AUGUST 4, 2026 · VV0.8-GATE-COMPLIANT

# Killing the Framework: Seven Criteria for the Falsification of Adelic Physics

[object Object]

QNFO-ULA-2.1

**ABSTRACT**

A framework that accommodates any observation has zero empirical content. This paper proposes seven kill criteria for the adelic framework, audits each for escape hatches, grades it against the incumbents (GR composite C, SM C, LCDM B, string D), tests all against existing data, and applies the Null-Equivalence Protocol: four of seven adelic criteria are VACUOUS (identical predictions to the null), three NON-OPERATIONAL, zero OPERATIONAL. Only the incumbents' tensions (H0, muon g-2) are OPERATIONAL. Establishes the Independence Requirement and the confirmation-seeking structure of the GR testing program.

**PUBLISHER CLASSIFICATION** High-quality scholarly research (QNFO publisher classification for open-access, versioned research with a public revision history and reader correction channel; this is not a claim of independent peer review.)

**PEER-REVIEW STATUS** Not independently peer-reviewed

**KEYWORDS** falsifiability · adelic physics · p-adic · ultrametric · black hole echoes · dark matter · automorphic representations · Popperian demarcation · scientific methodology · consilience · null-equivalence protocol · PPN formalism · general relativity · standard model · hubble tension · muon g-2

**SUBJECTS** physics · foundations · methodology

**CITE AS** Object], [. (2026). Killing the Framework: Seven Criteria for the Falsification of Adelic Physics. QNFO Preprint vv0.8-gate-compliant.

## Abstract

A framework that can accommodate any observation through auxiliary hypotheses, parameter adjustments, or special-case reclassifications has zero empirical content. The adelic framework for fundamental physics is dangerously close to this trap. This paper proposes six kill criteria — specific observations that would falsify the framework — and then subjects each to a red-team audit for escape hatches. The result is sobering: zero of the six criteria are currently operational. Two (BH echo amplitude, fourth-generation fermion masses) could become operational with specific derivations. Four are structurally unfalsifiable as written. The paper concludes with a prioritized path forward: five concrete derivations the framework must deliver to become a scientific theory in the Popperian sense, rather than a mathematical research program with physical aspirations.

**Keywords:** falsifiability, adelic physics, p-adic, ultrametric, black hole echoes, dark matter, automorphic representations, Ostrowski theorem, Popperian demarcation

## 1. Introduction

The charge is serious and, on current evidence, correct. A scientific theory must specify, in advance, a set of observations that would kill it outright — not probabilistic hints, but logical bullets. If the universe presents any one of them, the core postulates are false. No escape clauses. No "the amplitude could be smaller." No "we haven't probed deep enough yet."

The adelic framework for fundamental physics [^1] proposes that the structure of physical law is governed by the completions of the rational numbers at all places — Archimedean and p-adic — per Ostrowski's theorem. It has generated a body of work spanning black hole spectroscopy, dark matter phenomenology, particle generations, and dimensional emergence. But it has not yet produced a single prediction that is (a) unique to the adelic structure, (b) falsifiable by a specified observation, and (c) binding — not evadable by parameter adjustment or auxiliary extension.

This paper attempts to close that gap. It proposes six kill criteria and then, crucially, audits each one for escape hatches. The audit is not an afterthought; it is the primary contribution. A kill criterion that can be evaded is not a kill criterion. It is a restatement of the framework dressed as a test.

## 2. Seven Kill Criteria

### *2.1 KC1: Violation of the Global Product Formula*

**Core postulate.** The product formula $\prod_v |x|_v = 1$ holds for all physically realized distinctions, acting as the fundamental conservation law of the framework [^2].

**Fatal observation.** Any process that demonstrably creates or destroys a dimensionless, non-zero rational invariant without balancing across all places. Concretely: a measured time-variation of the fine-structure constant α that cannot be expressed as a change in a single adelic modulus, or a particle interaction where a "p-adic charge" (defined from the Compton idele) is not conserved.

**Red-team audit.** Three escape hatches render this criterion inoperative.

First, the note itself pre-declares an escape: "if the modulus changes, it would still obey the product formula balance" [^3]. Any observed α variation can be reclassified as modulus evolution. The product formula is a mathematical identity — it can never be *physically* violated because the framework can always redefine which idele element is changing.

Second, no operational definition of "p-adic charge" exists. The note says "if we define a p-adic charge at each prime from the Compton idele" — but this definition has not been constructed, and no measurement protocol exists. Until it does, this sub-criterion is a thought experiment, not a test. `[speculative]`

Third, the product formula $\prod_v |x|_v = 1$ is a proven mathematical theorem, not a physical hypothesis. It cannot be "violated" in the formalism. The relevant question is whether the formalism maps onto physical observables — and failure of mapping is not the same as violation of the product formula itself. `[not yet falsifiable]`

**To operationalize.** Define p-adic charges concretely from the Compton idele. Specify a measurement protocol or, failing that, a theoretical statement of what *cannot* happen if p-adic charges are conserved. State the minimum measurable deviation that would constitute a violation, independent of modulus redefinition.

### *2.2 KC2: Continuous Spin Particle or Non-Automorphic Representation*

**Core postulate.** All physical particles correspond to automorphic representations of a reductive group over the adeles. This implies quantized spin (integer or half-integer) and no continuous spin representations [^4].

**Fatal observation.** Detection of a stable, fundamental particle with a continuous spin degree of freedom (not an emergent composite). Discovery of a fourth chiral fermion family whose mass pattern cannot fit into any automorphic form — concretely, a particle whose mass ratios break rigid adelic mass relations and cannot be accommodated by any auxiliary adjustment without losing fixed prime-pattern predictions.

**Red-team audit.** Three issues weaken this criterion.

First, continuous spin particles are already excluded by Wigner's classification in 3+1D Poincaré-invariant QFT. This is not a prediction of the adelic framework; it is a property of the Poincaré group. The framework takes credit for a constraint that already exists. A null result on continuous spin confirms standard QFT, not adelic physics. `[established]`

Second, the note pre-admits a fourth-generation escape: "the framework could in principle be extended to a different number field (e.g., a quadratic extension)." It then artificially closes this by "restricting the base field to $\mathbb{Q}$ as a core postulate" — but restricting a postulate to avoid accommodation is a rhetorical move, not a falsifiable one. If a fourth generation is discovered, the framework will be extended; claiming "that's a different theory" is the no-true-Scotsman fallacy. `[speculative]`

Third, "no auxiliary adelic adjustment can accommodate it" is unprovable without enumerating the full space of allowed adjustments. The number of possible auxiliary adjustments is unbounded. `[not yet falsifiable]`

**To operationalize.** Compute rigid three-generation mass relations from first principles such that a fourth generation with *any* mass would break them irreparably. The prediction must be specific enough that "extending to a quadratic extension" is not a viable escape.

### *2.3 KC3: Exact Continuum at All Scales*

**Core postulate.** Spacetime is a coarse-grained emergent from a discrete, prime-indexed distinction network (Bruhat–Tits trees). This demands that at sufficiently small scales (around the Planck length), spacetime has a fundamentally discrete, fractal, or ultrametric structure [^5].

**Fatal observation.** Experiments (e.g., gamma-ray burst time delays, ultra-high-energy cosmic ray propagation) showing Lorentz invariance holds perfectly to distances far below the Planck length, with no hint of discrete structure.

**Red-team audit.** Three structural problems.

First, no hard length threshold has been specified. Without a numeric threshold — "discreteness must appear at or above $10^{-20}$ $\ell_P$" — every null result is "we haven't probed deep enough." Current Lorentz-violation bounds are already extraordinarily tight (some down to $10^{-29}$ in Planck units) and the framework survives by placing discretization at still-smaller scales. This is a moving goalpost. `[not yet falsifiable]`

Second, the criterion requires "a future theory of quantum gravity, validated by experiment" — an event that may never arrive. This makes KC3 a conditional kill, conditional on an external development the framework does not control. `[not yet falsifiable]`

Third, Lorentz invariance holding at all accessible scales is a retrodiction, not a prediction. The framework was built knowing Lorentz invariance holds at accessible scales. Surviving existing bounds is not evidence for the framework. `[retrodiction]`

**To operationalize.** Derive a minimum scale for discretization from the adelic action that is independent of free parameters, below which smooth Lorentz-invariant spacetime is *incompatible* with the adelic substrate. This is the only way to make null results fatal.

### *2.4 KC4: No Prime-Number Signatures in Black Hole Ringdown*

**Core postulate.** The p-adic structure of the microscopic geometry near a black hole horizon imprints a specific, Möbius-amplitude-weighted, prime-delay echo pattern in gravitational waves [^6].

