

# Quantum Physics 104

Commonalities between all the five accepted string theories are that they incorporate ten space/time dimensions. Physicists eventually came to the epiphany that the five theories were just five different perspectives of one theory. Bearing this in mind, they came up with yet another theory to lump it all together in a workable thesis.

One of my favorite folk physicists and futurist, Dr. Michio Kaku of City University, New York, tells us that string theorists are careful to point out that this does not prove the final correctness of the theory. But, M-Theory HAS solved much of the craziness of the string theory, and answers such posers as “why do we have five superstring theories?” This is because of different symmetries. Each of the five theories were reconciled by the introduction of M-Theory which added an 11th Dimension which also, by the way, offered up an explanation for the existence of P-Branes, or higher dimensional space/time objects, in addition to D-Branes, a special kind of P-Brane, where the ends of the string are localized on the Brane.

You think this sounds complex? You should see the math.

Now there is currently a new theory, called F-Theory, which incorporates the 12th dimension. F-Theory is the brainchild of Cumrun Vafa. Allowing string theorists to construct new realistic vacu in the form of F-theory compactified on elliptically fibered Calabi-Yau four-folds. The letter "F" reportedly stands for "Father". As stated, F-theory is a 12-dimensional theory, but the only way to obtain an acceptable background is to compactify this theory on a two-torus. By doing so, one obtains type IIB superstring theory in 10 dimensions! The  $SL(2,Z)$  S-duality symmetry of the resulting type IIB string theory is manifest because it arises as the group of large diffeomorphisms of the two-dimensional torus. A torus, for the uninitiated, is a surface of revolution generated by revolving a circle in three dimensional space about an axis coplanar with the circle. In most contexts it is assumed that the axis does not touch the circle and come in several varieties, such as when the surface has a ring shape and is called a ring torus or simply torus if the ring shape is implicit or the horn torus, which is generated when the axis is tangent to the circle, and the spindle torus, which is generated when the axis is a chord of the circle. A degenerate case would be when the axis is a diameter of the circle and surface is a sphere. The ring torus bounds a solid known as a toroid. (Think of them as doughnuts, inner tubes, lifebuoys, O-rings and vortex rings.)

Generally speaking, one can compactify F-theory on an elliptically fibered manifold known as an elliptic fibration, which in essence is a fiber bundle whose fiber is a two-dimensional torus also referred to as an elliptic curve. An example of this would be a subclass of the K3 manifolds that is elliptically fibered, and F-theory on a K3 manifold is dual to heterotic string theory on a two-torus. I know. I gave myself a headache with that one!

This is going to give some readers a fit, so if it cramps you up, skip past it. The well-known large number of semirealistic solutions to string theory referred to as string theory landscape, with 10500 elements or so, is *dominated* by F-theory compactifications on Calabi-Yau four-folds.

But that's not all...

This abstract theory has two time coordinates and violates, according to Kaku, 12-dimensional relativity. Still others, including myself, believe that once M-Theory is finalized, there will be no fixed dimension number at all.

So what does this have to do with our research?

Simply put, our universe can be described as a three dimensional membrane upon which we all exist. It is very possible (in fact I now believe) that it is just one of a very large number of universes (10 to the 10 to the 10 to the 6<sup>th</sup>) floating in a sea of broth in an even larger Megaverse. Another favorite physicist of mine, Lisa Randall of Harvard, writes about the possibility that our universe is a three brane reality floating in a higher dimensional space. Traditionally, we have always pictured these extra dimensions as tiny, curled up and invisible, but Lisa seriously considers the possibility that they are huge, maybe even near infinite in size. So...

*If* our universe is instead just one membrane, floating in a sea of membranes, meandering their way through 11 dimensions or reality, and *if* the Big Bang was the result of a contact point between two of these membranes, and *if* membranes collide all the time, then there is the potential of an inconceivable number of universes out there, with some of them capable of supporting life. Maybe not life as we know it, but life none-the-less.

