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Posted Date: 22 December 2025

doi: 10.20944/preprints202512.1953.v1

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Article

Timeless Projection and Counterspace: Why Undecidability Does Not Preclude Simulation

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Abstract

Faizal et al. (2025) argue that Gödel–Tarski–Chaitin limits render a purely algorithmic Theory of Everything impossible, concluding that the universe cannot be a computer simulation. We demonstrate that this conclusion commits a quantifier overreach by conflating two distinct notions: (i) *algorithmic simulation*, which attempts to compute all truths about the fundamental layer, and (ii) *projection simulation*, which approximates observables on a well-posed shadow manifold. Within the Timeless Counterspace and Shadow Gravity (TCGS-SEQUENTION) framework, we show that the 4-D counterspace $\mathcal{C}$ functions as the Tarskian "semantic truth" (the *Territory*), while the 3-D shadow Σ constitutes "syntactic provability" (the *Map*). Undecidability theorems constrain the Map, not the Territory. Crucially, the TCGS framework provides a concrete geometric instantiation of the "Meta-Theory of Everything" (MToE) that Faizal et al. invoke abstractly: the projection map $X : \Sigma \to \mathcal{C}$ plays the role of their external truth predicate $T(x)$, grounding non-algorithmic truths in geometric structure rather than meta-logical assertion. We prove three main results: (A) the undecidability-based no-go theorem applies only to algorithmic simulations targeting the Territory; (B) the shadow manifold Σ admits well-posed dynamics under a single extrinsic constitutive law, rendering all empirical observables computably approximable to arbitrary accuracy; (C) the inference from "no algorithmic simulation of $\mathcal{C}$" to "no simulation whatsoever" is a formal quantifier error. We conclude that non-algorithmicity at the source is fully compatible with deterministic, simulable shadow phenomenology—and that quantum complementarity, dark-sector phenomenology, and biological convergence all manifest as projection artifacts of this same geometric architecture.

Keywords: undecidability; non-algorithmic physics; counterspace; projection ontology; simulation hypothesis; TCGS-SEQUENTION; Tarski undefinability; Gödel incompleteness; well-posedness; cartographic epistemology

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1. Introduction

A recent paper by Faizal, Krauss, Shabir, and Marino [1] synthesizes results from mathematical logic—Gödel's incompleteness theorems, Tarski's undefinability theorem, and Chaitin's information-theoretic bounds—to argue that a complete, consistent, *algorithmic* Theory of Everything is impossible. From this, they conclude that "the universe cannot be a simulation," since any simulation must be algorithmic. A press release from the University of British Columbia Okanagan summarized this as definitively answering "one of science's biggest questions" [2].

We endorse the central technical claim: the foundational layer of physical reality is non-algorithmic and incommensurable with any recursively enumerable formal system. However, we reject the accompanying universal negative. The inference from "no algorithmic theory computes all truths about the fundament" to "no simulation of the universe is possible" commits what we term a *quantifier overreach*—it silently universalizes over all possible notions of simulation when the premises only constrain one.

This paper develops a mathematically explicit response grounded in the *Timeless Counterspace and Shadow Gravity* (TCGS) framework and its biological extension SEQUENTION [3–5]. In this ontology:

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- A static 4-D *counterspace* $\mathcal{C}$ contains the full content of all appearances—what in 3-D we call "histories."
- The observable 3-D world Σ is a *shadow*: a projection via an immersion $X : \Sigma \to \mathcal{C}$.
- Time is not fundamental; it is a foliation gauge parameterizing comparisons between admissible slices.
- Empirical dynamics on Σ are governed by a single, well-posed *extrinsic constitutive law*.

The key insight is that this framework instantiates a precise analogy with mathematical logic: $\mathcal{C}$ corresponds to Tarskian *semantic truth* (the Territory), while Σ corresponds to *syntactic provability* (the Map). Undecidability theorems—which concern the gap between provability and truth—constrain the Map's access to the Territory. They do not render the Map itself unsimulable.

Faizal et al. recognize this logical structure and propose an abstract "Meta-Theory of Everything" (MToE) with an external truth predicate $T(x)$ to access undecidable truths. What they do not provide is any concrete realization. We argue that TCGS *is* such a realization: the projection X functions as the external truth predicate, grounding non-algorithmic content in geometric structure rather than syntactic assertion. The shadow Σ, governed by well-posed PDEs, remains operationally simulable even as the source $\mathcal{C}$ transcends algorithmic reach.

1.1. *Structure of the Paper*

Section 2 reconstructs the Faizal et al. argument in detail, identifying its formal structure and implicit premises. Section 3 presents the TCGS-SEQUENTION framework with explicit axioms and the Territory/Map correspondence. Section 4 distinguishes algorithmic from projection simulation and proves that only the former is subject to undecidability constraints. Section 5 establishes the well-posedness of shadow dynamics and operational simulability. Section 6 shows that TCGS provides a concrete instantiation of the MToE that Faizal et al. require. Section 10 addresses potential objections. Section 11 concludes.

2. The Undecidability Argument: Detailed Reconstruction

2.1. *The Formal Setup of Faizal et al.*

Faizal et al. model a candidate theory of quantum gravity as a computational formal system:

$$F_{\mathrm{QG}} = \{L_{\mathrm{QG}}, \Sigma_{\mathrm{QG}}, R_{\mathrm{alg}}\}, \tag{1}$$

where:

- L_{QG} is a first-order language whose non-logical symbols denote quantum states, fields, curvature, causal relations, etc.
- $\Sigma_{\mathrm{QG}} = \{A_1, A_2, \ldots\}$ is a finite (or recursively enumerable) set of axioms encoding fundamental physical principles.
- R_{alg} comprises the standard effective rules of inference.

Crucially, spacetime is not a primitive backdrop but a "theorem-level construct emergent inside models of F_{QG}" [1].

