predictions for a coherence scale $\xi \approx 88$ μm, from which Λ follows directly.

Any such claim demands rigorous scrutiny. This paper presents a structured critical examination of the derivation's epistemic status, organized as a dialogue between the framework's proponent (Author) and a critical referee (Referee). The dialogue addresses the strongest available objections and traces their resolution through successive rounds of refinement. The result is a precise characterization of what the derivation establishes, what it assumes, and what remains to be demonstrated.

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2. Summary of the Three-Route Derivation

Route	Method	Scale Domain	Input	Predicted ξ
A	UV/IR gravitational consistency	Infrared (horizon)	H(z) measurements	88 μm
B	Foam→G amplitude with channel dilution	Mesoscopic	Converges to A	88 μm
M	Dimensional transmutation + percolation	Ultraviolet (Planck)	Foam combinatorics only	60–320 μm

Route M is the most significant for epistemic purposes: it derives ξ purely from Planck-scale simplicial foam combinatorics with no cosmological input. The dimensional transmutation formula is:

$$\ln(\xi/\ell_e) = (1/2b) \cdot (1/g_0^2 - 1/p^c)$$

where $\ell_e = 2\ell_p$ is the emergence scale, $b = 14/16 = 0.875$ is the β-function coefficient, $g_0^2 = 1/128$ is the bare coupling from maximum-entropy principles, and $p^c \in [0.17, 0.30]$ is the percolation threshold. Here p^c enters through the Route M identification of an effective critical coupling $g^{c2} \equiv p^c$ for loop-channel percolation on the triangle adjacency graph (see *Microphysical Foundations*, §8.2), so the transmutation exponent has the standard form $(1/g_0^2 - 1/g^{c2})$. The central estimate ($p^c \approx 0.18$) yields $\xi \approx 75$ μm, overlapping the 88 μm from Routes A and B.

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3. The Foundational Commitments

3.1 Nature of the Commitments

Every serious derivation in physics rests on foundational commitments. General relativity rests on differentiable manifolds and metric compatibility. Quantum field theory rests on locality, Lorentz invariance, and Hilbert space structure. ΛCDM rests on homogeneity, isotropy, and a free Λ parameter. The Two-Planck framework rests on: (i) relational ontology, (ii) simplicial discretization, (iii) UV neutrality (maximum entropy at the emergence scale), and (iv) the minimal-doubling Kadanoff blocking prescription.

The framework differs from ΛCDM in one crucial respect: **its commitments are structural and non-numerical**. There is no free length scale, no fitted density, and no adjustable coupling. Once the commitments are fixed, Λ is not adjustable. This places the framework in an epistemic posture distinct from approaches that treat Λ as a free parameter.

3.2 Independent Motivation

Referee concern: The strength of the derivation depends on whether the foundational commitments are independently motivated or form a package implicitly selected to reproduce the observed Λ.

Response: Several of the core commitments have long, independent histories and are not introduced ad hoc. The relational ontology underlying the construction is standard in modern approaches to quantum gravity, including Regge calculus, spin-foam models, and causal dynamical triangulations. Simplicial discretization and coarse-grained foam structures are well-established tools rather than framework-specific inventions. The assumption of UV neutrality is a direct application of maximum-entropy reasoning in the sense of Jaynes: in the absence of distinguishing information at the ultraviolet cutoff, no bias toward particular microstates is permitted. These elements therefore precede any consideration of the cosmological constant.

3.3 The K = 7 Sensitivity Argument

The constraint count K = 7 is enumerated from the geometric requirements for triangle coherence in simplicial foam: three edge admissibility conditions, one loop closure condition, two embedding consistency conditions, and one orientation consistency condition. The companion paper on structural closure verifies K = 7 through two independent methods (information-theoretic and obstruction-theoretic).

The exponential sensitivity of the dimensional transmutation formula makes K the most decisive parameter:

K	**$1/g_0^2$**	**Approximate Exponent**	**ξ**
6	64	$(64 - 5.5)/1.75 \approx 33$	$\sim 10^{-20}$ m
7	**128**	**$(128 - 5.5)/1.75 \approx 70$**	**$\sim 10^{-4}$ m**
8	256	$(256 - 5.5)/1.75 \approx 143$	$\sim 10^{27}$ m

The mesoscopic window is genuinely narrow in parameter space. K = 6 gives a subatomic scale; K = 8 gives a cosmological scale. This is not fine-tuning — K is determined by simplex geometry. The reverse-engineering objection is difficult to sustain: one would have to argue that the axioms were selected knowing they would produce K = 7 specifically, but K falls out of simplex geometry in a way that is resistant to manipulation.

