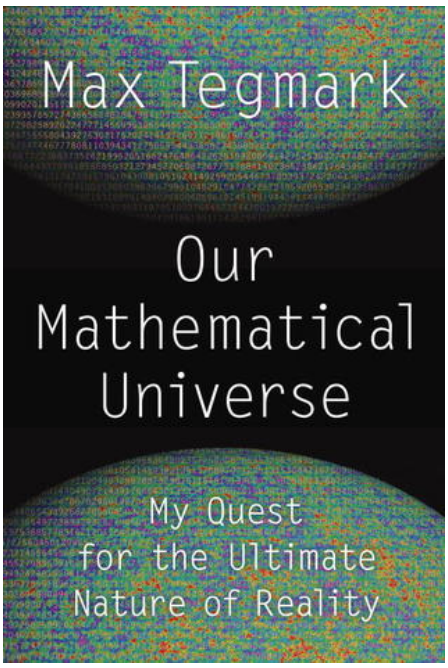

Our Mathematical Universe: My Quest for the Ultimate Nature of Reality

Max Tegmark

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Max Tegmark leads us on an astonishing journey through past, present and future, and through the physics, astronomy and mathematics that are the foundation of his work, most particularly his hypothesis that our physical reality is a mathematical structure and his theory of the ultimate multiverse. In a dazzling combination of both popular and groundbreaking science, he not only helps us grasp his often mind-boggling theories, but he also shares with us some of the often surprising triumphs and disappointments that have shaped his life as a scientist. Fascinating from first to last—this is a book that has already prompted the attention and admiration of some of the most prominent scientists and mathematicians.

Our Mathematical Universe: My Quest for the Ultimate Nature of Reality Details

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From Reader Review Our Mathematical Universe: My Quest for the Ultimate Nature of Reality for online ebook

Peter Mcloughlin says

This book starts with solid science on the advancements of cosmology in the early part with a solid scientific description of the Big Bang model and gets more speculative afterwards. If you don't like to indulge in theoretical and philosophical speculation the latter part of the book might not be for you. If you are like me and relish in some deep speculation about the nature of the cosmos even if the data hasn't backed it yet then read this book it is great at that.
Tegmark explains in a relatively breezy way the latest in current cosmology which has gone from theoretical speculation to a precise science. Of course once the frontier is mapped out if you press on a little further you come to a new and stranger frontier. That is what Tegmark does. He relates the big bang model and inflationary models of the universe which were at one time not so long ago speculations but now enjoy a solid backing by the data of the last twenty years and pushes out to new speculative ideas of Multiverses. Tegmark a few years proposed not only an infinite number of parallel universes (multiverse) but came up four levels or (flavors) of multiverses. Level I infinite universe in spatial extent, Level II eternal bubbling universes forming from inflation theory, Level III an interpretation of Quantum mechanics (many world or Everettian interpretation) where every moment countless universes are dividing off this universe to a nearly infinite number of Branches (BTW mathematically if level I universe is accurate it's equivalent for all practical purposes to many worlds.) Finally the level IV multiverse in which our universe is ultimately a mathematical structure complex enough to house sentient creatures one structure among the multiverse of all possible mathematical structures. In essence we live in a small section of Plato's world of the forms.
This is all heady stuff and Tegmark delivers it in an easy to digest manner. This is the kind of book I really go for. I wish I could give it six stars.

Third or fourth reading 6/14/15 This and Jim Holt's "Why does the world exist?" are books which captivate me. When I was younger it was Vonnegut then Camus, Then Bertrand Russell and Douglas Hofstadter and Dan Dennett nowadays its these two books.

Here is a youtube link to Max Tegmark talking about his book at Google Talks.

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

Sandra says

[we are told why it is *not* (hide spoiler)]

Max says

The title makes one feel this will be a daunting read and at times it is, but Tegmark starts out in a clear concise fashion reviewing current cosmological concepts. He provides detail on mapping the cosmic microwave-background radiation including his own considerable involvement. He describes how it mirrors our present day universe which maintains the background radiation’s uniform temperatures and densities.

This leads to Alan Guth's theory of inflation which explains the uniformity, flatness and the enormous size of the universe.

Tegmark accepts inflation as entirely consistent with everything we know but he admits to having some qualms. If gravity waves were proven, he would be completely convinced. Still he is comfortable using inflation to build his model. From here on Tegmark begins departing from what he considers widely accepted ideas. He sees inflation coming before the big bang not after as it is usually presented. Thus the universe did not start out as some super dense super-hot entity. The heat was caused by inflation. The big bang occurred when inflation stopped.

Tegmark believes inflation is always occurring in some region of space, a controversial idea called eternal inflation. This creates an infinite but still expanding universe contained in a finite volume. Those areas outside of our observable universe Tegmark calls Level I parallel universes. There are an infinite number of these parallel universes, some still inflating. The nomenclature here is what is unusual. Many physicists believe the universe is infinite, but dividing the portions we can't see into Level I parallel universes allows Tegmark to build his model. Level I parallel universes share our laws of physics and physical constants.