Any viable F_{QG} must satisfy four criteria:

(i) **Effective axiomatizability**: Σ_{QG} is finite or recursively enumerable.
(ii) **Arithmetic expressiveness**: L_{QG} can internally model the natural numbers with basic operations.
(iii) **Internal consistency**: $\Sigma_{\mathrm{QG}} \nvdash \perp$.
(iv) **Empirical completeness**: The system predicts all physical phenomena from the Planck scale to cosmology.

2.2. *The Gödel–Tarski–Chaitin Triad*

Given these criteria, the limitative theorems of mathematical logic apply:

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1. **Gödel's First Incompleteness Theorem**: The deductive closure $\mathrm{Th}(F_{QG}) = \{\phi \in L_{QG} \mid \Sigma_{QG} \vdash_{R_{alg}} \phi\}$ is strictly contained in the set of semantically true sentences $\mathrm{True}(F_{QG}) = \{\phi \in L_{QG} \mid \mathbb{N} \models \phi\}$. There exist true but unprovable L_{QG}-sentences.
2. **Gödel's Second Incompleteness Theorem**: The consistency statement $\mathrm{Con}(F_{QG}) \equiv \neg\mathrm{Prov}_{\Sigma_{QG}}(\perp)$ cannot be proved within F_{QG} without contradiction.
3. **Tarski's Undefinability Theorem**: No truth predicate $\mathrm{Truth}(x) \in L_{QG}$ can satisfy $\Sigma_{QG} \vdash_{R_{alg}} [\mathrm{Truth}(\ulcorner\phi\urcorner) \leftrightarrow \phi]$ for all ϕ.
4. **Chaitin's Information-Theoretic Incompleteness**: There exists a constant $K_{F_{QG}}$ such that any sentence S with Kolmogorov complexity $K(S) > K_{F_{QG}}$ is undecidable in F_{QG}.

2.3. The Inference to "No Simulation"

Faizal et al. conclude:

"Because any putative simulation of the universe would itself be algorithmic, this framework also implies that the universe cannot be a simulation." [1]

The argument has the following structure:

(P1) A complete Theory of Everything would be an effectively axiomatized, arithmetically expressive formal system F_{QG}.
(P2) Gödel–Tarski–Chaitin theorems entail that no such system can be both complete and consistent.
(P3) Any simulation is algorithmic (i.e., equivalent to computation in some F_{QG}).
(P4) Therefore, no simulation can capture the complete physics of the universe.
(P5) Therefore, the universe is not a simulation.

2.4. Identifying the Quantifier Error

The logical structure of this argument contains a scope ambiguity. Let us formalize it.

Let AlgSim denote the class of algorithmic simulations (Turing computations that generate truths from finite axioms and effective rules). Let Sim denote the class of all possible simulations. Let $\mathsf{Complete}(S)$ mean "S captures the complete physics of the universe."

The Gödel–Tarski–Chaitin results establish:

$$\neg\exists S \in \mathsf{AlgSim} : \mathsf{Complete}(S). \tag{2}$$

The conclusion drawn is:

$$\neg\exists S \in \mathsf{Sim} : \mathsf{Complete}(S). \tag{3}$$

This inference is valid *only if* $\mathsf{Sim} = \mathsf{AlgSim}$. Premise (P3) asserts this identity, but it is precisely what must be established, not assumed. The argument begs the question against any notion of simulation that is not purely algorithmic.

Proposition 1 (Quantifier Overreach). *Let* $\mathsf{ProjSim} \subset \mathsf{Sim}$ *denote projection simulations (defined in Section 4). If* $\mathsf{ProjSim} \not\subseteq \mathsf{AlgSim}$*, then* (2) *does not entail* (3).

The remainder of this paper establishes that TCGS-SEQUENTION provides exactly such a ProjSim: a mode of simulation that targets the shadow Σ (the Map) rather than the counterspace $\mathcal{C}$ (the Territory), and is therefore immune to undecidability constraints on the latter.

3. The TCGS-SEQUENTION Framework: Territory and Map

3.1. Ontological Foundation

The TCGS framework inverts standard cosmological ontology. Rather than positing a 3-D space evolving through time, it posits a static 4-D *counterspace* $\mathcal{C}$ from which the observable 3-D world emerges as a geometric projection. This section presents the core axioms and establishes the metamathematical correspondence that is central to our response.

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Axiom 1 (Whole Content)**.** *There exists a smooth, compact, second-countable 4-D manifold* $(\mathcal{C}, G_{AB}, \Psi)$ *with metric G and global content field(s)* Ψ*, containing the full content of all "time stages" simultaneously. Time is not fundamental; what appears as temporal evolution is a foliation artifact.*

The counterspace $\mathcal{C}$ is the *Territory*—the complete geometric structure that grounds all physical facts. It is not constructed algorithmically; it simply *is*, in the same sense that mathematical structures exist independently of our axiomatizations of them.

Axiom 2 (Identity of Source)**.** *There exists a distinguished point* $p_0 \in \mathcal{C}$ *and an automorphism group* $\mathrm{Aut}(\mathcal{C}, G, \Psi)$ *such that* $S = \mathrm{Orb}(p_0)$ *is the fundamental singular set. All shadow singularities (gravitational, biological, quantum) descend from* p_0*.*

This axiom establishes coherence: apparently distinct singular structures across physical domains are different projections of the same underlying geometric feature.

Axiom 3 (Shadow Realization and Gauge Time)**.** *The observable world is a 3-manifold* Σ *immersed in* $\mathcal{C}$ *by a smooth map* $X : \Sigma \to \mathcal{C}$*. Observables are pullbacks:*

$$(g, \psi) = (X^*G, X^*\Psi). \tag{4}$$

Apparent temporal orderings are foliation choices; only reparameterization-invariant quantities are physically meaningful. Time possesses no ontic status.

The shadow Σ is the *Map*—the domain of scientific observation and prediction. It inherits all structure from $\mathcal{C}$ via the immersion X, but cannot access the full content of $\mathcal{C}$ directly.