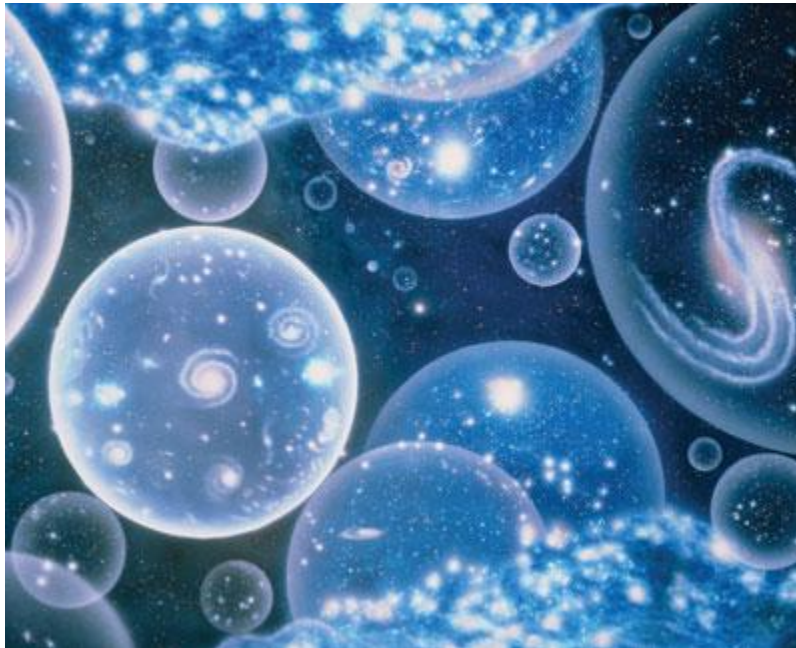
This would also be indicative of gravity not being the weak force as first defined, at least not at its point of origin, which may be a parallel membrane close to our own. Think of it like this; *if* some of the gravity leaks out into higher dimensional space, it would stand to reason that we would only experience it in a weakened state. But that's not all...

Kaku also thinks that membranes might be the Rosetta Stone in solving the mystery of Dark Matter. *If* there WERE parallel universes hovering very near our own, they would be invisible to us because they exist in another dimension that we have no access to. But it is very possible that Dark Matter is the manifestation of that parallel universe, which would in effect alter the measurable properties of our own galaxy, due to the role of gravity in attracting any large galaxy in the parallel universe.

M-Theory of course is not a single explanation, but instead, like all Quantum Mechanical theories has variations. The Ekpyrotic variation is a prime example of this. This variation states that two membranes colliding will create a new universe and lends to the existence of inflation, the flatness and uniformity of the universe. Other variations state that universes pinch off from each other, creating more and more universes much like a cell divides. Still another variation, by Robert Brandenberger and Cumrun Vafa, states the Big Bang resulted from the higher dimensions breaking free from a tightly wound perfectly symmetrical universe, due to the collision of many strings and anti-strings, expanding rapidly outward. I don't buy into the Big Bang at all, but instead subscribe to the Big Flow.

But in the end, no matter which theory you choose to subscribe to, the concept of parallel universes is here to stay. Even though there are those who would argue that it violates the laws of energy conservation, I would offer that it wouldn't if all the energy did was transfer from one universe to another, meaning a contracting universe would be feeding an expanding universe. The matter/energy would simply be traveling out of one realm and into another. This fits nicely into the concept called the multiverse.

The multiverse (or meta-universe, metaverse) is defined as the hypothetical set of multiple possible universes, including our own, that together comprise everything that exists from the entirety of space, time, matter, and energy to the physical laws and constants that describe them. The term was coined originally, believe it or not, by the American philosopher and psychologist William James back in 1895. The various universes within the multiverse are sometimes called “parallel universes”. The structure of the multiverse along with the nature of each universe within it and the relationship between the various constituent universes, depend on the specific multiverse hypothesis considered (and yes, there are many). Multiverses have been hypothesized for many, many years, and have reared their heads in cosmology, physics, astronomy, religion, philosophy, transpersonal psychology and fiction, specifically of course in science fiction and fantasy. In these contexts they carry many names, including "alternative universes", "quantum universes", "interpenetrating dimensions", "parallel dimensions", "parallel worlds", "alternative realities", and "alternative timelines.



The Multiverse

In an article in the May 2003 issue of Scientific American titled “Parallel Universes”, MIT professor and cosmologist Max Tegmark proposed that there are infinite copies of ourselves on infinite worlds identical to each other in every way except for one minor choice that splits us apart. The copies play out every conceivable permutation of our life choices. Tegmark, as well as others, believe that the existence of other universes is implied by direct observations. Max has provided taxonomy of universes beyond the familiar observable universe. These levels are arranged such that subsequent levels can be understood to encompass and expand upon previous levels, and they are briefly described below.

