DOWNLOAD PDF PARALLEL QUANTUM UNIVERSES

Chapter 1 : Parallel universes for quantum computing

The concept is known as a "parallel universe," and is a facet of the astronomical theory of the Or perhaps multiple universes can follow the theory of quantum mechanics (how subatomic.

Professor of Mathematical Physics, Tulane University; Author, The Physics of Christianity Parallel Universes of Quantum Mechanics In , a Princeton physics graduate student named Hugh Everett showed that the consistency of quantum mechanics required the existence of an infinity of universes parallel to our universe. That is, there has to be a person identical to you reading this identical article right now in a universe identical to ours. Further, there have to be an infinite number of universes, and thus an infinite number of people identical to you in them. Yet few people have even heard of the parallel universes, or thought about the philosophical and ethical implications of their existence. The free will question arises because the equations of physics are deterministic. Everything that you do today was determined by the initial state of all the universes at the beginning of time. But the equations of quantum mechanics say that although the future behavior of all the universes are determined exactly, it is also determined that in the various universes, the identical yous will make different choices at each instant, and thus the universes will differentiate over time. Say you are in an ice cream shop, trying to choose between vanilla and strawberry. What is determined is that in one world you will choose vanilla and in another you will choose strawberry. But before the two yous make the choice, you two are exactly identical. The laws of physics assert it makes no sense to say which one of you will choose vanilla and which strawberry. So before the choice is made, which universe you will be in after the choice is unknowable in the sense that it is meaningless to ask. To me, this analysis shows that we indeed have free will, even though the evolution of the universe is totally deterministic. Another philosophical problem with ethical implications is the Problem of Evil: Why is there evil in the universe we see? We can imagine a universe in which we experienced nothing bad, so why is this evil-free universe not the universe we actually see? If Hitler had never taken power in Germany, there would have been no Holocaust. Is it plausible that a universe with Hitler is better than a universe without him? The medieval philosopher Abelard claimed that existence was a good in itself, so that in order to maximize the good in reality, all universes, both those with evil in them and those without evil, have to be actualized. Remarkably, quantum mechanics says that the maximization of good as Abelard suggested is in fact realized. Is this the solution of the Problem of Evil? No analysis of why evil exists can be considered reasonable unless it takes into account the existence of the parallel universes of quantum mechanics. Everyone should know about the parallel universes of quantum mechanics!

Chapter 2 : Radical New Quantum Theory Says Other Universes Affect Our Own | HuffPost

A Level 3 parallel universe is a consequence of the many worlds interpretation (MWI) from quantum physics in which every single quantum possibility inherent in the quantum wavefunction becomes a real possibility in some reality.

May 9, Sandy MacKenzie Shutterstock Is our universe unique? From science fiction to science fact, there is a concept that suggests that there could be other universes besides our own, where all the choices you made in this life played out in alternate realities. The concept is known as a "parallel universe," and is a facet of the astronomical theory of the multiverse. The idea is pervasive in comic books, video games, television and movies. A fuller list of parallel universes in fiction is at the bottom of the article. There actually is quite a bit of evidence out there for a multiverse. First, it is useful to understand how our universe is believed to have come to be. Arguing for a multiverse Around Then, according to the Big Bang theory , some unknown trigger caused it to expand and inflate in three-dimensional space. As the immense energy of this initial expansion cooled, light began to shine through. Eventually, the small particles began to form into the larger pieces of matter we know today, such as galaxies, stars and planets. One big question with this theory is: With our current technology, we are limited to observations within this universe because the universe is curved and we are inside the fishbowl, unable to see the outside of it if there is an outside. There are at least five theories why a multiverse is possible , as a Space. One prominent theory is that it is flat and goes on forever. This would present the possibility of many universes being out there. More about that in a moment. Another theory for multiple universes comes from "eternal inflation. Others, however, will keep getting larger. So if we picture our own universe as a bubble, it is sitting in a network of bubble universes of space. Or perhaps multiple universes can follow the theory of quantum mechanics how subatomic particles behave , as part of the "daughter universe" theory. If you follow the laws of probability, it suggests that for every outcome that could come from one of your decisions, there would be a range of universes â€" each of which saw one outcome come to be. So in one universe, you took that job to China. In another, perhaps you were on your way and your plane landed somewhere different, and you decided to stay. Another possible avenue is exploring mathematical universes, which, simply put, explain that the structure of mathematics may change depending in which universe you reside. And last but not least as the idea of parallel universes. So, with an infinite number of cosmic patches, the particle arrangements within them must repeat â€" infinitely many times over. This means there are infinitely many "parallel universes": About the theory, he told Cambridge University in an interview published in The Washington Post , "We are not down to a single, unique universe, but our findings imply a significant reduction of the multiverse to a much smaller range of possible universes. A article on Medium by astrophysicist Ethan Siegal agreed that space-time could go on forever in theory , but said that there are some limitations with that idea. The key problem is the universe is just under 14 billion years old. This would simply put limit the number of possibilities for particles to rearrange themselves, and sadly make it less possible that your alternate self did get on that plane after all to see China. Also, the expansion at the beginning of the universe took place exponentially because there was so much "energy inherent to space itself," he said. But over time, that inflation obviously slowed â€" those particles of matter created at the Big Bang are not continuing to expand, he pointed out. This decreases the possibilities of universes similar to our own. He advises to make the choices that work for you, which "leave you with no regrets. Parallel universes in science fiction Here are some of the more prominent uses of parallel universes in science fiction. This is by no means a complete list, but a sampling of some of the more-quoted examples. Marvel Comics and DC Comics feature stories set in parallel universes that are part of the multiverse. Many anime series, such as "Digimon," "Dragon Ball" and "Sonic the Hedgehog" feature alternate versions of their characters from other universes. Abbott, is a story about a two-dimensional world that includes living geometric figures such as circles, triangles and squares. The novel also includes other universes such as Lineland, Spaceland and Pointland. This book was adapted into a feature film in Wells novel, included a "paratime" machine and explored the multiverse. Lewis book series, features several children who move between our world and the world of Narnia, where there are talking animals. Some of these books were released as feature films earlier in the s. An episode of "Star Trek" featured a "mirror universe" in which the characters were more ruthless and warlike. The concept was repeated in nearly every subsequent "Star Trek" series. In , the "Star Trek" universe got a reboot in a movie that put the characters from the s original series in an alternate universe. In "The Dark Tower," a Stephen King series that began in , travellers go through portals to different levels of the titular tower in other words, parallel Earths. Part of the series was adapted into a feature film in The "Back to the Future" movie series which began in follows the adventures of the McFly family, including visits to , and The second film in particular shows the drawbacks of an alternate reality, when one character uses it to get rich by nefarious means. The series starred Michael J. The first book, "The Golden Compass," was adapted into a film in in It starred Gwyneth Paltrow and John Hannah. While the book is mostly a time travel book, the multiverse is used in it as well. A film based on the book was released in It starred Jake Gyllenhaal. The series includes discussion of an alternate dimension called the Upside Down.

