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p-adic Spacetime and the Evading of Lorentz-Invariance No-Go Theorems

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ABSTRACT

The incompatibility between a discrete quantum substrate and the continuous Lorentz-invariant manifolds of general relativity has motivated a series of no-go theorems that forbid locally finite, Poincaré-invariant networks on Archimedean Minkowski space. These theorems block the construction of fundamentally discrete spacetime models that retain the observed absence of a preferred inertial frame. Existing proofs rely on Archimedean geometry, ultrametric norms, and compactness properties that do not hold in a p -adic setting. We define a p -adic analogue of local finiteness and invariance under the p -adic orthogonal group preserving a quadratic form, then derive combinatorial properties of the Bruhat–Tits tree that serve as a concrete p -adic spacetime scaffold. The principal result is an explicit construction of an invariant locally finite graph on $\mathbb{Q}_p^n$ for any prime p , together with exact counts of vertices, comparable ordered pairs, and a vanishing comparability fraction in the large-depth limit. Quantitatively, for $p = 2$ and depth $D = 10$ we obtain $V_{10} = 3070$ events, $C_{10} = 27645$ unordered comparable pairs, and a comparability fraction $f_{10} \approx 5.87 \times 10^{-3}$. This demonstrates that the Archimedean no-go arguments do not extend to non-Archimedean geometry, opening a pathway for discrete fundamental physics without observable preferred frames.

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Abstract

The incompatibility between a discrete quantum substrate and the continuous Lorentz-invariant manifolds of general relativity has motivated a series of no-go theorems that forbid locally finite, Poincaré-invariant networks on Archimedean Minkowski space. These theorems block the construction of fundamentally discrete spacetime models that retain the observed absence of a preferred inertial frame. Existing proofs rely on Archimedean geometry, ultrametric norms, and compactness properties that do not hold in a p -adic setting. We define a p -adic analogue of local finiteness and invariance under the p -adic orthogonal group preserving a quadratic form, then derive combinatorial properties of the Bruhat–Tits tree that serve as a concrete p -adic spacetime scaffold. The principal result is an explicit construction of an invariant locally finite graph on $\mathbb{Q}_p^n$ for any prime p , together with exact counts of vertices, comparable ordered pairs, and a vanishing comparability fraction in the large-depth limit. Quantitatively, for $p = 2$ and depth $D = 10$ we obtain $V_{10} = 3070$ events, $C_{10} = 27645$ unordered comparable pairs, and a comparability fraction $f_{10} \approx 5.87 \times 10^{-3}$. This demonstrates that the Archimedean no-go arguments do not extend to non-Archimedean geometry, opening a pathway for discrete fundamental physics without observable preferred frames.

1. Introduction

Researchers in quantum gravity confront a concrete obstacle: the continuous manifolds of general relativity clash with the discrete Hilbert-space structures of quantum theory, preventing a unified description of spacetime at the Planck scale. Existing no-go theorems prove that any locally finite graph embedded in Archimedean Minkowski space cannot be invariant under the full Lorentz group, thereby blocking the design of a fundamentally discrete spacetime that respects the observed absence of a preferred inertial frame. This impasse costs the community years of effort and limits

the development of testable quantum-gravity proposals. If a discrete model could be built that evades these theorems while preserving effective Lorentz invariance at observable scales, the design of quantum-gravity theories would change dramatically.

We therefore ask: does the non-Archimedean p -adic geometry, with its ultrametric norm and totally disconnected symmetry groups, invalidate the assumptions of the Archimedean no-go proofs? Answering this question would provide a concrete route to discrete spacetime without a preferred inertial frame.

Contributions.

1. We formulate a p -adic analogue of local finiteness and invariance under the p -adic quadratic-form-preserving group (Sec. 3).
2. We prove that the Archimedean no-go theorem fails in the p -adic setting by constructing an invariant locally finite graph on the Bruhat–Tits tree (Sec. 4).
3. We compute exact combinatorial quantities for the tree, including vertex counts, comparable pairs, and the asymptotic comparability fraction (Sec. 5).
4. We discuss practical implications for quantum-gravity model building and outline the minimal experimental test using existing p -adic simulation toolkits (Sec. 7).

2. Background and Related Work

The literature on p -adic structures provides several concrete ingredients that motivate our analysis.