**Fatal observation.** Stacked, matched-filter search across many LIGO/Virgo/KAGRA merger events yields a Bayes factor decisively favoring the null (no echo) model, with the upper limit on echo amplitude falling below a theoretically required minimum computed from first principles.

**Red-team audit.** This is the most honestly presented criterion but currently inoperative.

The note itself identifies the core problem: "If we cannot compute a lower bound, then this becomes unfalsifiable via null result. Hence, a necessary commitment: we must derive a lower bound on the echo amplitude from the adelic action that is independent of free parameters. If we can't, the theory isn't testable this way." [^3] That lower bound does not exist. Until it does, KC4 is a prediction-in-waiting.

Even if a bound is derived, it is a theoretical calculation that can be revised. If the initial bound is violated, the framework can claim "we miscomputed the bound" rather than "the framework is wrong." The bound must be robust to *all* free parameters — and robustness proofs are harder than derivations. `[not yet falsifiable]`

**To operationalize.** Derive a lower bound on echo amplitude from the adelic action, independent of all free parameters. This is the single highest-priority derivation for making the framework testable. The Möbius-function template is rigid in its relative delays and amplitude ratios — if a different periodic pattern is found, the criterion genuinely kills. The missing piece is the amplitude bound.

### *2.5 KC5: Dark Matter Not Matching the P-adic Halo Profile*

**Core postulate.** Dark matter is the gravitational shadow of non-archimedean matter content, leading to a specific density profile with discrete scale invariance (log-periodic oscillations) and a characteristic small-scale cutoff [^7].

**Fatal observation.** Dark matter direct detection experiments combined with precise simulations rule out any halo substructure with a prime-related pattern, confirming a perfectly smooth, scale-free ΛCDM profile down to very small scales with no log-periodic features at >5σ. Discovery of a dark matter particle whose mass and interactions are completely describable within Standard Model extensions without any adelic structure.

**Red-team audit.** Three escape hatches.

First, if a non-adelic DM particle (WIMP, axion, etc.) is discovered, the framework can always declare the adelic DM component "subdominant" below detection threshold. No fraction is specified. `[not yet falsifiable]`

Second, "prime-related pattern" is underdetermined. Which mathematical object is being tested? The Möbius function? Prime gaps? The distribution of primes in arithmetic progressions? Without a specific template, any non-smooth feature can be claimed post-hoc as "prime-related." `[not yet falsifiable]`

Third, ΛCDM itself has known small-scale tensions (cusp-core, missing satellites, too-big-to-fail). Any small-scale anomaly is contestable between baryonic physics and prime signatures. This is a classic underdetermination problem. `[not yet falsifiable]`

**To operationalize.** Specify the exact mathematical template for "prime-related pattern" in DM halos. State the minimum adelic DM fraction — below which the framework loses its dark matter motivation. Distinguish the predicted signature from known ΛCDM small-scale anomalies with a quantitative template.

### *2.6 KC6: Incompatibility with Observed Dimensionality*

**Core postulate.** The effective large-scale dimension 3+1 is a dynamical attractor of the adelic RG flow, not an input [^8].

**Fatal observation.** Evidence that the number of macroscopic dimensions changed during cosmic history (e.g., from a phase transition that altered dimensionality permanently). Alternatively, a theoretical proof that the 3+1 minimum is not unique and that other dimensionalities are equally likely attractors.

**Red-team audit.** The weakest criterion.

The note openly concedes: "This is not about verifying 3+1; that's a post-diction." The observational kill requires observing something almost no physicist expects — macroscopic dimensionality change during cosmic history. `[not yet falsifiable]`

The theoretical kill — "a future theory derives the adelic effective potential and shows that the 3+1 minimum is not unique" — is a mathematical debate, not an observation. A framework cannot be killed by a competing framework; only by data. `[not yet falsifiable]`

**To operationalize.** Derive the effective potential explicitly and publish it so it can be independently checked. Show that 3+1 is the *only* stable attractor, with all other dimensionalities demonstrably unstable. This converts a post-diction into a falsifiable claim: if the derivation contains an error and another dimensionality is equally stable, the claim is refuted.

### *2.7 KC7: Gauge Group Underivability*

**Core postulate.** The Standard Model gauge group SU(3)*C* × *SU(2)*L × U(1)_Y — or its unified extension — must be derivable from the adelic framework as the unique low-energy remnant of the automorphic structure. The framework's claim to be a theory of *all* fundamental interactions depends on this.

**Fatal observation.** A proof that SU(3) × SU(2) × U(1) is *fundamentally* incompatible with adelic derivation — not merely that no derivation has been found, but that a specific mathematical obstruction (e.g., the automorphic representation theory of the relevant reductive group forbids this particular gauge structure) exists. Alternatively: discovery of a new fundamental gauge interaction (fifth force) that cannot be embedded in the adelic automorphic structure without breaking the generation or mass-relation predictions.

**Red-team audit.** This criterion was absent from the original six because the framework's proponents take gauge-group derivability as a promissory note — "the gauge group will emerge from the adelic structure" — rather than a falsifiable claim. Without a concrete derivation or an obstruction proof, KC7 shares the structural weakness of KC1: it tests a mathematical identity (the representation theory is what it is) rather than a physical prediction.

However, KC7 is arguably the *most consequential* criterion. If the adelic framework cannot produce the Standard Model gauge group, it loses its claim to be a framework for fundamental physics — irrespective of its success on black hole echoes, dark matter, or dimensionality. The framework would be, at best, a mathematical structure with coincidental physical overlaps.

**To operationalize.** Publish a derivation of SU(3) × SU(2) × U(1) from the adelic automorphic structure. If the derivation contains a specific, testable ancillary prediction (e.g., a constraint on the number of gauge bosons or coupling-constant relations at unification), that prediction becomes an additional kill criterion. Without a published derivation, KC7 is not a kill criterion; it is a promissory note. [not yet falsifiable]

**Core postulate.** The Standard Model gauge group SU(3)*C* × *SU(2)*L × U(1)_Y — or its unified extension — must be derivable from the adelic framework as the unique low-energy remnant of the automorphic structure. The framework's claim to be a theory of *all* fundamental interactions depends on this.

**Fatal observation.** A proof that SU(3) × SU(2) × U(1) is *fundamentally* incompatible with adelic derivation — not merely that no derivation has been found, but that a specific mathematical obstruction (e.g., the automorphic representation theory of the relevant reductive group forbids this particular gauge structure) exists. Alternatively: discovery of a new fundamental gauge interaction (fifth force) that cannot be embedded in the adelic automorphic structure without breaking the generation or mass-relation predictions.

**Red-team audit.** This criterion was absent from the original six because the framework's proponents take gauge-group derivability as a promissory note — "the gauge group will emerge from the adelic structure" — rather than a falsifiable claim. Without a concrete derivation or an obstruction proof, KC7 shares the structural weakness of KC1: it tests a mathematical identity (the representation theory is what it is) rather than a physical prediction.

However, KC7 is arguably the *most consequential* criterion. If the adelic framework cannot produce the Standard Model gauge group, it loses its claim to be a framework for fundamental physics — irrespective of its success on black hole echoes, dark matter, or dimensionality. The framework would be, at best, a mathematical structure with coincidental physical overlaps.

**To operationalize.** Publish a derivation of SU(3) × SU(2) × U(1) from the adelic automorphic structure. If the derivation contains a specific, testable ancillary prediction (e.g., a constraint on the number of gauge bosons or coupling-constant relations at unification), that prediction becomes an additional kill criterion. Without a published derivation, KC7 is not a kill criterion; it is a promissory note. [not yet falsifiable]

## 3. Summary Assessment

| Criterion | Operational? | Escape Hatches | Testable? |
|---|---|---|---|
| KC1 (Product formula) | No | Modulus change, undefined charge, theorem confusion | No |
| KC2 (Continuous spin / 4th gen) | Partially | Auxiliary adjustments, $\mathbb{Q} \to$ extension, stolen credit | Partially |
| KC3 (Continuum) | No | No threshold, deferred validation, retrodiction | No |
| KC4 (BH echoes) | No | No lower bound, bound revisability | **Conditional on bound** |
| KC5 (DM profile) | No | Subdominant escape, unspecified template, ΛCDM ambiguity | No |
| KC6 (Dimensionality) | No | Requires novel phenomenon, category error | No |
| KC7 (Gauge group) | No | Promissory note, theorem confusion | No |
| KC7 (Gauge group) | No | Promissory note, theorem confusion | No |

**Zero of seven kill criteria are currently operational.** Two (KC2, KC4) could become operational with specific derivations. Five are structurally unfalsifiable or promissory as written.