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4. Scheme Dependence and the Blocking Prescription

4.1 The Concern

Referee concern: The blocking prescription s = 2 carries the most weight among the foundational commitments, because the coherence scale ξ is an amplitude-like quantity rather than a critical exponent. In condensed matter contexts, universality guarantees scheme-independence of exponents, whereas non-universal amplitudes may depend on blocking conventions. Is there a universality argument that makes ξ scheme-independent?

Varying the blocking factor changes the β-function coefficient by O(1) factors:

s	N_micro = s^4	b = $14/s^4$	Effect on ξ
√2	4	3.5	Subatomic
2	**16**	**0.875**	**Mesoscopic (~75 μm)**
3	81	0.173	Cosmological

We emphasize that s is not treated as a continuous dial; the admissible class is restricted to locality-preserving, discrete blocking maps on the simplicial microcells. The table is intended only to illustrate the exponential sensitivity of ξ to coarse-graining amplitude choices.

4.2 Resolution via the Λ_QCD Analogy

The coherence scale ξ plays a role analogous to a dimensional-transmutation scale (e.g., Λ_QCD) rather than a scheme-dependent observable. While intermediate quantities may vary under changes of blocking prescription, the transmuted scale itself is fixed up to an order-unity multiplicative factor. In QCD, nobody argues that confinement is an artifact of the MS-bar scheme; the same logic applies here.

In the present framework, this factor is constrained by independent structural requirements, most notably the Two-Planck closure condition that equates the microphysical (foam/RG) route to the cosmological (horizon-based) route. The agreement of the microphysical Route M with the cosmological Routes A/B constrains admissible scheme dependence to an order-unity multiplicative factor, consistent with the expected behavior of dimensional-transmutation scales. This does not eliminate scheme dependence, but it prevents arbitrary tuning or retrofitting of the prediction.

Importantly, the value s = 2 was not selected to reproduce the observed Λ; it is the standard locality-preserving blocking choice adopted prior to any numerical evaluation. Alternative blocking schemes would generically lead to different coherence scales and, consequently, different vacuum energies — rendering the framework **empirically falsified rather than adjustable**. In this sense, scheme dependence becomes a controlled theoretical uncertainty rather than a free parameter, and is itself subject to falsification by improved numerical determination of p^c.

4.3 Remaining Status

The present agreement restricts admissible scheme dependence to an order-unity multiplicative factor, consistent with standard behavior in RG-generated physical scales. This factor is not free to vary arbitrarily: values parametrically different from unity would destroy the observed cross-route consistency and falsify the framework. This converts scheme dependence into a bounded theoretical uncertainty with a clear numerical route to reduction.

A high-precision determination of the percolation threshold p^c via Monte Carlo simulation would convert the present order-unity agreement into a quantitative test of scheme independence. The framework therefore makes a clear prediction: if correct, such simulations should yield a coherence scale whose multiplicative normalization lies within the constrained O(1) window already indicated by the cosmological route.

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5. Three-Route Convergence as Evidence

5.1 The Structural Independence

Referee concern: Routes A and B are not fully independent, since both rely on cosmological input through the measured expansion history H(z). What is the genuine evidential weight of the convergence?

Response: We agree that Routes A and B share cosmological input and are not fully independent of one another. The genuine structural independence is between Route M (microphysical foam/RG derivation) and Routes A/B (cosmological/horizon-based derivation). The micro–macro separation is the critical evidential feature.

Route M uses:

- 14 loop channels from 4-simplex combinatorics and the discrete Bianchi identity
- 16 microcells from minimal-doubling Kadanoff blocking
- 7 constraints from geometric enumeration of triangle coherence
- ~0.18 percolation threshold from triangle adjacency graph analysis

None of these quantities involve cosmological measurements. The convergence of Route M's prediction ($\xi \approx 75$ μm) with Routes A/B ($\xi \approx 88$ μm) therefore constitutes a nontrivial consistency check between ultraviolet combinatorics and infrared cosmology.

5.2 Precision of the Agreement

The current agreement is at the order-unity level rather than at the level of precision matching. The values $\xi \sim 75$ μm (Route M) and ~88 μm (Routes A/B) are consistent within an O(1) multiplicative factor. This level of agreement does not yet quantitatively fix the scheme-dependent amplitude, but it does constrain it to lie within the expected range for a dimensional-transmutation scale.

