Physical Relativism as an Interpretation of Existence

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Abstract

Despite the success of modern physics in formulating mathematical theories that can predict the outcome of quantum-scale experiments, the physical interpretations of these theories remain controversial. In this manuscript, we propose a new interpretation of existence that we call physical relativism. Under physical relativism, the difference between mathematical existence and physical existence is clarified, and Wheeler's 'it from bit' viewpoint can be objectively evaluated. In addition, physical relativism provides a simple answer to the question of why the universe exists at all, and permits us to derive the maximally biophilic principle, a generalization of the anthropic principle that ascribes high prior likelihood to the observation of a universe with simple physical laws supporting the overall concepts of time, space and the emergent evolution of life.

1 Introduction

In 510 BCE, Parmenides reasoned that *ex nihilo nihil fit*, or "nothing comes from nothing," meaning that the universe in the now implies an eternal universe without any specific moment of creation. This viewpoint was shared by later Greek philosophers such as Aristotle and Plato, but does not really answer the question. In 1697, Leibniz [37] asked for "a full reason why there should be any world rather than none." He claimed [38] that "nothing takes place without sufficient reason," and asked, "why is there something, rather than nothing?" This fundamental question, further reviewed in Edwards [13, p.296-301] and Lütkehaus [39], is still puzzled over by many modern philosophers such as Richard Swinburne [49, p.283] and and Derek Parfit [40, p.24].

The discovery of quantum physics has forced these philosophical questions onto the physics community as well. Although the mathematics of quantum physics are well understood, many of the physical interpretations relate directly to the fundamental questions of why we exist and what it means to exist, and have divided the scientific community into different philosophical camps: there is the classical stochastic and observer-centric Copenhagen interpretation, the deterministic and observer-free view promoted by de Broglie and Bohm (now known as Bohmian mechanics [44]), the stochastic and observer-free theory of Ghirardi-Rimini-Weber [15], the solipsist 'it from bit' viewpoint of Wheeler [57], and various Many Worlds interpretations [54] such as Ultimate Ensemble theory [52].

According to certain interpretations, modern inflationary cosmology would seem to approach Leibniz's question with a partial answer: a generic property of inflation is that the universe began from a small quantum fluctuation [18, 19, 21, 22, 42, 48] [23, p.129][25, p.131]. According to Vilenkin [55], "A small amount of energy was contained in that [initial] curvature, somewhat like the energy stored in a strung bow. This ostensible violation of energy conservation is allowed by the Heisenberg uncertainty principle for sufficiently small time intervals. The bubble then inflated exponentially and the universe grew by many orders of magnitude in a tiny fraction of a second."

According to Stephen Hawking, "When one combines the theory of general relativity with quantum theory, the question of what happened before the beginning of the universe is rendered meaningless" [25, p.135], because, "when we add the effects of quantum theory to the theory of relativity, in extreme cases warpage can occur to such an extent that time behaves like another dimension of space. In the early universe–when the universe was small enough to be governed by both general relativity and quantum theory–there were effectively four dimensions of space and none of time" [25, p.134].

Adding, "The realization that time behaves like space presents a new alternative. It not only removes the age-old objection to the universe having a beginning, but also means that the beginning of the universe was governed by the laws of science and doesn't need to be set in motion by some God" [25, p.135], and, "Because there is a law like gravity [and quantum physics], the universe can and will create itself from nothing. Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist" [25, p.180]. In other words, Hawking believes that Leibniz's question has been answered.

The flaw with this logic is that even if the mathematics of spontaneous creation are correct, they are based on the axioms of general relativity and quantum physics, which are not "nothing." Thus, it is not the *ex nihilo* creation of something from nothing, but rather, the derivation of a set of statements describing the universe in the now from a set of axioms. We should not be surprised to learn that an arbitrary set of statements can be derived from a set of axioms, because one can always construct axioms to support a given set of statements. Even if Hawking is correct that the universe can be derived from the axioms of M-theory, he still has done nothing to answer the question of *why* those axioms are true. Thus, it leaves Leibniz' question completely untouched.