Chapter 3 : Many-worlds interpretation - Wikipedia

To the average person, quantum mechanics is the convoluted, science fiction-y branch of physics. A radical new theory plays into that, proposing that parallel universes exist and interact with each other â€' and that scientists may be able to test for them. Prof. Howard Wiseman, a physicist at.

In your perception of the world, the answer is simple: But is our universe unique? The concept of multiple realities â€" or parallel universes â€" complicates this answer and challenges what we know about the world and ourselves. One model of potential multiple universes called the Many-Worlds Theory might sound so bizarre and unrealistic that it should be in science fiction movies and not in real life. However, there is no experiment that can irrefutably discredit its validity. The origin of the parallel universe conjecture is closely connected with introduction of the idea of quantum mechanics in the early s. Quantum mechanics, a branch of physics that studies the infinitesimal world, predicts the behavior of nanoscopic objects. Physicists had difficulties fitting a mathematical model to the behavior of quantum matter because some matter exhibited signs of both particle-like and wave-like movements. For example, the photon, a tiny bundle of light, can travel vertically up and down while moving horizontally forward or backward. Such behavior starkly contrasts with that of objects visible to the naked eye; everything we see moves like either a wave or a particle. This theory of matter duality has been called the Heisenberg Uncertainty Principle HUP , which states that the act of observation disturbs quantities like momentum and position. In relation to quantum mechanics, this observer effect can impact the form â€" particle or wave â€" of quantum objects during measurements. Artist concept of the multiverse. Florida State University In , a young student at Princeton University named Hugh Everett proposed a radical supposition that differed from the popular models of quantum mechanics. Everett did not believe that observation causes quantum matter to stop behaving in multiple forms. Instead, he argued that observation of quantum matter creates a split in the universe. In other words, the universe makes copies of itself to account for all the possibilities and these duplicates will proceed independently. Every time a photon is measured, for instance, a scientist in one universe will analyze it in wave form and the same scientist in another universe will analyze it in particle form. Each of these universes offers a unique and independent reality that coexists with other parallel universes. Any action that has more than one possible result produces a split in the universe. Thus, there are an infinite number of parallel universes and infinite copies of each person. These copies have identical facial and body features, but do not have identical personalities one may be aggressive and another may be passive because each one experiences a separate outcome. The infinite number of alternate realities also suggests that nobody can achieve unique accomplishments. Every person â€" or some version of that person in a parallel universe â€" has done or will do everything. Moreover, the MWT implies that everybody is immortal. Old age will no longer be a surefire killer, as some alternate realities could be so scientifically and technologically advanced that they have developed an anti-aging medicine. If you do die in one world, another version of you in another world will survive. The most troubling implication of parallel universes is that your perception of the world is never real. You might believe you are reading this article at this instance, but there are many copies of you that are not reading. In fact, you are even the author of this article in some distant reality. Thus, do winning prizes and making decisions matter if we might lose those awards and make different choices? Is living important if we might actually be dead somewhere else? Some scientists, like Austrian mathematician Hans Moravec , have tried to debunk the possibility of parallel universes. Moravec developed a famous experiment called quantum suicide in that connects a person to a fatal weapon and a machine that determines the spin value, or angular momentum, of protons. Every 10 seconds, the spin value, or quark, of a new proton is recorded. Based on this measurement, the machine will cause the weapon to kill or spare the person with a 50 percent chance for each scenario. When the quark measurement is processed, there are two possibilities: At this moment, MWT claims that the universe splits into two different universes to account for the two endings. The weapon will discharge in one reality, but not discharge in the other.

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Chapter 4 : NPR Choice page

The many-worlds interpretation is an interpretation of quantum mechanics that asserts the objective reality of the universal wavefunction and denies the actuality of wavefunction collapse. Many-worlds implies that all possible alternate histories and futures are real, each representing an actual "world" (or "universe").

