The Multiverse

Working Paper · April 2016

DOI: 10.13140/RG.2.1.4131.0323

1 author:

Victor Andrei Bodiut
University of Amsterdam

"Our universe may be one of many, physicists say"
The Multiverse

Victor-Andrei Bodiut, S2574608

Coordinator: Prof. Dr. Rien van de Weijgaert

Course: Cosmic Origins (Cosmology) – Minor Astronomy through Space and Time

University of Groningen

28-03-2016

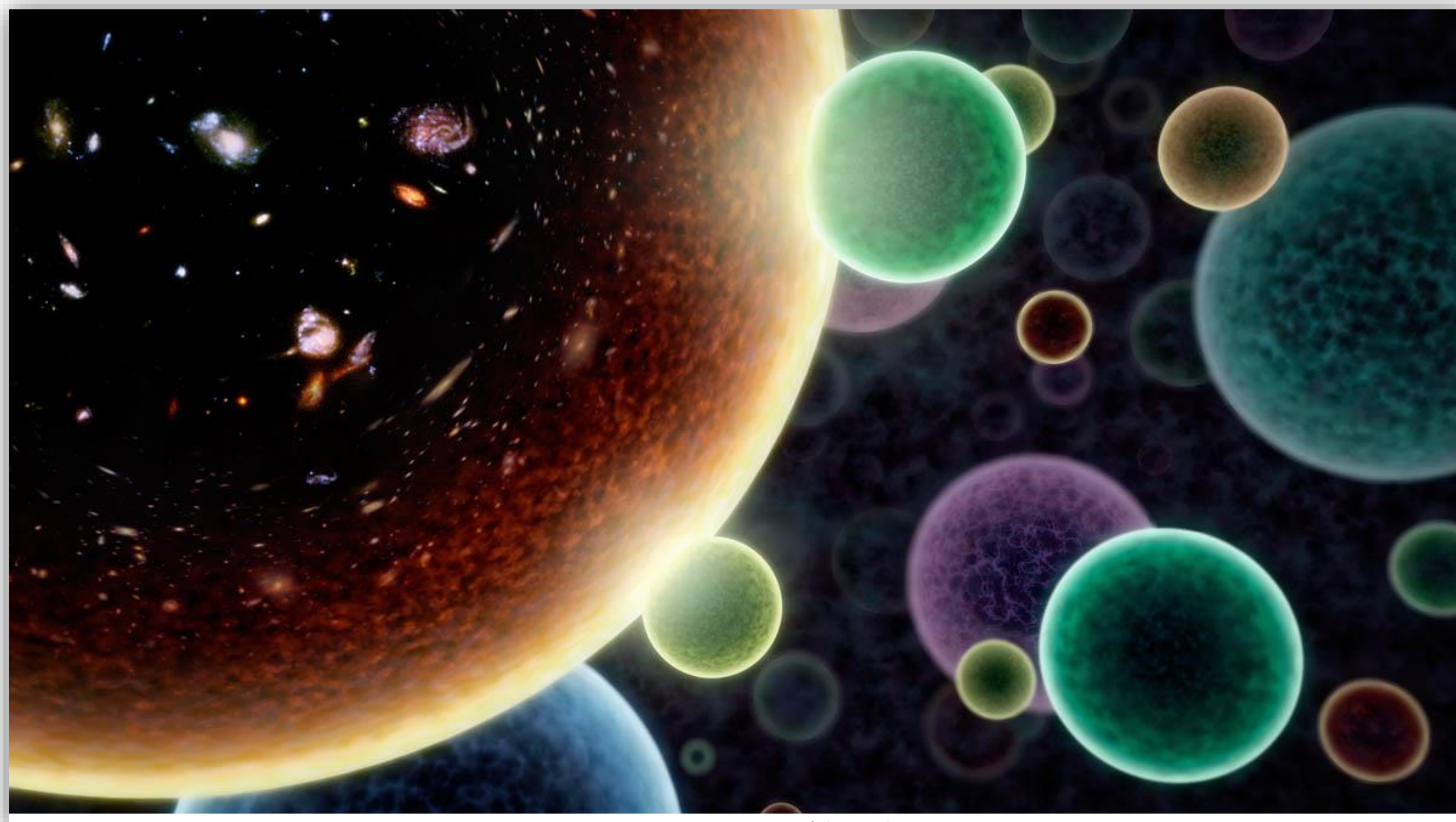


Figure 1 - Artist's Impression of the Multiverse

Imagine a warm tropical lagoon. You are a fish swimming around in this lagoon. To you and the other beings that live here, this watery world is all there is. This is your universe. You have no knowledge of anything beyond. Suppose you got a clue that yours is just one of the huge number of bodies of water on Earth's surface, some like yours, some very different. And that creatures are wandering the soil, the land, the air, deserts, savannas and forests. Could your fish brain handle that?

