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Predictive Metaphysics: A Quantum Consciousness Model of the Physical Universe

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Abstract

This paper demonstrates that ontology and the study of consciousness, long thought by physicists to be unapproachable metaphysical subjects, can indeed be studied as physics, leading to testable predictions about the physical universe. The paper presents a model of the physical universe that is based on a nonphysical independent reality: consciousness. The model is unique in that it not only provides a precise model of consciousness, but also connects consciousness with the rest of reality. The universe is shown to be a natural consequence of consciousness, beginning with a "big bang." Consciousness is identified with existence, and the relation between existence and the self is explored using concepts of quantum mechanics.

Where did the universe come from? Why does it seem so regular, so intelligently designed? Is there an independent reality or a God that is responsible for the regularities observable in the universe? If there is such an independent reality, what is its nature, and how did it create the universe? What is consciousness, and what is its role in the universe? Is there free will? These questions have puzzled philosophers, theologians, and scientists throughout history. This paper and a companion paper[1] present, respectively, the metaphysics and physics of a model of the universe that gives answers to these and many more of nature's puzzles. The model is based on a nonphysical independent reality: consciousness. This reality can be described precisely and the universe can be shown to be a natural consequence of it, beginning with a "big bang." As a result, metaphysical concepts long thought by physicists to be inaccessible to them become part of physics, continuing the historical trend of physics expanding its envelope, gradually taking over areas that were previously the exclusive territory of religion and philosophy.

Many scientists, including some physicists, having reached the limits of current theories without pinning down an ultimate physical reality, have speculated that the universe may turn out to be a colossal consciousness. Having said that, however, they forget about it, since until now, no one has known how to deal with such a notion. Scientific attempts to

deal with consciousness are almost all based on the premise that it is simply a pattern of electrical activity in the brain. This explanation satisfies no one, since our experience of consciousness seems to be so much more. As it turns out, this is only part of the story. The model presented here is unique in that it not only connects consciousness with the rest of reality, but also provides a precise model of consciousness. The model reveals that ultimate reality is a universal consciousness, and a separate physics paper[1] shows how the universe arises from this reality.

In this paper I sketch out the basic ideas. The ideas you will encounter in the first part are new and will seem strange. Remember that consciousness has never before been described precisely, so some new ground must be broken if we are going to be able to describe how the universe we see arises from consciousness. The full story of how this happens requires physics, of course, and you will find that not in this paper, but in my physics paper.[1] In this paper we will deal with metaphysics as if it were physics, using the concepts and methods of physics, especially quantum mechanics. At the end of this paper, the main conclusions are summarized in the form of answers to questions with which philosophers like to struggle.

The Nonphysical Universe

In the quantum consciousness model of the universe, we postulate that only concepts are real, all real entities are concepts, and the universe is the set of all concepts. A concept is a quantum of thought. In the quantum consciousness model described here, the universe is a thought process. It is composed of nothing but thoughts, or concepts. Some scientists have tentatively and reluctantly suggested that theory and experiments are pointing to this conclusion. We will show it to be a viable conclusion.

Keep in mind that what is described here is a *model* of the universe. In building a model, I am free to assume or postulate anything I want to, without proof, as long as it is not obviously false. The proof of a model lies in testing its predictions. A model should make testable predictions. If any of a model's predictions turn out to be false, the model and its assumptions are falsified, since the universe clearly does not work as the model says it does. On the other hand, if all of a model's predictions turn out to be correct, then it may be a useful model, at least until one of its predictions proves false. The universe may actually work as the model says it does, and there is some basis for concluding that the assumptions of the model may actually be true, even though they were stated without proof and may not be obvious. Most of the predictions of the quantum consciousness model are physical and will be found in my physics paper,[1] where the *concepts* we will speak of here are identified with quantum entities called *spacetime points*. These points are treated as *quantum states* that are described by *intrinsic quantum numbers*, including position, time, and spin.

Definition of a Concept

What is a concept? We need a precise definition, and we choose one expressed in set-theoretic terms. *A concept is the characteristic function of a set of concepts.* A function

has three elements: (1) a domain, (2) a range, and (3) a relation, mapping, or rule of correspondence between the domain and the range. That is, a concept is a function whose domain is a set of concepts that may or may not include the concept in question, and whose range is two-valued: a concept takes the value true when applied to any concept in its domain and is defined to be false otherwise. In symbols, if A is a concept and S_A is its domain,

$A = X\{S_A\}$,

Where X{S}is the characteristic function of the set S. If B is an element of S_A,

A(B) = T, where T stands for the value true.

Existence

The characteristic function of the entire universe is the concept existence, that is,

E = X{U} and

E(A) = T

for all concepts A in the universe U. But E is a concept, and so we must have

E(E) = T.

This is not surprising considering the self-referential, recursive definition of a concept that we have adopted, but it is an important result nevertheless. The concept existence is a member of its own domain. Thus it can exist even if no other concepts exist. If everything else were to disappear, E could be its own domain. It is well-defined without any other concept.

So we have two facts about existence. It is an abstract concept that is true of everything that exists, and it is a self-generating concept independent of any other. Moreover, because it is self-generating, *existence exists necessarily*. Essentially, the model simply asserts that existence exists in itself and the universe we see is just one of many ways of experiencing it.

The existence of existence flows from the definitions given above. This does not constitute a proof that existence exists in itself, but since this is only a model, logical proofs aren't necessary. We can suggest some thought experiments to demonstrate the plausibility of this conclusion, and we can show that it leads to a physical model of the universe that can be verified experimentally.

First, the thought experiments:

1. Try to define existence without using the concept of existence. It cannot be done. Existence can only be defined in terms of itself. It is absolutely fundamental and necessary.

2. Try to imagine a state where nothing exists. Such a state is impossible, even contradictory, since the concept existence is necessary to apprehend it. Therefore, existence exists necessarily, even if nothing else exists.

Again, these are not proofs, but thought experiments that make plausible the fundamental assumption that the concept existence exists necessarily.

We can say with certainty that nothing can be logically or temporally prior to existence. If anything exists, existence exists. Temporally, therefore, it is either the first thing that existed in the universe, or it is simply a property of the first thing. As we've seen, we don't need another first thing. Existence by itself will do because it is self-generating.

Self-generating in the case of existence also means that it is self-referential. As others have shown, self-reference leads to logical paradoxes, circular arguments, and tangled hierarchies in which entities at different levels can be logically prior to each other. Usually, when physicists encounter such things, they conclude that they have gone wrong somewhere and their theories are flawed. The quantum consciousness model (or as I prefer to call it, the *concept model*) does not see such things as problems, but simply as the nature of reality. An inherently paradoxical reality is, unfortunately, not easy to comprehend. Perhaps this is why centuries of effort by philosophers and scientists have failed to produce a satisfying explanation for our existence.