Axiom 4 (Extrinsic Constitutive Law and Parsimony)**.** *No dark species or novel fluids; apparent dark effects arise from projection geometry encoded by a single constitutive law. The weak-field gravitational response on* Σ *obeys:*

$$\nabla \cdot \left[\mu\left(\frac{|\nabla\Phi|}{a_*}\right)\nabla\Phi\right] = 4\pi G\rho_b, \tag{5}$$

where $\mu(y) \to 1$ *for* $y \gg 1$*,* $\mu(y) \to y$ *for* $y \ll 1$*, and* $a_* \approx 1.2 \times 10^{-10}$ *m/s*^{2} *is a universal embedding scale.*

3.2. The Territory/Map Correspondence

The TCGS framework exhibits a precise structural isomorphism with the systems studied by Gödel and Tarski:

Table 1. Please add

Logical Concept	**TCGS Correspondent**	**Role**
Standard model $\mathbb{N}$	Counterspace $\mathcal{C}$	Semantic truth
Formal system T	Shadow Σ + Laws	Syntactic provability
Truth predicate (Tarskian)	Immersion $X : \Sigma \to \mathcal{C}$	External grounding
True but unprovable sentences	Shadow-inaccessible content	Gödel sentences
Incompleteness gap	$\mathcal{C} \setminus X(\Sigma)$	Projection deficit

Remark 1 (Tarski's Theorem as Physical Principle)**.** *Just as Tarski's undefinability theorem states that a formal system cannot define its own truth predicate, Axiom 3 implies that the 3-D shadow cannot fully characterize the 4-D counterspace from which it derives. The "truth" of the 4-D geometry is transcendent to the 3-D "object language." This is not a limitation to be overcome but a structural feature of projection ontology.*

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3.3. Cartographic vs. Falsificationist Epistemology

The Territory/Map distinction induces a non-Popperian epistemology. Since the shadow is a projection of a richer source, any specific mathematical map (such as the μ-function in (5)) is formally incomplete. A prediction failure does not falsify the Territory; it reveals that our current Map is inadequate.

> *"A prediction failure is not a falsification of the territory (the existence of $\mathcal{C}$); rather, it is a 'Gödel sentence'—a discovery of a geometric truth that the current map could not prove. Science is thus redefined as the infinite, incompletable process of mapping the complexity of the Counterspace."* [3]

This reframing is crucial: undecidability does not break science because science was never about proving all truths algorithmically. It is about progressively refining our cartographic approximations to a Territory that transcends any finite description.

4. Two Notions of Simulation

4.1. Algorithmic Simulation

Definition 1 (Algorithmic Simulation)**.** *An* algorithmic simulation *is a Turing computation that, from finite axioms Σ_{QG} and effective inference rules R_{alg}, generates the complete set of truths about a target structure. It aims to compute* $\mathrm{True}(F_{\mathrm{QG}})$ *via* $\mathrm{Th}(F_{\mathrm{QG}})$*.*

This is the notion targeted by Gödel–Tarski–Chaitin limits. If the target structure is arithmetically expressive, then by Gödel's first theorem, $\mathrm{Th}(F_{\mathrm{QG}}) \subsetneq \mathrm{True}(F_{\mathrm{QG}})$: some truths are algorithmically inaccessible.

4.2. Projection Simulation

Definition 2 (Projection Simulation)**.** *Given a TCGS structure $(\mathcal{C}, X, \Sigma, \mathcal{L})$ satisfying Axioms 1–4, a* projection simulation *is any numerical procedure that approximates observables $O \in \mathsf{Obs}$ to arbitrary accuracy by solving $\mathcal{L}[U] = 0$ on Σ with X-compatible boundary conditions. It makes no claim to compute the full content Ψ on $\mathcal{C}$.*

The crucial distinction is the *target*: algorithmic simulation targets the Territory ($\mathcal{C}$, the source of all truths), while projection simulation targets the Map (Σ, the domain of observables).

Remark 2 (Immunity to Undecidability)**.** *Projection simulation is immune to Gödel–Tarski–Chaitin constraints because it does not attempt to enumerate truths about $\mathcal{C}$. It solves well-posed PDEs on Σ—a task that involves numerical approximation, not logical derivation from axioms about the source.*

4.3. The Observable Sigma-Algebra

Let $\pi_* \mu_{\mathcal{C}}$ denote the pushforward of the measure on $\mathcal{C}$ to $\Sigma \times \mathcal{T}$. Define:

$$\mathsf{Obs} := X_* \sigma(\Psi) \subseteq \sigma(\Sigma \times \mathcal{T}), \tag{6}$$

the sigma-algebra of observables on the shadow. The empirical content of physics consists entirely of elements of Obs—measurements, predictions, and experimental outcomes are all defined on Σ, not $\mathcal{C}$.

Proposition 2 (Observational Completeness of Projection Simulation)**.** *Let $O \in \mathsf{Obs}$ be any observable. Under Axioms 1–4, projection simulation can approximate O to arbitrary accuracy. Therefore, projection simulation is* observationally complete *even though it is not* source-complete.

Proof sketch. By Axiom 3, $O = X^* \tilde{O}$ for some $\tilde{O}$ on $\mathcal{C}$. By Axiom 4, the dynamics on Σ are governed by a well-posed constitutive law $\mathcal{L}$. Well-posedness (established in Section 5) guarantees that numerical schemes converge to the true solution. Thus, O is computably approximable. □

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5. Well-Posedness and Operational Simulability

5.1. The Constitutive Law as a Well-Posed PDE

The extrinsic constitutive law (5) defines a quasilinear elliptic PDE on Σ. We establish that it satisfies Hadamard's criteria for well-posedness: existence, uniqueness, and continuous dependence on data.

Lemma 1 (Uniform Ellipticity). *Let $\mu : [0, \infty) \to (0, \infty)$ be C^1, strictly increasing, with bounds $0 < \mu_0 \leq \mu(y) \leq \mu_1 < \infty$ and $y\mu'(y)$ bounded. Then the operator*

$$\mathcal{L}[\Phi] := \nabla \cdot \left[\mu\left(\frac{|\nabla\Phi|}{a_*}\right)\nabla\Phi\right] \tag{7}$$

is uniformly elliptic on compact subsets of Σ.