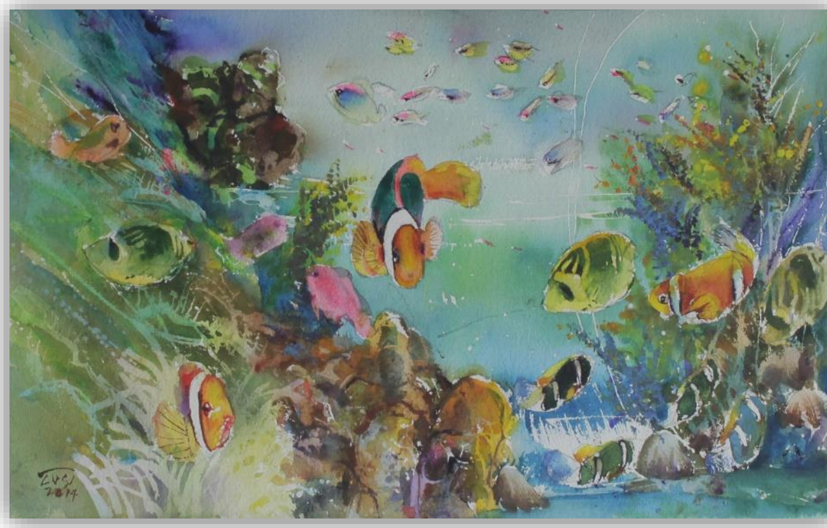


Figure 2 – A Lagoon

When we (humans now) say universe, we think of it as everything there is because of the Big Bang, around 13.8 billion years ago. However, the Big Bang that created our universe may not have been a onetime event. Instead, it could have happened again, and again, and again, an infinite number of times. And just as our Big Bang created our universe, each of those events would have created other universes, a process that would increase its rate exponentially in time. From this perspective, there are no reasons to believe that our universe was the 1st. The chances for that would be 1/infinity, right? If we want then the word universe to mean everything there is, we should be careful. For that purpose, the concept of multiverse was born. Mathematical computations show that the multiverse would contain an infinite number of universes, sometimes called "pocket" or "bubble" universes. Most of these "pocket" universes would be very boring, without structure or complexity and lifeless, while some might even resemble our own. By definition, an infinite number of possibilities means that everything that can happen, will happen in one universe or another. So is there another Earth, nurturing intelligent life? Is there/was there/will there be another you and me? This is certainly a mindboggling idea, but also very controversial, igniting a fierce debate in the scientific community. How seriously should we take this idea?

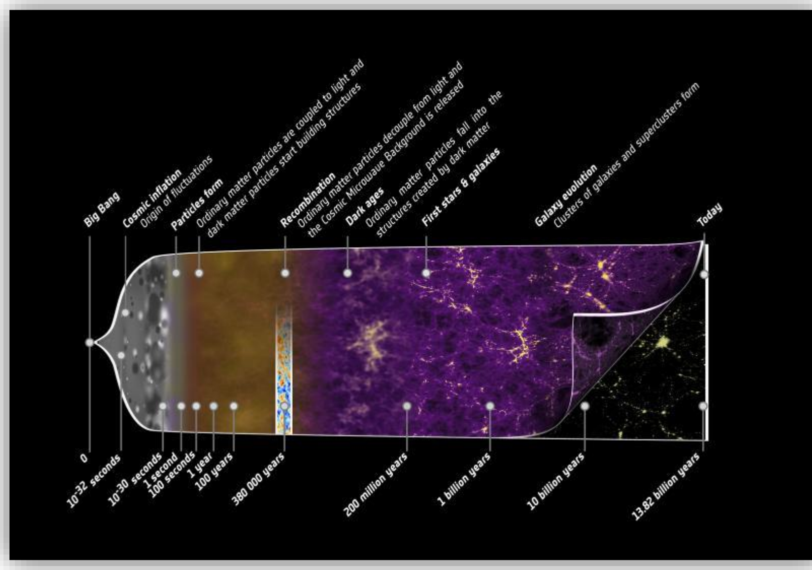
In the present paper, I am going to address this issue from a cosmological point of view. Before doing so, I want to start off with a quote from theoretical cosmologist Andreas Albrecht at the World Science Festival (2014), which describes the progress made in the last decades in the field: "I want to start by looking back. When I was a grad student, I wanted to be a particle theorist. I showed up into Paul Steinhardt's office (leading developer of cyclic and ekpyrotic cosmology). I thought he was a particle theorist, but he said - Well actually, I'm doing cosmology now. I had this old-school training in cosmology where there were big questions, no good theories and no good data and my heart sank when I heard that.

Fortunately, Paul knew about the pioneering work that Alan and Andrei had done (Alan Guth & Andrei Linde), bringing particle physics to the universe. What happened since then I think it's one of the most triumphant transformations of a scientific field ever – from having almost nothing to having an abundance of riches".

Cosmic Inflation

The classical Big Bang theory says nothing about what banged, why it banged and what happened before it banged. When we refer to the traditional Big Bang model, we talk about the aftermath of the bang, when the matter was already uniformly expanding with the space-time along with it.

Figure 3 - History of Inflationary Universe



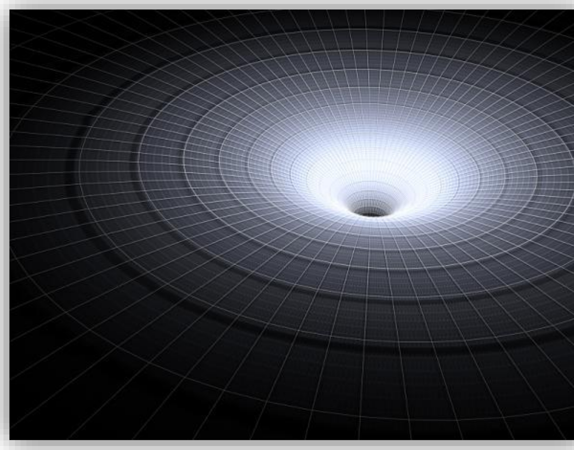
In a pursue to explain what happened in the instances closer to the singularity, as well as to account for several inconsistencies in the original theory, a group of young physicists including Andrei Linde, Paul Steinhardt, Andreas Albrecht and especially Alan Guth, came up with a twist to the Big Bang theory in the 1980s. The idea of cosmic inflation was proposed. It involves an exponential expansion of the universe in the very first split-second after the Big Bang, lasting from 10^{-36} seconds to ~ 10^{-32} seconds (see Figure 3). In the original theory, the universe expands relatively gradual.