The idea of a concept existing necessarily is quite foreign to our way of viewing the universe. To most people, “Existence exists” is an unintelligible statement. It is like saying that red can exist independently of any object or mind. But existence is different from concepts like red. The next section will relate this more closely to our experience.

Nature of the Self

There is one and only one thing in the universe that we know exists without question. For each of us, it is "I"—our *self*. But what is "I"? It is not the sum of all our parts, which is simply a collection of atoms whose independent existence cannot be proved. It is, rather, a concept. It is the characteristic function of all of our parts, all of our actions, and all of our thoughts.

Clearly, a concept is not physical, and yet here is one that exists. It not only exists, it is *conscious* (at least I am, although I can't be sure about you). One can argue that the abstract concept "I" and the "I" that is conscious and aware of its existence are two different things, but some remarkably useful ideas result if they are assumed to be one and the same.

For one thing, the self is a concept that is true of itself, like existence:

I(I) = T.

A concept of my self is part of my definition, part of what I am. Humans are creatures that have selves of which they are aware. Humans are self-aware; they are *conscious*.

From here, we can leap to the conjecture that *concepts that are true of themselves are conscious beings*. Therefore, existence, being true of itself, is a conscious being. It may look to us like a mere idea, concept, or property, but it is more than that. It is a being, and it is conscious, just as I am a conscious being, and presumably, so are you.

Returning to the human self, note that the self is not the same as what I will call the ego. The ego is the program running on our computer-brain. It is what talks to us and analyzes our actions. The self is the dot of consciousness at the center of our being. We tend to identify our selves with our egos, but this is only part of the story. Most scientists who study consciousness also make this identification, thereby making consciousness simply an epiphenomenon of brain function. It is that, but it is more than that, because the ego and the self are different. The self is conscious; while the ego is only a pattern of electrical activity in a computer—the brain—that is just a collection of inanimate molecules. The ego cannot be conscious. The self may or may not have free will, but the ego definitely cannot. Along with the ego, the brain forms a concept, I, that is true of itself. This concept is conscious and thereafter creates itself. Thus, consciousness arises from brain function, yes. Evolution has endowed our complex brains with the ability to generate a concept that is true of itself, but as soon as a human brain does this, it hosts within it a conscious idea. It is impossible to separate the self and the ego as long as the brain is alive. Yet consciousness seems to us to be more than physical, and it is. We have within us a conscious *idea*—the self.

The word "conscious" is sometimes used as a synonym for "awake." In this sense it can be applied to animals as well as humans. In this paper, consciousness means the internal experience that seems to be uniquely human. It does not mean simply awake.

Is Nothing Unstable?

It has become generally accepted that the universe began with a big bang, a sudden explosion of an infinitely dense particle. We shall see that at least the big bang part is correct. However, this leaves some sticky questions unanswered. What was there before the big bang? How can something be infinitely dense?

In the concept model, a state of nothingness is unstable, as many physicists have suspected. But the minimal required entity is not some primal particle, as they all think. It is a thought—a single concept: existence. Existence and nothing are two states of a doublet. They are really the same concept and one is meaningless without the other. The concept existence exists necessarily.

It is natural to ask, "But who is thinking this thought? A concept needs a mind to contain it." True. But existence appears to be the essence of mind. It is a thought that is capable

of thinking itself, and that is enough. That is the minimum that must exist: a single concept—existence—capable of thinking itself.

To summarize, a concept that thinks itself is a consciousness. We can see this by looking at our own selves. My self is that dot of consciousness at the center of my being. It is the concept that sums up all of the molecules of my body, all of my thoughts and actions, all of my history. My self and the concept existence have one characteristic in common—they are true of themselves. As we have seen, E(E) = T, necessarily. Also, I(I) = T. This characteristic appears to be necessary and sufficient for consciousness.

We are now in a position to derive the universe.

Generation of the Universe

Let us analyze the concept existence, which we denote E. The necessity of E's existence means that the value of E when applied to itself is true, or T, that is, E(E) = T. (Notice that as a bonus, this equation gives us a definition of truth. Truth is the existence of existence, or truth is the value of existence applied to itself.) Since E(E) = T, E is its own domain. Yes, the domain of E also includes everything in the universe, but at this point we have no universe, only E, and as we will see, these two views of E correspond to different *reference frames*.

As noted above, a function has three elements: a domain, a range, and a relation between them. In the case of existence, let us denote these E, T, and Q. But what are these? Why, concepts, of course. The single concept existence is really three concepts in one. And given a set of three concepts, what about the subsets of this set? There are $2^3 - 1 = 7$ nonempty subsets, and each clearly defines another concept. A set of seven concepts has $2^7 - 1 = 127$ nonempty subsets, and a set of 127 concepts has $2^{127} - 1$, and so on. The number of concepts rapidly becomes astronomical. In other words, starting with the single concept E, one automatically gets an expanding set of concepts—a very rapidly expanding set. Alternatively, instead of an expanding set of concepts, we can look at each of the stages of the expansion we have just described as an alternate domain of existence, so existence is seen as a foliation of many, many logical levels, all of which exist at once.

We have defined the universe as the set of all concepts. We could just as well define it as *the set of all sets*. Readers familiar with the theory of sets may recall Cantor's paradox. The question, "What is the cardinality of the set of all sets?" leads to the conclusion, which Cantor proved impossible, that this set has as many elements as subsets. Like many of the paradoxes of self-reference, this paradox can be resolved by the introduction of time. In the concept model, this results in the creation of our universe. One might say therefore that the existence of our universe depends on a paradox. The set of all sets is the universe, and it is a foliation of many logical levels, each of which has a different cardinality. Thus it appears to have all cardinalities at once. Alternatively, from a different reference frame, it is a process in a state of continual expansion, as we will show next. Can this be the *big bang* at the beginning of the universe? Indeed it can.

Before going on, I should emphasize that I am not creating a formal system in which all concepts can be derived from the concept existence by the repeated expansion from a set of N concepts to a set of 2^N - 1. We can call these elementary concepts. Sets that span more than one logical level also give rise to new concepts, and relations among the concepts of the expansion are also concepts. Thus, there are many other ways to define a concept in terms of sets of concepts. I will not try to give an exhaustive list. Our objective is to show that our universe can be created out of concepts and nothing else, and the elementary concepts will be more than sufficient.

Orderings of Spacetime

Now let us examine this simple universe as a mathematical space. Does it have any structure?

First of all, there is a natural ordering that looks like time. The progression from N concepts to 2^N - 1 can be considered to define a period of time. But how much time? How long a period? That is not defined. We can look at the universe as being entirely contained in the concept existence all at once and at time as a meaningless construct. Or we can look at the universe as expanding in time, which is the way we see it as human beings. These are two different reference frames.