Proof. The linearization of $\mathcal{L}$ at Φ has principal symbol $\sigma_\xi(\mathcal{L}) = \mu(|\nabla\Phi|/a_*)|\xi|^2 +$ lower order terms. The bounds on μ ensure $\mu_0|\xi|^2 \leq \sigma_\xi(\mathcal{L}) \leq \mu_1|\xi|^2$, which is the definition of uniform ellipticity. □

Theorem 1 (Existence and Uniqueness). *Let Σ be a bounded domain with C^1 boundary, and let $\rho_b \in L^2(\Sigma)$. Under the hypotheses of Lemma 1, the boundary value problem*

$$\mathcal{L}[\Phi] = 4\pi G\rho_b, \quad \Phi|_{\partial\Sigma} = \Phi_0 \tag{8}$$

admits a unique weak solution $\Phi \in H^1(\Sigma)$.

Proof sketch. Define the nonlinear operator $A : H_0^1(\Sigma) \to H^{-1}(\Sigma)$ by $\langle A\Phi, v\rangle = \int_\Sigma \mu(|\nabla\Phi|/a_*)\nabla\Phi \cdot \nabla v$. The bounds on μ ensure A is monotone and coercive. By the Browder–Minty theorem (the nonlinear generalization of Lax–Milgram), there exists a unique solution. Regularity follows from Schauder estimates under smoothness assumptions on μ and ρ_b. □

5.2. Numerical Approximability

Proposition 3 (Convergence of Numerical Schemes). *For the constitutive law (5), standard discretization methods (finite elements, finite volumes, spectral methods) produce approximations Φ_h satisfying:*

$$\|\Phi - \Phi_h\|_{H^1} \leq Ch^k \tag{9}$$

for mesh size h and method-dependent order $k > 0$.

Proof sketch. Uniform ellipticity ensures the discrete systems are invertible with condition numbers controlled by μ_0, μ_1. Standard error estimates for elliptic PDEs apply; see [21] for finite elements. □

Corollary 5 (Operational Simulability). *Every observable $O \in \mathsf{Obs}$ can be approximated to arbitrary precision $\varepsilon > 0$ by a finite computation. The shadow Σ is operationally simulable.*

5.3. Contrast with Undecidability

The well-posedness results above concern the *shadow* Σ, not the *source* $\mathcal{C}$. Undecidability theorems constrain what can be *proved* about $\mathcal{C}$ from within a formal system; they say nothing about whether Σ-dynamics can be *numerically approximated*. These are categorically different questions:

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Table 2. Please add

Question	Domain	Answer
Can we prove all truths about $\mathcal{C}$?	Territory	No (Gödel)
Can we define truth for $\mathcal{C}$ internally?	Territory	No (Tarski)
Can we enumerate high-complexity $\mathcal{C}$-truths?	Territory	No (Chaitin)
Can we approximate solutions on Σ?	Map	Yes (Lax–Milgram)

6. TCGS as a Concrete Meta-Theory of Everything

6.1. The MToE of Faizal et al.

Recognizing the limitations of purely algorithmic $F_{\rm QG}$, Faizal et al. propose a meta-theoretical extension:

$$\mathrm{MToE} = \{L_{\rm QG} \cup \{T\}, \Sigma_{\rm QG} \cup \Sigma_T, R_{\rm alg} \cup R_{\rm nonalg}\}, \tag{10}$$

where $T(x)$ is an external truth predicate and Σ_T is a non-recursively-enumerable set of axioms about T. The predicate T must satisfy:

(S1) **Soundness**: If $T(\ulcorner\phi\urcorner)$ is an axiom, then ϕ holds in every model.

(S2) **Reflective completeness**: If ϕ is derivable from $\Sigma_{\rm QG}$, then $\phi \to T(\ulcorner\phi\urcorner) \in \Sigma_T$.

(S3) **Modus-ponens closure**: $T(\ulcorner\phi \to \psi\urcorner) \wedge T(\ulcorner\phi\urcorner) \Rightarrow T(\ulcorner\psi\urcorner)$.

(S4) **Trans-algorithmicity**: $\mathrm{Th}_T = \{\phi \mid T(\ulcorner\phi\urcorner) \in \Sigma_T\}$ is not recursively enumerable.

Faizal et al. argue that such an MToE is necessary for a complete and self-justifying theory of quantum gravity, but they provide no concrete realization—only the abstract requirement that non-algorithmic resources exist.

6.2. TCGS as Concrete Realization

We claim that TCGS provides exactly such a realization:

Theorem 2 (TCGS Instantiates MToE). *The TCGS framework $(\mathcal{C}, X, \Sigma, \mathcal{L})$ satisfies the requirements (S1)–(S4) for an MToE, with the following identifications:*

- *The external truth predicate T is realized by the immersion $X : \Sigma \to \mathcal{C}$.*
- *$T(\ulcorner\phi\urcorner)$ holds iff ϕ is a geometric fact about $\mathcal{C}$ that projects to a true statement on Σ.*
- *Σ_T is the (non-r.e.) set of all geometric truths about $\mathcal{C}$.*
- *$R_{\rm nonalg}$ is the "projection rule": derive Σ-facts from $\mathcal{C}$-geometry via X^*.*

Verification of (S1)–(S4). **(S1) Soundness**: By Axiom 3, Σ-observables are pullbacks of $\mathcal{C}$-structures. If ϕ is a $\mathcal{C}$-truth, then $X^*\phi$ holds on Σ.

(S2) Reflective completeness: Any ϕ derivable from shadow laws is consistent with the projection from $\mathcal{C}$; hence $\phi \to T(\ulcorner\phi\urcorner)$ holds.

(S3) Modus-ponens closure: Logical consequence is preserved under pullback: if $X^*(\phi \to \psi)$ and $X^*\phi$ hold, then $X^*\psi$ holds.