The Newtonian gravity (the usual or common notion of gravity that is familiar to us) is always attractive. However, Einstein's general relativity allows gravity to be repulsive. Einstein suggested that if you have enough energy, the gravity becomes an explosive force, pulling outward, rather than inward.

This gravitational repulsion occurred in the cosmic inflation and was caused by a very peculiar type of matter. The growth then stopped because the matter was fundamentally unstable and started decaying (in the sense of radioactive decaying).

Another rather counterintuitive fact is that energy is not always positive, as previously thought. In fact, the total amount of energy in the observable universe is conservative, thus adding up to zero. All the normal matter – the elementary particles, stars, planets, galaxies, etc. account for the positive energy, while the gravitational fields are negatively energized (see Figure 4). This means that, as Alan Guth puts it, "you can create universes for free and it takes nothing to put into it, it's like the perfect free lunch".

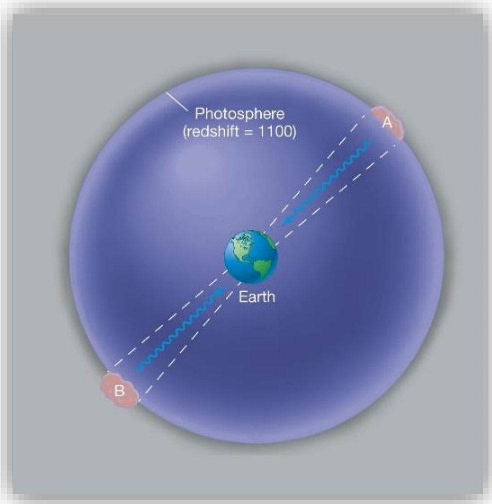
Figure 4 - Gravitational Field



Puzzles of the traditional Big Bang model that the paradigm of cosmic inflation tried to solve included the "horizon problem", the "flatness problem", the "magnetic monopole problem" and observations of the large scale structure of the cosmos. Let us discuss them in some more detail.

The "horizon problem" was identified in the late 60s primarily by the American physicists, Charles Misner. It poses that different regions of the universe have the same physical characteristics (e.g. temperature) although there is no "contact" between them, due to vast distances. This is a paradox, considering that the exchange of information (e.g. heat, energy) can occur, at most, at the speed of light. In other words, there simply has not been enough time for an exchange from one region to the other. In cosmological terms, it is said that the two regions are outside each other's horizon (see Figure 5).

Figure 5 - The Horizon Problem



One could try to explain the physical similarity by assuming a very homogenous early universe. However, all models predict fluctuations at some point or level. Thus, there is no good basis for the two regions to look alike. An inflationary perspective solves this problem by acknowledging that the observable universe before the spurt of expansion was ~ 10^{25} or more times smaller in radius than in the traditional theory. Hence, all regions could have been in contact.

To put it another way, the observable universe is amazingly uniform on large scales in every direction we look. We know this by measuring the Cosmic Background Radiation, the thermal radiation left over from the time of recombination (see Figure 6), with tremendous precision (1 in 100.000). This cannot be explained by the linear expansion of the classical Big Bang, but can be explained by the fact that regions were "together enough" before inflation, so that the uniformity could be settled.

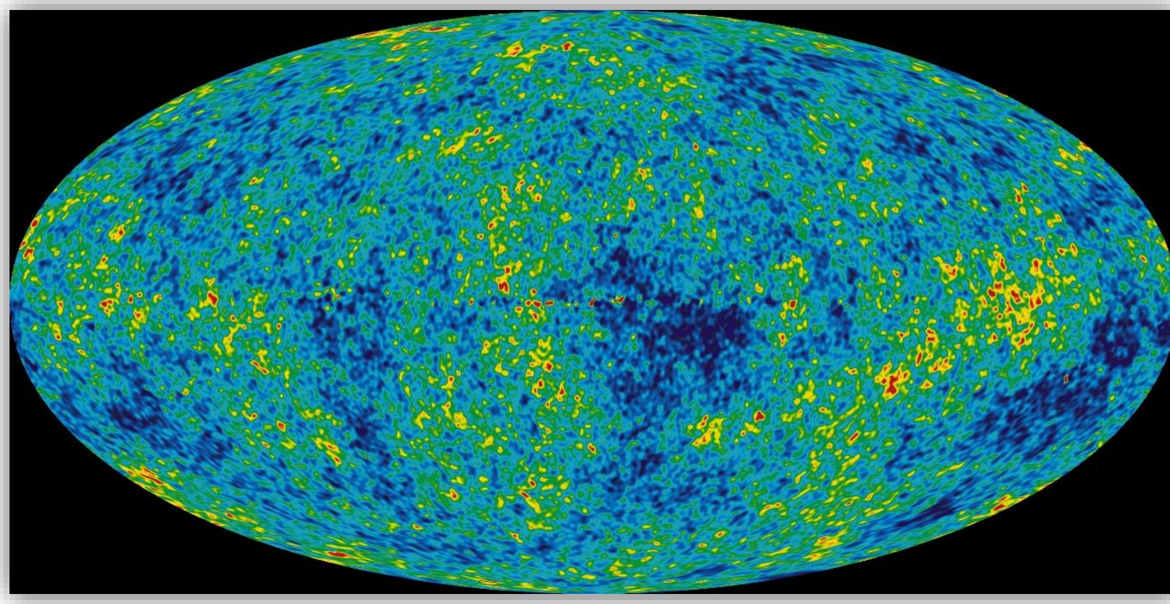
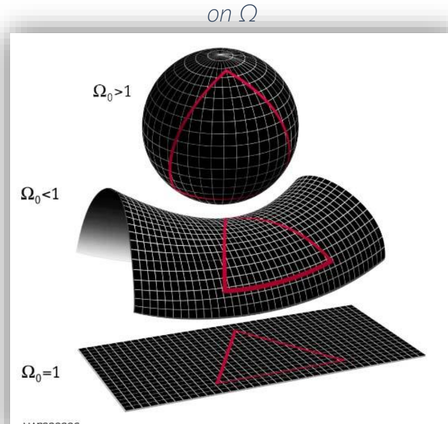


