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Letter

Discussion on Consequences of Undecidability in Physics on the Theory of Everything

Weicheng Cui
Zhejiang Engineering Research Center of Micro/Nano-Photonic/Electronic System Integration, Westlake University, Hangzhou, Zhejiang 310030, China;
Department of Electronic and Information Engineering, School of Engineering, Westlake University, Hangzhou, Zhejiang 310030, China
E-mail: cuiweicheng@westlake.edu.cn

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Abstract. This letter discusses the 2025 study by Faizal et al. (published in the Journal of Holographic Applied Physics, Volume 5, Issue 2, Pages 10–21). It fully endorses the core conclusions put forward in the original work: purely algorithmic frameworks (such as algorithmic quantum gravity, FQG) are inadequate for formulating a Theory of Everything (ToE), as supported by the theoretical foundations of Gödel, Tarski, and Chaitin; the "Meta-Theory of Everything" (MToE) provides an effective solution to address undecidable phenomena in physics; and the universe cannot be a product of simulation. However, this paper dissents from the original authors' pursuit of a "complete and consistent" effective theory. Given that completeness and consistency are sometimes mutually exclusive in nature, it advocates for a reframing of the MToE. The revised framework should prioritize logical consistency while explicitly abandoning the unattainable requirement of completeness.

Keywords: Meta-Theory of Everything (MToE); Unified Complex System Theory (UCST); Logical Completeness; Empirical Completeness; Completeness-Logical Consistency Trade-off; Algorithmic Limitations (Gödel/Tarski/Chaitin Theorems).

1 Introduction

This letter aims to offer constructive insights into the thought-provoking research conducted by Faizal et al. (2025) entitled "Consequences of Undecidability in Physics on the Theory of Everything" [1]. Their work makes a significant contribution to the field of foundational physics by establishing a connection between logical incompleteness (rooted in the theories of Gödel, Tarski, and Chaitin) and the ongoing efforts to develop quantum gravity and a viable effective theory. Notably, they propose an innovative framework, the "Meta-Theory of Everything" (MToE), designed to tackle undecidable phenomena in physics. This paper will elaborate on two key aspects: full concurrence with the core conclusions of Faizal et al., and a respectful divergence regarding their pursuit of an effective theory that is both complete and logically consistent.

2 Agreement with the Authors' Core Conclusions

First and foremost, we fully endorse the central arguments presented in Faizal et al.'s study. Their rigorous and insightful demonstration proves that purely algorithmic frameworks are inherently incapable of yielding a consistent Theory of Everything (ToE). In this context, the term "effective theory" is more appropriately used to replace "ToE".

By anchoring their analysis in three fundamental theoretical pillars—Gödel's incompleteness theorems (which confirm the existence of true yet unprovable statements within finite axiomatic systems), Tarski's undefinability theorem (which prohibits the existence of internal truth predicates within a formal system), and Chaitin's information-theoretic bounds (which impose limits on computable complexity), the authors persuasively illustrate the intrinsic limitations of algorithmic quantum gravity (FQG). Equally compelling is their proposal of the MToE, a meta-theory that enhances FQG by incorporating non-algorithmic resources, such as an external truth predicate T(x) and non-effective inference rules. For the remainder of this paper, this enhanced framework will be referred to as the effective MToE.

This innovative framework not only overcomes the impasse posed by undecidable phenomena (including but not limited to black-hole microstates and thermalization processes in many-body systems) but also clarifies a crucial distinction: "the breakdown of computational methods does not equate to the breakdown of scientific inquiry". We also express full support for their conclusion that the universe cannot be a simulation. Since all simulations are inherently algorithmic in nature, they are unable to capture the non-computational elements embedded in the effective MToE, rendering the simulation hypothesis logically untenable.

These conclusions align seamlessly with emerging perspectives in the field of complex systems physics [2,3]. In this domain, non-algorithmic behaviors, commonly observed in chaotic or adaptive systems, are increasingly recognized as fundamental characteristics of objective reality, rather than mere gaps in existing theoretical models. As such, Faizal et al.'s research successfully bridges the gap between logical foundations and quantum gravity, opening up a critical new avenue for future research. It is noteworthy that, similar to Newtonian mechanics (which does not aspire to be a universal theory of everything but effectively explains the majority of phenomena at the macroscopic scale accessible to human perception), the effective MToE can also fulfill a practical role in explaining and predicting physical processes within its defined scope of application.

3 Disagreement on the Pursuit of a "Complete and Logically Consistent" Effective Theory

While we concur with the majority of the arguments in Faizal et al.'s paper, we respectfully differ from their implicit objective of constructing an effective theory that achieves both completeness and logical consistency. To avoid misunderstandings in subsequent discussions, it is essential to first draw a clear distinction between two distinct concepts of completeness: logical completeness and empirical completeness.