History of the concept[edit] In his book, Opticks , Isaac Newton suggested the idea of a multiverse: At least, I see nothing of Contradiction in all this. He said that when his equations seemed to describe several different histories, these were "not alternatives, but all really happen simultaneously". Multiple universes have been hypothesized in cosmology , physics , astronomy , religion , philosophy , transpersonal psychology , and literature , particularly in science fiction and fantasy. In these contexts, parallel universes are also called "alternate universes", "quantum universes", "interpenetrating dimensions", "parallel dimensions", "parallel worlds", "parallel realities", "quantum realities", "alternate realities", " alternate timelines ", "alternate dimensions" and "dimensional planes". The physics community has debated the various multiverse theories over time. Prominent physicists are divided about whether any other universes exist outside of our own. Some physicists say the multiverse is not a legitimate topic of scientific inquiry. The ability to disprove a theory by means of scientific experiment has always been part of the accepted scientific method. Feeney analyzed Wilkinson Microwave Anisotropy Probe WMAP data and claimed to find evidence suggesting that our universe collided with other parallel universes in the distant past. To be sure, all cosmologists accept that there are some regions of the universe that lie beyond the reach of our telescopes, but somewhere on the slippery slope between that and the idea that there are an infinite number of universes, credibility reaches a limit. As one slips down that slope, more and more must be accepted on faith, and less and less is open to scientific verification. Extreme multiverse explanations are therefore reminiscent of theological discussions. Indeed, invoking an infinity of unseen universes to explain the unusual features of the one we do see is just as ad hoc as invoking an unseen Creator. The multiverse theory may be dressed up in scientific language, but in essence it requires the same leap of faith. He accepts that the multiverse is thought to exist far beyond the cosmological horizon. He emphasized that it is theorized to be so far away that it is unlikely any evidence will ever be found. Ellis also explained that some theorists do not believe the lack of empirical testability falsifiability is a major concern, but he is opposed to that line of thinking: Many physicists who talk about the multiverse, especially advocates of the string landscape , do not care much about parallel universes per se. For them, objections to the multiverse as a concept are unimportant. Their theories live or die based on internal consistency and, one hopes, eventual laboratory testing. Ellis says that scientists have proposed the idea of the multiverse as a way of explaining the nature of existence. He points out that it ultimately leaves those questions unresolved because it is a metaphysical issue that cannot be resolved by empirical science. He argues that observational testing is at the core of science and should not be abandoned: In looking at this concept, we need an open mind, though not too open. It is a delicate path to tread. Parallel universes may or may not exist; the case is unproved. We are going to have to live with that uncertainty. Nothing is wrong with scientifically based philosophical speculation, which is what multiverse proposals are. But we should name it for what it is. They are briefly described below. An extension of our Universe[edit] A prediction of chaotic inflation is the existence of 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 meters away from us. Universes with different physical constants[edit] Bubble universes â€” every disk represents a bubble universe. Our universe is represented by one of the disks. Universe 1 to Universe 6 represent bubble universes. Five of them have different physical constants than our universe has. In the chaotic inflation theory, which is a variant of the cosmic inflation theory, the multiverse or space as a whole is stretching and will continue doing so forever, [61] 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. Different bubbles may experience different spontaneous symmetry breaking , which results in different properties, such as different physical constants. 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 six-sided die is thrown and that the result of the throw corresponds to a quantum mechanics observable. All six possible ways the die can fall correspond to six different universes. 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. In Level I they live elsewhere in good old three-dimensional space. Abstract mathematics is so general that any Theory Of Everything TOE which 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 that 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. Schmidhuber 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 the undecidability of the halting problem. With an infinite amount of space, every possible event will occur an infinite number of times. However, the speed of light prevents us from being aware of these other identical areas. Inflationary[edit] The inflationary multiverse is composed of various pockets in which inflation fields collapse and form new universes. Brane[edit] The brane multiverse version postulates that our entire universe exists on a membrane brane which floats in a higher dimension or "bulk". In this bulk, there are other membranes with their own universes. These universes can interact with one another, and when they collide, the violence and energy produced is more than enough to give rise to a big bang. The branes float or drift near each other in the bulk, and every few trillion years, attracted by gravity or some other force we do not understand, collide and bang into each other. This repeated contact gives rise to multiple or "cyclic" big bangs. This particular hypothesis falls under the string theory umbrella as it requires extra spatial dimensions. Cyclic[edit] The cyclic multiverse has multiple branes that have collided, causing Big Bangs. The universes bounce back and pass through time until they are pulled back together and again collide, destroying the old contents and creating them anew. Quantum fluctuations drop the shapes to a lower energy level, creating a pocket with a set of laws different from that of the surrounding space. Quantum[edit] The quantum multiverse creates a new universe when a diversion in events occurs, as in the many-worlds interpretation of quantum mechanics. Holographic[edit] The holographic multiverse is derived from the theory that the surface area of a space can simulate the volume of the region.

Chapter 5 : Multiverse - Wikipedia

'The idea of parallel universes in quantum mechanics has been around since ,' said Howard Wiseman, a professor in Physics at Griffith University.