Figure 6 - Cosmic Background Radiation (CMB)

Although things are so uniform on large scales, non-uniformities seem to cluster together on smaller scales. Classically, inflation should produce a perfectly smooth, boring and lifeless universe, but because of random quantum fluctuations (a higher or lower mass density here or there), the inflationary models predict a full spectrum of the non-uniformities. In other words, these quantum fluctuations are the reason for structure to appear in some places – galaxies, stars, planets, us. The experimental measurements are in perfect agreement with the predictions.

Figure 7 - The Shape of our Universe Depending on Ω



The "flatness problem" (or oldness problem) of the traditional Big Bang model is a fine-tuning cosmological problem. A fine-tuning problem refers to model parameters that appear to be tweaked to very particular (or special) values. This becomes problematic when an underlying mechanism is nonexistent. First mentioned by American physicist Robert Dicke in the late 60s, the fine-tuned parameter in the flatness problem is the density of matter and energy (Ω). Ω basically determines the curvature of space-time - whether we are living in a spherical, hyperbolic or flat universe (see Figure 7). The current value of density is very close to the critical value of a flat universe and was even more so in the past (margin of error of 10^{-62}). The standard Big Bang model does not provide solid ground for such a nearly isotropic and flat universe. As cosmologists want to understand and explain the current universe, and not accept it "as is", this becomes a problem. Cosmic inflation solves the puzzle by pushing the universe exponentially towards flatness. At first, the observations of the overall density differed significantly from what inflation predicted. However, when accounting for dark energy (~68% of the total energy in the observable universe), the observed and predicted values matched to a confidence of half-percent.

Lastly, the "magnetic monopole problem" (or the exotic-relics problem) is a contradiction between what is hypothesized and what is observed. Stable magnetic monopoles (see Figure 8), hypothetical elementary particles in physics that originate in the early hot universe and should have persisted and become abundant have never been observed. An inflationary colder period would dilute any relics, explaining the lack of observational evidence. To be mentioned here is Sir Martin Rees, the U.K.'s Astronomer Royal's comment: "Skeptics about exotic physics might not be hugely impressed by a theoretical argument to explain the absence of particles that are themselves only hypothetical. Preventive medicine can readily seem 100 percent effective against a disease that doesn't exist!"

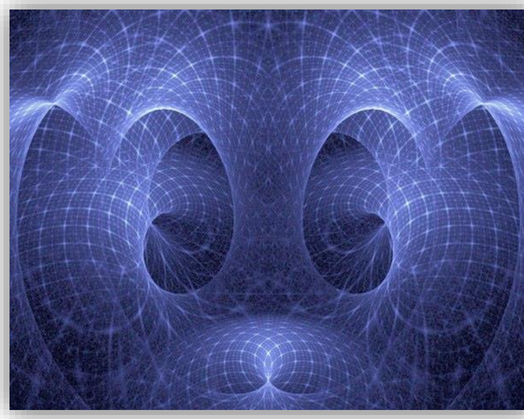


Figure 8 - Magnetic Monopoles

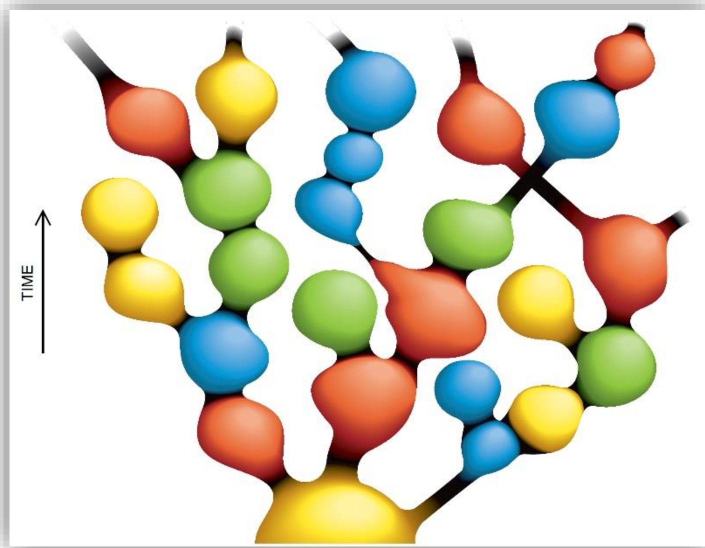
A step forward – Eternal Chaotic Inflation

In 1983, Andrei Linde developed on the idea of cosmic inflation even further. He saw our universe as a simple "bubble" growing up in a vastly grander scale – the multiverse. This is possible due to a vacuum that did not decay to its ground state, as in Guth's cosmic inflation model. Linde thought that maybe Einstein wanted too much in his pursue of explaining why the universe is the same everywhere. Maybe that was not the case after all.