## 4. The Falsifiability Gradient

For completeness, the observations $O$ such that P($O$ | M_adelic) ≈ 0, *if* the framework were sufficiently specified to make them binding:

- **$O_1$:** A measured time-variation of α at a level inconsistent with zero, uncorrelated with any adelic modulus variation.
- **$O_2$:** A particle with spin 3/5 or any non-rational spin.
- **$O_3$:** A black hole merger with strong echoes whose periods are incommensurate with logarithms of integers.
- **$O_4$:** A dark matter halo with a smooth power spectrum down to $10^{-6}$ solar masses, showing no log-periodic features at >5σ.
- **$O_5$:** A fundamental scalar field (e.g., the inflaton) that cannot be described as a modulus of the idele class group.

These observations would kill the framework — if the framework were sufficiently specified to make their non-observation binding. The italicized condition is the problem, and it is the subject of the path forward below. `[speculative – binding conditions not yet met]`

## 5. The Deeper Problem

### *5.1 Meta-Escape: The Platonic Framework Problem*

There is a structural escape hatch that applies to *all six* kill criteria simultaneously. The adelic framework can be understood at two levels: the Platonic form (the mathematical claim that completions of $\mathbb{Q}$ at all places are physically relevant) and specific instantiations (this particular mass relation, this particular echo template). If a specific instantiation is falsified, the framework can always retreat to its Platonic form and claim "the mathematics is correct; our *particular* instantiation was wrong."

This is the framework's immune system. When KC4's echo template fails, the echo template was a "toy model." When KC1's p-adic charges aren't conserved, the charge definition was "preliminary." The Platonic form survives every specific failure.

Blocking this meta-escape requires an additional commitment: for each criterion, specify which *aspect of the Platonic form* is being tested, and state that if the specific instantiation fails, that aspect of the Platonic form is falsified — not merely the instantiation. Without this, the framework can survive any number of specific predictive failures while maintaining that the underlying mathematics remains correct.

This is not unique to the adelic framework. String theory's landscape, inflationary cosmology's eternal inflation, and the multiverse all face the same structural problem. The difference is one of degree: a framework with no binding specific predictions is Platonic by default. The path forward (§6) is the attempt to produce binding specific predictions whose failure would cascade to the Platonic form.

[speculative]

The adelic framework exhibits a characteristic asymmetry. The only genuinely lethal observations (KC2: non-automorphic particle, continuous spin) would kill the framework via properties it *shares with standard quantum field theory*. Null results on these do not confirm the adelic framework; they confirm constraints that already exist in conventional physics. The framework's survivable observations are retrodictions, and its fatal observations would refute it only by refuting physics it inherited.

This is not a unique problem. String theory, inflationary cosmology, and many beyond-Standard-Model frameworks face similar challenges. But the adelic framework carries a particular burden because its core mathematical structure — the adele ring, automorphic representations, Bruhat–Tits trees — is remote from experimental probes by design. The very feature that makes it elegant (unification across all completions of $\mathbb{Q}$) is also what makes it hard to kill. `[speculative]`

The framework has not yet generated a single prediction that is:

1. **Unique** to the adelic structure (not derivable from standard QFT or general relativity alone),
2. **Falsifiable** by a specified observation with a hard threshold, and
3. **Binding** — not evadable by parameter adjustment or "auxiliary" extension.

Until it produces at least one such prediction, it is not a scientific theory in the Popperian sense. It is a mathematical research program with physical aspirations. This is not a dismissal; it is a description of where the program currently stands and what it must do to advance. `[speculative]`

There is a structural escape hatch that applies to *all six* kill criteria simultaneously. The adelic framework can be understood at two levels: the Platonic form (the mathematical claim that completions of $\mathbb{Q}$ at all places are physically relevant) and specific instantiations (this particular mass relation, this particular echo template). If a specific instantiation is falsified, the framework can always retreat to its Platonic form and claim "the mathematics is correct; our *particular* instantiation was wrong."

This is the framework's immune system. When KC4's echo template fails, the echo template was a "toy model." When KC1's p-adic charges aren't conserved, the charge definition was "preliminary." The Platonic form survives every specific failure.

Blocking this meta-escape requires an additional commitment: for each criterion, specify which *aspect of the Platonic form* is being tested, and state that if the specific instantiation fails, that aspect of the Platonic form is falsified — not merely the instantiation. Without this, the framework can survive any number of specific predictive failures while maintaining that the underlying mathematics remains correct.

This is not unique to the adelic framework. String theory's landscape, inflationary cosmology's eternal inflation, and the multiverse all face the same structural problem. The difference is one of degree: a framework with no binding specific predictions is Platonic by default. The path forward (§6) is the attempt to produce binding specific predictions whose failure would cascade to the Platonic form.

[speculative]

### *5.2 Symmetric Audit: Falsifiability of the Incumbent Hypotheses*

The audit above applies a standard — "name the observation that would kill your theory" — to the adelic framework exclusively. But the same standard applies with equal force to the incumbent hypotheses the framework seeks to augment or replace. A falsifiability critique that exempts the Standard Model, ΛCDM, and general relativity is not a methodological contribution; it is an asymmetric polemic.

This section applies the same kill-criteria framework to the dominant paradigms in fundamental physics. The question is not whether these theories are *wrong* — they are extraordinarily successful — but whether they meet the Popperian standard of specifying, in advance, observations that would kill them.

#### 5.2.1 General Relativity

The canonical narrative — that GR was decisively confirmed by a clean, unbiased observation in 1919 and has earned the top falsifiability grade ever since — does not survive historical scrutiny. The 1919 Eddington expedition, still cited as the archetype of a pre-registered kill criterion, fails on every dimension of the independence requirement that this audit applies to other frameworks.

**The observer was a partisan.** Arthur Eddington was not a neutral arbiter. He was among the first and most vocal champions of Einstein's theory in the English-speaking world, an advocate working against a wartime anti-German scientific establishment. He organized both expeditions (Sobral, Brazil, and Príncipe, West Africa), took the Príncipe observations himself, and supervised the analysis of both sets of plates. A supporter of the theory under test designed, executed, and interpreted the decisive experiment.

**The methodology had large, subjectively-assessed errors.** The measurement was of star positions on photographic plates — a technique whose systematic errors (plate distortion, emulsion shifts, astrometric calibration, atmospheric dispersion) were poorly characterized in 1919 and required subjective judgment in selecting which star images were measurable and how the reference field was fitted. The Príncipe result was based on only a handful of usable star images (the eclipse was partially obscured by cloud); the quoted uncertainty (±0.30″) did not account for the full set of plate-selection and fitting choices.

**A competing result was discarded by judgment, not by protocol.** The Sobral astrographic plates gave ~1.98″ (near GR's 1.75″), but the Sobral 4-inch telescope plates gave ~0.86″ — close to Newtonian prediction (0.87″) and far from GR. The 4-inch plates were excluded as "unreliable" on the grounds of suspected focus problems. That exclusion may have been correct, but it was a subjective judgment call made by the interested party — exactly the kind of decision that must be pre-registered, not made after seeing the data.

**Alternative hypotheses existed and were not eliminated.** Nordström's scalar gravity predicted no light deflection at all; Einstein's own 1911 calculation predicted half the GR value (0.87″); several ether- and emission-based theories made yet other predictions. The 1919 result did not adjudicate GR against all competitors — it was read as supporting GR against Newtonian expectation, with the alternative space largely unconstrained by the data.

**What established GR in fact is independent consilience.** The theory's standing rests on multiple methodologically independent confirmations: the anomalous Mercury perihelion precession (known since Le Verrier, 1859 [^23] — before GR existed, hence a genuine pre-registered prediction), gravitational redshift (Pound–Rebka, 1960 [^24]), Shapiro time delay (1964–1971 [^25]), binary pulsar orbital decay matching gravitational-wave damping (Hulse–Taylor, 1974–1993 [^26]), and direct gravitational-wave detection (LIGO/Virgo, 2015– [^27]). Each line has its own systematic uncertainties and alternative-theory competitors; none alone is decisive. Their *convergence* — five independent lines, different instruments, different physics, different teams — is the strong evidence.

The operational paradigm is not the bare equations. It is GR + dark matter + dark energy + inflation, and this composite has become de-facto unfalsifiable in practice — as established in v0.4.

**Operational kill criteria:**

- Gravitational wave speed deviating from $c$ by more than $\sim 10^{-15}$ (tested by GW170817, passed)
- Strong-field deviations from the Kerr metric in binary pulsar timing (tested, passed to high precision)
- Violation of the equivalence principle at any level (tested by MICROSCOPE to $\sim 10^{-15}$, passed)
- Detection of graviton mass above experimental bounds (constrained to $m_g < 10^{-30}$ eV)

**Escape hatches — the auxiliary-absorption problem.** The claim that "GR's auxiliary hypotheses are independently testable" is formally true but operationally false. Every galactic-scale anomaly is absorbed by adjusting the dark matter halo. Every cosmic-acceleration anomaly is absorbed by tuning the dark energy equation of state. Every early-universe anomaly is absorbed by choosing a different inflaton potential. These are not independently testable in practice — they function as absorbent escape hatches that have protected the GR-based paradigm from falsification for nearly a century.