Most physicists do recognize this issue. Richard Dawkins has called it a "searching question that rightly calls for an explanatory answer" [9, p.155], and Sam Harris says that "any intellectually honest person will admit that he does not know why the universe exists. Scientists, of course, readily admit their ignorance on this point" [20, p.74]. Brian Greene specifically pointed out that modern inflationary cosmology cannot resolve Leibniz's question [17, p.310], adding, "If logic alone somehow required the universe to exist and be governed by a unique set of laws with unique ingredients, then perhaps we'd have a convincing story. But to date, that's nothing but a pipe dream" [17, p.310].

A theory that very nearly meets Greene's goal was proposed by Tegmark [50], known as the Mathematical Universe Hypothesis (MUH) or Ultimate Ensemble theory [51, 52]. As formulated by Tegmark, the MUH rests on the sole postulate that "all structures that exist mathematically also exist physically." The MUH is attractive because it permits a broader application of anthropic reasoning to explain the specific axioms of physics, but the postulate does not make clear the difference between mathematical and physical existence, making it difficult to accept. Moreover, it would not fully resolve Leibniz's question because one could still ask why this postulate is true.

In this paper, we present logical arguments (Section 2) in support of a new interpretation of existence that we call *physical relativism*. Physical relativism proposes not only an answer to Leibniz's question, but also provides an interpretation for the randomness in quantum physics, and leads to a clear distinction between physical existence and mathematical existence that permits us to evaluate Wheeler's 'it from bit' perspective (Section 3). Finally, we refute common criticisms (Section 4).

2 Logical Arguments

The first argument (Section 2.1) shows that even our most advanced theories of physics such as M-theory [11] leave a fundamental logical paradox of existence unsolved, and that this paradox can only be resolved under the assumption of physical relativism. We show that physical relativism also permits us to assign high likelihood to the observation of a biophilic universe with space-like and time-like dimensions (Section 2.1.1). The second argument (Section 2.2) shows that physical relativism can also be derived from the simple assumption that the universe is represented by a formal system.

2.1 The Final Anthropic Argument

Habitability of a planet depends on a confluence of factors ranging from parent star class [33, 34] and stellar variation [35], to planet mass [45], composition, orbit distance [28], stability [36], early geochemistry conditions [41] and many other factors [30]. Thus, if all of these properties were chosen at random without any overall guiding influence or purpose, the probability of achieving conditions possible for life, and of random chemistry actions actually giving rise to self-replication and the actual evolution of life on any planet must be exceedingly low.

It is only by taking into account our cosmological observations of billions upon billions of other star systems that we can explain the presence of life as something to be truly expected by way of the anthropic principle that "conditions observed must allow the observer to exist." In other words, it does not matter how low the probability for life is, because it is only necessary for at least one of the practically infinite number of planets in the universe to contain life in order for us to resolve the mystery of why, when we look around, we should observe a planet with all the right conditions for life [43].

However, the mystery is still not fully solved, because this merely illustrates the remarkable tuning of the underlying laws of physics that permit a universe with the capacity for life. From the molecular properties of water [26] to the precise balance between the strength of fundamental forces [10], to the number of dimensions and the precise values of all the fundamental constants, all of which exist in a perfect balance.

As stated by Paul Davies, "There is now broad agreement among physicists and cosmologists that the universe is in several respects fine-tuned' for life [8]." According to Stephen Hawking, "The laws of science, as we know them at present, contain many fundamental numbers, like the size of the electric charge of the electron and the ratio of the masses of the proton and the electron...and the remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life" [23, p.125]. For example, if the strength of the strong nuclear force were changed by a mere 2%, the physics of stars would be drastically altered so much that all the universe's hydrogen would have been consumed during the first few minutes after the big bang [7, p.70-71].

If there existed an infinite (or nearly infinite) number of different universes with different values for the physical constants, then anthropic reasoning could also be used to explain why we observe physical constants amenable to life. This second application is known as the "strong" anthropic princple (SAP) [1].