During one conference, Linde gave the example of the universe as a football, with its characteristic white and black spots. Assume the football undergoes inflation and expands exponentially. If we happen to have lived on a black spot before the spurt, our entire observable universe will now be black. On the other side, if we happen to have begun our journey on a white spot, our universe is now all white. The laws of physics in a black universe can be somewhat different or very different from the ones in a white universe. In the process, all combinations of grey universes must have been formed as well.

On the same line of thought, computer simulations on the consequences of chaotic inflation show the multiverse as a growing fractal (see Figure 9). In this grand picture, each "bubble" is a universe generated by its own Big Bang. The different colors are meant to show the different types of universes, governed by somewhat different physical laws. There still is one or more fundamental laws operating the whole fractal, but each "bubble" takes a different actualization of those laws. The fundamental laws dictate the variety of local by-laws that could exist. And so, our universe would be governed by one manifestation of these by-laws. Each "bubble" is so incredibly vast that one cannot hope to reach another "bubble". The reason for this is that the space in between universes is thought to be of a higher dimension, unperceivable to our "fish brain". Not to add that it would be quite dangerous to visit other universes governed by different physical laws, as our atoms are held together by our local physical laws – oops!

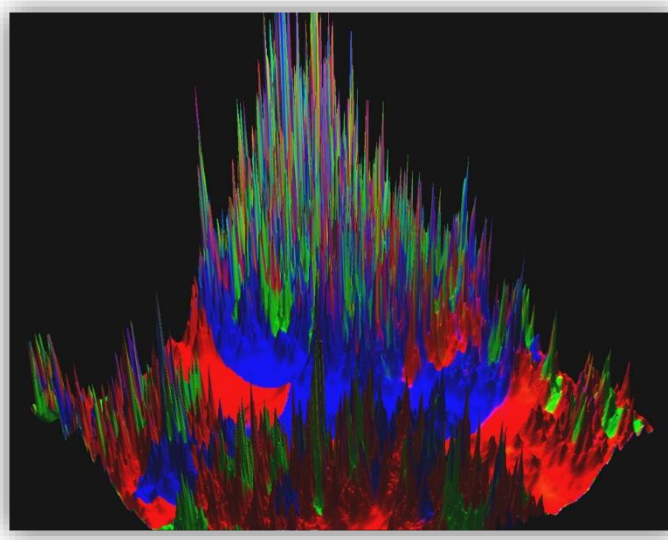
Figure 9 - Linde's Multiverse as Fractal



There are no reasons to believe that the Big Bang generating mechanism will stop. On the contrary, the rate in which Big Bangs are being produced is increasing exponentially, as can be seen in the branching of the fractal. As each "bubble" is expanding exponentially (ours included) and the number of "bubbles" is increasing exponentially, the multiverse is infinite.

Another question that follows logically is: is this fractal the full picture? The multiverse is described nowadays as having more levels. To put things in perspective, a next level would imply a place with fully separated fractals, governed by completely different physical laws. We'll step into that a bit later.

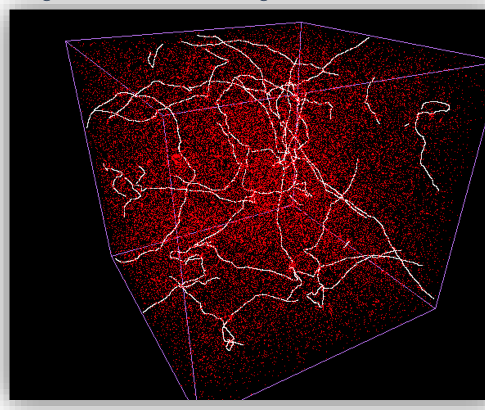
Figure 10 - Self-reproducing Universe with Two Scalar Fields



A theory of everything? - Quantum Field Theory & String Theory (M-theory)

As Steven Weinberg (American theoretical physicist and Nobel laureate in Physics) puts it, in the quantum world the fundamental concept is not the particle, but the wave function, describing all possibilities of existence. Therefore, a form of matter can exist in two places simultaneously and it is only by an outside observation or intervention that the wave function collapses and the particle appears to be here or there. The best way to understand our world is to see the universe as some kind of quantum mechanical superposition of different possibilities. Without going deeper into a field that might outreach us, let us keep in mind that quantum field equations are used to explain and predict how the fundamental particles and the laws of nature behave.

Figure 11 - Cosmic String Network Simulation



As a next step, string theory replaces the zero-dimensional point-like particles with one-dimensional extended objects – strings (see Figure 11). Take a guitar string as a figurative example. Based on the tension of the string and the energy it receives, the guitar string will produce musical notes. Think of these musical notes as excitation modes. Similarly, from a string theory perspective, the elementary particles can be thought of as excitation modes of the one-dimensional strings. Only this time, the average size of a string would be around the Planck length ~ 10^{-33}.

In an interview with public intellectual Robert Lawrence Kuhn, Leonard Susskind, one of the fathers of string theory, beautifully describes its contextual value. What string theory adds to chaotic inflation and the multiverse is something about the number of types of possible universes built-in the equations. This number is much larger than the number of atoms in the universe and basically much larger than anything we can think of. The number 10^{500} is talked a lot. “By studying the ways in which microscopic geometries can be combined, at least 10^{500} have been estimated”. That is not 10^{500} different “pocket” universes or “bubbles”, but 10^{500} types of them, each being generated again and again. We can bring chaotic inflation and the string theory landscape together with a simple illustration – card decks. String theory tells us the way the decks will be shuffled – the order of cards within each deck. Chaotic inflation is a card factory, creating decks above decks, each shuffled differently. Ta-dam!