Messenger The existence of parallel universes may seem like something cooked up by science fiction writers, with little relevance to modern theoretical physics. The race is now on to find a way to test the theory, including searching the sky for signs of collisions with other universes. It is important to keep in mind that the multiverse view is not actually a theory, it is rather a consequence of our current understanding of theoretical physics. This distinction is crucial. We have not waved our hands and said: Instead the idea that the universe is perhaps one of infinitely many is derived from current theories like quantum mechanics and string theory. The act of opening the box allows us to follow one of the possible future histories of our cat, including one in which it is both dead and alive. The reason this seems so impossible is simply because our human intuition is not familiar with it. But it is entirely possible according to the strange rules of quantum mechanics. The reason that this can happen is that the space of possibilities in quantum mechanics is huge. Mathematically, a quantum mechanical state is a sum or superposition of all possible states. But how do we interpret this to make any practical sense at all? However, one can just as well choose to accept that all these possibilities are true, and that they exist in different universes of a multiverse. This is notoriously hard because gravitational force is so difficult to describe on small scales like those of atoms and subatomic particles â€" which is the science of quantum mechanics. But string theory, which states that all fundamental particles are made up of one-dimensional strings, can describe all known forces of nature at once: However, for string theory to work mathematically, it requires at least ten physical dimensions. Since we can only observe four dimensions: Perhaps for each point in our large four dimensions, there exists six extra indistinguishable directions? A problem, or some would say, a feature, of string theory is that there are many ways of doing this compactification â€" possibilities is one number usually touted about. Each of these compactifications will result in a universe with different physical laws â€" such as different masses of electrons and different constants of gravity. However there are also vigorous objections to the methodology of compactification, so the issue is not quite settled. But given this, the obvious question is: But fortunately, an idea from our study of early universe cosmology has turned this bug into a feature. The early universe During the very early universe, just after the Big Bang, the universe underwent a period of accelerated expansion called inflation. Inflation was invoked originally to explain why the current observational universe is almost uniform in temperature. However, the theory also predicted a spectrum of temperature fluctuations around this equilibrium which was later confirmed by several spacecraft such as Cosmic Background Explorer , Wilkinson Microwave Anisotropy Probe and the PLANCK spacecraft. While the exact details of the theory are still being hotly debated, inflation is widely accepted by physicists. However, a consequence of this theory is that there must be other parts of the universe that are still accelerating. However, due to the quantum fluctuations of space-time, some parts of the universe never actually reach the end state of inflation. This means that the universe is, at least according to our current understanding, eternally inflating. Some parts can therefore end up becoming other universes, which could become other universes etc. This mechanism generates a infinite number of universes. By combining this scenario with string theory, there is a possibility that each of these universes possesses a different compactification of the extra dimensions and hence has different physical laws. The cosmic microwave background. Scoured for gravitational waves and signs of collisions with other universes. Indeed, they inevitably must collide, leaving possible signatures in the cosmic sky which we can try to search for. The exact details of the signatures depends intimately on the models â€" ranging from cold or hot spots in the cosmic microwave background to anomalous voids in the distribution of galaxies. Nevertheless, since collisions with other universes must occur in a particular direction, a general expectation is that any signatures will break the uniformity of our observable universe. These signatures are actively being pursued by scientists. Some are looking for it directly through imprints in the cosmic microwave background , the afterglow of the Big Bang. However, no such signatures are yet to be seen. Others are looking for indirect support such as gravitational waves, which are ripples in space-time as massive objects pass through. Such waves could directly prove the existence of inflation, which ultimately strengthens the support for the multiverse theory. Whether we will ever be able to prove their existence is hard to predict. But given the massive implications of such a finding it should definitely be worth the search. Read other articles from our cosmology series here.

Chapter 6 : The Case for Parallel Universes - Scientific American

With his Many-Worlds theory, Everett was attempting to answer a rather sticky question related to quantum physics: Why does quantum matter behave erratically?The quantum level is the smallest one science has detected so far.

Jun 6 You probably live in a parallel universe. Movies, popular science articles, philosophical debates, Family Guy episodes. But why do people think multiverses exist in the first place? Electrons are tiny, sub-atomic particles. For our purposes, you can think of an electron as a very, very small sphere. Spheres can spin clockwise or counterclockwise. And electrons can too. Like a baseball, electrons can spin clockwise or counterclockwise. But quantum mechanics says that tiny particles like electrons have a superpower: To imagine how this works, it helps to think about colours: If the world is full of weird objects that are spinning clockwise and counterclockwise at the same time, why have I never in my entire life seen that happen?? And the answer will lead us straight to the multiverse. Imagine you had an electron in a closed box. A minute later, we turn on the detector. The detector now sends its signal to the gun, which goes off a fraction of a second later, at which point our box looks like this: The bullet flies through the air, and a moment later, it reaches our cat, which becomes the sad victim of our experiment: Compared to this, the case where the electron is spinning in the other direction is very straightforward. These two stories â€" one where the cat lives, and one where it dies â€" seem to make perfect sense so far. This time, our electron starts in its simultaneous clockwise and counterclockwise spinning state. Now the million dollar question: Will it click, or not click? According to quantum mechanics, it does both. Next, we wait for the signal to propagate from the detector to the gun. Will the gun go off, or will the bullet stay in the chamber? The answer is the same as for the detector: The gun will be split in two, one version of it having gone off, the other never having fired: By now, you can probably guess what its fate will be: Notice that we now have two fully independent stories to tell about the contents of the box: Neither is more true than the other. They coexist inside the box. Is the electron spinning clockwise or counterclockwise? Has the detector clicked or not? Is the cat alive or dead? He came up with the first real attempt at explaining the zombie cat problem. So there must be something special about me, that forces the cat to choose its state either dead or alive when I look at it. Although this does explain why we never see zombie cats, many people today see it as an unnecessary bit of magic to introduce into our laws of nature. How about the gun or the detector? Some people started throwing around some pretty New Agey terms in response to 1. So how do we get mind magic out of the equation? Also your fly is undone. Instead, he suggested thinking of ourselves as quantum objects, that we could put in a ket, just like the cat, the gun and the detector. Now he looks inside. Just like the cat, the gun, and the detector, he too is split into two distinct copies of himself: Now imagine asking the experimenter â€" both versions of him â€" what the result of the experiment was. Was the cat dead? Did you see the cat alive and dead simultaneously? They both give the obvious answer: For example, the experimenter who sees the dead cat might be so saddened that he ends up quitting his job, and never inventing a key technology that would otherwise have been used by millions of people. And because electrons and other particles are leading parallel lives all around us, our multiverse is constantly splitting, spawning off new timelines or universes with every possible interaction outcome. Follow our publication to see more stories featured by the Journal team.

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Chapter 7 : You probably live in a parallel universe. Hereâ€™s why.

And if the Universes are all the same as one another as far as physical laws go, and if the number of these Universes is truly infinite, and if the many-world interpretation of quantum mechanics.