Logical completeness and empirical completeness are two distinct notions in the fields of epistemology and the philosophy of science, each evaluating the "completeness" of a theoretical system from a unique perspective. Logical completeness refers to the ability to prove all true statements within a given formal system, with a primary focus on the internal consistency and validity of the system. In contrast, empirical completeness concerns whether a theory can comprehensively explain all observed phenomena, emphasizing the correspondence between theoretical propositions and empirical reality.

Based on the Relativity of Simultaneity Axiom within the Unified Complex System Theory (UCST) [4,5] whose content is also given in Table 1 for readers' convenience, completeness and incompleteness coexist, and completeness and logical consistency are a pair of concepts that may either coexist harmoniously or conflict with each other in nature. In scenarios where such conflicts arise, logical consistency should take precedence over completeness. Similarly, empirical completeness remains an unattainable ideal in numerous complex situations, primarily due to inherent limitations in human observational capabilities.

From the perspective of UCST [4,5], completeness and logical consistency can sometimes coexist but are at other times mutually exclusive. A classic example is provided by Gödel's own work: he proved that first-order predicate logic is logically complete (Gödel's Completeness Theorem [6]), while first-order Peano Arithmetic (PA) is logically incomplete (Gödel's Incompleteness Theorems [7]). While Gödel's incompleteness theorem applies strictly to formal axiomatic systems encoding arithmetic, its relevance to physical theories depends on the extent to which such theories can be fully formalized in this way. The idea of mutually exclusiveness has already appeared in Faizal et al.'s earlier work [8], which argues that algorithmic completeness and consistency cannot be jointly satisfied for any formalized quantum-gravity theory.

UCST is built upon a set of clear core postulates, which provide a solid theoretical foundation for this perspective, as detailed in Table 1. Since UCST has not been widely accepted by scientific community, the UCST axioms used here serve as a conceptual framework for analyzing consistency constraints; they are not intended as empirically established physical laws.

To illustrate the mutually exclusive nature of completeness and logical consistency, we can use a rigorous logical analysis of a dictionary analogy: when defining Concept A, one might inevitably resort to the use of Concepts B and C. If the dictionary's editors aim to meet the requirement of completeness by claiming that "all concepts in this dictionary have explicit definitions", then defining Concept Z will inevitably involve reliance on previously defined concepts, resulting in logical circularity. To maintain logical consistency, certain concepts must be left undefined and treated as primitive terms, terms that are universally understood and require no further explanation. In such cases, the pursuit of logical completeness must be abandoned.

Table 1: Core Postulates of the Unified Complex System Theory (UCST)

Axiom Name	Axiom Content
Infinite Universe and Finite World Axiom	The universe is defined as the largest system conceivable by humans, possessing infinite attributes in both time and space. The world, by contrast, refers to the largest system observable by humans, characterized by finite properties in both time and space.
Relativity of Simultaneity Axiom	All described entities exist in a relative manner, as the very concept of "existence" depends on other concepts—at the very least, its opposite or complementary concept.
Axiom of Existence	When constructing any scientific theory, we must presuppose the objective existence of humans and the observable world.
Axiom of Causality	The observable world operates in accordance with causal laws: every cause gives rise to corresponding effects, and every effect can be traced back to corresponding causes. Notably, this does not require a one-to-one causal mapping.
Axiom of Locality	The strength of the interaction between two objects diminishes as the distance between them increases.
Axiom of Knowability	Humans possess the capacity to uncover the operational laws governing the observable world, but they are unable to fully comprehend the entire universe.
Axiom of Extrapolation	Laws derived from current finite observational data can be used to predict past and future phenomena to a certain extent, but such predictive power is not unlimited.
Completeness – Logical Consistency Contradiction Axiom	Completeness and logical consistency may not always be achievable simultaneously. A scientific theory should prioritize logical consistency over completeness.
Dualist Mind-Body Ontology	The mind and the body are two fundamentally distinct entities. The body is material, while the mind is non-material. When the mind separates from the body, the living organism ceases to exist and degenerates into a non-living entity.
Revised Newton's Second Law	Within an Earth-fixed non-inertial frame of reference, the product of mass and acceleration equals the sum of passive forces (as defined in classical mechanics) and active forces generated by the mind-body-support interactions of living beings.

In terms of empirical completeness, this requirement should also be discarded. The problems addressed by any scientific theory are inherently open-ended, making it impossible to prove that a theory achieves full empirical completeness. Quantum theory, widely regarded as the most accurate scientific theory to date, still cannot be deemed empirically complete.

The question of whether quantum mechanics constitutes an empirically complete theory was the subject of a long-standing debate between Einstein and Bohr [9-11]. Today, it is well established that orthodox quantum mechanics [12] is based on the Copenhagen interpretation, though alternative interpretations—such as Bohmian mechanics [13]—also exist.