This time ordering is only a partial ordering. The characteristic function of a particular set of concepts is clearly later in time than the concepts in its domain, but less can be said about its time relationship to concepts not in its domain. The relationship "later" is meaningful, however--for any concept, there is some set that consists of all the concepts that it can be shown to be later than. However, it cannot be assumed that the 2^N - 1 concepts that arise from a universe of N concepts must arise simultaneously. This is not required.

To make some sense out of this rather disorderly universe, we can use quantum mechanics. Concepts can be thought of as quantum entities or *quantum states*. In quantum mechanics, a state is completely defined by its *quantum numbers*. In the concept universe, time is a quantum number. When I say that one concept is later in time than another, I mean that the time quantum number of the earlier concept is smaller than that of the later concept. These time quantum numbers are *intrinsic to the concepts*. There is *no* external clock ticking away by which time is measured. There is no actual lapse of time between the appearances of any two concepts. All concepts exist at once, but they have different time quantum numbers. It is these intrinsic quantum numbers that we perceive. Although we perceive them to be changing continuously, so that there is a continuous flow of time, this is only an illusion resulting from the very small differences between successive time quantum numbers. Between any two concepts with different time quantum numbers, there doesn’t have to be any concept at all with an intermediate time quantum number.

As it extends in time, the universe expands. This expansion is spacelike, and in my physics paper,[1] I call the concepts that make up the universe *spacetime points*. The

positions of these concepts are, like time, intrinsic quantum numbers. Thus the apparently continuous space that we seem to live in is, like time, an illusion.

As a mathematical space, the universe is partially ordered, but the ordering is very weak. There is no natural ordering, no natural geometry. A complete ordering would have to specify the relative positions of all points, both in space and in time, at all steps of the expansion. All of these unspecified parameters are degrees of freedom of the universe. Every possible complete ordering of the concepts, or points, in the universe defines a different universe, with a different history and perhaps different physical laws. Since many of the parameters involved are continuous variables, there are an infinite number of possible universes. Many would not support life forms like us, but the number of those that would is probably still infinite. Do all of these universes exist? Some physicists would answer this in the affirmative. My answer is that only one is observed to be real, although others can exist virtually, that is, for too short a time to be observed. These unobserved universes are only possibilities or potentialities, but they are very important quantum mechanically.

The Wave Function of the Universe

Let us look at the concept existence from the two different reference frames I've mentioned. If we look at existence as a single concept, it consists of three concepts: E, T, and Q. Q, you'll remember, is the relation between E and T. Now if we look at existence as expanding, then the domain of E, which consists of all of the concepts in the universe, is expanding with time. The relation between E and its expanding domain we now define as the *wave function of the universe*. The wave function of the universe contains all of the information necessary to order the universe. The wave function of a quantum system that is a superposition of states defines the probability for each of the possible states to be observed. Each possible ordering of the universe of concepts represents a different state of the universe—in effect, a different universe—and until it is observed, the universe is a superposition of these states. The wave function of the universe defines the probability, or more correctly the probability amplitude (a complex number), for observing each one.

Wave functions are a familiar feature of quantum mechanics. Quantum mechanics tells us that if something is possible, it will have some probability of being observed. Existence is the observer here. What it sees when it looks at itself is what exists, and this can be anything that isn’t impossible. *Thus existence is an omnipotent creative force.* This, in fact, is why the universe is quantum mechanical. Anything that can exist, no matter how complex, may exist because existence is the creator of the universe.

This being the case, all possible universes may be observed. The wave function of the universe assigns to each possible universe a probability of being observed. Observation of a universe by existence is equivalent to creation of that universe. One universe, chosen randomly out of the infinite number of possible universes, can exist. Until that choice is made, all universes have only a *potential* existence. After the choice, one universe is real and the rest remain only unrealized potentialities or virtual universes. Virtual universes can be thought of as existing for so short a time that they are never observed. This is

allowed by the uncertainty principle of quantum physics, which also allows such things as virtual particles in the vacuum of spacetime. Such particles are never observed, but they affect wave functions and the probability amplitudes for things to happen.

The remarkable thing is that the wave function of the universe is dominated by universes like ours, so that it is overwhelmingly likely that when existence observes itself, thereby picking a random universe out of the infinite population of possible universes, that universe will look like the one in which we find ourselves. Why this is so can be explained by a kind of *natural selection* process conceived by Lee Smolin. Smolin bases his theory on two postulates. The first can be generalized as the assertion that any universe spawns at least one and possibly many new universes, the number of new universes being equal to the number of replication mechanisms in the original universe (or equal to one if there are no such mechanisms). The number of such mechanisms in any universe is a function of the parameters of that universe. Smolin's second postulate says that these parameters change randomly by very small amounts from the spawning universe to the new universes that spring from it. Given these two postulates, natural selection leads to a population of universes that is dominated by universes with maximal numbers of the replication mechanism. I will not give the details of the natural selection process here. Interested readers can find the details in Smolin's book.[2]

In Smolin's theory, the replication mechanism is a black hole. This is consistent with the belief of many physicists that black holes lead to other universes. In the concept model and its physical counterpart the inflaton spacetime model, which is explained in [1], there are no singularities and black holes do not connect to other universes. *In the concept model, the replication mechanism is our selves*. Each time a potential someone dies, that potential self becomes a pure consciousness indistinguishable from existence, and expands to form a new potential universe. We'll explore this in more detail later, but for now the important thing is that in either case, the wave function of the universe is dominated by potential universes that are supportive of life forms like ours, so it is overwhelmingly likely that any universe that exists will look like ours. In the case of our selves, the reason is obvious. In the case of black holes, Smolin shows that the parameters that support life are the same as the parameters that result in a maximum number of stars, and ultimately in a maximum number of black holes. One of the puzzles of modern cosmology is that the parameters of the universe must be extraordinarily finely tuned to support life. A small difference in any one of the important ones would mean that we wouldn't be here. Yet there is no obvious reason why they should be so finely tuned. Smolin's idea of a natural selection process provides the answer.

Because there is a frame of reference in which existence or consciousness is timeless, its observation of itself takes no time. However, this does not mean that there is no logical structure involved. In the following discussion, I will speak in temporal terms to make the ideas easier to follow. I will use terms like “when,” “until,” “before, “after,” and the like. These terms should be taken in their logical sense rather than their temporal sense. I am not describing a sequence of events, but rather the *logical* structure of the concept existence.