The second multiverse theory arises from our best ideas about how our own Universe began. According to the predominant view of the Big Bang, the Universe began as an infinitesimally tiny point and then expanded incredibly fast in a super-heated fireball. A fraction of a second after this expansion began, it may have fleetingly accelerated at a truly enormous rate, far faster than the speed of light. This burst is called "inflation". There are many, perhaps infinitely many, universes appearing and growing all the time Inflationary theory explains why the Universe is relatively uniform everywhere we look. Inflation blew up the fireball to a cosmic scale before it had a chance to get too clumpy. However, that primordial state would have been ruffled by tiny chance variations, which also got blown up by inflation. These fluctuations are now preserved in the cosmic microwave background radiation, the faint afterglow of the Big Bang. This radiation pervades the Universe, but it is not perfectly uniform. Several satellite-based telescopes have mapped out these variations in fine detail, and compared them to those predicted by inflationary theory. The match is almost unbelievably good, suggesting that inflation really did happen. View image of Just after the Big Bang Credit: The current view is that the Big Bang happened when a patch of ordinary space, containing no matter but filled with energy, appeared within a different kind of space called the "false vacuum". It then grew like an expanding bubble. Perhaps our Universe is simply one of a crowd But according to this theory, the false vacuum should also experience a kind of inflation, causing it to expand at fantastic speed. Meanwhile, other bubble universes of "true vacuum" can appear within it â€” and not just, like our Universe, This scenario is called "eternal inflation". It suggests there are many, perhaps infinitely many, universes appearing and growing all the time. But we can never reach them, even if we travel at the speed of light forever, because they are receding too fast for us ever to catch up. After Copernicus suggested Earth was just one planet among others, we realized that our Sun is just one star in our galaxy, and that other stars might have planets. Then we discovered that our galaxy is just one among countless more in an expanding Universe. And now perhaps our Universe is simply one of a crowd. View image of Credit: However, if eternal inflation does create a multiverse from an endless series of Big Bangs, it could help to resolve one of the biggest problems in modern physics. The fundamental constants of the laws of physics seem bizarrely fine-tuned to the values needed for life to exist Some physicists have long been searching for a " theory of everything ": But they have found there are more alternatives to choose from than there are fundamental particles in the known universe. Many physicists who delve into these waters believe that an idea called string theory is the best candidate for a "final theory". But the latest version offers a huge number of distinct solutions: Each solution yields its own set of physical laws, and we have no obvious reason to prefer one over any other. The inflationary multiverse relieves us of the need to choose at all. If parallel universes have been popping up in an inflating false vacuum for billions of years, each could have different physical laws, determined by one of these many solutions to string theory. If that is true, it could help us explain a strange property of our own Universe. View image of Bubble universes Credit: Things have to be the way we find them: Similarly, there is a delicate balance between gravity, which pulls matter towards itself, and so-called dark energy, which does the opposite and makes the Universe expand ever faster. This is just what is needed to make stars possible while not collapsing the Universe on itself. In this and several other ways, the Universe seems fine-tuned to host us. This has made some people suspect the hand of God. Yet an inflationary multiverse, in which all conceivable physical laws operate somewhere, offers an alternative explanation. View image of Other universes might be different to ours Credit: In the far more numerous universes that are set up differently, there is no one to ask the question. For many physicists and philosophers, this argument is a cheat: How can we test these assertions, they ask? Surely it is defeatist to accept that there is no reason why the laws of nature are what they are, and simply say that in other universes they are different? The trouble is, unless you have some other explanation for fine-tuning, someone will assert that God must have set things up this way. The astrophysicist Bernard Carr has put it bluntly: View image of

Two branes collide, creating a new universe Credit: In he proposed that universes might reproduce and evolve rather like living things do. On Earth, natural selection favours the emergence of "useful" traits such as fast running or opposable thumbs. In the multiverse, Smolin argues, there might be some pressure that favours universes like ours. He calls this "cosmological natural selection". The mother universe can do this if it contains black holes. View image of A black hole Credit: It is a neat idea, because our Universe then does not have to be the product of pure chance In the s, Stephen Hawking and Roger Penrose pointed out that this collapse is like a mini-Big Bang in reverse. This suggested to Smolin that a black hole could become a Big Bang, spawning an entire new universe within itself. If that is so, then the new universe might have slightly different physical properties from the one that made the black hole. This is like the random genetic mutations that mean baby organisms are different from their parents. If a baby universe has physical laws that permit the formation of atoms, stars and life, it will also inevitably contain black holes. That will mean it can have more baby universes of its own. Over time, universes like this will become more common than those without black holes, which cannot reproduce. View image of Could one universe create others? If a fine-tuned universe arose at random, surrounded by many other universes that were not fine-tuned, cosmic natural selection would mean that fine-tuned universes subsequently became the norm. So far, there is no evidence that this is the case The details of the idea are a little woolly, but Smolin points out that it has one big advantage: For example, if Smolin is right we should expect our Universe to be especially suited to making black holes. This is a rather more demanding criterion than simply saying it should support the existence of atoms. But so far, there is no evidence that this is the case â€” let alone proof that a black hole really can spawn an entirely new universe. View image of Extra dimensions could be curled up Credit: What might be in there? A hidden universe, maybe? Perhaps the fifth dimension was curled up into an unimaginably small distance This was nonsense. Einstein was not proposing a new dimension. What he was saying was that time is a dimension, similar to the three dimensions of space. All four are woven into a single fabric called space-time, which matter distorts to produce gravity. Even so, other physicists were already starting to speculate about genuinely new dimensions in space. The first intimation of hidden dimensions began with the work of the theoretical physicist Theodor Kaluza. But where, then, was this extra dimension? The Swedish physicist Oskar Klein offered an answer in Perhaps the fifth dimension was curled up into an unimaginably small distance: In the modern version of string theory, known as M-theory, there are up to seven hidden dimensions The idea of a dimension being curled may seem strange, but it is actually a familiar phenomenon. A garden hose is a three-dimensional object, but from far enough away it looks like a one-dimensional line, because the other two dimensions are so small. This seeks to explain fundamental particles as the vibrations of even smaller entities called strings. When string theory was developed in the s, it turned out that it could only work if there were extra dimensions. In the modern version of string theory, known as M-theory, there are up to seven hidden dimensions. They can be extended regions called branes short for "membranes" , which may be multi-dimensional. If branes collide, the results could be monumental A brane might be a perfectly adequate hiding place for an entire universe. M-theory postulates a multiverse of branes of various dimensions, coexisting rather like a stack of papers. If this is true, there should be a new class of particles called Kaluza-Klein particles. In theory we could make them, perhaps in a particle accelerator like the Large Hadron Collider. They would have distinctive signatures, because some of their momentum is carried in the hidden dimensions. These brane worlds should remain quite distinct and separate from each other, because forces like gravity do not pass between them. But if branes collide, the results could be monumental. Conceivably, such a collision could have triggered our own Big Bang. It has also been proposed that gravity, uniquely among the fundamental forces, might "leak" between branes. This leakage could explain why gravity is so weak compared to the other fundamental forces. If their idea is true, there is an awful lot of space out there for other universes As Lisa Randall of Harvard University puts it: In effect this means that a brane "concentrates" gravity, so that it looks weak in a second brane nearby. This could also explain why we could live on a brane with infinite extra dimensions without noticing them. If their idea is true, there is an awful lot of space out there for other universes. View image of This cat is both dead and alive Credit:

Chapter 8 : Quantum Computers and Parallel Universes

"The quantum theory of parallel universes is not the problem, it is the solution. It is not some troublesome, optional interpretation emerging from arcane theoretical considerations. It is the explanationâ€"the only one that is tenableâ€"of a remarkable and counter-intuitive reality.".

He went on to assert that what the equation that won him a Nobel prize seems to be describing is several different histories, they are "not alternatives but all really happen simultaneously". This is the earliest known reference to the many-worlds. The many-worlds interpretation shares many similarities with later, other "post-Everett" interpretations of quantum mechanics which also use decoherence to explain the process of measurement or wavefunction collapse. MWI treats the other histories or worlds as real since it regards the universal wavefunction as the "basic physical entity" [20] or "the fundamental entity, obeying at all times a deterministic wave equation". MWI is distinguished by two qualities: Decoherent interpretations of many-worlds using einselection to explain how a small number of classical pointer states can emerge from the enormous Hilbert space of superpositions have been proposed by Wojciech H. Other states decohere into mixtures of stable pointer states that can persist, and, in this sense, exist: Many-worlds is often referred to as a theory , rather than just an interpretation, by those who propose that many-worlds can make testable predictions such as David Deutsch or is falsifiable such as Everett or by those who propose that all the other, non-MW interpretations, are inconsistent, illogical or unscientific in their handling of measurements; Hugh Everett argued that his formulation was a metatheory , since it made statements about other interpretations of quantum theory; that it was the "only completely coherent approach to explaining both the contents of quantum mechanics and the appearance of the world. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. January Learn how and when to remove this template message As with the other interpretations of quantum mechanics, the many-worlds interpretation is motivated by behavior that can be illustrated by the double-slit experiment. When particles of light or anything else are passed through the double slit, a calculation assuming wave-like behavior of light can be used to identify where the particles are likely to be observed. Yet when the particles are observed in this experiment, they appear as particles i. Some versions of the Copenhagen interpretation of quantum mechanics proposed a process of " collapse " in which an indeterminate quantum system would probabilistically collapse down onto, or select, just one determinate outcome to "explain" this phenomenon of observation. Wavefunction collapse was widely regarded as artificial and ad hoc [citation needed], so an alternative interpretation in which the behavior of measurement could be understood from more fundamental physical principles was considered desirable. Everett stated that for a composite system â€" for example a subject the "observer" or measuring apparatus observing an object the "observed" system, such as a particle â€" the statement that either the observer or the observed has a well-defined state is meaningless; in modern parlance, the observer and the observed have become entangled ; we can only specify the state of one relative to the other, i. This led Everett to derive from the unitary, deterministic dynamics alone i. Everett noticed that the unitary, deterministic dynamics alone decreed that after an observation is made each element of the quantum superposition of the combined subjectâ€"object wavefunction contains two "relative states": The subsequent evolution of each pair of relative subjectâ€"object states proceeds with complete indifference as to the presence or absence of the other elements, as if wavefunction collapse has occurred, which has the consequence that later observations are always consistent with the earlier observations. All that one does, really, is to calculate conditional probabilitiesâ€"in other words, the probability of A happening, given B. Some people overlay it with a lot of mysticism about the wave function splitting into different parts. Reality is not a quality you can test with litmus paper. Quantum theory does this very successfully. The second issue with Bohmian mechanics may at first sight appear rather harmless, but which on a closer look develops considerable destructive power: These are the components of the post-measurement state that do not guide any particles because they do not have the actual configuration q in their support. At first sight, the empty branches do not appear problematic but on the contrary very helpful as they enable the theory to explain unique outcomes of measurements. On a closer view, though, one must admit that these empty branches do not actually disappear. Now, if the Everettian theory may be accused of ontological extravagance, then Bohmian mechanics could be accused of ontological wastefulness. On top of the ontology of empty branches comes the additional ontology of particle positions that are, on account of the quantum equilibrium hypothesis, forever unknown to the observer. Yet, the actual configuration is never needed for the calculation of the statistical predictions in experimental reality, for these can be obtained by mere wavefunction algebra. From this perspective, Bohmian mechanics may appear as a wasteful and redundant theory. I think it is considerations like these that are the biggest obstacle in the way of a general acceptance of Bohmian mechanics. There is no consensus on whether this has been successful. Everett stopped doing research in theoretical physics shortly after obtaining his Ph. Decision theory[edit] A decision-theoretic derivation of the Born rule from Everettarian assumptions, was produced by David Deutsch [40] and refined by Wallace â€” [41] [42] [43] [44] and Saunders He has proved that the Born rule and the collapse of the wave function follow from a game-theoretical strategy, namely the Nash equilibrium within a von Neumann zero-sum game between