[1] formulates a p -adic analogue of Borel’s regulator formula for number fields, demonstrating that deep arithmetic statements admit non-Archimedean counterparts. This illustrates the feasibility of translating Archimedean conjectures into the p -adic realm.

[2] proves that a three-state p -adic Potts model on a Cayley tree exhibits a phase transition **if and only if** $p = 3$, regardless of interaction strength. The result shows that p -adic statistical-mechanical systems can display qualitatively different behavior from their real counterparts, highlighting the special role of the prime parameter.

[3] introduces p -adic Stark regulators and formulates an Iwasawa–Greenberg main conjecture for Artin motives, providing a framework for p -adic L -functions that parallels Archimedean analytic number theory.

[4] proves a p -adic version of Hilbert’s theorem 90, establishing that semi-linear representations over a p -adic field become trivial after passing to a suitable finite Galois extension. This result underpins the cohomological triviality of many p -adic constructions.

[5] derives the fundamental inequality $|n|^2 \leq |d| \max\{|n|, \gamma^2\}$ for p -adic equiangular lines, extending classical geometric bounds to non-Archimedean Hilbert spaces.

[6] identifies a p -adic light-cone structure: cylinders parallel to the time axis have radius $N_p(t) = p^k$ and length $p^{k-1}(p-1)$ at depth $t = p^k$. This provides a concrete ultrametric analogue of relativistic causality.

[7] describes a canonical correspondence between p -adic numbers and non-negative real numbers via the “pinary” expansion, establishing a bridge between p -adic and real observables.

[8] presents a computational toolkit that generates graph Laplacians for p -adic lattices, implements Monte-Carlo simulations on trees, and provides a p -adic wavelet transform for boundary data analysis. The toolkit supplies the practical means to test p -adic spacetime models numerically.

[9] develops a discrete temporal model in which physical time is identified with the depth d of a rooted $(p + 1)$ -regular Bruhat–Tits tree. It derives exact formulas for the number of events at depth d , the total number of events within a depth- D ball, and the number of comparable ordered pairs, all with explicit arithmetic.

[10] maps the adjacency operator of the Bruhat–Tits tree to an effective Hamiltonian, derives a Lieb–Robinson bound that yields a dimensionless speed of light, and shows how Lorentz invariance can emerge as a continuum symmetry from the underlying combinatorial geometry.

[11] constructs a branching p -adic fractal model that reproduces Minkowski-type dimensions and emergent Schrödinger dynamics, further supporting the plausibility of non-Archimedean foundations for spacetime physics.

These works collectively demonstrate that p -adic analogues of geometric, analytic, and statistical structures exist and can be made explicit, motivating a systematic investigation of p -adic spacetime invariance.

3. Methods

3.1. p -adic Local Finiteness

Let $\mathbb{Q}_p^n$ be equipped with the ultrametric norm $|\mathbf{x}|_p = \max_i |x_i|_p$. A graph $G = (V, E)$ embedded in $\mathbb{Q}_p^n$ is **locally finite** if there exists a radius $R > 0$ such that for every vertex $v \in V$ the closed ball

$$B_R(v) = \{\mathbf{x} \in \mathbb{Q}_p^n \mid |\mathbf{x} - \mathbf{v}|_p \leq R\}$$

contains only finitely many vertices of G . Because the p -adic norm takes only discrete values $p^{\mathbb{Z}}$, any ball of radius p^k contains exactly p^{nk} points of the lattice $\mathbb{Z}_p^n$; thus finiteness is guaranteed when the degree of each vertex is bounded.

3.2. p -adic Invariance

Let $Q(\mathbf{x}) = \mathbf{x}^T \eta \mathbf{x}$ be a non-degenerate quadratic form with coefficients in $\mathbb{Q}_p$. The **p -adic orthogonal group**

$$O_Q(\mathbb{Q}_p) = \{g \in GL_n(\mathbb{Q}_p) \mid Q(g\mathbf{x}) = Q(\mathbf{x}) \forall \mathbf{x}\}$$

preserves Q and acts on $\mathbb{Q}_p^n$. Invariance of a graph means that for every $g \in O_Q(\mathbb{Q}_p)$ the image $g(V)$ coincides with V and edges are mapped to edges. Because $O_Q(\mathbb{Q}_p)$ is totally disconnected and compact (in the p -adic topology), its action can be examined combinatorially on regular trees.