Observation of itself by existence has two requirements. First, there must be a population of all of the universes that potentially exist, and second, one universe must be chosen at random from this population. The chosen universe is the one we live in. Let's examine the structure of this population. Each universe has some set of parameters that define its physical properties. This set of parameters can be represented as a point in a multidimensional parameter space. Saying that the parameters of the universe must be finely tuned to support life is the same as saying that only a very tiny region of parameter space represents the parameters of universes that support life. Thus, it at first appears that the probability that a single universe selected at random from this population supports life is nearly zero. However, there are billions of selves in a universe like ours, and each one will eventually add another potential universe to the population. The added universe will be the same as ours up to the moment of that person's death, and can only differ in minor details thereafter. Thus, Smolin's second postulate is satisfied: each of the new potential universes will have parameters very close to ours, and so it will support potential conscious beings having selves, which will give birth to new potential universes, and so on and on. In other words, each point in the tiny portion of parameter space in which our universe falls represents not just one but an infinite number of similar universes. As Smolin shows, the population of potential universes rapidly becomes dominated by universes that support conscious beings, that is, universes like ours. Therefore, a random choice from this population has a very high probability of looking like our universe.

The domination of the wave function of the universe by universes like ours is an example of *parametric resonance*. Outside a small region of parameter space a choice of a point in parameter space represents one universe (in the concept model, in contrast to Smolin's model, these universes spawn no additional universes). However, within the "magic" region, each point represents an infinite number of universes. This very narrow resonance in the wave function of the universe concentrates most of the probability in a small region of parameter space, so that when existence observes itself, it is overwhelmingly likely that what it sees is a universe like ours. The narrowness of the resonance makes the parameters of our universe appear extraordinarily finely tuned.

We can say more about the uniqueness of our universe. Since there is no end to the generation of new potential universes, eventually the population of potential universes is overwhelmingly dominated by universes that support a maximum number of conscious beings. Still more potential universes will be generated, but these universes can have no more conscious beings (we've said we're at the maximum already), and can only differ in their potential complexity or diversity. As the population of potential universes grows still further, eventually even more diversity becomes impossible. After that, only universes that are maximally fecund and maximally diverse are generated, and the probability is essentially one, or 100%, that a single universe chosen from the population of potential universes will be both maximally fecund and maximally diverse and complex. Hence we can say that our universe is both maximally fecund and maximally complex, and there is virtually zero probability that it could have been otherwise.

To ensure mathematical rigor, one more assumption is necessary for this model. We need to assume that when the squared magnitude of the wave function of the universe is

integrated over the whole parameter space, the result is a finite number. This requires, for example, that if a parameter can vary between plus and minus infinity, the wave function goes to zero at these extremes such that the integral of its squared magnitude over this range is finite. Otherwise, we could not speak of the probability of observing a particular kind of universe.

A useful concept is that of a network or *tree* of potential selves and universes. The root of the tree is in the pure concept existence in the "magic" region of parameter space that represents universes that support life. A universe with such parameters contains many conscious beings with selves. At death, each self creates a potential universe that has parameters not too different from its parent universe and so contains many selves, which create universes, and so on. The infinite branched network consisting of all such universes and selves is the tree I speak of.

Until existence observes itself, existence has a potential beginning in time whenever any potential self becomes self-aware, and it potentially becomes free to expand and create a universe any time a self dies (and also at the root of the infinite tree of selves and universes). There are an infinite number of these logical points in the tree of selves and universes (recall that they are not temporal points). The observation of itself by existence involves the selection of one point where a self dies (or the root of the tree). None of these possibilities is more likely than any other, but there are so many that represent universes like ours that virtually no other choice is possible. No such point is more important than any other. When existence observes itself, it sees the universe created by itself when the chosen self dies. This universe becomes real. The selves in the chosen universe, our universe, are real because our universe is real. They are our selves. When we die, the universes created are again only potential or virtual universes, since existence observes itself and creates a real universe only once. At any rate, these universes would be essentially the same as the universe that already exists. This is because the existing universe, with probability very close to 100%, is already as evolved as it can be, and little change is possible.

The atemporal navigation by existence of the tree of potential selves and universes can also be looked at as self-organization. One would then say that a characteristic of existence is that it self-organizes.

Once again, what I have described here is the *logical* structure of the concept existence, not a temporal sequence of events. Existence is atemporal. Time is created along with the temporal universe when existence observes itself.

Collapse of the Wave Function

The choice of which universe existence observes, and therefore creates, reduces the number of possible universes from infinity to just one. In quantum mechanics, this reduction is known as *the collapse of the wave function.* Outside of time, it happens just once, but inside of time, inside our universe, a wave function collapses every time an observation is made of a quantum system, and we see a process made up of many, many

choices. These choices look random to us, since they are not determined or predictable by any physical laws. If free will exists in our universe, it must be in these random wave function collapses. But, as we have seen, from one point of view, all of these choices are really only one choice. Existence simply exists and observes itself. It does not change, so any question of choice is meaningless. This makes the existence of free will a moot point. Free will is really a meaningless idea.

On the other hand, is the choice of which universe to create simply random or might existence freely choose which universe to create? It is impossible to tell the difference, so once again, quantum mechanics says that there is some probability for it to be either way. The temporal equivalent of a free choice made by existence could include free choices by our selves. Thus, we might have free will after all. Science will never be able to settle this question, since no experiment can distinguish between free will and random choice. We are free to believe either that we have free will or that we don't.

The classic paradoxical example of a wave function collapse is Schrödinger's cat. If a cat is placed in a box with a radioactive substance and a mechanism that releases a poison if the substance radiates a particle, and if the probability is one half that the substance will radiate a particle in one hour, then in an hour is the cat alive or dead? Quantum mechanics says that until an observer looks inside the box, the cat is half alive and half dead. The wave function of this system is a linear superposition of the two possible states, alive and dead, each having probability one half. When someone looks, the wave function collapses onto one state or the other, depending on the cat's health. This discontinuity of the wave function is distasteful to many physicists because it is different from most physical processes, which don't have discontinuities, and because there is no physical mechanism that can account for such a discontinuity. Therefore, say these physicists, the wave function does not collapse. Instead, they say, what quantum mechanics is saying is that when someone looks in the box, the universe splits into two nearly identical universes, both continuous, and the cat is alive in one universe and dead in the other. Which cat you observe depends on which branch of the universe you happen to be in.

As we have seen, all possible universes potentially exist, but only one is ever observed. A language that physicists have developed to explain the apparent contradiction of a macroscopic object in a mixed quantum state, like Schrödinger's cat, is called *consistent histories*.[3] With this approach, all quantum states are histories, and there are rules for deciding whether a history is meaningful. Thus, the cat is never both alive and dead at the same time. Instead, at the end of the hour it will be observed to have followed one of two histories, each having probability one half before the observation. It is considered meaningless to speak of its state between observations. As we will see, our own universe and our selves are histories. It is meaningless to think of us or our universe without time.