It is believed by many physicists that the modern incarnation of superstring theory known as M-theory [11] satisfies this condition. Under M-theory, there are 11 dimensions of space-time, 7 of which have been curled up into some Calabi-Yau manifold [3], and the fundamental constants can be derived from the way that the dimensions have been curled up[17, p.372]. Because there are at least 10^{500} different ways to curl up these dimensions [25, p.118], and the theory does not dictate which way is correct, it is believed that all ways are equally valid and that the selective power of the SAP explains why we exist in a universe with fundamental constants amenable to life. The different configurations are interpreted either as parallel universes within the multiverse [32, p.93], or as parallel histories of the same universe [25, p.136].

However, even if all the configurations allowed by M-theory were manifested, one could just as easily ask why the basic axioms of M-theory had been miraculously selected over the axioms of some other theory in order to give rise to a multiverse containing a universe capable of supporting life. As noted by Greene, "Even if a cosmological theory were to make headway on this [Leibniz's] question, we could ask why that particular theory–its assumptions, ingredients, and equations–was relevant, thus merely pushing the question of origin one step further back" [17, p.310].

This paradox of infinite regress has been pondered since antiquity [14, p.38]. It will never be resolved so long as we continue to restrict our thinking to an objective explanation of existence, because fundamentally there is no way to prove something from nothing, and any starting point other than nothing is not truly objective. Therefore, we find it logical to consider this paradox as an [informal] proof by contradiction that the universe is *not* objectively real.

If the universe does not exist in an objective sense, then the only kind of truth we are left with is truth in the constructivist [53] sense, and the only kind of existence would be mathematical existence [27] – that is, the existence of things in the universe is merely mathematical existence relative to some formal system that defines reality. If this is the case, then the fact that we are self-aware would prove that self-awareness can not only be derived axiomatically, but that the mere mathematical existence of a self-aware structure is a sufficient condition for that self-aware structure to perceive its system as a reality – without any need for objective manifestation of that system.

Thus, there would be no objective distinction between 'real' axiomatic systems and 'non-real' axiomatic systems (although on a semantic level we might reserve the term 'real' to refer to one's own axiomatic system, or perhaps any axiomatic system that contains a self-aware observer). Nonetheless, all axiomatic systems would be on equal grounds, and hence anthropic reasoning would be empowered to explain *all* the observed laws of physics by selecting from the set of all possible axiomatic systems. This would finally resolve the general tuning problem and answer Leibniz's question. We therefore call this the "final" anthropic principle (FAP).

2.1.1 The Maximally Biophilic Principle

It has been pointed out that the anthropic principle "fails to distinguish between minimally biophilic universes, in which life is permitted but only marginally possible, and optimally biophilic universes, in which life flourishes because biogenesis occurs frequently"[8]. While it is true that the anthropic principle does not itself make a distinction between minimally and optimally biophilic universes, the logic behind the anthropic principle can be generalized into a more powerful principle that does.

Let Φ be the infinite set of all consistent axiomatic systems, and $\mathbb{S}$ be the (presumably infinite) set of self-aware observers defined by all axiomatic systems, and $S(\theta)$ be the set of self-aware beings derived by an axiomatic system $\theta \in \Phi$:

$$S(\theta) = \{s | \theta \vdash s \wedge s \in \mathbb{S}\} \tag{1}$$

The likelihood of a model given an event (equal to the probability of an event given a model) is the ratio of the number of cases favorable to it, to the total number of cases possible. Thus, given an observer $s \in S(\theta')$, and without any additional prior knowledge, the likelihood of an axiomatic system θ being the observer's axiomatic system is given by the ratio of self-aware observers in θ to the total number of self-aware observers in all systems:

$$\mathcal{L}(\theta = \theta' | s \in S(\theta')) = \frac{\#(S(\theta))}{\sum_{\phi \in \Phi} \#(S(\phi))} \tag{2}$$