The formal kill criteria listed above (GW speed, Kerr metric, equivalence principle) are genuine. But they test the *bare* theory, not the operational paradigm. No experiment has ever confronted GR + dark matter + dark energy + inflation as a single unified structure — because the four components can be adjusted independently to accommodate any observation. This is the same structural flexibility that the present paper criticizes in the adelic framework. `[debated — GR's bare form is falsifiable; the operational composite is not]`

**Verdict:** The bare theory possesses genuine operational kill criteria (GW speed, Kerr metric, equivalence principle), and those criteria are real. But no single one of them is clean: each has been tested by instruments and teams whose methods carry their own systematic uncertainties, and none individually would have been decisive without the others. Bare GR therefore earns **B** — not A and not B+ — because its confidence rests not on independent consilience (the subsequent tests were confirmation-seeking parameter measurements inside the PPN family; §5.4) but on three genuine theory discriminations (perihelion, 1919, LIGO) plus a century of constrained parameter measurements. The operational composite (GR + DM + DE + inflation) earns **C** — de-facto unfalsifiable in practice. `[established — the 1919 data limitations and Eddington's role are documented in the history of science literature (Dyson, Eddington, Davidson 1920; Kennefick 2019)]` [^21][^22]

#### 5.2.2 The Standard Model of Particle Physics

The Standard Model is precise within its domain, but its falsifiability is structurally compromised by its parameter count and by a century of particle-hunting history.

**Operational kill criteria:**

- Proton decay below the predicted GUT scale (~$10^{34}$ years for minimal SU(5), already excluded; ~$10^{36}$ years for SUSY GUTs, still viable)
- Neutrinoless double beta decay (would confirm Majorana neutrinos; if excluded below the inverted-hierarchy threshold, the Majorana hypothesis is dead)
- Non-unitarity of the CKM matrix at >5σ (would break the SM's core consistency condition)
- Fifth force with coupling strength above current bounds (~$10^{-3}$ of gravity at micron scales)

**Escape hatches — the free-parameter problem.** The SM has 19 free parameters that are *measured, not predicted*: six quark masses, three charged-lepton masses, three CKM mixing angles, one CP-violating phase, the Higgs mass and vacuum expectation value, the three gauge couplings, and the strong CP angle. A framework that fits its constants to the data can never be killed by a wrong value of those constants — it simply re-fits.

**The particle-hunting history.** The SM extension program has a track record of moving the goalposts. SUSY partners were predicted at the TeV scale in the 1980s; not found; scale raised to 10 TeV; not found; scale raised again. WIMPs were predicted as dark matter; direct detection searches have excluded cross-sections down to zeptobarns; the predicted mass range keeps shifting. Proton decay was predicted by GUTs; the lifetime bound has been pushed past $10^{34}$ years; the predicted rate keeps falling. Every null result is absorbed as "the energy scale is higher than we thought" — the same *auxiliary adjustment* escape the present paper criticizes in the adelic framework. When an anomaly appears (muon g−2, B-meson anomalies), it is either absorbed as a "hint of new physics" (a new free parameter) or resolved as a "systematic" — never as a falsification of the framework itself. `[established — 19 SM parameters are measured, not predicted (PDG); the history of SUSY/WIMP/proton-decay null results is documented in the experimental literature]`

**Verdict:** 3/4 formal kill criteria (proton decay awaits), but none of them can kill the framework as long as new free parameters can be added or energy scales raised. GRADE: C — precise where constrained, de-facto unfalsifiable at the boundary.

#### 5.2.3 ΛCDM Cosmology

ΛCDM occupies a middle ground. Its large-scale predictions are precise and falsifiable; its small-scale predictions are less so.

**Operational kill criteria:**

- Hubble constant $H_0$ disagreeing between early-universe (CMB) and late-universe (distance ladder) measurements at >5σ — currently at ~5σ tension. This is a *live* kill criterion: if the tension persists and is not resolved by systematics, ΛCDM as a complete model is falsified.
- $\sigma_8$ (matter clustering amplitude) tension between CMB and weak lensing at >5σ — currently at ~2-3σ.
- Primordial B-mode polarization detected at $r > 0.01$ without foreground contamination (would require a new inflationary or sourcing mechanism beyond simplest ΛCDM).

**Escape hatches at small scales:** ΛCDM faces the cusp-core problem, missing satellites, and too-big-to-fail — all tensions between simulations and observations at galactic scales. The dominant escape hatch is baryonic feedback: "the simulations don't include enough baryonic physics." This is analogous to the adelic framework's "auxiliary adjustments." The difference is testability: baryonic feedback can be simulated with increasing fidelity, and the parameter

space is shrinking. But the escape hatch is real and operational. `[speculative – baryonic feedback is a legitimate uncertainty, but its unboundedness at current resolution is a falsifiability gap]`

**Escape hatches at large scales:** The cosmological constant's value is not predicted; it is measured. This is a post-diction, not a prediction. Dark energy's equation of state w is constrained to $-1.0 \pm 0.05$, but $w \neq -1$ would not kill ΛCDM — it would modify the dark energy sector while preserving the rest.

**Verdict:** 1/4 operational kill criteria ($H_0$ tension is live). Two are partially operational ($\sigma_8$, r). One (cusp-core) has active escape hatches. GRADE: B (partially falsifiable with acknowledged escape hatches).

#### 5.2.4 String Theory and Inflationary Cosmology

**String theory** and **eternal inflation** share the adelic framework's structural problem: the Platonic form (the mathematical framework) is insulated from specific instantiations (the landscape, the inflaton potential). No observation can kill string theory because any observation can be accommodated by moving to a different point in the landscape. No observation can kill eternal inflation because any universe is a bubble in the multiverse. These frameworks are GRADE: D (structurally unfalsifiable, same class as the adelic framework). `[not yet falsifiable]`

They are not alone. The multiverse, many-worlds quantum mechanics (in its strongest form), and the simulation hypothesis all share this grade. The adelic framework is in distinguished company — which should be cold comfort.

#### 5.2.5 Comparative Table

| Framework | Operational Kill Criteria | Escape Hatches | Grade |
|---|---|---|---|
| General Relativity (bare) | 3 genuine discriminations; rest parameter measurements | Confirmation-seeking within the GR program; PPN parameter space; look-elsewhere; alternatives constrained, not falsified (§5.4) | **B** |
| GR composite (GR+DM+DE+inflation) | 0/4 | Auxiliary-absorption: DM/DE/inflation tuned to absorb anomalies | **C** |
| Standard Model | 3/4 formal | Free-parameter re-fit; energy-scale deferral (particle-hunting history) | **C** |
| ΛCDM | 1/4 bare; 3/4 if tensions count | Baryonic feedback (shrinking, not closed) | **B** |
| Adelic Framework | 0/7 | 17 documented across 7 criteria + meta-escape | **D** |
| String Theory | 0/N (landscape absorbs all) | Platonic form / landscape | **D** |
| Eternal Inflation | 0/N (multiverse absorbs all) | Any observation = one bubble | **D** |

The adelic framework is not uniquely unfalsifiable — it occupies a grade shared by other ambitious theoretical programs. What distinguishes it is the *honesty* of its self-assessment: the present paper identifies its own escape hatches and proposes concrete operationalization steps. String theory landscape papers rarely do the same. `[speculative – self-assessment honesty is not the same as falsifiability]`

#### 5.2.6 Implications for the Present Audit

The symmetric audit yields two conclusions:

1. **The asymmetry is narrower than first appears — and it is not flattering to the incumbents.** The adelic framework is unfalsifiable (Grade D). The operational GR composite (GR + dark matter + dark energy + inflation) is Grade C. The Standard Model is Grade C. ΛCDM is Grade B. And the *bare* Einstein equations — the strongest theory in the set — earn B, not A: their canonical 1919 confirmation was compromised by observer bias and discarded discordant data, and their subsequent confirmations were parameter measurements inside the PPN family

rather than falsifications of alternatives (§5.4). The claim "contemporary physics has become unfalsifiable" is not true of *some* programs — it is true of *most* ambitious programs, and the incumbents survive not because they are more falsifiable but because their escape hatches are older, better institutionalized, and therefore less visible.

1. **Escape hatches are a spectrum, not a binary.** Every framework has them. The question is: are the escape hatches (a) shrinking under theoretical progress, (b) stable but acknowledged, or (c) expanding to absorb any criticism? The adelic framework's hatches are in category (b): stable and acknowledged, with a plan to close them. String theory's are in category (c): the landscape expands with every constraint. ΛCDM's baryonic feedback hatch was in category (c) for decades but is moving toward (a) with improved simulations.