Tegmark next posits the Level II multiverse, his term for a concept popular with string theorists. These are other finite volumes containing their own infinite parallel universes with their own laws of physics, physical constants and particle relationships. The Level II multiverse addresses the anthropic principle which holds that our universe seems to be fine-tuned to support life. With infinite universes just as with infinite planets one is bound to be just right for us.

Next Tegmark explores the quantum world. Everything is made of particles (quarks, electrons, etc.) but all we know about them are the mathematical values of their attributes (charge, spin, etc.). These values arrayed in space are described by quantum field theory. Tegmark believes that there is an underlying layer of reality that we perceive as particles; perhaps strings, quantum loops or something not yet thought of. Coincidentally while reading this my January 2017 issue of Scientific American arrived with an article about a group of physicists working on quantum gravity who are collaborating with scientists involved in quantum computer development. They have formed a program called "It from Qubit" to look for an underlying structure of information bits held together by entanglement that would generate space and time as its emergent property.

Tegmark's take on quantum mechanics eschews the Copenhagen interpretation. He is smitten with Schrodinger's equation, but does not believe the wave function ever collapses which leads to the many-worlds theory of Hugh Everett III. This theory holds that all outcomes are real not just those that are observed. Thus reality splits. Tegmark calls these separate realities Level III parallel universes. He points to small surveys that show more physicists now believe in the many-worlds theory than in the formerly popular Copenhagen interpretation, although many don't ascribe to either theory. Tegmark describes his discussions with the famous theoretical physicist John Wheeler who died at 96 in 2008. Wheeler who coined the term black hole postulated the one electron universe that inspired his student Richard Feynman even if Feynman did not completely accept the idea. Hugh Everett and Richard Feynman had been Wheeler's doctoral students at Princeton. The many-worlds theory was Hugh Everett's doctoral thesis which Wheeler championed.

From this point on, Tegmark leaves traditional thinking completely behind. He posits the Level IV multiverse which is comprised of mathematical structures. These are Tegmark's ultimate reality. Each structure generates a different universe. The mathematical structures could be anything, say a cube where the corners are connected to each other. A structure that would yield our universe would be much more complicated. Tegmark's mathematical reality is a relational reality. "… the properties of the world around us

stem not from the properties of its ultimate building blocks, but from the relations between these building blocks". He offers an analogy to the brain in which it is the connections between neurons that form ideas not the properties of the individual neurons. It is the relationship between the neurons that yield consciousness just as the relationships in the mathematical structure yield the universe we perceive.

Tegmark points to symmetries as an important way mathematical structures produce the physical properties we perceive. Tegmark references German mathematician Emmy Noether who proved that continuous symmetries of mathematical structures produce conservation laws of physics yielding the physical constants. For example energy corresponds to time translation symmetry, momentum to space-translation symmetry, angular momentum to rotation symmetry, electric charge to a particular symmetry of quantum mechanics. Nobel Prize winner Eugene Wigner showed these symmetries dictated all the quantum properties of particles such as spin and mass.

The Level IV multiverse would not just have different physical constants like Level II but different equations. This answers John Wheeler who wondered, "Why these particular equations, why not others." Or as Eugene Wigner put it "The enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious…there is no rational explanation for it." Or as Stephen Hawking asked, "What is it that breathes fire into the equations and makes a universe for them to describe?" Tegmark answers with the Level IV multiverse.

So what can we make of all this? I have no idea how valid Tegmark's thesis is, but I thoroughly enjoyed his presentation in which I learned about new concepts and lines of thought. In the 1930's John Wheeler studied under Niels Bohr and worked alongside Einstein, two men who led revolutionary thinking in physics 100 years ago. Wheeler encouraged Tegmark writing him, "...behind quantum mechanics lies some deep and wonderful principle to be discovered…The likelihood of such a discovery is surely proportional to our belief that there is something there to be discovered." Before we dismiss Tegmark's wild abandon in his search for a mathematical universe, we should keep in mind that the ideas of John Wheeler, his famous students Richard Feynman and Hugh Everett, his mentor Niels Bohr and associate Albert Einstein were all considered silly at one point.