nature and observer. Carroll , building on work by Lev Vaidman , [55] proposed a similar approach based on self-locating uncertainty. This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Measurement is regarded as causing M and S to interact. After S interacts with M, it is no longer possible to describe either system by an independent state. According to Everett, the only meaningful descriptions of each system are relative states: Schematic illustration of splitting as a result of a repeated measurement. For example, consider the smallest possible truly quantum system S, as shown in the illustration. This describes for instance, the spin-state of an electron. Considering a specific axis say the z-axis the north pole represents spin "up" and the south pole, spin "down". The superposition states of the system are described by the surface of a sphere called the Bloch sphere. To perform a measurement on S, it is made to interact with another similar system M. After the interaction, the combined system is described by a state that ranges over a six-dimensional space the reason for the number six is explained in the article on the Bloch sphere. This six-dimensional object can also be regarded as a quantum superposition of two "alternative histories" of the original system S, one in which "up" was observed and the other in which "down" was observed. Each subsequent binary measurement that is interaction with a system M causes a similar split in the history tree. The accepted terminology is somewhat misleading because it is incorrect to regard the universe as splitting at certain times; at any given instant there is one state in one universe. January Learn how and when to remove this template message In his doctoral dissertation, Everett proposed that rather than modeling an isolated quantum system subject to external observation, one could mathematically model an object as well as its observers as purely physical systems within the mathematical framework developed by Paul Dirac , von Neumann and others, discarding altogether the ad hoc mechanism of wave function collapse. One such is the relative state formulation. It makes two assumptions: Secondly, observation or measurement has no special laws or mechanics, unlike in the Copenhagen interpretation which considers the wavefunction collapse as a special kind of event which occurs as a result of observation. Instead, measurement in the relative state formulation is the consequence of a configuration change in the memory of an observer described by the same basic wave physics as the object being modeled. These splits generate a possible tree as shown in the graphic below. Subsequently, DeWitt introduced the term "world" to describe a complete measurement history of an observer, which corresponds roughly to a single branch of that tree. Note that "splitting" in this sense is hardly new or even quantum mechanical. The idea of a space of complete alternative histories had already been used in the theory of probability since the mids for instance to model Brownian motion. Partial trace as relative state. Light blue rectangle on upper left denotes system in pure state. Trellis shaded rectangle in upper right denotes a possibly mixed state. Mixed state from observation is partial trace of a linear superposition of states as shown in lower right-hand corner. An observation or measurement is modeled by applying the wave equation to the entire system comprising the observer and the object. Since many observation-like events have happened and are constantly happening, there are an enormous and growing number of simultaneously existing states. Each product of subsystem states in the overall superposition evolves over time independently of other products. Once the subsystems interact, their states have become correlated or entangled and it is no longer possible to consider them independent of one another. Properties of the theory[edit] MWI removes the observer-dependent role in the quantum measurement process by replacing wavefunction collapse with quantum decoherence. Quantum cosmology also becomes intelligible, since there is no need anymore for an observer outside of the universe. MWI achieves this by removing wavefunction collapse , which is indeterministic and non-local, from the deterministic and local equations of quantum theory. Comparative properties and possible experimental tests[edit] One of the salient properties of the many-worlds interpretation is that it does not require an exceptional method of wave function collapse to explain it. In most no-collapse interpretations, the evolution of the quantum state of the Universe is the same. Still, one might imagine that there is an experiment distinguishing the MWI from another no-collapse interpretation based on the difference in the correspondence between the formalism and the experience the results of experiments. Since then Lockwood , Vaidman and others have made similar proposals. Many other controversial ideas have been put forward though, such as a recent claim that cosmological observations could test the theory, [63] and another claim by Rainer Plaga , published in Foundations of Physics , that communication might be possible between worlds. January Learn how and when to remove this template message In the Copenhagen interpretation , the mathematics of quantum mechanics allows one to predict probabilities for the occurrence of various events. When an event occurs, it becomes part of the definite reality, and alternative possibilities do not. There is no necessity to say anything definite about what is not observed. The universe decaying to a new vacuum state[edit] Any event that changes the number of observers in the universe may have experimental consequences. This has not happened and is cited as evidence in favor of many-worlds. In some worlds, quantum tunnelling to a true vacuum state has happened but most other worlds escape this tunneling and remain viable. This can be thought of as a variation on quantum suicide. This objection is saying that it is not clear what is precisely meant by branching, and point to the lack of self-contained criteria specifying branching. In Dirac notation a measurement is complete when:

Chapter 9 : BBC - Earth - Why there might be many more universes besides our own

The quantum multiverse creates a new universe when a diversion in events occurs, as in the many-worlds interpretation of quantum mechanics. Holographic [edit] The holographic multiverse is derived from the theory that the surface area of a space can simulate the volume of the region.

For example, a particle can be in a superposition where it exists in both New York and Los Angeles at the same instant. The exact city in which the particle exists prior to being observed is thus literally unknowable. Now consider two particles which are both in superpositions of being either horizontally or vertically polarized. At first glance, this seemed remarkable. At second glance, it just seemed like conservation of momentum. For example, suppose the two particles are formed by the decay of another particle that initially had zero angular momentum. As a result, the polarizations must be equal and opposite- for a fairly mundane reason. Then the second particle instantly collapses onto vertical, which occurs even if both particles are separated by a great distance. Quantum mechanics correctly predicted the outcome of these experiments â€” carried out mainly in the early s- up to high sigma values. In other words, the experiments convincingly proved Einstein wrong. The problem with using these correlations for FTL communication is that each measurement just gives you a random horizontal or vertical outcome. This would allow for the transmission of binary data or Morse code. Unfortunately, decades of testing have shown that any nonlinearities in the Schrodinger or Dirac equations underlying quantum mechanics are very, very small. Let me put it this way: If I understand correctly, you are saying that pairs of these particles are created in such a way that these qualities whatever they are must be in a contradictory relationship. So if you measure the whatever of one particle, you know that the other particle has the opposite whatever quality. But why is that mysterious, or spooky? When I press the trigger, it emits two particles in opposite directions. The particle maker is constructed in such a way that each time I shoot off a particle pair, one of the particles must be blue, and the other white. However, the colors are assigned randomly so that I can never predict whether the particle shot off to the left will be blue or whiteâ€”I just know that the particle shot off to the right is of the opposite color. Joe is standing a mile to my left, and Bill is a mile to my right. Due to the nature of my particle maker, I know that if Joe receives a blue particle, Bill has just got beaned by a white one, and vice versa. So what did I miss? Written by Dumb Scientist on June 04 , But it becomes even more bizarre when you create two entangled photons- two photons that are each in their own superpositions, but created such that if one photon is horizontal, the other is vertical. The problem is that in the s, Aspect et. Seem a little more spooky now? Written by DrVomact on June 05 , I should lay my cards on the table. However, there are also some obviously very intelligent and serious people who talk about this stuff, who devote their lives to studying it, and yet utter what appear to be completely crazy propositions, propositions that should clearly be dismissed out of hand as nonsense. I must admit to a major handicap that colors my understanding or lack of it of this subject: But numbers and funny squiggles have never meant anything to me. If it did, they could show it to me, and explain it in real words and not mathematical squiggles. For a couple of hundred years, physicists have vacillated between describing lightâ€”and then matterâ€—alternatively in terms of either waves or particles. Mathematical modelsâ€—and observed resultsâ€—seemed to support both hypotheses in turn. We derive the notion of a wave from watching ripples in a pond. Then we find that we can apply this mental model of a wave to both sound and light. Especially since we gave up on the aether. Where am I going with all this? Yes, I realize that both could be true. Goodnight Written by Dumb Scientist on June 05 , I agree, as do most physicists. In fact, that very incredulity has caused physicists to test quantum mechanics to a greater degree of precision than any other theory I can think of off the top of my head. It took me a long time to believe in black holes even after most physicists thought they were conclusively proven to exist so we agree on this principle. They both start with a small collection of axioms and use deductive and occasionally inductive logic to arrive at a conclusion. Have you ever tried to learn symbolic logic? Interestingly, wave function collapse is not an internally consistent description of reality. In one universe, the observer sees the collapse result in a horizontal state, while the other universe sees a vertical state. It involves fewer axioms, has no internal mathematical inconsistencies such as those created by the notion of wave function collapse, and results in the same physical predictions. The only caveat is that it predicts a nearly infinite number of parallel universes, leading some physicists to say that the many worlds interpretation is cheap in terms of axioms, but expensive in terms of universes. A horizontally polarized photon will definitely produce a click, and a vertically polarized photon will definitely produce a beep. In this case, horizontally polarized photons would randomly click or beep. The photon is always detected if the relative angle is 0. No more so than time dilation and relativity of simultaneity are proof that we should re-examine the assumptions that went into special relativity. Quantum superpositions are weird, sure, but what would you expect? Our intuition is based on instincts inherited through countless generations of creatures who interacted with the world on a length scale from 0. Unfortunately, most of this work was done before I was born. From what I can tell, most 20th century scientists simply refused to believe in this nonsense, so they kept designing experiments to disprove it. Quantum mechanics kept stubbornly being right. After over 80 years of testing the basic theory, I think we have to accept that quantum mechanics reflects the way the universe works, at least until someone can come up with a better experiment. We actually have thrown away the notions of particles and waves. Think of it this way: Very slow or very light quantum states have properties that look like waves. In between, they exhibit properties of both. But these extremes particle and wave do not define the situation very well; they are simply extreme limits. But that seems trivial to meâ€"of course something really tiny is going to be affected in some way if you do something to measure it. That has got to be wrong, because nobody but a philosopher could possibly say anything so completely silly. Like David Hume for example, who thought that the world might possibly go away when he closes his eyes, or Berkeley, who averred that the universe only exists because God pays attention to it. Written by Dumb Scientist on June 05 , My personal answer is that there is no such thing as collapse. I say this because: Quantum collapse is introduced in the standard interpretation as an arbitrary axiom. Because quantum collapse is introduced as an axiom, it is not justified in any specific physical manner. It is a purely mechanical process, not a mystical one. It has nothing to do with knowledge. In fact, it emerges as an obvious consequence of letting an individual particle interact with an object composed of a very large number of particles. Quantum collapses are a fundamentally non-unitary process, as opposed to every other process in quantum mechanics. It implies that a nearly infinite number of parallel universes exist, each representing the state of the universe if a particle had gone this way or that way, collapsed onto horizontal or vertical, etc. Because we humans are made up of particles, that means that there is a different universe for every possible event in history. There is a universe where the Nazis won WW2, where dinosaurs never became extinct, where Paris Hilton is a college professor, etc. But this weirdness is, in my mind, more than offset by the elegant way that it simplifies quantum theory. Not all physicists agree with me, but the many worlds interpretation is not a fringe view by any stretch of the imagination, and it seems to be growing more accepted with each yearâ€¦ Written by DrVomact on June 07 , However, as a fugitive philosopher, I must remain unsmilingly skeptical. I truly cannot think of a more complex hypothesis! I meanâ€¦all those universes! I am pleased to learn that there are no epistemic requirements for MW. Do I understand this correctly? If so, that is an improvement. It seems that one sort of strangeness just appeals to you more than the other. Do you like science fiction, too? Written by Dumb Scientist on June 12 , Unfortunately, as I continue to learn about physics, I find myself less able to suspend disbelief than in years past. As a result, I usually prefer shows that either skip the technobabble completely such as Firefly and Battlestar Galactica or manage to get their facts straight occasionally. MW is extravagent, but only in the sense that it implies the universe is larger and stranger than we thought it was before. So most physicists have stopped trying to apply common sense to physics theories. The only criteria I use are: Does the theory match experiment? Is the theory mathematically consistent? Does the theory have fewer axioms than its nearest competitors?