The Natural Universe and the Hierarchical Cantorian Multiverse: Toward an Ontological Computation of Reality

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This paper is part of an ongoing independent study exploring the ontological foundations of computation and the discrete structure of reality.

***Abstract*—This paper proposes a formal axiomatic framework for understanding reality as a discrete, computable, and linguistically representable system—referred to as the *Natural Universe*. Starting from Planck's postulate of quantized energy, we derive three fundamental theorems that establish computability and linguistic expressibility as intrinsic properties of the universe. By relaxing these conditions, we deduce the existence of universes that do not satisfy them, leading to a *Hierarchical Cantorian Multiverse* ordered by increasing levels of mathematical and computational cardinality. We further argue that the definition of energy itself determines the ontological and computational structure of each possible universe, suggesting a paradigm shift from physics to computation as the language of being.**

***Index Terms*—Computational ontology, quantum discreteness, Turing universes, Cantorian multiverse, linguistic physics**

I. Introduction

Since the early twentieth century, physics has been guided by the assumption that reality can be described through continuous mathematical laws. Planck's discovery of energy quantization introduced the first discrete limit to this view, while Turing's formalization of computation provided the first rigorous notion of algorithmic transformation.

By combining these insights, we reinterpret physical reality not merely as a continuous system governed by differential equations, but as a *computational structure* governed by discrete transitions—a universe that is both arithmetical and grammatical in nature.

We propose an axiomatic system that defines such a *Natural Universe* and show that universes that do not satisfy these axioms form a *Hierarchical Cantorian Multiverse*. We then extend this model to reveal that the very definition of energy determines what kind of "machine" can exist in a given universe—whether Turing-equivalent, hypercomputational, or transfinite.

II. Definition of the Natural Universe

[Natural Universe] A universe U is called *natural* if it satisfies:

1) **Discrete Energy:** Total energy at any time t can be expressed as a multiple of a fundamental quantum E_0:
$$E(t) = M(t)E_0, \quad M(t) \in \mathbb{N}.$$
2) **Discrete Mass:** There exists $N \in \mathbb{N}$ such that:
$$M_{\text{mass}}(t) < N < M(t).$$
3) **Computability:** A universal and decidable Turing machine T_U exists such that:
$$T_U(n) = f(n), \quad f : \mathbb{N} \to \mathbb{N} \text{ is total and computable.}$$
4) **Linguistic Representability:** Every physical law of U can be expressed as a formal grammar $G = (V, \Sigma, R, S)$ generating a recursive language L_G that encodes the state transitions of T_U.

III. Fundamental Theorems of the Natural Universe

[Quantized Energy Universe] For every time t, there exists $M \in \mathbb{N}$ such that $M > E(t)/E_0$. Thus, the total energy of the universe is finite and countable.

Sketch. From Planck's postulate $E = nh\nu$, energy exists in discrete units. Hence, there is always an integer greater than the total count of energy quanta. □

[Existence of Intermediate Natural Numbers] For each t and for every M in Theorem 1, there exists N such that:
$$M_{\text{mass}}(t) < N < M.$$

[Computable Universe Theorem] Every natural universe possesses a universal and decidable Turing machine that can represent one possible mechanism of the universe.

Sketch. Since energy and mass are discrete and finite, all physical configurations can be encoded as finite binary strings. Transitions between configurations are computable, and because the number of states is finite, the machine halts. □

[Linguistic Representation of Physics] If every physical law can be expressed as a grammatical rule, then there exists a set

of grammars that generates the description of one possible mechanism of the universe.

Outline. Every decidable Turing machine defines a recursive language; hence, there exists a grammar G_T equivalent to the universe's operational rule set. □

IV. The Hierarchical Cantorian Multiverse

[Cantorian Multiverse] Let $\mathcal{M} = \{U_i\}_{i \in I}$ denote the set of all possible universes. Each universe U_i has a computational cardinality $|U_i|$. The ordering relation is defined as:

$$U_i \prec U_j \iff |U_i| < |U_j|.$$

Thus, $\mathcal{M}$ forms a Cantorian hierarchy of universes based on their structural cardinality.

TABLE I
Cantorian hierarchy of universes

Level	Type	Computability	Analogue
U_0	Natural	Turing-decidable	$\aleph_0$
U_1	Continuous	Non-computable	$2^{\aleph_0}$
U_2	Hypercomputational	Beyond Turing	$2^{2^{\aleph_0}}$

Each level represents a distinct mode of existence, expanding from countable discreteness to transfinite continuity.

V. Ontological Consequences: Redefining Energy

[Ontological Dependence of Computation on Energy Definition] If energy is redefined in a form $E' \neq h\nu$ but remains empirically consistent, then a new ontological logic $\mathcal{L}'$ and a corresponding class of physical machines M' emerge, possessing computational capacities $C' \neq C_T$.

Formally:

$$\mathcal{E} \leftrightarrow \mathcal{M} \leftrightarrow \mathcal{C},$$

where $\mathcal{E}$ denotes possible energy definitions, $\mathcal{M}$ the set of physical machines, and $\mathcal{C}$ their computational capacities.

The definition of energy determines the fundamental logic of the universe and thus defines what kind of computation—and what kind of existence—is possible.

VI. Reflection: Standing at the Shoreline of Physics

We now stand at the edge of the known continent—the continent of physics. Before us stretches a new land, broader and deeper, where our old instruments—equations, forces, and fields—begin to dissolve into *processes, grammars, and computations*.

On this new land, the vehicle we use is no longer physics, but computation itself.

Energy becomes information. Matter becomes syntax. Space-time becomes the structure of execution. And the universe becomes a self-running program—a recursive sentence written in the language of being.

Computation here is not a human invention; it is the ontological operation of existence. Reality computes itself into being.

VII. Conclusion

Starting from Planck's quantization of energy, we have constructed an axiomatic model where energy, mass, and law are discrete, computable, and grammatical. From these assumptions, the *Natural Universe* arises as the smallest countable subset of a *Hierarchical Cantorian Multiverse*, whose higher levels correspond to realities beyond computability.

If energy is ever redefined—while remaining empirically valid—the entire logical structure of reality could change, giving rise to universes governed by non-Turing or transfinite computation.

Thus, physics may not be the foundation of computation; **computation may be the foundation of physics—and of being itself.**

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