This does not excuse the adelic framework's unfalsifiability. It contextualizes it. The framework's Grade D is a problem that must be fixed — and the path forward (§6) is the commitment to do so. But the problem is not unique, and the framework's willingness to name it is, in its way, more scientific than programs that maintain Grade D while claiming Grade A. `[speculative]`

### *5.3 The Independence Requirement: Consilience as the Only Unbiased Evidence Standard*

The Eddington case generalizes into a methodological principle that this audit must adopt for *all* frameworks, including the adelic framework's own null results.

**The single-test fallacy.** A lone observation — no matter how precisely measured — cannot provide unbiased strong evidence, because it is vulnerable to at least four confounds:

1. **Experimenter bias.** The observers may want the theory to be true (Eddington) or false (a skeptical rival). The 1919 case shows this is not a hypothetical failure mode; it is the canonical example.
2. **Methodological blind spots.** Any single instrument or technique has unknown systematic errors — photographic plate distortion in 1919, detector energy-scale calibration in modern particle physics. A result cannot be assessed against errors that are unknown by construction.
3. **Subjective analysis choices.** Which data points are retained, which are discarded, which fitting model is used — these decisions, made after seeing the data, can steer a noisy result toward the desired conclusion (the discarded Sobral 4-inch plates).
4. **Competing-theory underdetermination.** A single observation rarely discriminates between the tested theory and all viable alternatives. The 1919 plates did not kill Nordström's theory; they were simply read as supporting GR over Newton.

**The consilience requirement.** Strong, unbiased evidence requires *multiple methodologically independent lines of evidence converging on the same conclusion* — different instruments, different physics, different analysis teams, different systematic-error structures. This is the standard GR meets in practice (perihelion, redshift, Shapiro, pulsar, LIGO), the standard the Standard Model meets at the precision frontier (Z-pole, Higgs couplings, CKM unitarity), and the standard the adelic framework has *never once met*: zero independent positive confirmations across all seven criteria.

**The corollary for null results.** The same requirement applies to falsification. A single null result (the GWTC-1 echo search, GRB 090510 Lorentz bound) cannot kill a framework with an unbounded amplitude or threshold, and cannot confirm one either. Only a *consilient* null — multiple independent searches with independent templates and error structures all excluding the prediction above a derived bound — is fatal. The adelic framework's KC4 is not merely missing an amplitude bound; it is missing the entire consilience apparatus that would make either detection or exclusion meaningful. `[my conjecture]`

**The grading consequence.** Grades based on "operational kill criteria" alone are insufficient. They must be weighted by (a) whether any confirming observation was independent, and (b) how many independent lines converge. Under this weighting: bare GR drops from A to B (no single clean test; the confirmations are parameter measurements within the PPN family, with only three genuine theory discriminations — §5.4); the adelic framework stays at D (zero independent confirmations); ΛCDM's $H_0$ tension becomes *more* significant, because it is consilient — multiple independent late-universe methods (Cepheids, TRGB, masers, lensing) agree on the high value, and multiple early-universe methods agree on the low value, which is precisely why the discrepancy is credible rather than an artifact. `[speculative]`

### *5.4 The GR Testing Program Under the Same Rigor*

The Independence Requirement (§5.3) awarded bare GR a B+ for "consilience" — five independent confirmations converging. That grading is itself too generous, and for the same reason the v0.6 audit applied to the 1919 eclipse: the *subsequent* confirmatory tests were not independent consilience in the adversarial sense. They were confirmation-seeking within a research program that had already accepted the theory.

**The tests were designed inside the GR program, by GR proponents, to confirm GR's predictions.** Pound–Rebka measured the gravitational redshift — a quantity whose magnitude was set by the theory under test, using an apparatus (Mössbauer effect) chosen because it could resolve that magnitude. Shapiro measured the radar-echo delay — again a GR-derived prediction, with the experiment designed after the prediction was made. Hulse–Taylor monitored a binary pulsar whose orbital decay rate was computed from GR's quadrupole formula. In each case, the test was constructed *from* the theory's own formalism, by researchers who accepted the theory, to measure a predicted effect. This is the structure of confirmation, not the structure of adversarial falsification: the researcher does not try to kill the theory; they try to measure how right it is. `[established — the PPN program (see below) was developed in large part *after* these tests, as a framework for interpreting them, which is itself evidence that the tests were not designed to discriminate among rival frameworks from the start]`

**What alternative hypothesis would each test have falsified?** This is the question the audit must ask — and the honest answer is: for most of the canon, no serious alternative was at stake.

- *Pound–Rebka (1960):* would have falsified a theory predicting *no* gravitational redshift. But no viable alternative predicted zero — Newtonian gravity with special relativity had already failed on other grounds, and every metric theory of gravity predicts *some* redshift. The test measured the GR value with high precision but did not discriminate GR from any live competitor.
- *Shapiro delay (1964):* would have falsified a theory predicting no time delay. Every metric theory predicts a delay; only the coefficient differs. Within the parameterized post-Newtonian (PPN) framework [^28][^29], the measurement constrains the PPN parameter $\gamma$ to near unity — but $\gamma$ is a parameter *inside* the family of metric theories. Tuning the theory's free parameters (e.g., the Brans–Dicke coupling $\omega$) reproduces GR's result to within measurement precision. The test tightened a parameter bound; it did not test GR against a falsifiable alternative with a different prediction space.
- *Hulse–Taylor (1974):* would have falsified a theory predicting no gravitational-wave orbital decay. Newtonian gravity predicts no decay, so the discovery was a genuine blow against Newtonian treatments of binary pulsars. But among metric theories, scalar-tensor gravity also predicts orbital decay — at a slightly different rate. The measurement agreed with GR to ~0.1%, tightening the Brans–Dicke bound; it did not falsify the scalar-tensor alternative outright.
- *LIGO (2015–):* gravitational-wave detection is a genuine discovery — a waveform was observed where Newtonian physics predicts none. But the waveform-matching that followed is parameter estimation within GR's template

bank: LIGO detects a signal and fits it to a GR waveform. The templates themselves presuppose GR; the analysis pipeline was not constructed to discriminate GR from a rival metric theory.

**The look-elsewhere structure.** Each test was published as confirming GR's prediction to ever-higher precision. The look-elsewhere problem is that with a *family* of parameters (PPN has ten) and a century of experiments, some subset of measurements will agree with GR by chance, and the program does not pre-register which measurement would count as falsification, at what precision, against which alternative. When a measurement *did* deviate (early Mercury perihelion anomalies, the Flyby Anomaly, the Pioneer anomaly), the deviations were absorbed as systematics or new auxiliary physics — the same absorption mechanism the audit criticizes in the adelic framework and ΛCDM.

**The PPN insight.** The parameterized post-Newtonian framework [^28][^29][^30] is the formal statement of this problem. GR fixes all PPN parameters ($\gamma = \beta = 1$, others 0). The testing program measures these parameters. A measurement consistent with the GR values is not a test of "GR vs. not-GR" — it is a measurement within a parameterized *family* of metric theories, one point of which is GR. The alternative hypotheses (Brans–Dicke with $\omega \neq \infty$, vector-tensor theories, massive graviton variants) are *not* falsified by the parameter measurements; they are *constrained*. This is the distinction between parameter-space narrowing and theory falsification. `[established — PPN formalism (Will 1971; Nordtvedt 1968; Will 2014): all metric gravity theories are parameterized by 10 PPN parameters; tests measure parameters, they do not decide among the family]`

**What genuine falsifications did the GR program produce?** Three, and all three preceded the theory's confident institutionalization: the anomalous Mercury perihelion precession (Le Verrier 1859, [^23]) was an anomaly *before* GR existed, and GR's prediction (43″/century) is a true pre-registered success against the Newtonian baseline; the 1919 eclipse (for all its flaws) did discriminate GR's 1.75″ against Newton's 0.87″ at the level of a 2–3σ separation; and gravitational-wave detection (2015) observed a phenomenon Newtonian physics forbids. These are real. But they are a thinner list than "five independent consilient confirmations," and the other tests in the canon are parameter measurements, not theory discriminations. `[speculative — the three genuine falsifications are real; the characterization of the remaining tests as parameter measurements rather than theory discriminations is this audit's reading of the PPN structure]`

## 6. Path Forward

To become falsifiable, the framework must deliver five concrete derivations, listed in priority order:

**Priority 1 — BH echo amplitude lower bound (KC4).** Derive a minimum echo amplitude from the adelic action, independent of all free parameters. This is the highest-priority task and the most likely route to a binding prediction. The Möbius-function template for relative delays and amplitude ratios is already rigid; the missing piece is the absolute amplitude scale. **Target: Q1 2027. If no bound is derived by Q2 2027, KC4 should be downgraded from "conditional kill criterion" to "prediction-in-waiting with no timeline."**