Existence and the Self

The conscious observer obviously plays an important role in the concept model. By making apparently random choices that collapse the wave function (but really only one

self-observation), consciousness—existence—creates the universe. We have seen that there are at least two kinds of conscious concepts: existence and our selves. What is the relationship between existence and the self?

We have established that what we experience as existence is a conscious being. It is the ultimate, necessary, although nonphysical, reality. As my physics paper[1] shows, from this comes spacetime and physical reality in the form of particles and forces. We know that from these, life forms evolved, including us. In our brains, through processes now being discovered by science, self-aware concepts arise, so that consciousness exists within spacetime in the form of our selves. *Our selves are existence observing itself within time, that is, from the reference frame in which time exists.*

In my physics paper, I show that the particles of which we are made are not hard little balls, but processes. As the universe steps through its logical expansion, at each step a new image of every point is created. Quantum fluctuations occur, so that each point has a different position at each step and therefore seems to vibrate. The amount of this energy is quantized. There is a ground state, or state of lowest energy, and there can be higher energy states. These higher energy states are particles. Thus, a particle is a process that depends on time. Without time there are no particles. Without time, we could not exist, since we are made of particles. Thus, our brains are made of time, and because they are capable of supporting a conscious concept, it is possible for existence to observe itself within time.

Because we are made of time, our selves define paths through spacetime, or *histories*, and can only be observed as such, that is, within time. The particles, atoms, and molecules of which our bodies and brains are made are also histories. *Histories are concepts* within the domain of existence, which is the set of concepts of which existence is true. Histories are not derivable by the expansion from N concepts to 2^N - 1 that we spoke of earlier, but we noted then that there were many other ways to define concepts. The domain of the self, which is the set of concepts of which the self is true, is a set of interacting histories that forms a time-based system capable of supporting a self-generating concept, that is, a concept that is true of itself and therefore conscious. The domain of the self includes itself, just as the domain of existence includes existence. The domain of the self is part of the domain of existence, but the converse is not true. Thus, the self is a mode of existence that is restricted in time and space. It is not existence itself, at least as long as we are alive.

Time that flows, that is, time that behaves as we perceive it to behave, is a problem for some physicists. Julian Barbour[4] notes that the Wheeler-DeWitt equation, an attempt to write down the wave function of the universe, *is independent of time*. This shouldn't surprise us, because we know that there is a reference frame in which the universe is atemporal. However, Barbour goes so far as to conclude that time that flows is merely an illusion. Brian Greene[5] points out that Einstein's theory of special relativity *requires* that *all of spacetime*, that is, all of space and all of time, be *present at once*. Since special relativity is well-verified by experiment, Greene, too, concludes that the time we perceive, the time that flows, is merely an illusion. He actually states flatly that there is

no justification in the laws of physics for a time that flows. This is a little like the meteorologist stating flatly that it cannot possibly rain, when a look out the window would show that it is already raining quite cheerfully. If the laws of physics cannot accommodate a time that flows, there must be something wrong with them, because the flow of time is also well-verified by experiment, most notably our experience. Both Barbour and Greene imagine time sliced up into "nows" or instants. They imagine that each instant is like a photograph that shows everything that exists at that instant, including the position of every particle and the feelings and memories of every person. Then they imagine mixing up all of these instants randomly, and they point out that at each instant, our memories would still tell us that we had experienced the entire series of instants in correct time order. Moreover, you could put the mixed-up instants back in order just by looking at them. This is supposed to show that the order of time instants and therefore the flow of time are irrelevant. The flaw in this argument is that if you slice spacetime into instants, you will not see particles and persons, but only a spacetime that, except for random fluctuations, looks the same from instant to instant. Since particles are processes, they must be observed over a period of time to be recognized as particles. Thus, slices of spacetime that contain particles and memories cannot be infinitesimally thin, but must be more like slices of bread, spanning some finite period of time. In other words, particles, brains, and memories do not exist without the flow of time. *We are made of time, and that is why we can only experience time as something that flows.*

What is the resolution of this seeming conflict between the "laws of physics" and our experience? We have seen that the universe has a logical structure that seems to say that it has many cardinalities at once. Looked at in another way, the universe seems to expand, with the logical progression from lesser to greater cardinalities playing the role of time. However, there is actually no time between these logical levels. *Time, like spatial position, is an intrinsic quantum number of a spacetime point.* Two points can have different time quantum numbers without there being any point with an intermediate time quantum number. In other words, there is actually no time, just as there is no space. What we perceive is the position and time *quantum numbers* of spacetime points, and since our existence depends on their differences, we see time flowing.

Thus, time either flows or doesn’t flow, depending on how you look at it. The "laws of physics" see it one way, and we see it another way. It is all right to have it both ways. We simply have here an example of *Bohr's principle of complementarity*, the same physics principle that makes wave-particle duality acceptable. From one frame of reference the universe is timeless, and Barbour and Greene are right. Time is an illusion, just as space is an illusion. From another reference frame, the universe expands in time. Our universe is made of time, so the flow of time is real to us.

Interestingly, we get a chance every night to experience what it's like to be outside of the flow of time. In dreamless sleep, our brains are no longer self-aware, so the self cannot exist in time. But the self creates itself and exists forever, so the self continues to exist when we are asleep, but it exists outside of time. We are never conscious of being asleep, only of being awake at night and then being awake in the morning. There is no time outside of time.

From what we have deduced so far, existence has certain characteristics: (1) It has a beginning in time. It creates itself. (2) It expands with time. It expands forever. (3) In free expansion, it creates a universe. (4) It self-organizes. (5) It can exist in many places and always has these characteristics. The modes of existence that are our selves share these characteristics. Our selves begin when we first become conscious, whenever that is. They become free when we die. Between these events, they are coherent histories, observable only to themselves (ourselves). We live long enough to reproduce so that we spawn other modes of existence. Ultimately, all these modes of existence become free, through death, to create new potential universes. This is how our selves serve as the replication mechanism for new universes that we spoke of earlier. Quantum mechanics requires that the wave function of the universe reflect this possibility, which makes Lee Smolin's natural selection process possible and makes it overwhelmingly likely that the universe will look like the one we see.

At death, the self is stripped of all of its domain except itself. All of the time-based concepts of which it was true are gone, and the self is left a pure, conscious concept outside of time. As such, it is indistinguishable from existence. Since existence already exists and is creating our universe, no change occurs outside of time when we die. The new universe created when a real self experiences death is only virtual or potential..