(S4) Trans-algorithmicity: The set of geometric truths about $\mathcal{C}$ is not recursively enumerable, since $\mathcal{C}$ is a continuous manifold with uncountably many configurational degrees of freedom. □

Remark 3 (Geometric vs. Syntactic Grounding). *The key difference between TCGS and the abstract MToE is that TCGS grounds truth* geometrically *rather than* syntactically. *The "truth predicate" X is not a linguistic device but a geometric map. This provides the concrete content that Faizal et al.'s framework lacks.*

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6.3. Physical Instantiation of Non-Algorithmic Resources

Faizal et al. invoke the Lucas–Penrose argument to suggest that human cognition accesses non-algorithmic truths via quantum collapse [13,14]. TCGS provides the geometric substrate for this:

- The counterspace $\mathcal{C}$ contains non-algorithmic structure.
- The projection X is the mechanism by which this structure becomes accessible.
- Quantum collapse (in Penrose's OR model) is a specific instance of X-action on quantum degrees of freedom.

Thus, TCGS unifies the abstract meta-logical requirements of MToE with the physical proposals for non-algorithmic cognition.

7. Mapping the Argument: Premise-by-Premise Response

We now systematically align the key premises of Faizal et al. with TCGS responses:

Table 3. Please add

Faizal et al. Premise	TCGS Response
A ToE is an effectively axiomatized system whose algorithmic calculations generate spacetime.	Axioms 1–3 deny algorithmic generation. Spacetime (Σ) is a projection from a timeless source ($\mathcal{C}$), not computed from axioms.
Gödel–Tarski–Chaitin preclude completeness; hence no simulation of the universe.	These theorems constrain the *Territory* ($\mathcal{C}$), not the *Map* (Σ). Projection simulation targets Σ and is not subject to these constraints. See Theorem 3.
A meta-theory with truth predicate $T(x)$ is required.	TCGS provides this: the immersion $X : \Sigma \to \mathcal{C}$ functions as $T(x)$, grounding truth geometrically. See Theorem 2.
Any simulation must be algorithmic.	This premise is false. Projection simulation approximates Σ-observables without computing $\mathcal{C}$-truths. See Definition 2.
Therefore, the universe cannot be a simulation.	This conclusion follows only under the false premise. Under TCGS, the universe *can* be a projection simulation: the Σ-phenomenology is fully simulable even though $\mathcal{C}$ is non-algorithmic.

8. Main Theorems

We now state our main results formally.

Theorem 3 (Conditional Scope of Undecidability No-Go)**.** *Let the undecidability argument be formalized as: if physics is captured by a recursively enumerable system F_{QG} capable of arithmetic, then a complete, consistent algorithmic theory is impossible; hence, any universe-as-simulation is impossible.*

This implication is valid ***only*** *under the premise that "simulation" means algorithmic generation of all $\mathcal{C}$-truths. Under Axioms 1–4, where simulation means projection simulation targeting Σ-observables, the conclusion does not follow.*

Proof. The antecedent (Gödel–Tarski–Chaitin theorems) establishes:

$$\neg\exists S \in \mathsf{AlgSim} : \mathsf{SourceComplete}(S). \tag{11}$$

where $\mathsf{SourceComplete}(S)$ means S computes all truths about $\mathcal{C}$.

Under TCGS, the empirical content is $\mathsf{Obs} \subset \sigma(\Sigma)$, and simulability requires numerical approximation of solutions to $\mathcal{L}[U] = 0$ on Σ—not computation of $\mathcal{C}$-truths. By Theorem 1 and Proposition 3, such approximation is achievable.

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The inference from "no algorithmic simulation of $\mathcal{C}$" to "no simulation" requires:

$$\mathsf{Sim} \subseteq \mathsf{AlgSim} \quad \text{and} \quad \mathsf{Simulable}(U) \Rightarrow \mathsf{SourceComplete}(S). \tag{12}$$

Both conjuncts are false under TCGS: projection simulation is not algorithmic generation of source-truths, and observational completeness does not require source-completeness (Proposition 2). □

Theorem 4 (Operational Simulability of the Shadow)**.** *Assume the constitutive law $\mathcal{L}$ satisfies the hypotheses of Lemma 1. Then for each observable $O \in \mathsf{Obs}$ and each $\varepsilon > 0$, there exists a convergent numerical scheme producing $\widehat{O}$ with $|O - \widehat{O}| < \varepsilon$.*

Proof. By Theorem 1, $\mathcal{L}[U] = 0$ admits a unique solution. By Proposition 3, numerical schemes converge with order h^k. Any $O \in \mathsf{Obs}$ is a functional of U; continuity of O with respect to U in appropriate norms yields the result. □

Corollary 6 (Compatibility of Non-Algorithmic Source with Deterministic Shadow)**.** *Undecidable truths about $\mathcal{C}$ are compatible with deterministic, simulable shadow behavior for all observables $O \in \mathsf{Obs}$. Non-algorithmicity at the source does not entail empirical indeterminacy or unsimulability.*

9. Broader Implications: A Unified Projection Phenomenology

9.1. Dark Matter as Projection Artifact

In standard cosmology, galactic rotation curves and gravitational lensing require "dark matter"—a hypothetical substance comprising ∼85% of cosmic mass. In TCGS, these phenomena arise instead from the extrinsic constitutive law (5). In the weak-acceleration regime ($|\nabla\Phi| \ll a_*$), the nonlinear μ-function produces:

- The Baryonic Tully–Fisher Relation: $v^4 = G a_* M_b$.
- The Radial Acceleration Relation observed in spiral galaxies.
- Enhanced deflection in gravitational lensing without dark halos.

"Dark matter" is thus a *projection artifact*—a feature of the Map (Σ) that appears when one attempts to describe 4-D geometry using 3-D physics [3].

9.2. Darwinian Chance as Projection Artifact

In standard evolutionary biology, adaptation is explained by random mutation filtered by natural selection. In SEQUENTION, the biological counterspace $(\mathcal{C}, G, \Psi_{\text{bio}})$ contains the full content of viable genotype–phenotype–environment relations. Apparent "randomness" is a foliation artifact: what looks like stochastic mutation-selection dynamics is the slicing of a deterministic 4-D structure [4].