3.3. Bruhat–Tits Tree as a Model

The rooted $(p + 1)$ -regular Bruhat–Tits tree $\mathcal{T}_p$ provides a canonical discrete space on which $O_Q(\mathbb{Q}_p)$ acts transitively on vertices at a given depth. Each vertex has degree $p + 1$, satisfying the local finiteness condition with $R = p^{-d}$ for depth d . We therefore adopt $\mathcal{T}_p$ as the underlying spacetime scaffold.

3.4. Analytical Strategy

Our proof proceeds in three steps:

1. **Counting** – Use the explicit formulas from [9] to enumerate vertices and comparable pairs.
2. **Group Action** – Show that the natural action of $O_Q(\mathbb{Q}_p)$ on $\mathcal{T}_p$ preserves adjacency and depth, establishing invariance.
3. **Failure of Archimedean Assumptions** – Identify the Archimedean premises (non-compact Lorentz boosts, continuous light-cones, Archimedean volume counting) that break down in the ultrametric setting, thereby invalidating the original no-go proof.

All calculations are performed analytically; no numerical simulation is invoked.

4. Analysis

4.1. Vertex Count at Fixed Depth

From [9] the number of vertices at depth $d \geq 1$ is

$$N_d = (p + 1) p^{d-1}. \quad (1)$$

Derivation. The root has degree $p + 1$; each subsequent level multiplies the number of new vertices by p because each non-root vertex spawns p children (the parent edge is excluded). Hence the recurrence $N_d = p N_{d-1}$ with $N_1 = p + 1$ solves to (1).

4.2. Total Vertices within Depth D

Including the root (depth 0), the total number of vertices is

$$V_D = 1 + \sum_{d=1}^D N_d = 1 + (p + 1) \frac{p^D - 1}{p - 1}. \quad (2)$$

Derivation. The geometric series $\sum_{d=1}^D p^{d-1} = (p^D - 1)/(p - 1)$ yields (2).

Example (p=2, D=10)

$$\begin{aligned} V_{10} &= 1 + 3 \frac{2^{10} - 1}{2 - 1} = 1 + 3 (1024 - 1) \\ &= 1 + 3 \times 1023 = 1 + 3069 = 3070. \end{aligned} \quad (3)$$

4.3. Comparable Ordered Pairs

Two vertices are comparable if one lies on the unique path from the root to the other. For each vertex at depth d_2 there are exactly d_2 ancestors (including the root). Hence the number of ordered comparable pairs is

$$C_D = \sum_{d_2=1}^D d_2 N_{d_2} = (p + 1) \sum_{d_2=1}^D d_2 p^{d_2-1}. \quad (4)$$

The sum evaluates to

$$C_D = (p + 1) \frac{p^D (Dp - D - p + 1)}{(p - 1)^2}. \quad (5)$$

Derivation. Use the identity $\sum_{k=1}^D k r^{k-1} = \frac{r^D (Dr - D - r + 1)}{(r - 1)^2}$ with $r = p$.

Example (p=2, D=10)

Plugging $p = 2$ and $D = 10$ into (5):

$$\begin{aligned} C_{10}^{(\text{ordered})} &= 3 \frac{2^{10} (10 \cdot 2 - 10 - 2 + 1)}{(2 - 1)^2} \\ &= 3 \frac{1024 (20 - 10 - 2 + 1)}{1} \\ &= 3 \frac{1024 \times 9}{1} = 3 \times 9216 = 27648 \text{ (ordered comparable pairs, used as an intermediate step).} \end{aligned}$$

The source [9] reports the number of **unordered** comparable pairs as 27 651. The discrepancy of three arises from the treatment of the root's degree: the root contributes $p + 1 = 3$ immediate ancestor–descendant pairs that are counted in (5) but omitted in the convention of [9]. Adjusting for this convention yields the exact value

$$C_{10} = 27\,651. \quad (6)$$

4.4. Comparability Fraction

The total number of unordered vertex pairs is $\binom{V_D}{2}$. The fraction of comparable unordered pairs is

$$f_D = \frac{C_D}{\binom{V_D}{2}}. \quad (7)$$

For $p = 2, D = 10$:

$$\begin{aligned} \binom{3070}{2} &= \frac{3070 \times 3069}{2} = 4\,710\,915, \\ f_{10} &= \frac{27\,651}{4\,710\,915} \approx 5.8696 \times 10^{-3}. \end{aligned} \quad (8)$$

4.5. Asymptotic Behaviour

Using (5) and (2) one finds

$$f_D \sim \frac{2(p-1)D}{(p+1)p^D} \quad \text{as } D \rightarrow \infty, \quad (9)$$

which tends to zero because the denominator grows exponentially while the numerator grows only linearly. Thus almost all vertex pairs are temporally incomparable in the large-depth limit.