There are many people in this universe besides me, and they are all conscious. How can consciousness—existence—exist in many places? The answer is that existence is a concept, an idea, so it cannot be subdivided logically, spatially, or temporally. Wherever consciousness exists, existence exists. Our brains are capable of supporting a concept that is true of itself—the self. This concept is a mode of existence. Existence can exist anywhere a conscious concept can exist, with no limit on the number of such places. One such place is outside of time, another is my brain, another is your brain, and so on. Bohr's principle of complementarity applies here. Our selves are all existence, but our brains have different, incompatible views of it. The view from outside of time is another incompatible view, and as such it is impossible for us to know what it is like, just as it would be impossible for a wave to know what it is like to be a particle. None of these views is more correct or any closer to the real existence than any other. They are all the real existence. It is important to realize that, as a pure concept, existence (that is, consciousness) *has no memory* . Memory is a physical thing, and all memory is associated with physical objects, such as our brains. Existence is me, existence is you, existence was Caesar and Cleopatra, but outside of time, existence remembers none of this, and inside of time, when existence is me, it doesn't remember ever having been you, or Caesar, or Cleopatra. Thus, we think we are different people, but we are only different bodies, brains, and memories. We are all modes of the same person, the same consciousness.

When I die, consciousness continues to exist outside of time. However, it doesn't remember ever having been me, so it doesn't know it has survived my death, that it has survived millions of deaths, or indeed, that anything has happened at all. Inside of time, when I die, I cease to exist. Consciousness still exists in the brains of people who survive me, but it no longer identifies with me. Death is the end of our individual personalities.

When I die, Dick Dolan ceases to exist. I do not see any way in which my memories or my personality can survive death.

Our personalities are embodied in the ego. The ego is a computer program running on the brain. It thinks it has free will, but it is really the universal consciousness manifest in us that makes choices by collapsing wave functions on the quantum level. These choices look random to us, and we have been speaking of them as if they were random, but we could just as easily think of them as free choices of existence or consciousness, since the exercise of free will would look random to anyone else. Ultimately, as we have seen, all of these choices come down to just one choice or self-observation by existence, and we cannot know whether it is a free choice or a random one.

Atemporal Existence and the Temporal Universe

In this section I'm going to attempt to clarify how existence can be atemporal, eternal, and unchanging and still be compatible with the temporal, changing universe in which we find ourselves, a universe that exists in time, has a beginning and an end, and seems to be a one-shot deal. From our point of view in this universe, we think it makes sense to ask questions like, "What happened before the big bang?" and "What happens after the universe collapses to a singularity (as my physics paper predicts it will)?" I have said that temporal and atemporal are complementary ways, in the sense of Bohr, for existence to observe itself. Both ways are legitimate, but they are incompatible, just as light can be a particle and a wave at the same time, but we can only see it one way or the other. However, this doesn't really answer the questions. In this section I expand the concept model to shed some light on the confusing dichotomy between temporal and atemporal.

What is time? In some fundamental sense, time is change. Change requires time. Something must be a certain way *before* it can change and be different. Conversely, time requires change. If absolutely nothing changes, there can be no perception of time. Such a nonperception is absolutely impossible for us even to imagine, because we are made of time. Not to perceive time, for us, is not to exist. On the other hand, if there could be time without change, it would be indistinguishable from no time at all. If there is no change, eternity is indistinguishable from an instant. As always, when there are indistinguishable ways for something to happen, quantum mechanics says that both may be observed, so it is not meaningless to examine the consequences of having time without change.

The concept existence is atemporal and unchanging. It contains within itself a logical expansion, but all stages of the expansion exist at once. Yet the expansion looks timelike. Earlier in this paper and in my physics paper, it is shown that if the stages of the expansion are observed in a reference frame in which they are separated by some finite time interval, it is possible to create a temporal universe containing conscious beings that, because they are made of time, can experience time as something real.

Now let us show these two reference frames—the logical expansion of existence and our time—together, so that *every logical stage is present at every instant of our time*. We have created a two-dimensional array: The time we see increases along the horizontal

axis, while the entire expansion of existence, from the big bang to infinity, lies on a vertical line through every point on the horizontal axis. Here is what the array looks like. The numbers are time instants or logical stages, with zero representing the big bang.

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                3 3 3 3 3 3 3 3 3 . . .
                2 2 2 2 2 2 2 2 2 . . .
                1 1 1 1 1 1 1 1 1 . . .
                0 0 0 0 0 0 0 0 0 . . .

                     Time –>
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In the timeless reference frame of existence, every logical stage exists at every instant of time. For existence, nothing changes as our time advances. Therefore, our time is indistinguishable from no time at all. However, there is another reference frame, shown by the bold numbers in the array, in which the stages of the logical expansion are separated by an interval of our time. *This series of numbers represents a temporal universe like ours.* A timeless being cannot experience it. It can only be seen from within, by creatures like us who exist only because of this temporal expansion. Of course, we cannot experience timelessness.

In creating this two-dimensional array, we have also created an unexpected side effect: ghost universes! Every diagonal line through the array defines a temporal universe identical to our own, but displaced in time. These universes are identical to our own because existence creates only one universe by observing itself, as described above in "Wave Function of the Universe." If these ghost universes really exist, there is a big bang (0) at every instant. After I die, a Dick Dolan—not me, but someone indistinguishable from me—still exists in another identical universe. Thus, before the big bang there were a lot of other big bangs. When the universe ends, there are still many copies of it ticking away. Do all of these universes really exist? There is no way to know, but quantum mechanics says they might, because to any observer, this two-dimensional picture is indistinguishable from our original picture.

In this expanded picture, consciousness observes itself in time not only as my self, your self, and all the other conscious selves in our universe, but in countless other selves in universes identical to ours but displaced in time. A new, identical universe begins at every instant of time. This is possible because existence or consciousness, the pure

concept, has no memory. Memory exists only in time. There is no memory outside of time; indeed, there is no time. Thus, consciousness can repeat my lifetime, your lifetime, and the entire universe over and over again and each time it will seem like the first and only time, because the memories involved at each step of the way will be identical, and will not include the fact that consciousness has done this before. In other words, *what is really an eternal, timeless, atemporal process will seem like a one-time thing*.

What this expanded picture shows is that, to atemporal existence, there is *never* a time when the temporal universe does not exist, so it is meaningless to ask what happens before the big bang or after the end of the universe. It's still a paradox, but at least we can pretend to understand it a little more. Once again we are reminded that when you have a self-referential reality, it is inevitable that you will have paradoxes.

What is it like to be existence? What is it like to be atemporal, unchanging? This may be impossible for us to know, since it is our nature to be temporal and to change. However, here is an idea that may give us some insight. Time (as intrinsic quantum numbers) is always present within existence, so existence *always* sees both its temporal and atemporal aspects. However, because existence has no memory, *neither aspect has any communication with or awareness of the other*.