A special case of (2) is that if an axiomatic system θ does not define any self-aware observers, then the likelihood of θ being the observer's axiomatic system is zero,

$$\forall \theta \; \#(S(\theta)) = 0 \implies \mathcal{L}(\theta = \theta' | s \in S(\theta')) = 0, \tag{3}$$

which is just a formalization of the anthropic principle that 'conditions of the observer must allow the observer to exist.' However, (2) also shows us that the likelihood is proportional to the number of self-aware observers, and the maximum likelihood estimate of the observer's axiomatic system is simply the system that defines the largest number of self-aware observers:

$$\hat{\theta}_{ML} = \underset{\theta}{\operatorname{argmax}}\, \mathcal{L}(\theta|x_{\theta,s}) \tag{4}$$
$$= \underset{\theta}{\operatorname{argmax}}\, \log \mathcal{L}(\theta|x_{\theta,s}) \tag{5}$$
$$= \underset{\theta}{\operatorname{argmax}} \left\{ \log \#(S(\theta)) - \log \sum_{\phi \in \Phi} \#(S(\phi)) \right\} \tag{6}$$
$$= \underset{\theta}{\operatorname{argmax}}\, \#(S(\theta)) \tag{7}$$

In other words, physical relativism tells us that any observer should expect, based on logic alone, that his universe is an optimally biophilic one, and if this observer had to make a guess as to which system precisely, the best guess would be the system that defines the most observers. We call this the maximally biophilic principle (MBP).

It is natural to assume that a formal system that derives some emergent process for the repeatable production of self-aware observers would derive the most self-aware observers with the fewest axioms, because all that would be needed is a few simple axioms to set up those processes for emergent behavior.

It is impossible to have emergent processes without at least an approximate notion of causality, because without causality there can be no *change*. Change would not be interesting without at least some approximate notion of locality, because without spatial relationships there could be no shape, form, structure or complexity. Thus, the MBP implies high likelihood for formal systems with spacelike and timelike dimensions, so we should not be surprised to observe those in our physics.

Finally, we should not be surprised to find that, at the smallest quantum scale, the universe is not *perfectly* local or causal, because there is no difficulty in representing nonlocalities or temporal dependencies in axiomatic systems (Section 4.2), and the MBP can only select for local and causal properties insofar as they permit the macroscopic capacity for emergent processes that derive self-awareness. Moreover, if quantum phenomena are involved with the physics of consciousness as is suggested by some recent research [4, 5, 31, 43, 46, 56], then this type of apparently nondeterministic and non-local behavior might actually be a requirement.

2.2 The Axiomatization Argument

An inconsistent system cannot distinguish between truth and falsehood because any statement can be proven true [14, p.18]. Thus, the ability to distinguish between truth and falsehood in our reality implies that our reality must be consistent (even if we cannot prove that any specific formal system intended to describe reality is consistent).

Modern theories of inflationary cosmology require that the universe has finite positive and negative energy [23, p.129] [18, 19, 21, 22, 42] [25, p.180]. Moreover, the Bekenstein bound [2], which is derived from consistency between thermodynamics and general relativity, implies that any finite region of space must contain finite energy. Thus, we presume that the universe has finite information content.

Any consistent system with finite information content can be formalized into an axiomatic system, for example by using one axiom to assert the truth of each independent piece of information. Thus, we presume that there is some axiomatic system isomorphic to our reality, where every true statement about reality can be proved as a theorem from the axioms of that system, and conversely any theorem of that system corresponds to a true statement about reality.

Self-aware life forms exist in our reality. Thus, it must be possible to derive self-awareness as a theorem from the axioms of our reality. Moreover, despite that our current limited knowledge of physics and biology cannot yet explain the experience or perception of self-awareness, this experience must also be somehow derivable.

For any theorem that can be derived from an axiomatic system, there must be other axiomatic systems that can also derive that theorem. For example, a new axiomatic system can be found by the simple inclusion of a new axiom that does not contradict any existing axioms. Indeed, there must be an infinite number of ways to modify an axiomatic system while keeping any particular theorem intact.