The Serendipity Aegis ~ ?Misericordia? ?????? ✺✲❤❣ says

An unexpectedly deep perusal of the mathematial nature of this baffling world we find ourselces in. Well-written and rich in ideas to ponder on.
Q:
... to me, an electron colliding with a positron and turning into a Z-boson feels about as intuitive as two colliding cars turning into a cruise ship. On microscopic scales, particles schizophrenically appear in two places at once, leading to the quantum conundrums mentioned above. On astronomically large scales —surprise!—weirdness strikes again: **if you intuitively understand all aspects of black holes, I think you're in a minority of one, and should immediately put down this book and publish your findings before someone scoops you on the Nobel Prize for quantum gravity.**(c)
Q:
we'll explore the fascinating relations between computation, mathematics, physics and mind, and explore a crazysounding belief of mine that **our physical world not only is described by mathematics, but that it is mathematics**, making us self-aware parts of a giant mathematical object. We'll see that this leads to a new and ultimate collection of parallel universes so vast and exotic that all the above-mentioned bizarreness pales

in comparison, forcing us to relinquish many of our most deeply ingrained notions of reality (?)
Q:
I wanted to do my small part to make our planet a better place, and felt that the main problem wasn't that we lacked technical solutions, but that we didn't properly use the technology we had. I figured that the best way to affect people's behavior was through their wallets, and was intrigued by the idea of creating economic incentives that aligned individual egoism with the common good. Alas, I soon grew disillusioned, concluding that **economics was largely a form of intellectual prostitution** where you got rewarded for saying what the powers that be wanted to hear. Whatever a politician wanted to do, he or she could find an economist as advisor who had argued for doing precisely that. Franklin D. Roosevelt wanted to increase government spending, so he listened to John Maynard Keynes, whereas Ronald Reagan wanted to decrease government spending, so he listened to Milton Friedman.(c)
Q:
Although the book wasn't really about physics, dwelling more on topics such as how to pick locks and how to pick up women, I could read between the lines that this guy just loved physics. Which really intrigued me. (c)
Q:
physics is the ultimate intellectual adventure, the quest to understand the deepest mysteries of our Universe... Physics doesn't take something fascinating and make it boring. Rather, it helps us see more clearly, adding to the beauty and wonder of the world around us. When I bike to work in the fall, I see beauty in the trees tinged with red, orange and gold. But seeing these trees through the lens of physics reveals even more beauty, captured by the Feynman quote that opens this chapter. And the deeper I look, the more elegance I glimpse: ... **the trees ultimately come from stars, and ... studying their building blocks suggests their existence in parallel universes.**(c)
Q:
I love questions. Especially big ones. I feel so fortunate to be able to spend much of my time tackling interesting questions. That I can call this activity work and make a living from it is just luck beyond my wildest expectations.(c)
Q:
There's no better guarantee of failure than convincing yourself that success is impossible,
and therefore never even trying. (?)
Q:

Read as ???? ???????. ???? ?????????????? ?????????. ? ??????? ?????????????? ??????? ??????????.

Richard Palmer says

I really wanted to like this book.

The promise of tying together concepts of modern physics with mathematics and a philosophy of what life and the universe are all about kept me going.

I did appreciate the enthusiasm and energy that Tegmark has for his field. Unfortunately, this came through a bit too often as being full of himself.

When it got to layman's term explanations of quantum physics and relativity, the wording was either too brief or too obscure. I recognized that a lot has been accomplished since I was first reading about these topics twenty five years ago.

In the later chapters, when Tegmark pushes the boundaries of what I think is experimentally provable, when he argues that all reality is just math, I think he has gone a little too far.

I found myself skimming through rather than diving in for more understanding. Perhaps you may like it. I found it in the end rather empty.

Emma Sea says

I have three things I'd like to say about this book.

1) I accidentally left it behind at a cafe. When I went back it was gone :(
Imagine my surprise when I discovered some nice person had found the book and returned it to the library for me. Thank you, kind human!

2) Tegmark writes fantastically. Wisely, he doesn't try to make the reader *cough me cough* follow his maths, but instead offers URLs for papers offering the mathematical proofs for the concepts he discusses as additional reading, for those so inclined. Tegmark walks us through the information gradually, and interspersing the heavy concepts with light personal anecdotes. His analogies are so clear and this makes the book gripping, understandable, and illuminating.

3) Tegmark's writing is in fact *so* clear that I had a moment of the most exquisite understanding while reading it. I was lying in bed, and I started crying, because for a split second I had an clear conceptualization of the beauty of the mathematical universe, and it was vast and overwhelming and fucking gorgeous. I was weeping with a sublime bliss. It was a very special moment. I doubt I'll ever have another like it, and I'm ok with that. I feel privileged to have had that glimpse.

Recommended.

Manuel Antão says

If you're into stuff like this, you can read the full review.

The Stages of Truth: "Our Mathematical Universe - My Quest for the Ultimate Nature of Reality" by Max Tegmark

Forget about Tegmark’s 4 levels. The stages of truth I can remember are:

• Old Greeks saying "We only see a faint reflection of reality", i.e. we have observation, and that's flawed.
• Old Chinese saying "All we have is observation. Reality is observation, and observation is a function of the human form" which is a most interesting thing. They state that sense is inherently limited by our being. Excellent.
• Descartes saying "to know stuff, you must have doubt. Knowledge is developed by doubt" which means testing: the scientific method. Which he didn't invent, but put on a logical footing. And also founding it all on "I think, therefore I exist".