Misra and Sudarshan [14] provided a rigorous mathematical proof of the quantum Zeno effect (QZE). While the QZE and its counterpart, the Anti-Zeno Effect (AZE), do not directly contradict the Copenhagen interpretation's core "wave function collapse" mechanism, they expose a critical ambiguity in the framework: the interpretation fails to explain why repeated measurement operations can yield two seemingly diametrically opposite outcomes (suppressed vs. accelerated collapse) and cannot clearly delineate the boundary between a "measurement that induces wave function collapse" and ordinary environmental interactions. This ambiguity was further corroborated by Fischer et al. [15]. Additionally, the Frauchiger-Renner Paradox uncovered the logical inconsistency of the Copenhagen interpretation when addressing measurement problems involving multi-level observers [16]. The paradox demonstrated that when nested measurement relationships exist (e.g., an observer conducting measurements inside a closed laboratory, while another observer measures the entire laboratory), the Copenhagen interpretation leads to contradictory conclusions regarding the same quantum state. Meanwhile, Minev et al. [17] provided support for the realistic trajectory predictions of de Broglie-Bohm theory, a view that was subsequently challenged and negated by Sharoglazova et al. [18]. Consequently, neither orthodox quantum theory [12] nor Bohmian mechanics [13] can be claimed to be empirically complete. Furthermore, the criticisms to the Copenhagen interpretation here are mainly from scientists who prefer Bohmian mechanics. These results pose challenges to certain interpretations of quantum mechanics, although not definitively falsify them.

UCST is predicated on the observation that complex systems, ranging from quantum fields to cosmic structures, exhibit a characteristic of "hierarchical emergence". Higher-level phenomena (such as macroscopic objects) emerge from the interactions of lower-level particles (including molecules, atoms, and subatomic particles). For such complex systems, maintaining logical consistency necessitates strict adherence to a finite set of axioms and inference rules (to avoid logical contradictions). However, this inherent finiteness inevitably imposes limitations on the completeness of the theory. In accordance with Gödel’s first incompleteness theorem, any consistent axiomatic system sufficiently powerful to model arithmetic will contain true statements that cannot be proven within the system. Conversely, pursuing completeness would necessitate the inclusion of contradictory axioms, thereby violating the principle of logical consistency.

In practical terms, this implies that in the field of physics, logical consistency must take precedence over completeness—whether in the context of logical completeness or empirical completeness. Regrettably, this crucial principle has not been sufficiently emphasized in many existing theoretical frameworks [19,20]. For instance, certain quantum gravity theories attempt to encompass all physical phenomena while disregarding potential logical contradictions within their axiomatic systems.

Faizal et al.’s MToE seeks to "restore completeness" by incorporating non-algorithmic resources. However, from the perspective of UCST, this endeavor is unnecessary. A viable foundational theory need not aspire to explain all physical phenomena (i.e., achieve empirical completeness), as humans can never fully grasp the "totality" of all phenomena, nor can they definitively prove that a single theory encompasses every aspect of reality. Instead, a sound scientific theory should focus on explaining phenomena within its defined domain without logical contradictions (i.e., ensuring logical consistency). The undecidable truths identified by Faizal et al.—such as the specific properties of black-hole microstates—are not "gaps" that need to be filled. Rather, they are inevitable byproducts of the universe’s inherent complexity. A consistent scientific theory should acknowledge these undecidable truths rather than attempting to eliminate them.

We therefore propose revising Faizal et al.’s framework to explicitly abandon the pursuit of completeness. The MToE could be redefined as a "consistent meta-theory of quantum gravity" that accounts for undecidable phenomena without striving for universal completeness. This revision would align the theory with the inherent trade-offs inherent to complex systems and prevent it from overreaching toward unattainable goals.

4 Conclusion

Faizal et al.'s paper represents a landmark contribution to the field of foundational physics, successfully linking the concept of logical incompleteness to quantum gravity and the development of effective theories [1]. From the perspective of UCST, we fully support their core conclusions but advocate for a key refinement: the abandonment of the pursuit of completeness in favor of prioritizing logical consistency [4,5]. To achieve this, the MToE should be transformed into a "consistent effective meta-theory with conceptual coherence". This revised framework would focus on explaining physical phenomena within its scope without logical contradictions, rather than striving for the unattainable goal of universal completeness. We believe that this revision will enhance the robustness of the MToE and align it more closely with the inherent complexity of the natural world, thereby providing a more solid foundation for future research in quantum gravity and foundational physics.

Data Availability

This discussion paper does not involve the use of any associated data.

Conflicts of Interest

The author declares no conflicts of interest. The funding agency had no role in the design of the study, the collection, analysis, or interpretation of data, the writing of the manuscript, or the decision to publish the results.

Ethical considerations

The author has diligently addressed ethical concerns, such as informed consent, plagiarism, data fabrication, misconduct, falsification, double publication, redundancy, submission, and other related matters.

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