### Level 1: Regions beyond our cosmic horizon

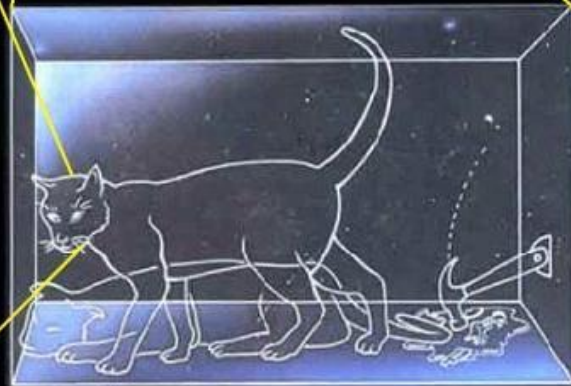
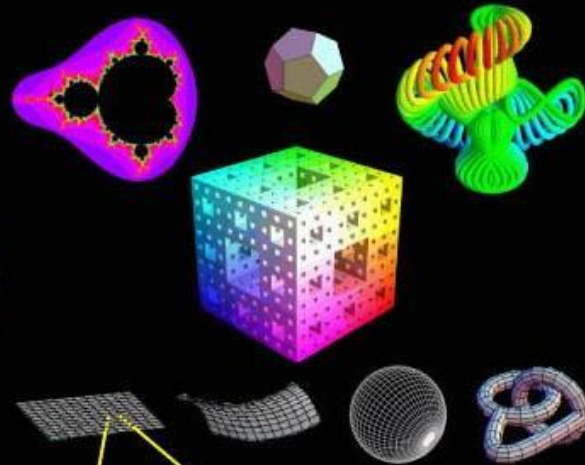
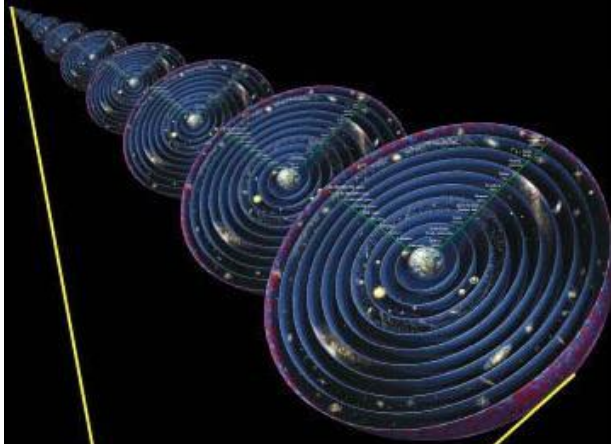
**Features:** Same laws of physics, different initial conditions  
**Assumptions:** Infinite space, ergodic matter distribution  
**Evidence:**

- Microwave background measurements point to flat, infinite space, large-scale smoothness
- Simplest model

### Level 4: Other mathematical structures

**Features:** Different fundamental equations of physics  
**Assumption:** Mathematical existence = physical existence  
**Evidence:**

- Unreasonable effectiveness of math in physics
- Answers Wheeler/Hawking question: "why these equations, not others"



### Level 2: Other post-inflation bubbles

**Features:** Same fundamental equations of physics, but perhaps different constants, particles and dimensionality  
**Assumption:** Chaotic inflation occurred  
**Evidence:**

- Inflation theory explains flat space, scale-invariant fluctuations, solves horizon problem and monopole problems and can naturally explain such bubbles
- Explains fine-tuned parameters

### Level 3: The Many Worlds of Quantum Physics

**Features:** Same as level 2  
**Assumption:** Physics unitary  
**Evidence:**

- Experimental support for unitary physics
- AdS/CFT correspondence suggests that even quantum gravity is unitary
- Decoherence experimentally verified
- Mathematically simplest model

## **Tegmark's Taxonomy**

### **Level I: Beyond our cosmological horizon**

A generic prediction of chaotic inflation is an infinite ergodic universe, which, being infinite, must contain Hubble volumes realizing all initial conditions.

Accordingly, an infinite universe will contain an infinite number of Hubble volumes, all having the same physical laws and physical constants. In regard to configurations such as the distribution of matter, almost all will differ from our Hubble volume. However, because there are infinitely many, far beyond the cosmological horizon, there will eventually be Hubble volumes with similar, and even identical, configurations. Tegmark estimates that an identical volume to ours should be about  $10^{10^{15}}$  meters away from us (a number larger than a googolplex).

### **Level II: Universes with different physical constants**

In the chaotic inflation theory, a variant of the cosmic inflation theory, the multiverse as a whole is stretching and will continue doing so forever, but some regions of space stop stretching and form distinct bubbles, like gas pockets in a loaf of rising bread. Such bubbles are embryonic level I multiverses. Linde and Vanchurin calculated the number of these universes to be on the scale of  $10^{10^{107}}$ .

Different bubbles may experience different spontaneous symmetry breaking resulting in different properties such as different physical constants.

This level also includes John Archibald Wheeler's oscillatory universe theory and Lee Smolin's fecund universes theory.