• Karl Popper saying that the essential property of what's knowable is what can be tested, questioned. This continues from Descartes and quite a few more in between including Kant obviously who's really cool but illegible.

Gendou says

The thesis of this book is nothing but a giant exercise in circular reasoning.

Max Tegmark calls his idea the Mathematical Universe Hypothesis, that the external physical reality described by the Theory of Everything is a mathematical structure. He starts off by, I kid you not, assuming that the external physical reality is a mathematical structure.

This radical idea, that reality is "made of math" is embodied in the title of the book, but nowhere within the pages is there any logical argument in for the idea. It's merely assumed.

This assumption is necessary to apply the rule of isomorphism to the external physical reality and the Theory of Everything, an undertaking which is supposed to provide support for the Mathematical Universe Hypothesis. But you can't start out assuming the thing you're trying to prove!

Mad Max, as he's known in the physics community, has the gall to let this glaring logical error stand uncorrected. On his Facebook page, I asked him about this circular reasoning, and he dodged the question but admitted the starting assumption.

It's infuriating that someone can publish a book claiming the universe is "made of math" and have no argument inside the book to support this outrageous claim. This isn't speculative. It's unscientific.

Aside from his own pet theory, he presents an out-of-date picture of the Everett's Many Worlds interpretation as thought it were a unique theory from other interpretations of quantum mechanics. This is wrong.

There's also a whole chapter full of bogus Anthropic arguments, like quantum suicide, etc. Max has got to be the sloppiest thinker who's eyes I've ever had the displeasure of being forced to see the world through.

The first half of the book does contain some half-way decent introduction to cosmology, but you're better off reading a real author like Stephen Hawking or even Brian Greene.

See also http://thephysicspolice.blogspot.com/...

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ka?yap says

The first half of the book is a basic overview of modern physics and i moved through it quickly. He explores the current multiverse scenario in here. He classifies the multiverse into four categories. Level I multiverse consists of all the objects that lie beyond our cosmological horizon. Level II multiverse apparently consists of infinite number of Level I multiverses produced by inflation with different physical constants. Level III multiverse comes from the Everett interpretation of quantum mechanics. Everett interpretation actually makes some intuitive sense to me.

The second metaphysical part of the book where he presents his thesis is what i was looking forward to. His thesis seems to be that "our universe is a mathematical structure". He isn't just suggesting that our universe is described by mathematics but that it is mathematics, including us. There is nothing out there but mathematical relations, time is an illusion and nothing in the universe actually changes. This is where Level IV multiverse comes. All the structures that exist mathematically exist in the fourth level multiverse. All the structures that exist mathematically have the same ontological status.I found Tegmark's monism, an all-encompassing mathematical multiverse to be very appealing.

He comes to his idea of mathematical universe by reducing an empirical physical model of universe to mathematics. So for example, from what i understand, there are no objects such as quarks and leptons, but there are groups and the properties of quarks are described by the group. From this and considering the explanatory power of mathematics, a mathematical universe does make some intuitive sense. Perhaps the reason why mathematics is so successful in explaining our universe is because they are one and the same. I'm not sure that he made a convincing argument if everything can be reduced to mathematics ontologically. What about an emergent property like consciousness? His suggestion of mathematical self-aware structures didn't tell me much and his conjecture that Consciousness is a state of matter didn't make much sense to me. I never really understood what he means when he talks about subjective randomness and subjective immortality either. To whom is it subjective?

A lot of criticism for this book, as it seems to me, is that his theory is not "scientific". While i agree with this, it doesn't bother me. While there is nothing new or radical about Tegmark's mathematical monism, I was actually hoping that this book would be more mathematically and philosophically enlightening. But unfortunately there isn't much discussion about mathematical structures in here and this isn't a very good metaphysical treatise either. But if you are interested in an overview of modern physics, this is a very lucid and clear account.

Manny says

"*Aaargh! No! Make it stop!*"

That's my girlfriend, who's just been unwise enough to let me read her a paragraph of this book. But our guest K, a local nuclear physicist, is more tolerant. "Well," she smiles, "it doesn't sound so bad. A bit exciting, a bit populistic..." Blah blah blah. On the other hand, she isn't a native speaker of English.

Okay, let's start by getting the bad news out of the way. Max Tegmark's chatty, informal, slightly manic style is on the irritating side, and if you know some physics it may also give you the impression that you're not going to learn anything from *Our Mathematical Universe*. Unless you're working at the cutting edge of the subject, that impression is almost certainly false. When I briefly explained the content to K, I soon found that it wasn't just a question of a few interesting details that she hadn't previously come across. Isolated like most working scientists in her own specialty, the dating of rocks using radioactive isotopes, she hadn't even heard that a major paradigm shift was under way in the theoretical basis of her field. I hope I managed to convince her that the book was well worth looking at.