This limitation points to a concrete and testable next step. Monte Carlo simulation of triangle percolation in 4D dynamical triangulations would convert order-unity agreement into a quantitative test. The framework predicts that such simulations should confirm $p^c \approx 0.18$, tightening the three-route convergence from qualitative to quantitative.

Equivalently, the present cross-route agreement implies a multiplicative normalization $C \equiv \xi\_M/\xi\_A \approx 0.85$, and constrains C to remain within an order-unity band ($C \in [0.3, 3]$) if the framework is to remain viable. We adopt this as a conventional "order-unity" window (one decade wide) for the present epistemic assessment; future Monte Carlo determinations of p^c would replace it with a computed uncertainty band.

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6. Robustness and the Error Budget

6.1 The Discrete Bianchi Identity

The loop channel count $N_{loop} = 14$ rests on the discrete Bianchi identity ($\prod_{i=1}^{5} C_i = I$), which establishes $N^{cl} = 4$ as a topological necessity. This is mathematically rigorous: the cancellation from opposite orientation signs follows from $\partial^2 = 0$. Combined with $N\triangle = 10$ triangular faces (exact combinatorics of the 4-simplex), the total $N_{loop} = 14$ is established with the two constraint types shown to be algebraically independent via explicit U(1) constructions.

6.2 UV Neutrality and the Bare Coupling

The bare coupling $g_0^2 = 2^{-7} = 1/128$ follows from maximum-entropy reasoning under UV neutrality (the symmetry $C_k \leftrightarrow 1 - C_k$ for each constraint channel). Sensitivity analysis shows that 10% deviations from perfect neutrality shift ξ by factors of ~1.5–2, remaining within the predicted band.

Referee concern: Why should the foam at $\ell_e = 2\ell_p$ be maximally disordered rather than slightly biased by whatever dynamics produced the foam?

Response: This is a legitimate question. UV neutrality is a maximum-entropy prior in the Jaynes sense: it represents maximal ignorance about the UV foam ensemble. Any bias would require a physical mechanism to break the $C_k \leftrightarrow 1 - C_k$ symmetry, and such a mechanism would need to be identified and justified. The framework's robustness to 10% biases means that moderate departures from perfect neutrality do not destroy the prediction.

6.3 The Percolation Threshold

The dominant uncertainty is $p_c \in [0.17, 0.30]$, arising from incomplete knowledge of the effective clustering and coordination in simplicial foam. The Bethe approximation with coordination $z_{eff} \in [6, 7]$ gives $p_c \in [0.167, 0.20]$. Clustering effects (local clustering coefficient C = 0.6 within a 4-simplex) raise the upper bound. Cross-simplex dilution reduces effective clustering.

p_c	Exponent	ξ
0.17	69.7	60 μm
0.18	69.9	75 μm
0.20	70.3	110 μm
0.25	70.9	180 μm
0.30	71.2	320 μm

The Monte Carlo program identified in the companion paper is the single highest-value next step for tightening the prediction.

6.4 The Additivity Assumption

Referee concern: The claim that constraint satisfaction events are weakly correlated at the emergence scale (Assumption 4.9) is plausible for a disordered UV phase but hasn't been demonstrated from microphysics. If correlations are non-negligible, the effective N_{loop} could differ from the naive count of 14.

Response: This is acknowledged as an open question. The assumption is well-motivated by the disordered nature of the UV phase, where connected correlations are expected to decay within one block. Numerical simulation of the foam ensemble could test this directly. The sensitivity analysis shows that $N_{loop} \in [12, 16]$ changes b by ~15%, producing O(1) changes in ξ that remain within the predicted band.

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7. Falsifiability and Predictive Structure

7.1 Maximal Predictiveness

Unlike GR, which admits families of solutions once boundary conditions are specified, or the Standard Model, which requires ~25 free parameters, the Two-Planck framework makes a unique quantitative prediction. Once the foundational commitments are fixed, no parameters remain to absorb discrepancies. This is not a vulnerability but a strength: the framework is maximally constrained and explicitly falsifiable.

A single robust disagreement with observation would rule it out entirely. Specific falsifiers include:

- Detection of anomalies at scales inconsistent with $\xi \sim 88\ \mu m$
- Late-time equation of state $w \neq -1$
- Monte Carlo percolation threshold falling outside the O(1) window consistent with Routes A/B
- Failure of the discrete Bianchi identity in more general simplicial complexes

7.2 Conditional but Non-Retrofitted

The derivation of Λ should be understood as **conditional but non-retrofitted**, in the sense that no arbitrary retrofitting is possible once the commitments are fixed: given a small set of independently motivated structural commitments, the cosmological constant is fixed without adjustable parameters. The empirical success of this prediction constitutes a nontrivial consistency test of the underlying commitments rather than a consequence of reverse-engineering.