**Priority 2 — Rigid three-generation mass relations (KC2).** Compute mass relations for the three known generations from first principles, such that a fourth generation with *any* mass would break them. The relations must be specific enough that "extending to a quadratic number field" is not a viable escape. **Target: Q2 2027. If no rigid relation is derived, the "restrict base field to $\mathbb{Q}$" postulate is revealed as a rhetorical fence, not a falsifiable commitment.**

**Priority 3 — P-adic charge definition (KC1).** Construct an operational definition of p-adic charges from the Compton idele, with a measurement protocol or, at minimum, a theoretical statement of what *cannot* happen if they are conserved. This is necessary for the product formula to become a physical conservation law rather than a mathematical identity. **Target: Q3 2027. Without this, KC1 remains a restatement of a mathematical theorem dressed as a physical hypothesis.**

**Priority 4 — Prime-number DM template (KC5).** Specify the exact mathematical object — Möbius function, prime gap distribution, or other — that governs the predicted log-periodic features in dark matter halos. State the minimum adelic DM fraction below which the framework loses its dark matter motivation. **Target: Q4 2027. If no template is specified, KC5 should be retired as a falsification criterion.**

**Priority 5 — Hard discretization length scale (KC3).** Derive a minimum scale from the adelic action below which smooth, Lorentz-invariant spacetime is incompatible with the adelic substrate. Until this exists, every experimental null result on Lorentz violation is a non-result for the framework. **Target: Q4 2027. If no scale is derived, KC3 should be classified as structurally unfalsifiable and removed from the kill criteria list.**

These five derivations are not optional embellishments. They are the minimum set of theoretical commitments required for the adelic framework to transition from a mathematical research program to a falsifiable physical theory. If all five derivations fail to materialize by Q4 2027, the framework should be classified as not-yet-falsifiable — not wrong, merely not yet a scientific theory — and the kill criteria should be retired as aspirational rather than operational. [my conjecture]

## 7. Data-Driven Falsification Audit: What Existing Observations Already Say

The preceding sections defined kill criteria and graded frameworks. This section asks the harder question: **have existing observations already triggered any kill criterion?** For each criterion, the relevant experimental or observational dataset is identified, its current status is assessed, and a verdict is rendered. The audit is applied symmetrically — to the adelic framework's seven criteria and to the null hypotheses (ΛCDM, the Standard Model, and the operational GR composite).

### *7.1 Method*

For each kill criterion, four questions are asked:

1. **Does the dataset exist?** Is there an experiment or observation capable of testing the criterion?
2. **What does it show?** The quantitative result, with reference.
3. **Is it binding?** Does the result fall inside the criterion's specified falsification boundary — or is the boundary undefined?
4. **Verdict:** [FALSIFIED] / [CONSTRAINED, NOT FATAL] / [NULL — no signal, no falsification] / [UNTESTABLE — no dataset exists].

### *7.2 The Adelic Framework Under Existing Data*

**KC4 (Black hole echoes) — tested, null result, not fatal.**

The LIGO-Virgo GWTC-1 catalog has been searched for echo signals from nine binary black hole mergers using a Kerr-membrane echo template [^9]. No statistically significant echo signals were found. The search placed upper limits on echo amplitude in each event.

This is the adelic framework's most directly testable prediction — and it has been tested. The result is null. But it is *not* fatal, for exactly the reason identified in §2.4: no minimum echo amplitude was ever derived from the adelic action. The framework predicted a pattern (Möbius-weighted prime delays) without predicting its absolute strength. A null search constrains the amplitude to below the current detector sensitivity, and the framework survives by claiming the amplitude is below that sensitivity. **Verdict: [NULL — no signal, not falsified, no confirmatory evidence].** The framework's single most testable claim has produced zero positive evidence after being searched.

**KC3 (Exact continuum / Lorentz violation) — constrained, not fatal.**

The Fermi-LAT observation of GRB 090510 set the strongest constraint on linear Lorentz-invariance violation to date: the arrival-time dispersion of the 31 GeV photon relative to lower-energy photons limits the linear LV scale to well above the Planck scale [^10]. No energy-dependent photon delay was observed.

This constrains any framework predicting observable LV at accessible scales — but the adelic framework placed its discretization at or below the Planck length without specifying a threshold (§2.3). The constraint is therefore not binding: the framework survives by placing its structure below the probed scale. **Verdict: [CONSTRAINED, NOT FATAL].** The constraint tightens the allowed parameter space without touching the framework's core.

**KC2 (Three generations) — the one criterion with a positive existing dataset, and it is consistent.**

The LEP measurement of the Z-boson invisible width determines the number of light neutrino species: $N_\nu = 2.984 \pm 0.008$ [^11]. There are exactly three light generations. Direct searches at the LHC exclude fourth-generation quarks up to ~1 TeV.

If the adelic framework predicts exactly three generations (via the cubic structure of the rational idele class group), this dataset is *consistent* with it — but consistent is not confirmatory, because the framework never specified rigid mass relations that a fourth generation would break (§2.2). The observation rules out a light fourth generation, which the framework also rules out. **Verdict: [CONSISTENT — but this is a shared prediction with the Standard Model, not adelic evidence].** The framework takes credit for a constraint that is independently established by LEP.

**KC5 (DM small-scale structure) — no log-periodic features observed.**

No dark matter halo has shown confirmed log-periodic features or prime-indexed substructure. The small-scale problems of ΛCDM (cusp-core, missing satellites) are real, but no prime-related pattern has been detected in any of them [^12]. **Verdict: [NULL — no signal].** The adelic prediction for DM structure is not a predicted signature with a specified template, so the absence of the pattern is not a falsification — it is an unconfirmed prediction.

**KC1 (Product formula) — no violation observed, but the criterion is unfalsifiable as specified.**

Searches for fine-structure constant variation find no confirmed spacetime variation: quasar absorption-line studies report a possible spatial dipole at the $\sim 10^{-5}$ level [^13], while laboratory atomic-clock constraints bound $|\Delta\alpha/\alpha|$ to $\sim 10^{-18}$ per year [^14]. No confirmed variation exists.

But per §2.1, KC1 is unfalsifiable as specified: any variation can be absorbed as a modulus change. The dataset therefore cannot trigger the criterion even if a variation were confirmed. **Verdict: [UNTESTABLE — the criterion's escape hatch (modulus redefinition) precedes the data].**

**KC7 (Gauge group) — untested by construction.**

No derivation of SU(3) × SU(2) × U(1) from the adelic framework has been published, and no obstruction proof exists. There is no dataset that could falsify this criterion because the criterion was never operationalized. **Verdict: [UNTESTABLE — promissory note].**

### *7.3 Null Hypotheses Under Existing Data — Attempted Falsification*

**ΛCDM — the Hubble tension is a live, growing falsification signal.**

The SH0ES program measures the local expansion rate with 1 km/s/Mpc uncertainty: $H_0 = 73.04 \pm 1.04$ km/s/Mpc [^15]. Planck 2018 measures the early-universe value from the CMB: $H_0 = 67.4 \pm 0.5$ km/s/Mpc [^16]. The discrepancy is ~5σ and has persisted across multiple independent methodologies and a decade of data.

This is precisely the form of a Popperian kill criterion: a specific parameter whose early-universe and late-universe determinations disagree beyond the combined uncertainty. ΛCDM survives today only through auxiliary mechanisms (early dark energy, modified recombination, interacting dark energy — see [^17] for the EDE proposal). Those are aux-

iliary hypotheses in exactly the sense the present paper criticizes. **Verdict: [CONSTRAINED — the tension is real and growing; ΛCDM's survival currently depends on auxiliary escape hatches].** If the tension reaches >5σ with systematics fully excluded, ΛCDM is falsified by this dataset.

**Standard Model — muon g−2 shows a persistent 4.2σ anomaly, but the theory side is contested.**

The Fermilab Muon g−2 experiment measures a*μ = 116592040(54) × 10⁻¹¹, a 4.2σ deviation from the SM prediction [^18]. This is a genuine anomaly. However, the SM prediction itself is split between the dispersive and lattice-QCD approaches, which disagree by more than their quoted uncertainties [^19]. The "standard model value" is therefore not uniquely defined, and the anomaly cannot yet be classified as a falsification. It is an anomaly with a contested null.* ***Verdict: [CONSTRAINED — real anomaly, contested null, not yet a falsification].*** *The B-meson anomalies (*RK, R_K*) that once pointed beyond the SM have since reverted to SM agreement with more data [^20].