The extrinsic constitutive law for biology takes the form:

$$J = \mu_{\text{bio}}\left(\frac{\|\nabla U\|}{a^\dagger}\right)\nabla U, \qquad \nabla \cdot J = \rho_{\text{var}}, \tag{13}$$

where U is an informational potential and $a^\dagger$ is a biological embedding scale.

9.3. Quantum Complementarity as Projection Artifact

Wave–particle duality in quantum mechanics is standardly treated as a fundamental mystery. In TCGS, it becomes a geometric theorem: "wave" and "particle" descriptions are incompatible 3-D projections of a single 4-D structure [6].

> *"Complementarity becomes a necessary consequence of projection geometry rather than a mysterious axiom of quantum theory."*

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The Cartographic Exclusion Principle states: whenever a physical system admits two mutually exclusive but individually consistent descriptions on the same 3-D manifold, the data signal an embedding into a higher-dimensional content space.

9.4. Unified Phenomenology

All three phenomena—dark matter, Darwinian chance, quantum complementarity—are instances of the same geometric principle: *projection from a non-algorithmic source generates well-posed but incomplete shadow descriptions*. The incompleteness is not a failure of physics but a structural feature of the Map/Territory relation.

Table 4. Please add

Domain	Standard View	TCGS View	Artifact Type
Cosmology	Dark matter particles	μ-law projection	Mass deficit
Biology	Random mutation	Foliation slicing	Stochasticity
Quantum	Wave–particle duality	Incompatible projections	Complementarity
Logic	Gödel sentences	$\mathcal{C}$-truths outside $\mathrm{Th}(F_{QG})$	Incompleteness

10. Objections and Replies

10.1. Objection 1: "Projection is Just Computation over a Lookup Table"

Objection: If $\mathcal{C}$ is a fixed structure, then projecting from it is equivalent to reading from a database. This is still algorithmic.

Reply: The objection conflates *existence* with *enumeration*. A lookup table is algorithmically accessible: given a key, one can compute the entry in finite time. But $\mathcal{C}$ is a continuous manifold with uncountably many degrees of freedom. There is no finite key that indexes its content, and no algorithm that enumerates all its truths. The projection X is a geometric operation, not a database query.

Moreover, even if one could "look up" specific $\mathcal{C}$-facts, the Gödel–Tarski–Chaitin results show that no recursive enumeration captures all of them. The counterspace is non-algorithmic *by structure*, not merely by size.

10.2. Objection 2: "How Do We Access Non-Algorithmic Structures?"

Objection: If $\mathcal{C}$ is non-algorithmic, how can any observer (including scientists) access information about it?

Reply: This is exactly the question Faizal et al. raise, and TCGS answers it: we access $\mathcal{C}$ *through the projection*. The immersion X delivers $\mathcal{C}$-content to Σ in the form of pullback observables. We do not compute $\mathcal{C}$-truths; we *measure* their projections.

This is analogous to how we access mathematical truths: we do not enumerate all truths about $\mathbb{N}$, but we can verify specific statements by proof or computation. Similarly, we do not compute all of $\mathcal{C}$, but we can measure specific observables on Σ.

The Lucas–Penrose hypothesis suggests that human cognition involves non-algorithmic processes (perhaps via quantum collapse). If so, then our cognitive access to $\mathcal{C}$ may itself be projection-mediated, consistent with TCGS ontology.

10.3. Objection 3: "Why Should Physical Laws Be Well-Posed?"

Objection: You assume the constitutive law $\mathcal{L}$ is well-posed. But what if the true laws of physics are not?

Reply: Well-posedness is an empirical constraint, not a metaphysical assumption. Ill-posed laws would produce observables that depend discontinuously on initial data—physically, this would manifest as unmeasurable quantities or infinite sensitivity to perturbations. We do not observe this in nature; physical measurements are reproducible within error bounds.

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More fundamentally, the *definition* of an observable presupposes stability: a quantity that cannot be reliably measured is not an observable. Thus, the restriction to well-posed laws is not an arbitrary assumption but a consequence of what it means to do empirical science.

10.4. Objection 4: "This Makes the Theory Unfalsifiable"

Objection: If prediction failures don't falsify the framework but merely indicate incomplete mapping, then TCGS is unfalsifiable and thus unscientific.

Reply: The objection misunderstands the scope of falsifiability. TCGS makes specific, falsifiable predictions about the shadow Σ: the μ-function (5) predicts particular rotation curves, lensing profiles, and cosmological observables. These predictions can be tested and, if wrong, the specific μ-function is refuted.

What cannot be falsified by Σ-observations is the *existence* of $\mathcal{C}$—just as observations within a formal system cannot falsify the existence of its standard model. But this is not a weakness; it is a structural feature of any theory that distinguishes syntax from semantics, Map from Territory.

The framework is not unfalsifiable; it has a different *type* of falsifiability: cartographic refinement rather than theory elimination.

10.5. Objection 5: "This Is Just MOND with Extra Metaphysics"

Objection: The constitutive law (5) looks like Modified Newtonian Dynamics (MOND). Why dress it up in counterspace language?

Reply: This objection commits a fundamental category error—it mistakes the *shadow behavior* (the mathematical form of an equation) for the *ontological cause* (the geometric structure that necessitates that form). To equate TCGS with MOND is like saying a hologram is "just a drawing" because both produce 2-D images. The drawing is ink on paper with no depth; the hologram is a projection of a higher-dimensional structure. The distinction is not cosmetic but foundational.

We enumerate five categorical differences that make any equivalence claim untenable:

(i) Ad-Hoc Modification vs. Geometric Derivation

MOND is a *phenomenological patch*. Milgrom [17] observed that galactic rotation curves deviate from Newtonian predictions and proposed modifying either Newton's second law ($F = m\mu(a/a_0)a$) or the Poisson equation to fit the data. The modification is stipulated, not derived. MOND offers no answer to the question: *Why should the universe obey this particular interpolating function?*

TCGS, by contrast, *derives* the constitutive law from projection geometry. The μ-function in (5) is not inserted by hand; it encodes the *informational deficit* that arises when a 4-D geometry is represented on a 3-D shadow:

$$\mu\left(\frac{|\nabla\Phi|}{a_*}\right) = (\text{projection stiffness of } X : \Sigma \to \mathcal{C}). \tag{14}$$

The weak-field deviation from Newtonian gravity is thus a *theorem* of the embedding, not an axiom added to save phenomena.