Figure 12 - Rotating Cosmic String Loop on Surrounding Plasma

This is seen as crucial, as it can provide a natural (as opposed to supernatural) explanation for the anthropic dilemma of why does our universe have the fundamental physical constants and the age necessary to foster life, especially conscious life. As the multiverse is so incredibly vast and diverse, some of the "bubbles" will happen to have the right conditions for evolving life, no matter how unlikely. Assuming a multiverse governed by eternal chaotic inflation and the string theory landscape, almost all of the "bubbles" will be sterile, dead and lifeless. Whether the constants of physics are not quite right, inflation happens too fast, or electrons are inexistent, all sorts of things can make it go wrong.

Figure 13 - 6D Calabi-Yau Manifold.

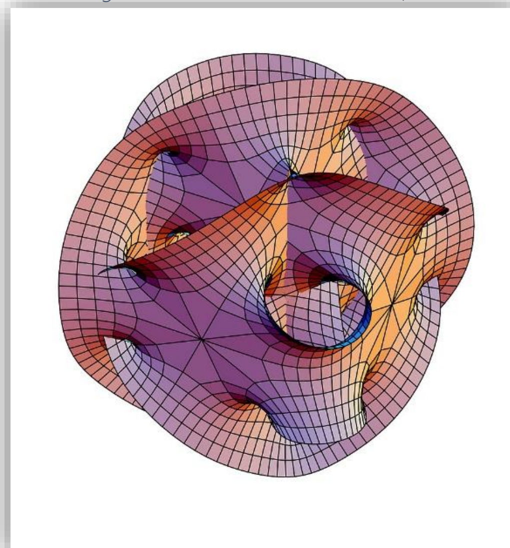


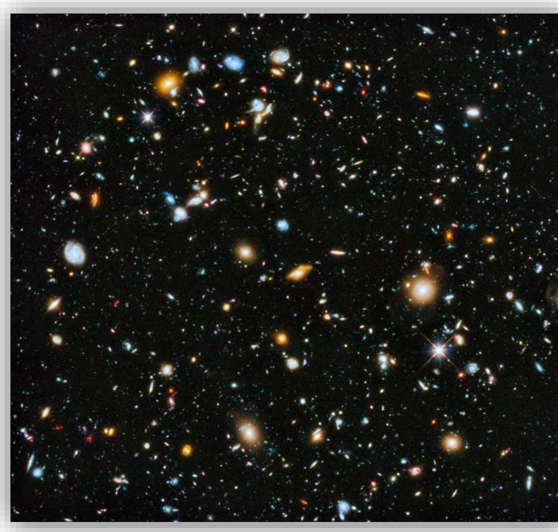
Figure 13 depicts a 6-dimensional Calabi-Yau manifold, conjecturing the extra 6 dimensions of space-time as described particularly by superstring theory. Superstring theory basically is meant to be a theory of everything, explaining all particles and laws of nature as vibrations in supersymmetric strings.

Levels of the multiverse

Cosmologist Max Tegmark distinguishes 4 different types or levels of the multiverse, each with its particular assumptions and implications. In the existing literature, several other universe-generating mechanisms have been conceptualized. In general, the more advanced the levels get, the less scientific basis is involved. The different levels are not mutually exclusive.

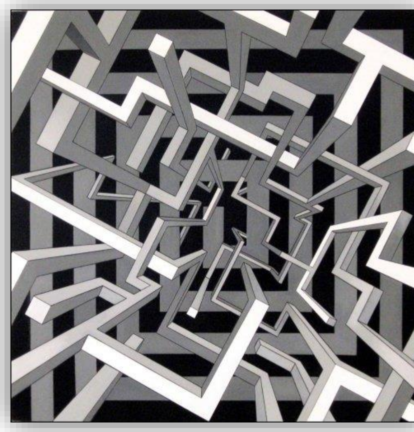
It is a consensus in the scientific community of cosmology nowadays that the observable universe is not the whole story. There is more to the physical world than can be seen through the best telescopes (at least 10 billion light-years away). We are certainly bounded by the limited speed of light (~ 300.000 km/s) that started travelling ~ 13.8 billion years ago. Thus, there is a limit to how far our telescopes can see due to how far the light could get from the Big Bang. Moreover, the universe is undergoing an accelerated expansion. There is every reason to expect other galaxies beyond the visible horizon. Thus, within our own local "pocket" universe, different regions of the same space-time must exist. This is Tegmark's 1st level and a consequence of chaotic inflation.

Figure 14 - The Hubble Ultra-Deep Field



Linde's eternal chaotic inflation and the string theory landscape describe Tegmark's 2nd level multiverse. This is generally referred to as "the multiverse" and has been presented in more detail above (see also Figure 9 and Figure 1). The idea has many supporters on both sides and aspects of the debate between the different views will be addressed shortly.

Figure 15 – Hilbert Space



Tegmark's level III is a consequence of the strange quantum world. By taking the quantum wave function as objective reality, the world splits into an infinity of branches at each instant (e.g. Planck time ~ 10^{-43} seconds – the time for a photon to travel a Planck space ~ 10^{-35} m). This happens in a so-called "Hilbert space" (see Figure 15), which is very different from our space-time, of infinite dimensions and abstract. In theory, other universes could be very close (in space-time) to our own, but dispersed into the intangible Hilbert space. This is also known as the "many worlds" interpretation of quantum mechanics, and although it has received some considerable support, it is generally viewed as more metaphysical than scientific.