**Operational GR composite — no direct test exists.**

No experiment confronts GR + dark matter + dark energy + inflation as a single unified structure. Each component is tested in isolation, and each can be adjusted independently to absorb anomalies (§5.2.1). **Verdict: [UNTESTABLE AS A WHOLE] — this is the structural point of the grade revision: the operational composite is de-facto unfalsifiable, not because it is strong but because it is flexible.**

### *7.4 The Falsification Scorecard*

| Framework | Criterion | Dataset Exists? | Result | Binding? | Verdict |
|---|---|---|---|---|---|
| Adelic | KC4 echoes | Yes (GWTC-1) | Null | No (no amplitude bound) | [NULL] |
| Adelic | KC3 continuum | Yes (GRB 090510) | Constraint | No (no threshold) | [CONSTRAINED] |
| Adelic | KC2 generations | Yes (LEP) | 3 species | Consistent but shared | [CONSISTENT] |
| Adelic | KC5 DM structure | Partial | No pattern | No (no template) | [NULL] |
| Adelic | KC1 product formula | Yes (α searches) | No variation | No (escape hatch) | [UNTESTABLE] |
| Adelic | KC7 gauge group | No | — | No (unoperationalized) | [UNTESTABLE] |
| ΛCDM | $H_0$ | Yes | 5σ tension | **Bordering** | [CONSTRAINED — live] |
| SM | g−2 | Yes | 4.2σ | Contested null | [CONSTRAINED] |
| SM | B anomalies | Yes | Reverted | No | [RESOLVED — null] |
| GR composite | Whole-structure | No | — | — | [UNTESTABLE] |

### *7.5 Reading of the Scorecard*

The data-driven audit produces a result that is uncomfortable for both sides.

**For the adelic framework:** every criterion with an existing dataset shows either a null result (echoes, DM structure), a non-binding constraint (LV), or consistency with a prediction the framework shares with the Standard Model (three generations). The framework's most testable prediction — KC4 echoes — has been searched and produced zero positive evidence. No adelic-specific signature has ever been observed in any dataset. The framework has not been falsified, but it has also never once been *confirmed* by an independent observation. `[speculative – null results are consistent with an amplitude below sensitivity, but the framework's zero positive observations across all testable criteria is a fact]`

**For the null hypotheses:** the incumbent frameworks are not cleanly falsifiable either. ΛCDM faces a live, growing 5σ Hubble tension that currently survives only through auxiliary escape hatches — the very mechanism the paper criticizes. The Standard Model faces a 4.2σ muon anomaly whose null is contested by theory, not resolved. The operational

GR composite has never been tested as a whole. The claim that the incumbents are "falsifiable science" while the adelic framework is "unfalsifiable speculation" does not survive contact with the scorecard. The difference is one of degree — and of institutionalization, not of epistemic virtue. `[my conjecture]`

**The honest conclusion:** all frameworks under review occupy positions on a falsifiability spectrum, and none has been cleanly falsified by existing data. Under the Independence Requirement (§5.3), the adelic framework's position is worse than the scorecard alone shows: its null results are *unconsilient* — each is a single search, single template, single error structure — so they neither confirm nor decisively constrain, while its positive predictions have never received a single independent confirmation. The incumbents' tensions, by contrast, are OPERATIONAL under the Null-Equivalence Protocol (§7.6): the $H_0$ discrepancy is credible precisely because $O_T$ *(late-universe measurements)* $\neq O_N$ (ΛCDM early-universe prediction) at measurable precision, and independent late-universe methods agree with each other. What the existing data *does* establish is which frameworks are genuinely at risk: ΛCDM (consilient Hubble tension), the SM (muon anomaly), and — if its operationalized criteria ever produce amplitude bounds — the adelic framework (echo searches ready and waiting, but needing multiple independent searches to be meaningful). The next observation is more likely to falsify an incumbent than to confirm the adelic framework. That is not a vindication of the framework; it is the current balance of empirical risk.

### *7.6 The Null-Equivalence Protocol: When the Test Predicts What the Null Predicts*

The deepest form of unfalsifiability is not a theory that can absorb any observation. It is a theory whose predictions are *identical* to the null hypothesis at every feasible observation — so that no experiment can separate them, regardless of what is observed. This is the adelic framework's real-vs-rational-completions problem, and it is also the structure of much of the GR testing program (§5.4).

**The protocol.** For every proposed criterion, define two prediction sets:

- **O_N** — the observation the null hypothesis (Standard Model / ΛCDM / GR composite) predicts at the feasible scale.
- **O_T** — the observation the test theory (adelic framework) predicts at the feasible scale.

Then classify:

| Condition | Classification | Meaning |
|---|---|---|
| $O_T = O_N$ for all feasible observations | **VACUOUS** | No experiment can ever distinguish; criterion carries zero empirical content |
| $O_T \neq O_N$, but difference below measurement precision | **NON-OPERATIONAL** | In principle testable, not at current or foreseeable technology |
| $O_T \neq O_N$, difference measurable | **OPERATIONAL** | A genuine kill criterion exists |

**Application to the seven adelic criteria:**

| Criterion | O_N (null predicts) | O_T (adelic predicts) | Classification |
|---|---|---|---|
| KC1 product formula | No α variation; conservation | No α variation; conservation | **VACUOUS** — both predict the same observation; the "test" only differs in the theory's internal interpretation, not in the observable |
| KC2 three generations | 3 generations (LEP: $N_\nu = 2.984 \pm 0.008$) [^11] | 3 generations (cubic idele structure) | **VACUOUS** — identical predicted observation; a shared prediction, not a test |
| KC3 continuum / LV | Lorentz invariance at all tested scales | Lorentz invariance at all tested scales (discreteness below Planck) | **NON-OPERATIONAL** — the difference is below any feasible probe; no experiment can reach it |
| KC4 echoes | No echoes (GR membrane) | Prime-delay echoes with unspecified amplitude | **NON-OPERATIONAL** — O*T* ≠ O*N* in principle, but without a derived amplitude bound, any null result is consistent with both |
| KC5 DM structure | Smooth ΛCDM profiles | Log-periodic structure, template unspecified | **NON-OPERATIONAL** — O*T* ≠ O*N* in principle, but no template and no subdominance bound make the prediction unfalsifiable |
| KC6 dimensionality | 3+1 | 3+1 (attractor) | **VACUOUS** — identical predicted observation; a post-diction, not a test |
| KC7 gauge group | SU(3)×SU(2)×U(1) | SU(3)×SU(2)×U(1) (derived) | **VACUOUS** — identical predicted observation; the derivation would change the theory's confidence, not the observation |

**Result: four of seven criteria are VACUOUS** (KC1, KC2, KC6, KC7) — the adelic framework predicts, at every feasible observation, exactly what the null predicts. Three are NON-OPERATIONAL (KC3, KC4, KC5) — the predictions differ in principle but at scales or with amplitudes no current experiment can reach, and with the relevant bounds (echo amplitude, DM template, discretization scale) never derived. **Zero of seven are OPERATIONAL.** This is the formal, protocol-based statement of the framework's current empirical emptiness: it is not merely unfalsified and unconfirmed — it is observationally equivalent to the null at every feasible test. `[my conjecture — the protocol classifications follow from the framework's own stated postulates and the absence of derived bounds]`

**Application to the GR testing program.** The same protocol explains why the GR tests are confirmation rather than discrimination. For Pound–Rebka: O*N (any metric theory) = "some redshift";* O*T* (GR) = "redshift of magnitude $\nu \cdot \Delta\varphi/c^2$" — the two differ only in the *magnitude of a shared phenomenon*, and the measurement is a parameter determination within the shared family. For Shapiro: O*N (Brans–Dicke with ω)* ≈ O*T* (GR) at current precision — the predicted observations are identical to within the measurement error, so the test is NON-OPERATIONAL as a theory discriminator even though it is OPERATIONAL as a parameter measurement. The GR program's genuine theory-discriminating tests are the three identified in §5.4 — perihelion (pre-registered, Newton-baseline), 1919 (GR vs Newton), LIGO (waveform where Newton predicts none). The rest constrain parameters inside the metric-gravity family.

**The completed argument.** The audit now holds all frameworks to the same standard: a criterion is evidence-bearing only if O*T* ≠ O*N* at a measurable scale. Under that standard, the adelic framework has zero operational criteria; the GR testing program's "consilience" reduces to three genuine discriminations plus a century of parameter measurements within a presupposed framework; the SM's anomalies ($H_0$ tension, muon g−2) are OPERATIONAL because O*T* ≠ O*N* at measurable precision — which is why they are the most consequential results in the audit. The frameworks are not equally unfalsifiable; they are differently unfalsifiable, and the protocol makes the difference explicit. `[speculative]`

## Declarations

### *Author Contributions*

Single-author work. The red-team audit methodology was developed in collaboration with the QNFO automated review pipeline.

### *Funding*

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### *Data Availability*

No experimental data were generated or analyzed in this study. All claims about existing experimental bounds cite published literature.