Yes, the style is annoying at first, but after a couple of chapters I stopped noticing it. I was in the bar, I'd had a few beers, and my new buddy Max ("Mad Max", he'd said, with an ironic smile) was telling me about his research, life in the charmed inner circle of theoretical physics, and his ideas about the ultimate nature of

reality. Every now and then, I managed to get a word in edgeways and complain about some of the more outrageous claims. Max had evidently heard it all before, and deftly batted back my objections. I wasn't exactly convinced, but he made it sound a whole lot more plausible than I'd expected.

Max's central idea is the Multiverse, where he has been one of a small number of people who's played an evangelical role. More or less considered as science-fiction fifteen years ago, it's now almost respectable; it's astonishing how quickly the change has happened. Max has a cunning scheme in which the Multiverse is presented in four increasingly bolder versions, from Level I to Level IV. I'd seen a fair amount of his material already, particularly in Brian Greene's *The Hidden Reality*, but Max's presentation is much better. He's worked directly on several of the key ideas, and his hands-on experience makes the stories considerably more believable. He starts off with Level I, which at first sounds innocuous.

What is there in the universe? he asks. A naive answer might be that it's everything we can see through our telescopes. But even a moment's thought will prompt some revision. Sometimes there are things in the way - clouds of dust and gas along the galactic plane, for example. Surely there's something behind those clouds. Well then, the universe consists of all the things we can see, plus all the similar things we can infer must also be there.

But what are those other things? Objects getting in the way is just one problem. There are also things that are very distant - so distant that light from them hasn't had time to reach us yet. How far away could these other objects be? That's a complicated question which has to do with the structure of space. Max has done a lot of work with the Cosmic Background Radiation, the light from the Big Bang, to see what it can tell us about that structure. It was fascinating to see him quickly sketching graphs on paper napkins, explaining how he'd analyzed the data and what the results told us. One key finding, as I'd heard before, is that space turns out to be flat. That means it goes on forever, so there are infinitely many more galaxies over the horizon of visibility. In that infinite expanse, every possible history has played out, including histories arbitrarily close to our own. It's sort of Nietzsche's Eternal Recurrence, but in space instead of time. At some unfathomable distance (he makes a rough estimate), there are doppelgangers of Max and me, sitting in the same bar and having the same conversation. An extremely weird conclusion... but, oddly enough, it seems to follow from entirely reasonable premises.

And this is only Level I. So *why* is the universe flat? asks Max rhetorically. Inflation? I say, as I order another round. I've seen many explanations of inflation, but it's hard to decide how seriously I should take them. Max knows all the ins and out, and argues both sides of the case. He collects some beer mats and arranges peanuts on them to demonstrate a simple argument, due to his buddy Alexander Vilenkin, that shows why inflation has to be "eternal". If it happened at all, it more or less had to generate an infinite number of Level I multiverses, all with different physical laws; that's Level II. But did it happen? I ask. What's the evidence? Max scribbles down more pictures of the power spectrum from the CBR, and explains how they fit the inflation scenario while ruling out a bunch of other theories. He really has that talent for showing you what the mathematics means in intuitive terms. I have to admit it: the case looks better than I'd realized.

Level III is the quantum multiverse: everything that can happen, does happen. I've read several books about this and am more or less convinced already, but Max's version of it is very nice. He describes how he invented the quantum suicide thought experiment and tells me about some clever details that I should have thought of but hadn't. It's even weirder than I'd realized. And now, we need to proceed to Level IV before closing time. But surely we should get some more beer first? I mumble something about how I've maybe had enough, but Max isn't taking no for an answer. *Du sa nåt om att du bott in Sverige?* he says, and before I know what's happened there's a bottle of akvavit on the table between us. He pours out a couple of generous

glasses.

Level IV, it turns out, makes all the others look modest in comparison. Think about the fundamental particles, urges Max. We can see that they are entirely specified by their mathematical properties. So what's the simplest explanation? Reality just *is* mathematical structure. Every mathematical structure specifies a reality! But what breathes fire into the equations? I ask. Nothing does! says Max. *Skål!* I empty my glass, which is magically full again a moment later. The room seems to be revolving slowly. It's... uh... interesting, I say. But surely there's no way to investigate the idea empirically? Maybe! replies Max, and sketches out yet another graph, this time showing constraints on the Higgs VEV. His explanation is fiendishly clever, unless that's just the effect of the akvavit.

But surely there are problems with all this? I say weakly, ashamed that I can't immediately come up with half a dozen objections. Max suddenly looks thoughtful and almost sober. The measure problem is very serious, he says. It's a crisis in physics. He and his identical twin, who's just appeared next to him, proceed to explain it. I nod every now and then and try to put my hand over my glass, but he's too quick for me.