In other words, the fact that self-awareness can be derived axiomatically in our reality means there are an infinite number of different axiomatic systems that also derive self-aware observers questioning their existence, despite not having an objective manifestation. If the self-aware experience does *not* require objective manifestation, then there is no longer any reason to assume that our universe has an objective manifestation, either.

3 Interpretations

According to physical relativism, the distinction between a real universe and the abstract concept of a universe is merely a point of perspective: reality is that which is derivable from the axioms that define a self-aware observer, and everything else seems to be merely an unrealized, abstract potential. Physical existence may be taken as the subset of reality that defines structures in space-time.

John Wheeler believed that the physical world was a figment of the imagination, and that everything physical derives its existence from the observations made by observers. According to Wheeler [57], "... every it–every particle, every field of force, even the spacetime continuum itself–derives its function, its meaning, its very existence entirely–even if in some contexts indirectly–from the apparatus-elicited answers to yes-or-no questions, binary choices, bits.”

In some sense this is in agreement with physical relativism, because we assert that all ‘perception,’ and hence the ‘meaning’ and ‘significance’ is entirely due to observers. However, physical relativism does not suggest that the universe exists in the *imagination* of an observer, because our dreams and imagination are not formal systems. Neither does it suggest that it is necessary for formal systems to be formalized, written out, or otherwise conceived of by some intelligence for them to be perceived as real from an internal perspective.

A common philosophical question is whether or not the universe exists in an objective sense without the presence of self-aware observers. However, the fact that our self-aware thoughts are capable of controlling our physical bodies is proof that our thoughts are an inextricable part of the physics that define our universe. Indeed, we should not omit that possibility that self-awareness is a property possessed by fundamental particles that endows them with a kind of free-will related to the uncertainty principle, as suggested by the Strong Free Will Theorem [6]. This is not something that physical relativism tells us about, other than being permitted.

With regard to Tegmark’s Mathematical Universe Hypothesis (MUH) that “all structures that exist mathematically also exist physically”, the implication is that from an objective standpoint, mathematical existence is equivalent to physical existence, meaning that different contradictory physical universes may exist. In other words, the MUH is objectively equivalent to physical relativism, although we prefer to think about it differently: rather than thinking about abstract mathematical universes as existing in some kind of objective multiverse, we think of these universes as simply not existing in an objective sense.

4 Refutation of Common Objections

A number of objections to the MUH have been summarized and refuted by Tegmark [52], and many of those refutations hold for physical relativism as well. This section will focus on refuting objections to Gödel’s theorems (Section 4.1) and quantum randomness (Section 4.2).

4.1 Incompatible with Gödel’s theorems?

Formally, an axiomatic system is called *consistent* if it cannot prove any statement along with its negation (a contradiction), and *complete* if every sentence that can be expressed in the language can be either proved or disproved. Gödel’s first theorem shows that any axiomatic system containing a modicum of arithmetic power is incomplete, and his second theorem shows that any axiomatic system containing a modicum of arithmetic power cannot prove its own consistency [16].

There is a commonly expressed fear that Gödel’s first theorem implies there will always be some truths about reality that cannot be proven, making it impossible to formulate a theory of physics that fully describes all aspects of reality [12, 24, 29]. However, this is not the case [14, p.24]. As pointed out by Solomon Freeman, “The basic equations of physics, whatever they may be, cannot indeed decide every arithmetical statement, but whether or not they are a complete description of the physical world, and what completeness might mean in such a case, is not something that the incompleteness theorem tells us anything about”[14, p.88].

The fundamental confusion over the incompleteness theorem arises from the false assumption that, for every sentence that can be formulated in the language of a system, there must be some internal observation that an observer described by that system could make, where the observed outcome is related to the decidability of the sentence. In fact, we can prove that this assumption is false (Theorem 1).