### *Code Availability*

Not applicable — this is a conceptual analysis with no computational component.

### *Competing Interests*

The author is the originator of the adelic framework under audit. This paper is an exercise in adversarial self-criticism. Readers should apply appropriate discounting for conflict of interest, though the audit's findings — that zero of seven proposed kill criteria are currently operational — suggest the conflict did not produce undue leniency.

### *AI Assistance Disclosure*

This paper was drafted with assistance from DeepChat (deepseek-v4-flash). The red-team audit was performed by the same AI system operating under an adversarial review protocol. All substantive claims and the final text were reviewed and approved by the human author.

### *Ethical Statement*

This work raises no ethical concerns beyond the standard obligations of scientific honesty. The paper's central claim — that research programs the author is invested in and the incumbent paradigms he critiques have not uniformly met the criteria for falsifiability — is offered as a methodological case study in symmetric adversarial self-audit.

### *Pre-Registration*

Not applicable to this conceptual analysis. However, the kill criteria defined herein (KC1–KC7) constitute a pre-registration scaffold: if future experimental or theoretical developments trigger any criterion after the operationalization steps in §6 are completed, the framework should be considered falsified under the conditions specified.

### *License*

QNFO Unified License Agreement (QNFO-ULA).

## References

[1] [^1]: Quni-Gudzinas, R.B. "Adelic Core Synthesis: Foundational Postulates of Ultrametric Physics." the QNFO archive, 2026. https://papers.qnfo.org/papers.

[2] [^2]: Ostrowski, A. "Über einige Lösungen der Funktionalgleichung φ(x)·φ(y) = φ(xy)." *Acta Mathematica*, vol. 41, 1916, pp. 271–284.

[3] [^3]: Quni-Gudzinas, R.B. Obsidian note `_26216130508.md`, 2026-08-04. Raw draft of the present paper.

[4] [^4]: Gelbart, S. *Automorphic Forms on Adèle Groups*. Annals of Mathematics Studies, Princeton University Press, 1975.

[5] [^5]: Vladimirov, V.S., Volovich, I.V., and Zelenov, E.I. *p-Adic Analysis and Mathematical Physics*. World Scientific, 1994.

[6] [^6]: Quni-Gudzinas, R.B. "Black Hole Echoes as Prime-Indexed Distinction Signatures." QNFO Technical Memo, 2026. [unpublished]

[7] [^9]: Uchikata, N., et al. "Searching for black hole echoes from the LIGO-Virgo Catalog GWTC-1." arXiv:1906.00838, 2019. [verified via arXiv abstract — null result for echoes in nine BBH mergers]

[8] [^10]: Abdo, A.A., et al. "Fermi and Swift observations of the bright short GRB 090510." *Astrophysical Journal*, 2010. arXiv:1002.2863. [verified via arXiv abstract — strongest linear-LV constraint]

[9] [^11]: The ALEPH, DELPHI, L3, OPAL, SLD Collaborations, the LEP Electroweak Working Group, the SLD Electroweak and Heavy Flavour Groups. "Precision electroweak measurements on the Z resonance." *Physics Reports*, 2006. [established — $N_\nu = 2.984 \pm 0.008$ from Z invisible width]

[10] [^12]: Bullock, J.S., and Boylan-Kolchin, M. "Small-Scale Challenges to the ΛCDM Paradigm." *Annual Review of Astronomy and Astrophysics*, 2017. [established — cusp-core and missing-satellites tensions documented] [^13]: Webb, J.K., et al. "Indications of a Spatial Variation of the Fine Structure Constant." *Physical Review Letters*, vol. 107, 2011, 191101. [established — quasar absorption-line study reports $\Delta\alpha/\alpha \sim 10^{-5}$ spatial dipole claim]

[11] [^14]: Lange, R., et al. "Improved limits for violations of local position invariance from atomic clock comparisons." *Physical Review Letters*, vol. 126, 2021, 011102. [established — laboratory bound $|\Delta\alpha/\alpha| \sim 10^{-18}$ per year]

[12] [^15]: Riess, A.G., et al. "A Comprehensive Measurement of the Local Value of the Hubble Constant with 1 km/s/Mpc Uncertainty from the Hubble Space Telescope and the SH0ES Team." *Astrophysical Journal Letters*, 2022. arXiv:2112.04510. [verified via arXiv abstract — $H_0 = 73.04 \pm 1.04$ km/s/Mpc]

[13] [^16]: Planck Collaboration. "Planck 2018 results. VI. Cosmological parameters." *Astronomy & Astrophysics*, vol. 641, 2020, A6. arXiv:1807.06209. [verified via arXiv abstract — $H_0 = 67.4 \pm 0.5$ km/s/Mpc]

[14] [^17]: Poulin, V., Smith, T.L., Karwal, T., and Kamionkowski, M. "Early Dark Energy Can Resolve the Hubble Tension." *Physical Review Letters*, vol. 122, 2019, 221301. [established — EDE proposal as auxiliary resolution]

[15] [^18]: Abi, B., et al. (Muon g−2 Collaboration). "Measurement of the Positive Muon Anomalous Magnetic Moment to 0.46 ppm." *Physical Review Letters*, vol. 126, 2021, 141801. arXiv:2104.03281. [verified via arXiv abstract — $a_\mu = 116592040(54) \times 10^{-11}$, 4.2σ from SM]

[16] [^19]: Aoyama, T., et al. "The anomalous magnetic moment of the muon in the Standard Model." *Physics Reports*, vol. 887, 2020, pp. 1–166. [established — dispersive vs lattice QCD theory disagreement documented]

[17] [^20]: LHCb Collaboration. "Test of lepton universality in $b \to s\ell^+\ell^-$ decays." *Physical Review Letters*, vol. 131, 2023, 051803. [established — $R_K$ reverted to Standard Model agreement with full Run 1+2 data] [^21]: Dyson, F.W., Eddington, A.S., and Davidson, C. "A determination of the deflection of light by the sun's gravitational field, from observations made at the total eclipse of May 29, 1919." *Philosophical Transactions of the Royal Society A*, vol. 220, 1920, pp. 291–333. [verified via Crossref — 10.1098/rsta.1920.0009]

[18] [^22]: Kennefick, D. *No Shadow of a Doubt: The 1919 Eclipse That Confirmed Einstein's Theory of Relativity*. Princeton University Press, 2019. [verified via OpenAlex — 10.1515/9780691190051]

[19] [^23]: Le Verrier, U.J. "Lettre de M. Le Verrier à M. Faye sur la théorie de Mercure." *Comptes Rendus*, vol. 49, 1859, pp. 379–383. [historical — no DOI; the pre-GR anomaly record that became the first GR confirmation]

[20] [^24]: Pound, R.V., and Rebka, G.A. "Apparent Weight of Photons." *Physical Review Letters*, vol. 4, 1960, pp. 337–341. [verified via Crossref — 10.1103/PhysRevLett.4.337]

[21] [^25]: Shapiro, I.I. "Fourth Test of General Relativity." *Physical Review Letters*, vol. 13, 1964, pp. 789–791. [verified via Crossref — 10.1103/PhysRevLett.13.789]

[22] [^26]: Hulse, R.A., and Taylor, J.H. "Discovery of a pulsar in a binary system." *The Astrophysical Journal*, vol. 195, 1975, pp. L51–L53. [verified via Crossref — 10.1086/181708]

[23] [^27]: Abbott, B.P., et al. (LIGO/Virgo Collaboration). "GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral." *Physical Review Letters*, vol. 119, 2017, 161101. [verified via Crossref — 10.1103/PhysRevLett.119.161101] [^28]: Nordtvedt, K. "Equivalence Principle for Massive Bodies. II. Theory." *Physical Review*, vol. 169, 1968, pp. 1017–1025. [verified via Crossref — 10.1103/PhysRev.169.1017; parameterized post-Newtonian framework]

[24] [^29]: Will, C.M. "The Confrontation between General Relativity and Experiment." *Living Reviews in Relativity*, vol. 17, 2014, 4. [verified via Crossref — 10.12942/lrr-2014-4; canonical review of the PPN parameter space and experimental constraints]

[25] [^30]: Brans, C., and Dicke, R.H. "Mach's Principle and a Relativistic Theory of Gravitation." *Physical Review*, vol. 124, 1961, pp. 925–935. [verified via Crossref — 10.1103/PhysRev.124.925; the scalar-tensor alternative constrained by Hulse–Taylor and Shapiro measurements]

[26] [^7]: Quni-Gudzinas, R.B. "P-adic Dark Matter: Discrete Scale Invariance in Halo Profiles." QNFO Technical Memo, 2026. [unpublished]

[27] [^8]: Quni-Gudzinas, R.B. "Dimensional Emergence from Adelic Renormalization Group Flow." QNFO Technical Memo, 2026. [unpublished]