The next morning, I have no memory at all of how I got back to my hotel room, though I dimly recall Max saying something about the dangers of nuclear war, meteorites and evil AI entities. Or was that a dream? I do at any rate have a pile of paper napkins, covered in illegible scrawls and smelling strongly of akvavit.

Read this book. It's fun.

Khalil says

All bad books are alike , each good book is good in its way\s (I think Tolstoy will forgive me for stealing his most famous quote.As the rating indicates, we are in the second state, good book, or rather a fucking unbelievable amazing good and fresh book.

Max Tegmark is(as I see him) the Pythagorean of our era.Pythagoras and his students were interested in the mysticism of numbers, realizing that when odd numbers starting from one are added together, the sum is always a square number. From here, they got the idea that everything in the world can be measured and described by numbers, and that "all is number" In this book Tegmark using theoretical physics, he wanted to show us something similar, but in scientific way not mystic, in a journey from the vast infinite space to the tiniest particle inside our brains (which are part of the journey)

This book stands in three parts. Part one talked about space in general and our place in it, putting us in the most recent (sometimes most complex) problems of modern cosmology.He showed us how the Inflation Theory by Alan Guth solved these problems such as the horizon problem and the flatness problem.

The inflation theory says that our baby Universe grew much like a human baby, an accelerating growth phase where the size doubled at regular intervals was followed by a more leisurely decelerating growth phase.So where and when did this inflation end?! Indeed it ended 14 billion years ago, in the part of space that we now inhabit, This means that there must be some physical process which can get rid of the inflating substance, causing it to decay into ordinary non-inflating matter, which then keeps expanding, clustering, and ultimately forming galaxies, stars and planets.

Alex Vilenkin Professor of Physics and Director of the Institute of cosmology at Tufts University, found that the question of where and when inflation ends is quite subtle and interesting. We know that inflation ends in at least some places, since 14 billion years ago, it ended in the part of space that we now inhabit, No not our planet, neither our galaxy, but *our universe*. Inflation theory gave us the Level I and Level II Multiverse which occupy the first part of the book.

Part tow talked about the subatomic world, it gives us a new picture of the current Standard Model(new at least for me), and produced the level III of multiverse(The Quantum Multiverse).Tegmark used the analogy of Schrodungar's cat experiment and made what he called The Quantum Card thought experiment and showed how you can be in quantum superposition(in tow places at once)

Part Three is the heart core of the book in this part Tegmark showed how mathematics by means of numbers and symbols can describe out physical world precisely, I will quote the author to be more sincerely and to avoid falling in troubles:

"The fabric of our physical reality contains dozens of pure numbers which all measurement constants can in principle be calculated"

"Our reality isn't just described by mathematics ,it is mathematics not just aspects of it, but all of it, including you."

"our external physical reality is a mathematical structure"
Tegmark called this the Mathematical Universe Hypothesis(MUH) call it Hypothesis number one.The External Reality Hypothesis (ERH)(number tow) stands that "There exists an external physical reality completely independent of us humans."

Tegmark's argument is that our most successful theories such as general relativity and quantum mechanics describe only part of the reality, for a complete description of external reality must be defined in a form "devoid of any human baggage like 'particle', 'observation' or other words" in other words it have to be a Mathematical Structure .Thus everything physical is ultimately mathematical, including you and me, "making us self-aware parts of a giant mathematical object".

This means that all structures that exist mathematically exist physically as well, forming the Level IV multiverse (this is a mind blowing conclusion)"Exploring the Level IV multiverse doesn't require rockets or telescopes, merely computers and ideas". (reminds me of Berekley)

"Mathematical structures, formal systems and computations are closely related, suggesting that they’re all aspects of the same transcendent structure whose nature we still haven’t fully understood"

Now the question of whatever we have to believe in all of this or not, one simply can be narrow minded and reject all of it, ,another one influenced by Popper's thought, can say that this is unscientific non-sense and can't be tested or falsified, for my part I found this Level VI Multiverse a little bit strange (as another levels) but worth thinking .Tegmark as he said moved the thinking of Multiverse from " this is non-sense I hate it " to "I hate it"

The book was complex and hard to follow in some parts (and hard to remember in all parts), but it was "Fantastic" in every sense of the word.

David Katzman says

Before I begin, a brief word about physics from a ninja.

This is a book of speculative physics. At the same time it is a mostly lucid walkthrough of the latest theories in physics. It's important to distinguish between theories and speculation. Theories are directly testable. Results of the theories are repeatable. Special and General Relativity are examples of theories that have been demonstrated over and over again. A result is calculated from the theory, an experiment is performed...the results match. Where the speculative part of the book comes in to play is where Tegmark attempts to project what he sees as the natural outcome, the logical result of these theories or the "real world" ramifications. That is to say, if the mathematical theories are accurate representations of the real world, then what must this real world look like? Really. He describes these hypotheses as "predictions" of theories.