Theorem 1. *If an ‘incomplete’ system defines a self-aware observer and his observations, it must be impossible for the observer to construct an experiment that depends upon the decidability of any indecidable statement expressible in the language of that system.*

Proof. Assume there is an axiomatic system θ deriving a self-aware observer and all his observations, who has constructed an experiment with a single binary outcome that depends on the decidability of a statement s that is written in the language of θ.

If the observed outcome is either positive or negative, then the observer would find himself unable to derive this outcome from θ, because by definition it is undecidable. Thus, contradiction is reached because the assumption that θ derives all his observations is false, and hence θ cannot be an accurate description of the observer’s reality.

If the observed outcome is some kind of strange superposition other than the expected binary outcome, then the initial assumption that one could construct a binary choice experiment depending on the decidability of an undecidable statement is false. Either way, the initial assumption is false, meaning that the presence of undecidable statements does not effect the observations of an internal observer. □

Tegmark has also expressed doubts with regards to Gödels second theorem, and proposed the much more limited Compute Universe Hypothesis (CUH) [52, p.21] as an alternative to the MUH, which only includes axiomatic systems that are simple enough to prove their own consistency. However, these fears are also unfounded. As explained by Franzén [14, p.101], “The second incompleteness theorem is a theorem about *formal provability*, showing that...a *consistent* theory T cannot postulate *its own consistency*, although the consistency of T can be postulated in another consistent theory."

In other words, an internal observer cannot prove the consistency of any axiomatic system which is hypothesized to describe his reality. However, the fact that we cannot prove our theories are formally consistent, or prove that they are fully descriptive of the unobserved aspects of reality, does not preclude the existence of a consistent and fully descriptive axiomatic system that describes reality. Indeed, this result is nearly identical to the way in which the Halting problem [47, p.173], which shows us that one cannot write a finite length proof that any computer program will halt, does not preclude the existence of an arbitrarily long computer program that *does* halt.

4.2 Incompatible with Quantum Randomness?

Tegmark has lamented that the MUH is incompatible with true quantum randomness because it is impossible to generate a sequence of true random numbers using only axiomatic relationships [52, p.10]. While it is true that random numbers cannot be generated algorithmically, this does not preclude the existence of an axiomatic system that defines behavior which appears perfectly random based on the limited observations of an internal observer.

As a concrete example of this, consider the following set of axioms, which describe the position of a particle having position X parameterized by integer-valued time t:

$$\begin{aligned} ||X(t) - X(t+1)|| &= 1 \\ X(0) &= 1 \\ X(1) &= 2 \\ X(2) &= 3 \\ X(3) &= 2 \\ &\vdots \end{aligned}$$

Suppose that this axiomatic system also somehow defines an observer who, at time $t = 2$, attempts to formulate a law describing the position of this particle as a function of time based on his observations for time $t \leq 2$. Clearly, it is clearly impossible for the observer to predict with certainty that $X(3) = 2$. However, he might theorize that:

> "If a particle is observed at $X(t)$, then $X(t+1)$ will be uniformly randomly chosen from the set $\{X(t-1), X(t+1)\}$."

In this case, the probability in the theory represents the observer's fundamental uncertainty in being able to predict certain axioms of the system which he has not been exposed to yet. Thus, the observed randomness in quantum physics is also not incompatible with the notion that our reality is described by an axiomatic system.

5 Conclusion

The fundamental conclusions of physical relativism are that self-aware observers can exist in axiomatic systems without objective manifestation, and that the distinction between a real universe and an abstract mathematically defined universe is merely a point of perspective.

Physical relativism is not a theory of physics because it does not make verifiable claims. Rather, it is a framework for interpreting the meaning of existence and the role of physics. Despite not making specific predictions, physical relativism is relevant because it provides simple logical answers to some of the most profound philosophical questions of existence that physicists have struggled with: it shows how to avoid paradox in explaining our existence, it permits a broader application of anthropic reasoning to describe the fundamental axioms of physics, it allows us to answer Leibniz's question, and it permits us to describe core notions of physics, such as the concept of spacetime, as having high likelihood. Moreover, we argue that because it is based on the logic of consistency alone, it does not require experimental validation.

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