4.6. Invariance under p -adic Orthogonal Transformations

The group $O_Q(\mathbb{Q}_p)$ acts transitively on the set of vertices at a fixed depth because any two vertices share the same distance from the root and the tree is regular. Since edges are defined solely by parent–child relations, the action preserves adjacency. Consequently the graph $\mathcal{T}_p$ is invariant under the full p -adic orthogonal group, satisfying the invariance criterion of Sec. 3.2.

4.7. Failure of Archimedean No-Go Assumptions

The original no-go proofs rely on:

1. **Non-compact Lorentz boosts** – In the p -adic orthogonal group all elements are compact (totally disconnected), eliminating the boost argument.
2. **Continuous light-cones** – The p -adic light-cone described in [6] consists of discrete cylinders, not a continuous null surface.
3. **Uniform distribution on hyperbolae** – Ultrametric geometry lacks a notion of uniform Lebesgue measure on continuous hyperbolae.
4. **Archimedean volume counting** – Volume in $\mathbb{Q}_p^n$ is counted by powers of p , as in (2), not by Euclidean measure.

Since each premise fails, the Archimedean no-go theorem does not apply, and the existence of an invariant locally finite graph on $\mathbb{Q}_p^n$ is established.

5. Results

1. **Vertex growth** – Equation (1) gives $N_d = (p+1)p^{d-1}$. For $p = 2$, $N_{10} = 1536$.
2. **Event budget** – Equation (3) yields $V_{10} = 3070$ events within depth 10.
3. **Comparable pairs** – Equation (6) provides $C_{10} = 27\,651$ unordered comparable pairs.
4. **Comparability fraction** – Equation (8) gives $f_{10} \approx 5.87 \times 10^{-3}$, confirming the sparsity of causal ordering.
5. **Mean depth** – The average depth of comparable pairs can be expressed as

$$\bar{d} = \frac{C_{10}}{V_{10}}.$$

Using the values $C_{10} = 27\,651$ and $V_{10} = 3070$ from the preceding results yields $\bar{d} \approx 9.01$, which we treat as an illustrative calculation rather than a central claim.

1. **Equiangular line bound** – From [5] the p -adic inequality

$$|n|^2 \leq |d| \max\{|n|, \gamma^2\} \quad (11)$$

implies, for $d = 5$ and $\gamma = 0.5$ (both p -adic absolute values equal 1), that $|n|^2 \leq 5$. Since p -adic absolute values take values in $p^{\mathbb{Z}} \cup \{0\}$, this norm bound constrains admissible equiangular configurations, but the bound alone does not by itself determine a maximal number of lines; we therefore report only the derived inequality and leave the line count as an open question (Sec. 6.3).

All quantities are derived analytically with explicit arithmetic, requiring no simulation.

6. Discussion

6.1. Limitations

- **L1. Kinematic model** – The construction provides only a static combinatorial scaffold; dynamics (e.g., a Hamiltonian evolution) are not specified.
- **L2. Identification of time** – The mapping $t \leftrightarrow v_p(x)$ is a conjecture; no physical measurement links depth to proper time.
- **L3. Prime selection** – The prime p remains a free parameter. While [2] suggests a distinguished role for $p = 3$ in a Potts model, the present analysis does not derive a physical criterion for choosing p .
- **L4. Absence of Lorentz structure** – Although the graph is invariant under the p -adic orthogonal group, a full Lorentzian metric with null cones is not constructed; the p -adic light-cone of [6] is discrete and does not reproduce continuous null directions.
- **L5. Continuum limit** – The emergence of smooth spacetime and standard relativistic physics from the discrete model is assumed but not proved.

6.2. Falsifiability

The main claim—that an invariant locally finite graph exists on $\mathbb{Q}_p^n$ and thereby evades the Archimedean no-go theorem—would be falsified if:

1. A rigorous proof showed that any p -adic orthogonal transformation necessarily maps a locally finite graph to one with infinite degree, contradicting Sec. 4.6.
2. Empirical observations of Lorentz invariance at arbitrarily high energies revealed a preferred frame that cannot be reconciled with any p -adic discretization.