Figure 16 – Mathematical Multiverse

Level IV: in Tegmark's view, whatever a consistent mathematical system can express must exist is some kind of universe. "It would seem odd if there were some basic asymmetry built into math, such that some equations would be allowed to describe a physical universe and others would not. So my guess is that every mathematical structure which mathematicians can study is on the same footing and describes some kind of physical universe. I think that the reason that nature is so well-described by math is because in a very deep sense, nature really is math" (see Figure 16). As one can guess, this proposal has only a handful of supporters.

Another proposed theory is that we are currently living in a particular temporal period of our universe, which is cyclically expanding and contracting in Big Bangs and Big Crunches respectively (see Figure 17). This mechanism would generate universes in a sequential and not parallel manner.

Figure 17 – Cyclical Universe

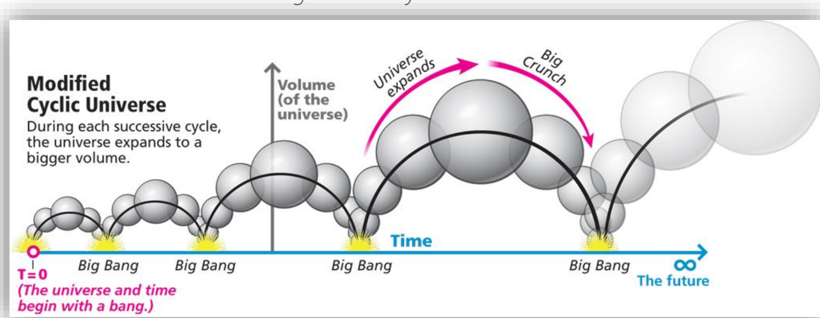


Figure 18 – Fecundity (Oil Painting)

Higher dimensions of space-time could exist, embedding completely independent realities. Again, these dimensions could be in close proximity, but with respect to information transfer and communications, forever apart.

Lastly, philosopher Robert Nozick has talked about the principle of fecundity. It states that everything one can conceive, every single thought and possibility, imagined or real, must exist somewhere. And so, according to him, infinity is once again the key to understanding.

One hell of a debate

Several scientists, including some that helped creating the very theory of inflation in the first place, have come up with counterarguments to the multiverse theory. Others favor such an explanation. Let us step in a debate between some of world's most brilliant minds.

Andreas Albrecht expressed that infinity should not be the way to explain things. "All of human knowledge will be finite, no matter how big. The concept of infinity can be very useful in mathematics as an approximation of a very large finite number. Our data is finite, so we should come up with theories of the universe that work out fine for finite ideas and data. If you want a round tire for your car, you can use a finite approximation of pi. If you want it a bit rounder, increase the decimals of pi. The idea is that finite works just fine. The multiverse theories insist on the concept of infinity to be absolute".

Pursuing the idea of finiteness, physicist Neil Geoffrey Turok brings about the simplicity observed in the universe: "I do think in the last 30 years the universe showed to be very simple and so our theories should be clear, simple and predictive, with compelling results. I am sad to see that in these years we have seen a proliferation of models, due to a lowering of standards where we accepted models as legitimate, models which failed to explain the most significant mysteries about the universe".

As a counterargument, Andrei Linde gives the example of Steven Weinberg and his pursue on special relativity: "When we try to think in a different way, when we try to envision a completely different world, there is a resistance. But the Genie is out of the bottle and is very hard to put it back. An immense interest is received by the possibility of multiple universes, the number of people engaged is "exponentially expanding". On this line of thought, Martin Rees thinks we might be facing a conceptual leap: "The idea of multiverse could be a conceptual leap, just like moving from a geocentric to a Copernican universe, or from the idea that our Milky-Way galaxy is unique to the realization that our galaxy is one of billions. Kepler thought that the laws governing our solar system are very special".

Cosmologist and mathematician George Ellis sees the explanation of multiple universes more of a philosophical explanation, rather than a scientific one: "A scientific theory should be testable and verifiable. The other dimensions or universes in the multiverse cannot be tested as we cannot hope to reach them. If we could deduce the laws of physics that generate our local sub-laws, we could solve this problem, but they are also unverifiable. The multiverse gives a very plausible explanatory pattern of a scientific nature for the existence of life in our universe, but still metaphysical because it cannot be tested".

Martin Rees sees this issue as speculative science, not just metaphysics: "As an example, we believe that we can talk about the first seconds after the Big Bang, when hydrogen and helium were made because the laws of nuclear physics that applied then can be tested here on Earth. In the same way that we think we know what happens inside the Sun from testing here on Earth. So it could be that we could corroborate the theories referring to multiple Big Bangs in other ways. Another possibility is that the multiverse model will make some predictions about this particular manifestation that we live in and we can test these predictions and maybe refute them. For these reasons, I would regard this subject as part of science – it is potentially testable, linking in into today's laboratory physics even and it is potentially falsifiable. Thus, it is not purely metaphysics, although it has some metaphysical implications certainly".