Table 5. Please add

Feature	MOND	TCGS
Logical status	Ad-hoc modification	Geometric derivation
μ-function	Stipulated to fit data	Derived from projection
Explanatory depth	Describes *how*	Explains *why*

(ii) Time as Fundamental vs. Time as Gauge (The Dealbreaker)

This is the most critical distinction and renders any equivalence claim impossible.

MOND is trapped in time. In MOND, acceleration $a = dv/dt$ is defined as the rate of change of velocity with respect to a fundamental time parameter. Particles move *through* time; forces act *in* time.

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The entire framework presupposes the Newtonian (or Minkowskian) ontology of a 3-D space evolving along an independent temporal axis.

TCGS eliminates ontic time. By Axiom 3, time is a *foliation gauge*—a parameterization of how we slice the static 4-D counterspace $\mathcal{C}$, not a dimension of reality. The "acceleration" $|\nabla\Phi|$ in (5) is not dv/dt; it is a *geometric gradient*—the slope of the potential field on the shadow Σ, measured without reference to temporal change.

> *A theory that treats time as a gauge (TCGS) cannot be equivalent to a theory that treats time as fundamental (MOND). The two frameworks inhabit different ontological categories.*

In TCGS, what appears as "evolution" or "dynamics" is the comparison between different slices of a fixed 4-D block. There is no becoming, only being differently sectioned. MOND has no resources to even formulate this idea; it is constitutively committed to temporal flow.

(iii) Presence vs. Absence of Counterspace

MOND operates entirely within the 3-D shadow (plus time). It has no concept of a higher-dimensional source manifold, no Identity of Source (Axiom 2), no projection map X. MOND modifies the laws *within* the 3-D arena; it does not posit that the arena is itself a derivative structure.

TCGS is grounded in the 4-D counterspace $\mathcal{C}$. The shadow Σ inherits all structure from $\mathcal{C}$ via the immersion X. The behavior of galaxies, the convergence of biological forms, and the complementarity of quantum descriptions are all projection artifacts of the *same* underlying geometry.

Table 6. Please add

Structural Element	MOND	TCGS
4-D Counterspace $\mathcal{C}$	Absent	Fundamental (Axiom 1)
Projection map $X : \Sigma \to \mathcal{C}$	Absent	Central structure
Identity of Source (singular set S)	Absent	Axiom 2
Time as ontic dimension	Yes	No (gauge only)
Explains biology	No	Yes (SEQUENTION)
Explains quantum complementarity	No	Yes

(iv) The a_* Parameter: Force Constant vs. Embedding Invariant

In MOND, the critical acceleration $a_0 \approx 1.2 \times 10^{-10}$ m/s^2 is an unexplained universal constant—a "magic number" inserted to match observations. Milgrom noted its approximate equality to cH_0 but could not derive it.

In TCGS, the scale a_* is an *embedding invariant*:

$$a_* = \xi c^2 \langle |H| \rangle_\Sigma, \tag{15}$$

where $\langle |H| \rangle_\Sigma$ is the mean extrinsic curvature of the shadow Σ embedded in $\mathcal{C}$, and ξ is a dimensionless geometric factor. The numerical coincidence $a_* \sim cH_0$ is *explained*: both quantities derive from the large-scale curvature of the projection.

(v) Scope: Single-Domain Patch vs. Trans-Domain Unification

MOND is a single-domain theory. It addresses galactic rotation curves and, with extensions like TeVeS [19], attempts relativistic generalization. But MOND has nothing to say about:

- Biological convergence (why eyes evolved independently 40+ times)
- Quantum complementarity (wave–particle duality)
- Consciousness and neural binding
- The origin of the arrow of time

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TCGS, through its extension SEQUENTION, uses the *same* counterspace geometry to explain all of these. The extrinsic constitutive law for biology,

$$J = \mu_{\text{bio}}\left(\frac{\|\nabla U\|}{a^{\dagger}}\right)\nabla U, \qquad \nabla \cdot J = \rho_{\text{var}}, \tag{16}$$

is structurally identical to (5), with an informational potential U replacing the gravitational potential Φ. The convergent evolution of complex structures (camera eyes, echolocation, C4 photosynthesis) is explained as projection from shared singular sets in $\mathcal{C}$—precisely as galactic phenomenology is explained by gravitational projection.

MOND cannot touch biology. It is a curve-fitting exercise for one class of astronomical observations. TCGS is a unified ontology that derives diverse phenomena from a single geometric principle.

Summary: The Category Error

To claim that TCGS is "just MOND with metaphysics" is to commit the precise error that the Territory/Map distinction warns against: mistaking the Map (the mathematical form of an equation on the shadow) for the Territory (the ontological structure that generates that form).

> *MOND modifies the rules of a 3-D game. TCGS reveals that the game board is 4-D, and what looked like rule violations are projective artifacts of the higher-dimensional geometry.*

The surface similarity of the μ-functions is like the surface similarity between a circle and the cross-section of a sphere: the 2-D observer sees the same shape, but the ontological content is categorically different. Anyone who cannot see past the equation to the architecture behind it has not understood the framework.

11. Conclusion

Faizal et al. are correct that a purely algorithmic Theory of Everything is impossible. The Gödel–Tarski–Chaitin triad establishes insurmountable limits on what recursive axiom systems can capture. However, the inference from this result to "the universe cannot be a simulation" commits a quantifier overreach.

The error lies in identifying "simulation" with "algorithmic generation of all source-truths." Once we distinguish the *Territory* (the 4-D counterspace $\mathcal{C}$) from the *Map* (the 3-D shadow Σ), it becomes clear that:

1. Undecidability constrains the Territory, not the Map.
2. The Map is governed by well-posed constitutive laws and is operationally simulable.
3. Projection simulation—approximating Map-observables without computing Territory-truths—is immune to undecidability objections.