As an overview of the current state of physics, this is highly digestible. It's exciting to get a window into the latest thinking in cosmology and subatomic space. I'm going to focus on his speculations. According to Tegmark, the latest theories result in their being a possibility of four different types of multiverses. At the core of these propositions are two contentious suppositions.

Inflation
The Schrodinger Equation.

I think most of us have heard that the universe is "expanding" although I think few of us can really envision what this means. Space is getting larger...like a balloon. However, inflation is different. Imagine taking an object and then duplicating it. Duplicate it exponential times. Then duplicate each of those duplicates exponential times. This is inflation and apparently the hypothesis that inflation occurred immediately after the Big Bang explains several big puzzles of cosmology. (At least for now.) Such as, why the background radiation is *evenly* distributed throughout the universe. With inflation, you get your matter for nothing and the matter comes from Energy (E=MC2) being converted. And inflation can propagate faster than the speed of light. Not all scientist are in agreement; inflation is still a hypothesis, but Tegmark points out that it neatly answers many conundrums. I did see this article recently about a discovery that could be inflation.

A lot of "could bes." More on inflation in a bit.

The Schrodinger Equation is the mathematical formula that captures the state of a quantum particle. What it has always shown is a range of probabilities and never a defined location. When a particle is captured, it is always found in one of the positions defined by the Schrodinger Equation, and the probability of finding it in any given position can be calculated with this formula before you locate it. The Schrodinger Equation has been demonstrated to be accurate over and over again through experimentation.

The mind-bending issue arises because physicists haven't been able to explain why the equation "collapses" when a particle is observed. That is, before observation, a particle exists only in a state of probability, it does not have an exact position (or velocity). But the moment it is observed, it assumes instantly a location. You've likely have heard of the Schrodinger Cat thought experiment (the cat being both alive and dead until observed) that demonstrates the absurdity and mind-bending nature of this result. If not, here's a description of it.

How is it that the act of observation (or measurement) causes the quantum particle to assume a state? The common solution called the Copenhagan Interpretation simple says *it does* but not *why*. Observation closes

the loop, end of story. What is the mechanism that causes an interaction with a probability sphere to collapse into actuality? There are now quite a few other interpretations. Such as that it never collapses, only seems to. Tegmark sees the most coherent solution to this to be the Everett Many-World's Interpretation. More on that in a bit.

As a result of both the concept of inflation and the difficulty in explaining how the Schrodinger Equation relates to reality, Tegmark suggests that there are four possible conditions that may describe the universe(s). But all are preceded by the idea that if inflation is correct then space must be infinite. This an important assumption and one that there is really zero proof of, but it makes for interesting conceptual thinking. These are his "Universe Levels."

ONE: Given space as infinite there are infinitely many "universe islands" like our own. That would mean there are infinite beings just like us but different in some small or large aspects. These beings are beyond the distance that light could even travel to us since the Big Bang. In some universes, our "duplicates" don't exist at all. In others, our species doesn't exist or our planet. In others, everything exists exactly as it does except your eyes are purple. He claims this is the natural outcome of having infinite space along with fairly similar starting conditions. This reminds me a lot of Nietzche's Eternal Recurrence hypothesis.

TWO: Same as one except that in these universe islands, the laws or constants of physics might be different. He uses the "fine-tuning argument" as some justification for this view. More on fine-tuning in a bit. And...each universe island may have had it's own Big Bang moment.

THREE: Multiverse time....Tegmark's preferred explanation of the Schrodinger Equation is that at each moment in time when a particle can exist in different states, the universe splits into a unique universe for each potential state. All states occur and then due to "decoherence" they separate and cannot interact with each other. There is no state vector/equation collapse...all states occur and split us into multiple universes. These universe all exist "simultaneously" (doesn't really mean anything because all time exists at the same time) in an infinite Hilbert Space. The Hilbert Space is basically the uber-universe. All time and space as an unmoving object.

FOUR: The Universe is a mathematical object. This is his pet preferred hypothesis. My interpretation of it is something like this: Particles can be fully described mathematically. The universe can be thought of as a collection of particles in a particular arrangement. Therefore, the universe is much like a computer program, an arrangement of numbers. The matrix. An individual life form is a complex mathematical object traveling within this mathematical universe. Kind of like a parenthesis in a larger formula Universe = (being 1) + (being 2) + etc. He essentially says that consciousness (and free will) is an illusion and is merely the sensation of experiencing the split into multiverses (I'm given the impression that he believes in Levels 2, 3, and 4 combined). And here's where it gets really weird (abstract/abstruse/absurd), he suggests that all that exists *is*math. A sort of reverse Platonism. Somehow when mathematical formulas are complex enough, they become self-aware and perceive the mathematical universe as a reality. Even basic mathematical systems exist in their own universe, albeit one not complex enough for life. He gives the example of how videos are constructed from ones and zeros but give us the impression that they are real images. The universe is kind of like that. A self-contained mathematical formula that simulates reality. Although he actually doesn't believe in the simulated universe hypothesis, it seems to me to be the same thing. Math formulas take on a life of their own. Jeff Noon wrote a book called Nymphomation that was about math formulas coming to life as I recall.