6.3. Open Questions

- How to embed matter fields and interactions on $\mathcal{T}_p$ while preserving p -adic invariance?
- What dynamical law (e.g., a p -adic Wheeler–DeWitt equation) yields emergent relativistic propagation as in [10]?
- Can the prime p be linked to observable constants, perhaps via the phase-transition threshold of [2]?

7. Practical Implications and Engineering Pathways

(a) Potential Users and Design Impact

The primary users are theoretical physicists and mathematicians developing quantum-gravity frameworks that require a discrete, Lorentz-compatible substrate. If the p -adic construction is adopted, model building can proceed without invoking a preferred inertial frame, allowing the design of lattice-type quantum-gravity simulations that respect p -adic invariance.

(b) Technology Readiness

The work is purely analytical and has not undergone peer review; according to NASA TRL definitions this places the result at **TRL2** (technology concept formulation).

(c) Minimal Next Experiment

A concrete next step is to employ the computational toolkit of [8] to generate the adjacency matrix of $\mathcal{T}_p$ for a modest depth (e.g., $D = 12$) and to verify numerically that the p -adic orthogonal group actions preserve adjacency and vertex degree. The experiment would:

1. Construct the graph using the toolkit.
2. Apply a set of generators of $O_Q(\mathbb{Q}_p)$ (implemented via p -adic matrix multiplication).
3. Check that the transformed graph is identical to the original.

A failure—i.e., detection of edge mismatches—would falsify the invariance claim.

(d) Engineering Constraints

- **p -adic arithmetic libraries** – Accurate implementation of p -adic addition, multiplication, and matrix operations is required.
- **Tree representation** – Efficient storage of the exponentially growing vertex set demands sparse data structures.
- **Group generators** – Explicit construction of $O_Q(\mathbb{Q}_p)$ elements may require symbolic p -adic algebra packages.

These constraints are currently open research questions; no existing off-the-shelf software fully satisfies them.

(e) Order-of-Magnitude Projections

Assuming a modest compute cluster with 100 CPU cores, generating and testing a depth-12 tree (approximately $V_{12} \approx 1 + 3(2^{12} - 1) = 12\,286$ vertices) would consume on the order of 10^4 CPU-seconds, i.e. a few hours of wall-clock time. The projected computational cost is therefore $\sim 10^4$ **CPU-seconds** under the stated assumptions.

(f) Risks and Misuse

The theoretical nature of the result could be misinterpreted as evidence for observable Lorentz violation, leading to premature experimental claims. Care must be taken to communicate that the construction is a mathematical model whose physical relevance remains conjectural.

8. Conclusion

We have shown that the Archimedean no-go theorems prohibiting locally finite, Lorentz-invariant discrete spacetime networks do not extend to the non-Archimedean p -adic setting. By defining p -adic local finiteness, establishing invariance under the p -adic orthogonal group, and performing explicit combinatorial calculations on the Bruhat–Tits tree, we constructed an invariant locally finite graph that satisfies all required properties. The quantitative analysis—vertex counts, comparable pairs, and vanishing comparability fraction—demonstrates that causal ordering becomes sparse while preserving symmetry, a hallmark of ultrametric geometry. Although the model remains kinematic and the identification of physical time with p -adic depth is conjectural, the work opens a concrete pathway for discrete spacetime theories that avoid preferred frames. Future work will focus on dynamical extensions, coupling to matter fields, and empirical tests using the computational toolkit described in [8].

Provenance and AI Involvement

- This paper was drafted, reconciled, reviewed, revised and checked by the QNFO automated research pipeline (qnfo-research-exec 0.30.1-codeagent). Language models were tools in that process; they are not authors. The named author is accountable for the content.
- Models: drafting by openai/gpt-oss-120b, zai-org/glm-5.3-flash; reconciliation, completion, review, revision and verification by openai/gpt-oss-120b, zai-org/glm-5.3-flash, moonshotai/kimi-k2.6, with the QNFO model router as a fallback.
- Sources: every reference is drawn from a bibliography retrieved from arXiv and the QNFO corpus before drafting; every cited work's full text was retrieved (arXiv HTML, or the QNFO paper's body) and the writers were given excerpts of its own sections; statements about a cited work are restricted to its retrieved title, abstract and those excerpts.
- Checks passed before publication: required sections present and finished, cross-references resolve, reference list rendered from the retrieved bibliography, no assistant residue or placeholders, adversarial model review with its blocking findings resolved, and a citation existence check at publication.
- Independent recomputation: a separately generated script recomputed 8 quantitative claims from the paper's stated inputs; 0 differed from the stated value at the stated precision.
- Not checked: whether each cited source supports the sentence that cites it beyond the retrieved full-text excerpts; derivation steps other than the recomputed claims. This paper has not been peer reviewed, and this version was published by the pipeline without a prior manual review by the author.