### **Level III: Many-worlds interpretation of quantum mechanics**

Hugh Everett's many-worlds interpretation (MWI) is one of several mainstream interpretations of quantum mechanics. In brief, one aspect of quantum mechanics is that certain observations cannot be predicted absolutely. Instead, there is a range of possible observations each with a different probability. According to the MWI, each of these possible observations corresponds to a different universe. Suppose a die is thrown that contains 6 sides and that the result corresponds to a quantum mechanics observable. All 6 possible ways the die can fall correspond to 6 different universes. (More correctly, in MWI there is only a single universe but after the "split" into "many worlds" these cannot in general interact.)

Note: Tegmark argues that a level III multiverse does not contain more possibilities in the Hubble volume than a level I-II multiverse. In effect, all the different "worlds" created by "splits" in a level III multiverse with the same physical constants can be found in some Hubble volume in a level I multiverse. Tegmark writes that "The only difference between Level I and Level III is where your doppelgängers reside. In Level I they live elsewhere in good old three-dimensional space. In Level III they live on another

quantum branch in infinite-dimensional Hilbert space." Similarly, all level II bubble universes with different physical constants can in effect be found as "worlds" created by "splits" at the moment of spontaneous symmetry breaking in a level III multiverse.

Related to the many-worlds idea are Richard Feynman's multiple histories interpretation and H. Dieter Zeh's many-minds interpretation.

### **Level IV: Ultimate Ensemble**

The Ultimate Ensemble hypothesis of Tegmark himself. This level considers equally real all universes that can be defined by mathematical structures. This also includes those having physical laws different from our observable universe. Tegmark writes that "abstract mathematics is so general that any Theory Of Everything (TOE) that is definable in purely formal terms (independent of vague human terminology) is also a mathematical structure. For instance, a TOE involving a set of different types of entities (denoted by words, say) and relations between them (denoted by additional words) is nothing but what mathematicians call a set-theoretical model, and one can generally find a formal system that it is a model of." He argues this "implies that any conceivable parallel universe theory can be described at Level IV" and "subsumes all other ensembles, therefore brings closure to the hierarchy of multiverses, and there cannot be say a Level V."

Jürgen Schmidhuber, however, says the "set of mathematical structures" is not even well-defined, and admits only universe representations describable by constructive mathematics, that is, computer programs. He explicitly includes universe representations describable by non-halting programs whose output bits converge after finite time, although the convergence time itself may not be predictable by a halting program, due to Kurt Gödel's limitations. He also explicitly discusses the more restricted ensemble of quickly computable universes. But there is much more... I have made a list here of many of the possible multiverse theories out there.

### **M-theory**

11 or 26 dimensional (the number of dimensions depends on the chirality of the observer) string theory suggesting universes are created by membranes colliding with each other. These universes operate under different laws of physics, so essentially, anything goes.

### **Many-Worlds Interpretation**

This is Hugh Everett's theory, which suggests that the universes split off from each other and share the same fundamental laws and constants, but exist in different states. This explains the lack of communication ability between the universes. This theory is also linked to the Many-Minds interpretation.

### **String Landscape**

The theory that there are numerous ways to bring 10 dimensional string theory into the 4 dimensional world we live in. Each of these ways would result in a universe vastly different from our own.

### **Bubble Theory**

I call this the Gas theory (because it gives me gas). Our universe is just a bubble that spewed from a multiverse, and like a soft drink, bubbles are rising up to create more baby universes from the quantum foam of the parent universe. Kaku supports this continual genesis idea.

### **Big Bounce or Oscillatory Universe hypothesis**

This states that the universe goes through a series of infinite oscillations (frequency again) that began with the Big Bang and ending with the Big Bounce, in which the universe collapses inward from the gravitational pull of matter. This is also linked to brane cosmology.

### **Open Multiverse**

An infinite number of universes exist in the same regions of space as our universe. It suggests multiple Big Bangs that occur along a network of regions separated by vast distances and is dependent on matter being evenly distributed across space.

Of course, none of these theories have been proven beyond a doubt yet and all of these are locked solidly in the theoretical stage, and personally I have an issue with the observer determining the existence of a parallel universe. But with new discoveries on Everett's Many-Worlds Interpretation, we may be inching closer to the truth. Recently, the Large Hadron Collider went online at CERN, unleashing a discovery of hundreds of new particles and now they are going to start colliding lead atoms in an effort to recreate the Big bang. But there remains a perplexing question:

So, how many universes are there? Is there any proof to support his notion of a multiverse? Possibly. Laura Mersini-Houghton claims that the WMAP cold spot may provide testable empirical evidence for a parallel universe within the multiverse!