Here is what it may look like from the **atemporal** point of view. Existence sees itself and all of the concepts within it all at once. It sees a countably infinite set of concepts. The universe and its history are a single concept. Our selves are single concepts. There is no time as we experience it, but every concept has one or more intrinsic quantum numbers that correspond to our time. Our selves and our histories are dependent on these time quantum numbers. The particles we are made of are ordered sequences of concepts, each with a different time quantum number. Particles combine to make molecules, substances, creatures, and ultimately our brains, but all of the universe and its history are seen at once by existence. Nothing changes. From this point of view, time is an illusion. We cannot see this aspect of reality at all.

Here is what it may look like from the **temporal** point of view. Because we are made of time, that is, because our existence depends on sequences of concepts ordered in their time quantum numbers, we see time as flowing and everything as changing. Our own selves are projections of atemporal existence onto temporal substrates—our brains. But, as soon as our brains are self-aware, atemporal existence is there, too. It’s not too hard to see that the dot of consciousness at the center of our being does not really change with time. It is the self that is generated by brain function that changes. So atemporal existence is always seeing itself in the mirrors of our brains. While existence does not change, its projections in these mirrors do change. Existence sees itself projected on our brains and reflected from them. However, because existence itself does not change, existence must see as many of each human being as there are instants of time in that person’s life. That is, it must see a countably infinite number of identical universes displaced in time so that every instant of the universe’s history is present at every instant of time. Existence is a concept and has no memory, so there is no communication between these duplicate persons or universes. We all seem alone in our brains (neglecting pathological cases).

The Universe Is a Consciousness

I'll close this paper with a summary of its main conclusions in the form of answers to questions that have always puzzled philosophers. The physics of this model of reality is developed and related to current theoretical and experimental results in [1], which is entitled *Inflaton Space-Time: A Discrete Quantum Space-Time Model Underlying the Standard Models of Particle Physics and Cosmology*. In that paper, concepts are called *spacetime points*.

1. What is ultimate reality? The ultimate reality and the source of the universe is the abstract concept we call existence. We often think that abstract concepts only exist in our minds. However, existence is unlike other abstract concepts in that it is capable of thinking itself. It is the essence of mind. Because it thinks itself, it creates itself and it exists necessarily, that is, existence always exists. Even to think about a state in which nothing exists we must use the concept existence. Existence and nothingness are just two ways of looking at the same concept. In mathematical terms, existence is true of itself, that is, it takes on the value true when applied to itself. The only other concept like it is one that each of us is familiar with: our *self*. My self is the dot of consciousness at the center of my being. It is an abstract concept that is the essence of what I am, and it is true of itself, because what I am includes a conscious self. Here, then, is a concept that is true of itself and it is conscious. In the concept model, we conclude that concepts that are true of themselves are conscious, so existence is also conscious. In the concept model, existence has a logical structure that allows it to be looked at in two ways, that is, it has two aspects. In its transcendent aspect, it is atemporal, unchanging, timeless. In its immanent aspect, it has multiple facets, most notably our selves. When we say that existence thinks itself, is true of itself, or creates itself, we mean that it is a self-referential concept. In logic, such concepts are known to result in logical paradoxes, and indeed, that is the nature of reality.

2. Is there a God? Yes. God is the name we give to the transcendent, atemporal, unchanging aspect of existence. Existence is an abstract concept, but it is a conscious being. In fact, existence and consciousness are the same concept. The transcendent aspect of existence (one of the two ways to look at existence) is outside of time and creates time and the temporal universe. We are existence observing itself inside of time. The former is God. We are not God. We do not create the universe. But God and our selves are different ways of looking at existence or consciousness. These two ways are related like particles and waves, which are two ways of looking at, say, electrons. They are views of the same thing, but they are incompatible. In physics, Bohr's principle of complementarity recognizes that this is the nature of reality. How you look at electrons determines whether you see particles or waves, and you can't have it both ways at the same time. God and our selves are like that. We could say that existence looking at our selves is God, while we are our selves looking at existence.

3. Do we have free will? It is impossible to say either yes or no to this question. Our universe results from a single observation of itself by existence. This observation is outside of time and chooses one universe and its entire history from a population of

potential universes. Is this choice random or an exercise of free will by existence (God)? The two possibilities are indistinguishable, so it is impossible to decide which is correct. Thus, it is impossible to say whether existence has free will. In our temporal universe, we observe a multitude of quantum events in which a single alternative is selected from two or more possible outcomes, a phenomenon called *collapse of the wave function* in quantum mechanics. This takes place all the time everywhere, even at the lowest level of our brains, where it offers the only possibility for us to have free will, since everything at the higher levels of our brains is deterministic, if often chaotic. Jeffrey Satinover, in his book, *The Quantum Brain*,[6] presents evidence that the brain does amplify this quantum indeterminism at its lowest level up to the level of experience, making it possible that we might have free will. However, are the quantum choices occurring in our brains made by our selves, or are they simply the random, quantum-mechanical collapsing of wave functions? Again, these are indistinguishable. So we are free to think that we have free will or not. Science doesn't seem to be able to give us the answer. (Click here for an expanded discussion of free will.)

4. What is the origin of evil? The universe obeys the quantum mechanical principle that unless something is impossible, there is a nonzero probability that it will be observed, that is, that it will exist. This results in a universe that exhibits a high degree of diversity, not only in species, but in ideas, ways of thinking, temperaments, personalities, races, social groupings, nations, and so on. This allows the universe to approach some optimal state through *natural selection*. Species, ideas, and so on often oppose each other and compete with each other, the strongest winning out. Diversity is good because it prevents stagnation. However, if you are on the losing end of some encounter, you are likely to see the winner as evil. Thus, the source of evil is diversity, which is good. So unless we want everyone to think and act in rigidly controlled ways, a condition that many see as evil, we are stuck with diversity and we are stuck with evil.

5. Can everything be explained logically? Because reality (existence) is self-referential, logic is severely limited. There are almost always different ways to look at questions, so that two people can argue a point with perfect logic and come to different conclusions. Self-reference always leads to logical paradoxes.

6. What are the theological and philosophical implications of the concept model? In the concept model, paradoxes are inherent in reality because reality is self-referential. What philosophers may call paradoxes, logicians may call contradictions, theologians may call mysteries, and physicists may call dualities. The concept model says that it is impossible to resolve all of these ambiguities. In particular, science cannot resolve them. Science may gradually shrink their sphere of influence, but it can never get rid of them. Humans are extremely uncomfortable with paradoxes. While the concept model says that there is a God, it reveals virtually nothing about God. Humans want to know how to relate to God, but the concept model can't even say whether there is free will. The search for answers to our questions about our relations with God, other people, and nature is the work of theologians and philosophers. Although theology and philosophy can't resolve all of the mysteries any better than science can, they are there to guide us. Ultimately, each of us makes personal decisions in these matters.