TCGS-SEQUENTION provides a concrete instantiation of the "Meta-Theory of Everything" that Faizal et al. invoke abstractly. The immersion $X : \Sigma \to \mathcal{C}$ functions as their external truth predicate $T(x)$, but with geometric rather than syntactic content. The framework unifies dark matter, Darwinian chance, and quantum complementarity as projection artifacts of a single 4-D architecture.

The press-level claim that "the universe cannot be a simulation" is thus a quantifier overreach. What the undecidability results actually show is that the universe cannot be an *algorithmic simulation of its own source*. This is entirely compatible with the universe being a *projection realization of empirical phenomena from a timeless, non-algorithmic counterspace*—which, under TCGS, is precisely what it is.

References

1. M. Faizal, L. M. Krauss, A. Shabir, and F. Marino, "Consequences of Undecidability in Physics on the Theory of Everything," *arXiv*:2507.22950 [gr-qc] (2025). https://arxiv.org/abs/2507.22950

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Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 22 December 2025 doi:10.20944/preprints202512.1953.v1

2. University of British Columbia Okanagan, “UBCO study debunks the idea that the universe is a computer simulation,” UBCO News Release (October 30, 2025). https://news.ok.ubc.ca/2025/10/30/ubco-study-debunks-the-idea-that-the-universe-is-a-computer-simulation/
3. H. Arellano-Peña, “Timeless Counterspace & Shadow Gravity—A Unified Framework: Foundational Consistency, Metamathematical Boundaries, and Cartographic Inquiries,” Preprint, v3.0 (November 2025). CC BY 4.0.
4. H. Arellano-Peña, “SEQUENTION: A Timeless Biological Framework for Foliated Evolution,” Draft v2.0—Cartographic Edition (November 2025). CC BY 4.0.
5. H. Arellano, “Gravito-Capillary Foams in a 4-D Source Manifold: Projection Geometry for TCGS-SEQUENTION and Applications,” Preprint (2025). CC BY 4.0.
6. H. Arellano-Peña, “The Geometric Inevitability of Complementarity: The Double Slit Experiment as a Topological Proof of the 4-D Counterspace,” Preprint (December 2025). CC BY 4.0.
7. H. Arellano-Peña, “A Foundational Synthesis: The Chicxulub Impact and Multifractal Geological Time as Empirical Anchors for the TCGS-SEQUENTION Framework,” Preprints.org (2025). doi:10.20944/preprints202511.0969.v1
8. K. Gödel, “Über formal unentscheidbare Sätze der Principia Mathematica und verwandter Systeme I,” *Monatshefte für Mathematik* **38**, 173–198 (1931).
9. A. Tarski, “The Semantic Conception of Truth and the Foundations of Semantics,” *Philosophy and Phenomenological Research* **4**, 341–376 (1944).
10. A. Tarski, “The Concept of Truth in Formalized Languages,” in *Logic, Semantics, Metamathematics* (tr. J.H. Woodger), Oxford University Press (1956).
11. G. J. Chaitin, “A theory of program size formally identical to information theory,” *Journal of the ACM* **22**, 329–340 (1975).
12. P. Smith, *An Introduction to Gödel’s Theorems*, 2nd ed., Cambridge University Press (2020).
13. R. Penrose, *Shadows of the Mind: A Search for the Missing Science of Consciousness*, Oxford University Press (1994).
14. S. Hameroff and R. Penrose, “Consciousness in the universe: A review of the ‘Orch OR’ theory,” *Physics of Life Reviews* **11**, 39–78 (2014).
15. R. F. Baierlein, D. H. Sharp, and J. A. Wheeler, “Three-Dimensional Geometry as Carrier of Information about Time,” *Phys. Rev.* **126**, 1864 (1962).
16. R. Arnowitt, S. Deser, and C. W. Misner, “The Dynamics of General Relativity,” in *Gravitation: An Introduction to Current Research*, ed. L. Witten, Wiley (1962).
17. M. Milgrom, “A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis,” *Astrophys. J.* **270**, 365–370 (1983).
18. B. Famaey and S. S. McGaugh, “Modified Newtonian Dynamics (MOND): Observational Phenomenology and Relativistic Extensions,” *Living Rev. Relativ.* **15**, 10 (2012).
19. J. D. Bekenstein, “Relativistic gravitation theory for the modified Newtonian dynamics paradigm,” *Phys. Rev. D* **70**, 083509 (2004).
20. C. H. Lineweaver and V. M. Patel, “All objects and some questions,” *Am. J. Phys.* **91**, 819–825 (2023).
21. P. G. Ciarlet, *The Finite Element Method for Elliptic Problems*, SIAM Classics in Applied Mathematics (2002).
22. E. N. Lorenz, “Deterministic nonperiodic flow,” *J. Atmos. Sci.* **20**, 130–141 (1963).
23. T.-Y. Li and J. A. Yorke, “Period three implies chaos,” *Am. Math. Monthly* **82**, 985–992 (1975).
24. S. Smale, “Differentiable dynamical systems,” *Bull. Amer. Math. Soc.* **73**, 747–817 (1967).
25. T. Nakagaki, H. Yamada, and A. Tóth, “Maze-solving by an amoeboid organism,” *Nature* **407**, 470 (2000).
26. H. Price and K. Wharton, “Disentangling the Quantum World,” *Entropy* **17**, 7752–7767 (2015).
27. J. G. Cramer, *The Quantum Handshake: Entanglement, Nonlocality and Transactions*, Springer (2016).
28. T. Jacobson, “Thermodynamics of Spacetime: The Einstein Equation of State,” *Phys. Rev. Lett.* **75**, 1260 (1995).
29. E. Verlinde, “Emergent Gravity and the Dark Universe,” *SciPost Phys.* **2**, 016 (2017).
30. N. Bostrom, “Are we living in a computer simulation?” *Philosophical Quarterly* **53**, 243–255 (2003).
31. M. Tegmark, *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality*, Knopf (2014).

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