Ockham's Razor (William Ockham, 14th century sage) also known as the Principle of Parsimony, states that "One should never increase beyond what is necessary the number of entities required to explain something, or the "Keep It Simple Stupid" equivalent of the 14th century. But many cosmologists and theoretical physicists put forth that Ockham's Razor loses its edge at the Quantum level, and are starting to agree that the idea of parallel universes is a far easier explanation of a lot of observed data, versus the once commonly held notion that our universe is the only universe in existence. This poses a few mind bending questions though, directly related to observable paranormal phenomena;

Is our universe producing other universes?

Can we be annihilated by another membrane colliding with us again?

Can energy or matter move between universes in any state or form?

Do universes compete for higher dimensional resources?

Do black holes play a role in producing other universes?

Do all universes allow for intelligent life?

It is the last question that has my head swimming, and interests most of the physicists out there. This is called the "Anthropic Principle" and this theory states that while there may be an infinite sea of universes, all may not have the potential to support life. Does it have the stuff required to make stars, planets, galaxies and the raw material for life?

We have the 1970s and Brandon Carter of Cambridge University to blame for this concept. At a conference in Poland celebrating the 500th year birthday of Nicolaus Copernicus, this British astrophysicist presented a paper to explain the observable fact that the fundamental constants of physics and chemistry must be perfectly in tune for life to exist. Essentially he said that there must be the exact interactions between gravity, electromagnetism, strong and weak nuclear forces as well as the presence of water and the synthesis of carbon in order for the magic of life to blossom.

Some scientists have taken this concept a step further to justify the existence of God, or a central intelligence guiding the development of the universes, determining which shall have life, and which shall not. Others shoot this down as being improvable, impossible to test, and holds no predictive power.

Why would God allow the perception of predictability among the human race when it comes to his intent?

Dr. Amit Goswami is convinced, along with a number of others who subscribe to the same view, that the universe, in order to exist, requires a conscious sentient being to be aware of it. Without an observer, he claims, it only exists as a possibility. And as they say in the world of science, Goswami has done his math. Marshalling evidence from recent research in cognitive psychology, biology, parapsychology and quantum physics, and leaning heavily on the ancient mystical traditions of the world, Goswami is building a case for a new paradigm that he calls "monistic idealism," the view that consciousness, not matter, is the foundation of everything that is. Enter the Metaphysical/Physical crossroad.

A professor of physics at the University of Oregon and a member of its Institute of Theoretical Science, Dr. Goswami is part of a growing body of renegade scientists who in recent years have ventured into the domain of the spiritual in an attempt both to interpret the seemingly inexplicable findings of their experiments and to validate their intuitions about the existence of a spiritual dimension of life. The culmination of Goswami's own work is his book *The Self-Aware Universe: How Consciousness*

Creates the Material World. Rooted in an interpretation of the experimental data of quantum physics (the physics of elementary particles), the book weaves together a myriad of findings and theories in fields from artificial intelligence to astronomy to Hindu mysticism in an attempt to show that the discoveries of modern science are in perfect accord with the deepest mystical truths.

Quantum physics, as well as a number of other modern sciences, he feels, is demonstrating that the essential unity underlying all of reality is a fact which can be experimentally verified. Because of the enormous implications he sees in this scientific confirmation of the spiritual, Goswami is ardently devoted to explaining his theory to as many people as possible in order to help bring about what he feels is a much needed paradigm shift. He feels that because science is now capable of validating mysticism, much that before required a leap of faith can now be empirically proven and, hence, the materialist paradigm which has dominated scientific and philosophical thought for over two hundred years can finally be called into question. I believe that it is all entangle with the consciousness, and that the physical and metaphysical will eventually have to be unified for either side to make any semblance of sense. I have of coursed been ridiculed and laughed at for holding this opinion.

So, is our universe, so perfectly outfitted for life just a random fart in the solar breeze of space/time? Some physicists don't believe this to be so. Sir Martin Reese compares the multiverse to an off the rack clothes shop. If the shop has a very large stock, it is not a surprise that we find a suit to fit. Consequently, if our universe were selected from a multiverse, it's seemingly designed or fine-tuned features would not be surprising, nor would the discovery that God had a hand in it. If you believe in the Holographic Theory, God may simply be a child at the keyboard of an elaborate computer game, and we are merely the characters playing out our rolls. All of these things must be held out for exploration, regardless of our notions or beliefs. I can't say this enough; the duty of science is to investigate the unexplained, not explain the uninvestigated. We are now just scratching the surface on understanding the mechanics of the consciousness.