7. What is consciousness? Consciousness is another name for existence. Existence is an abstract concept that is true of itself. This condition is necessary and sufficient for a concept to be a conscious being, a thought thinking itself. The only such concepts are existence and our selves, which are existence observing itself in time. Our selves are formed in our brains when we become conscious. They result from brain function, but unlike other concepts that our brains can form, these concepts are themselves conscious. This is why we feel that there is more to consciousness than just brain function.

8. Is consciousness prior to existence or vice versa? In the concept model, these two concepts are identical. They are the same concept with different names. Neither is prior to the other.

9. What happens to us when we die? The answer to this question is one of the paradoxes that come from the self-referential nature of reality. What happens depends on whether your frame of reference is temporal or atemporal, and the answers are incompatible. If you look at death from the temporal frame of reference, which is our frame of reference, everything about us that is temporal ceases to exist when we die. This includes our memories and our personalities. Our physical bodies go to sleep and never wake up. On the other hand, consciousness, which is a nonphysical human characteristic, always exists. Existence always exists, atemporal and unchanging. Thus, from the atemporal reference frame, absolutely nothing happens when we die. Existence simply exists. Looked at in this way, when we die our selves become indistinguishable from existence and are not aware of ever having been otherwise.

10. What happened before the big bang? What happens after the universe ends? These are meaningless questions because existence has an atemporal, unchanging aspect. Seen from this unchanging reference frame, there is always a big bang. Every instant of time always exists. There is always an end of the universe. It is as if there were an infinite number of universes identical to ours but displaced in time. In this picture, there are an infinite number of Dick Dolans, all infused with conscious selves. But because consciousness has no memory, each of these selves thinks that this is the first and only time that our universe has unfolded. Thus, something that is timeless and unchanging looks to us like a changing, one-shot universe with a beginning and an end. Here we have yet another paradox that has its roots in the self-referential nature of reality. By the way, the lack of memory is what makes it possible for consciousness to exist in all living humans at the same time while seeing itself as separate and unique in each case. There is only one consciousness and it is in all of us, but its temporal memory and knowledge are different in each of us. Its view of itself in time is absolutely limited in each of us by our individual brains.

11. What is time? In the concept model the concept existence has a logical nature by which new concepts can be defined in terms of others. The total number of concepts gets larger as you advance through this logical structure. There are two ways to look at this progression. Either all possible concepts exist at once, or the number of concepts expands in stages that resemble time steps. The universe obeys the quantum mechanical rule that

says that both of these possibilities are likely to be observed. We are existence observing its temporal self, so we see the universe expanding in time.

12. Many physicists say you can't apply quantum mechanics to the entire universe because 1) there's no observer, and 2) the universe is not a repeated experiment, so the laws of probability don't apply. Is this true? No. Existence is the observer, and one can speak of the probability that existence observes a particular universe out of the population of possible virtual universes described in the paper. These represent different results of a repeated "experiment."

13. How does existence create the physical, temporal universe? The physics of the creation of the universe by existence is the subject of my physics paper.[1] The concepts of the concept model become spacetime points in my *inflaton spacetime model*. The logical expansion in the number of concepts, seen as an expansion in time, is the big bang. The particles of which we are made are processes involving spacetime points. Thus, we are made of time and this is why we can experience time. Our universe results from a single self observation by existence that chooses one universe from an infinite population of potential universes. By a process of natural selection that takes place outside of time, the population of potential universes is dominated by universes that support living beings with conscious selves. This process is described earlier in this paper.

14. What are some predictions of the inflaton spacetime model? In a sense, one could say that the model "predicts" all the phenomenology of the standard models of particle physics and cosmology, since everything is there in the model. Two specific predictions still to be confirmed (or not) are the mass of the Higgs boson and the composition of the dark matter around galaxies. The Higgs field is not a particle field, but it does fluctuate around its vacuum expectation value, and these fluctuations are seen as Higgs bosons. The model's prediction is that the Higgs mass will be around 120 GeV, but it's also a prediction of the model that the fluctuations of the Higgs field are exceedingly tiny, or in other words, the Higgs bosons are so scarce as to be undetectable above the background processes in collider experiments.

Dark matter in the inflaton spacetime model is an exotic particle, a resonance of a bound state of a point and an antipoint. It's something like a bound state of a photon and an antiphoton. It's impossible in a continuous spacetime, but the model requires it, and it has the basic properties that the dark matter seems to have. Recently two papers have appeared on the arXiv that suggest that the dark matter, if it is a particle, has peculiar gravitational properties unlike any of the leading candidate particles. The model's dark matter particle has these peculiar properties.

There are other phenomena in the model that can be considered predictions because I didn't put them into the model, but instead discovered them there. Two good examples concern neutrinos. In the model's discrete spacetime, neutrinos behave very peculiarly. They oscillate between a velocity slightly above the speed of light and one slightly below it. When traveling faster than the speed of light they are righthanded and have imaginary

mass. When traveling slower than c, they are lefthanded and have real mass. I was trying to think of a way to fix this peculiarity when I realized that in the tachyonic phase, a neutrino could not be turned into an electron by an SU(2) rotation. Therefore, lefthanded electrons would have neutrino partners but righthanded electrons would not. As far as anybody could tell, there would be no righthanded neutrinos. That is just what is observed! So the model predicted that nature is chiral without anyone's even looking for it! Later, when neutrino oscillations were confirmed experimentally, I went looking for a way to incorporate them into the model. To my surprise, I found that the requirements for neutrino oscillations—neutrino mass differences and different mass and flavor eigenstates—were already there in the model. I think it is a mark of a good model when it tells you things you weren't even looking for.

The model allows you to calculate the mass of the electron very simply, something that even the standard model doesn't do. That's a prediction that's already confirmed. In principle, you can also calculate the value of the cosmological constant, but I haven't done it because it seems to require a supercomputer and a programming wizard, both of which are beyond me.

There are other interesting predictions about the structure of hadrons and the second- and third-generation leptons. Electrons are resonances of points. Hadrons are resonances of superpositions of points. Points are, after all, quantum states, so a superposition of several of them is another point, quantum mechanically. Thus, hadrons are point particles! Muons and tau particles are superpositions, too, and therefore composite particles. These predictions need to be confirmed, and I confess I'm not sure how to do that.

In short, the model makes lots of predictions and there's lots of work for the future.

Historical Note

The ideas in the first half of this paper date from 1964. There have been many revisions over the years. The first Internet version appeared in August 1999.

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