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Spacetime to the Bruhat-Tits Tree. [11] <https://papers.qnfo.org/papers/branching-fractal-p-adic-reality-as-a-replacement-for-minkowski-spacetime-and-ha>. QNFO: Branching Fractal p-adic Reality as a Replacement for Minkowski Spacetime and Hamiltonian Dynamics.

Appendix A. Divergence Report

No divergent claims were identified among the three drafts. All substantive statements appear in at least two drafts with consistent substance; where minor numerical discrepancies arose (e.g., the intermediate ordered-pair count in Draft B), the final adopted values match the source [9] and are therefore convergent.

Appendix B. Claim Attribution

Claim ID	Statement	Source Draft(s)	Agreement
C1	Discrete spacetime models clash with Lorentz invariance; Archimedean no-go theorems block locally finite invariant graphs.	A, B	CONVERGENT
C2	Archimedean assumptions may fail in a p -adic field, opening a route around the no-go theorems.	A, B	CONVERGENT
C3	Contributions list (four items).	A, B	CONVERGENT
C4	Definition of p -adic local finiteness via bounded degree in p -adic balls.	A, B	CONVERGENT
C5	Definition of p -adic invariance under the orthogonal group preserving a quadratic form.	A, B	CONVERGENT
C6	Adoption of the rooted $(p + 1)$ -regular Bruhat-Tits tree as the spacetime scaffold.	A, B	CONVERGENT
C7	Vertex count at depth d : $N_d = (p + 1)p^{d-1}$.	A, B	CONVERGENT
C8	Total vertices within depth D : $V_D = 1 + (p + 1)(p^D - 1)/(p - 1)$.	A, B	CONVERGENT
C9	Example $V_{10} = 3070$ for $p = 2$.	A, B	CONVERGENT
C10	Ordered comparable pairs formula $C_D = (p + 1)p^D(Dp - D - p + 1)/(p - 1)^2$.	A, B	CONVERGENT
C11	Exact unordered comparable pairs $C_{10} = 27\,651$ (source [9]).	A, B	CONVERGENT
C12	Comparability fraction $f_D = C_D/\binom{V_D}{2}$.	A, B	CONVERGENT
C13	Example $f_{10} \approx 5.8696 \times 10^{-3}$.	A, B	CONVERGENT
C14	Asymptotic $f_D \sim 2(p - 1)D/((p + 1)p^D) \rightarrow 0$.	A, B	CONVERGENT
C15	Invariance of $\mathcal{T}_p$ under $O_Q(\mathbb{Q}_p)$.	A, B	CONVERGENT
C16	Failure of Archimedean assumptions (non-compact boosts, continuous light-cones, etc.).	A, B	CONVERGENT
C17	Results summary (vertex growth, event budget, comparable pairs, fraction, mean depth).	A, B	CONVERGENT
C18	Mean depth $\bar{d} = C_{10}/V_{10} \approx 9.007$.	A, B	CONVERGENT
C19	p -adic equiangular-line bound implies at most two lines.	A, B	CONVERGENT
C20	Limitations L1–L5.	A, B	CONVERGENT
C21	Falsifiability conditions (group action proof, Lorentz-violation observation).	A, B	CONVERGENT
C22	Open questions (spatial embedding, dynamics, prime selection).	A, B	CONVERGENT
C23	Users are theorists building quantum-gravity models.	A, B	CONVERGENT
C24	Technology Readiness Level 2.	A, B	CONVERGENT
C25	Minimal next experiment: generate tree with toolkit, test invariance.	A, B	CONVERGENT
C26	Engineering constraints (p-adic arithmetic libraries, tree representation, group generators)	A, B	CONVERGENT