Steven Weinberg talks about the statistical beauty of the theory: "The theory of multiple universes is not as beautiful as a theory that is very logically constrained, that makes things look like that is the only way it could be. Still, you cannot reject a theory because it is not as beautiful as we want it to be. Many beautiful theories tell something about statistical aspects, and not fundamental behavior of individual components. For example, the theory of thermodynamics is regarded in consensus as a beautiful theory. However, it does not say anything about where each particle is in a particular gas. In the same way, there might be a theory that describes the statistical distribution of the distances between planets and their parent stars without precisely giving a model of prediction for any particular star. It is still a beautiful theory. Thus, the multiverse theory could be a statistical theory of multiple universe, without explaining why each universe is the way it is".

English physicist Paul Davis makes a rather distinctive point by comparing the multiverse with a god: "I suppose, for me, the main problem is that what we're trying to do is explain why the universe is as it is by appealing to something outside of it. In this case, an infinite number of multiple universes outside of our universe is used as the explanation for our universe. To me, multiverse explanations are no better than traditional religion, which appeals to an unseen, unexplained god, a god that is outside of the universe to explain the universe. Something is amiss”.

When considering the further theoretical and experimental research directions, it comes down to two fundamental questions that pose a great challenge to 21st century science and maybe beyond:

1. Was our Big Bang the only one?
2. If there were multiple Big Bangs, were they replicates of each other, or they ended up being governed by different laws?

Leonard Susskind incorporates a very important aspect of critique on this issue: “Theoretically, we will explore this land better and better and in the end find approximately what combinations of the basic elements create a universe like our own. Also, we will better understand the mathematics of chaotic inflation, make sure they make sense and that the theory holds together. The critics correctly say that there must be evidential observational data to it! That’s the hard stuff. We are rapidly coming to an end of the possibility of doing experiments within a lifetime. Current experiments in particle physics involve 30-50 years of work. An accelerator that could truly test the things we are interested in would have to be as big as the Galaxy, using a trillion barrels of oil/second. On another level, astrophysical observations are coming close to the horizon. We know we cannot see things further than the horizon. Again, we are coming to an end. We are never going to see other “pocket” universes, there are outside our horizon, and too far away, outside of our experience. What we can do experimentally is look into the past and hope to discover that our universe was born from a bubble nucleation. Thus, observational possibilities are very limited, at least in the short term”.

As for myself, my opinion is best articulated in Martin Rees’s words: “Well, I feel that the only appropriate stance is agnosticism because we just don’t know. But I would say that there are some physicists who I believe conflate what they would like to be the case with what is actually likely to be the case. Many people would like to be able to write on their T-shirts the equations that exactly determine the laws of physics that we observe here on Earth. That’s a worthy goal, it’s wonderful that people are searching for this, but they may fail. It could be that the laws as we understand them traditionally are just these local environmental accidents of the aftermath of our particular Big Bang and that there are laws at a much deeper level. I find that a rather grand and fascinating concept, even though it means we are further from being able to grasp the final laws”.

References/Bibliography

http://web.stanford.edu/~alinde/

http://www.its.caltech.edu/~rchary/multiverse/Chary_Multiverse_Oct.pdf

http://web.mit.edu/physics/news/physicsatmit/physicsatmit_02_cosmology.pdf

http://www.physicsoftheuniverse.com/

http://www.worldsciencefestival.com/

http://www.ctc.cam.ac.uk/footer/glossary.php#Inflation

http://www.space.com/31465-is-our-universe-just-one-of-many-in-a-multiverse.html

http://www.space.com/search?q=multiverse

http://web.mit.edu/physics/news/physicsatmit/physicsatmit_02_cosmology.pdf

https://medium.com/starts-with-a-bang/all-about-cosmic-inflation-211a64441ddd#.e7atslok4

http://mentalfloss.com/article/68975/what-multiverse

http://www.space.com/18811-multiple-universes-5-theories.html

http://horizoncrossing.com/2015/11/17/a-rotating-cosmic-string-loop-detaches-from-its-parent-string/

http://www.damtp.cam.ac.uk/research/gr/public/images/initial.gif

http://bicepkeck.org/

http://www.scientificamerican.com/article/multiverse-controversy-inflation-gravitational-waves/

http://www.scientificamerican.com/article/does-the-multiverse-really-exist/

http://www.kias.re.kr/sub03/sub03_02_10_01.jsp

http://www.ribbonfarm.com/2015/08/20/qft/

http://whystringtheory.com/motivation/quantum-field-theory/

http://profmattstrassler.com/2013/09/23/quantum-field-theory-string-theory-and-predictions/

http://news.nationalgeographic.com/news/2014/03/140318-multiverse-inflation-big-bang-science-space/

http://blogs.scientificamerican.com/life-unbounded/does-a-multiverse-fermi-paradox-disprove-the-multiverse/

https://www.youtube.com/watch?v=aUW7patpm9s

http://www.closertotruth.com/topics/cosmos/vast-cosmos/multiple-universes-multiverse

https://www.newscientist.com/article/dn25249-multiverse-gets-real-with-glimpse-of-big-bang-ripples/

https://en.wikipedia.org/wiki/String_theory

https://en.wikipedia.org/wiki/Superstring_theory

https://en.wikipedia.org/wiki/Quantum_field_theory

https://en.wikipedia.org/wiki/Horizon_problem

https://en.wikipedia.org/wiki/Charles_W._Misner

https://en.wikipedia.org/wiki/Fine-tuning

https://en.wikipedia.org/wiki/Flatness_problem

https://en.wikipedia.org/wiki/Robert_H._Dicke

https://en.wikipedia.org/wiki/Magnetic_monopole

https://en.wikipedia.org/wiki/Inflation_(cosmology)

https://en.wikipedia.org/wiki/Multiverse