The key distinguishing features are:

Feature	ΛCDM	Two-Planck Framework
Status of Λ	Free parameter (measured)	Derived output (predicted)
Adjustability	Λ absorbs discrepancies	No parameters for arbitrary retrofitting
Commitments	Numerical (Λ value)	Structural (geometry)
Falsifiability	Λ can always be refit	Single prediction, no rescue
Convergent routes	N/A	Three convergent routes; independence between Route M and Routes A/B

7.3 The Role of Improved Precision

Improved numerical precision — particularly through Monte Carlo determination of p^c — can only sharpen the test, not rescue the theory. If simulation yields $p^c \approx 0.18$, the three-route convergence becomes quantitatively precise and very difficult to dismiss. If simulation yields p^c outside the viable range, the framework is falsified. Either outcome advances the science.

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8. Summary of the Dialogue

The critical dialogue proceeded through four rounds, each refining the epistemic claims:

Round 1 — Initial Assessment: The three-route convergence is identified as the framework's strongest feature. Principal concerns raised: the "no fitting" claim needs qualification, the percolation threshold range is wide, scheme dependence of $s = 2$ is underweighted, and the monotone-feedback assumptions for the CSS attractor are not derived from microphysics.

Round 2 — Foundational Commitments: The comparison with GR, QFT, and ΛCDM is established. The framework's commitments are shown to be structural and non-numerical, placing it in a categorically different epistemic position from ΛCDM. The $K = 7$ sensitivity table is identified as the single most persuasive element against the retrofitting objection.

Round 3 — Scheme Dependence Resolution: The Λ_QCD analogy resolves the scheme-dependence concern at the conceptual level: dimensional-transmutation scales are scheme-dependent in precise numerical value but scheme-independent in existence and order of magnitude. The "empirically falsified rather than adjustable" argument is identified as decisive against the retrofitting objection. The formulation is refined to "conditional but non-retrofitted."

Round 4 — Precision and Convergence: The distinction between full independence (Route M vs. Routes A/B) and partial independence (Route A vs. Route B) is made explicit. The agreement is characterized precisely as constraining scheme dependence to an O(1) multiplicative factor. Monte Carlo determination of p^c is identified as the concrete next step that would convert order-unity agreement into a quantitative test.

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9. Conclusions

The Two-Planck framework derives the cosmological constant $\Lambda \approx 1.1 \times 10^{-52}\ \text{m}^{-2}$ from a small set of independently motivated structural commitments, through three convergent routes that span the ultraviolet, mesoscopic, and infrared domains. The derivation is parameter-free within the stated commitments: no length scale, density, or coupling is adjusted to match observation.

The critical dialogue establishes the following precise characterization:

1. **The derivation is conditional but non-retrofitted.** The foundational commitments (relational ontology, simplicial discretization, UV neutrality, minimal-doubling blocking) have independent histories in quantum gravity and statistical mechanics. Once adopted, they determine Λ without remaining freedom.
2. **Scheme dependence is constrained, not eliminated.** The blocking prescription $s = 2$ is the standard Wilson–Kadanoff choice, not a fit parameter. The coherence scale ξ is analogous to Λ_QCD: scheme-dependent in precise value, scheme-independent in existence and order of magnitude. Cross-route agreement constrains the scheme-dependent factor to O(1), preventing arbitrary retrofitting while leaving a controlled theoretical uncertainty that is itself subject to falsification.

3. **The K = 7 sensitivity provides the strongest evidence against retrofitting.** The mesoscopic window in K-space is genuinely narrow (K = 6 gives subatomic scales, K = 8 gives cosmological scales), and K is enumerated from simplex geometry rather than selected.
4. **The framework is maximally falsifiable.** No parameters remain to absorb discrepancies. Improved precision sharpens rather than rescues the theory.
5. **Monte Carlo verification of p^c is the decisive next step.** Simulation of triangle percolation in 4D dynamical triangulations would convert the current order-unity three-route convergence into a quantitative test, either confirming the framework or falsifying it.

The cosmological constant, on this account, is not a free parameter of nature but a geometric consequence of relational structure at the Planck scale, amplified to cosmological significance through dimensional transmutation. The framework is therefore maximally constrained: it makes a small set of linked quantitative predictions (with Λ as the central one) and admits no parameter freedom to absorb discrepancies.

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Companion Papers

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