Unfortunately, although Tegmark presents this model, he really can't explain it. It is certainly intriguing and unanswered what reality is and how we perceive it as such...and how we could (if we do) have free will.

However, it is even harder to explain how an abstract structure (a "computationally valid" mathematical formula) could somehow form a reality. Math is pure abstraction. So how could an abstraction perceive? How could an abstraction create a form? Saying something is "emergent" doesn't explain it, it's just saying that you can't explain it.

The universe may be imaginary, but it sure damn feels real. How could a mathematical formula feel real? How could math develop the ability to "feel." His hypothesis doesn't really explain anything. He says the theory doesn't need to explain consciousness...that's someone else's job.

One justification he has for level 2 universe is the "fine-tuning" argument. I'm no mathematician and Tegmark is one of the top in the world apparently. So I say this with humbleness that I may be wrong...but I see a profound gulf in one simple area. It is a misunderstanding of the relationship between probability and "real" life. If something has actually happened, i.e., exists, then the probability of it happening is 100%. There is no probability. Before it occurs, there is a probability. Therefore, when the so-called "fine-tuning argument" is used as a factor to sell a theory, my back gets up. The fine tuning argument states that some constants are so "finely tuned" to support life, that either God tuned them (Tegmark doesn't say this but creationists do)...or there is a significant theory missing to explain why the quantities are such as they are so specifically. For example, if dark energy energy was minimally less dense then the universe would have flown apart already. If dark energy was slightly denser then it would have collapsed. Of course, dark energy hasn't even been proven to exist yet...although...there was this recently.Tegmark believes all these constants will be justified mathematically at some point. Lot of belief there. But regardless of why the constants are in the state they are, they *are*. There is no "chance" or probability that they could be anything else. So regardless of how you explain them, there is no proof that they could anything other than what they are, which means the probability of them being what they are is 1. It's not amazing that the odds turned up life. Life is. The constants are. It wasn't god who made them, nature did. I'm not saying we won't necessarily learn more which will explain why some values are what they are. I'm saying that the fine-tuning argument falls apart because probability is not relevant to the outcome. There are no "other states."

In the end, this book is both lucid and whimsical. It's quite entertaining and rather farfetched at the same time. After I had completed most of this review I went and read a few professional reviews on the NYTimes website, The Guardian, etc. All of these reviewers find the multiverse theory to still be bunk and unprovable and/or the mathematical universe idea to be absurd. So take it all with a grain of salt. Still, a fun read.

WarpDrive says

This is a complex and very interesting book, addressing many important questions about the fundamental nature of reality.

The author adopts (and convincingly explains) a particular version of mathematical Neo-Platonism stating that reality is essentially nothing but mathematical structures. His position might be classified as a form of mathematical “monism” (as it essentially denies ontological reality to anything except mathematical objects). From a philosophical perspective, the author can be allocated to what is termed "Ontological Structural Realism", whose main statement (crudely expressed) is the claim that there are no ‘things’ as such, and that “structure” is all there is. This approach has proved quite attractive to a few philosophers of physics, philosophers of mathematics (such as Stewart Shapiro) and physicists, and I personally find it quite compelling (my Neo-Platonism was (at least, until I finished reading this book) more of the Heisenberg or

Roger Penrose flavour – the latter famously positing the existence of three worlds – the world of conscious perception, the physical world and the Platonic world of mathematical forms, interconnected in a complex fashion).

The author starts his argument by observing, in a convincing way, that the very fabric of our physical world appears to be fully describable in a mathematical way. Look at "space" itself, for example, whose only intrinsic properties are "mathematical" (such as dimensionality, curvature and topology); and this equally applies to the “stuff” our physical world is made of – the only intrinsic properties of elementary particles are mathematical (charge, spin and lepton number, for example).

I think that the author here is correct, and I must add that this debunks the myth of the Kantian “thing in itself” (das Ding an sich), this mysterious “essence” which Kant confusingly opposed to the phenomenological behaviour of the object. The most fundamental entity in classical quantum mechanics, the wave function, can be considered, after all, a mathematical object which "lives" in the infinite-dimensional place called Hilbert space. Fields can be considered mathematical objects, or at least spatially defined clusters of information.
Just as a side note, I would have expected the author to also explore the concept of entropy, which is a fundamental, emergent phenomenon ultimately driving the time arrow evolution of the Universe, and which again is nothing but a “mathematical”/statistical concept based on the measure of the number of specific ways in which a system may be arranged (commonly understood as a measure of “disorder”). This would have further confirmed his theory.

I tend to share the author's views here: the more I have studied quantum mechanics and relativity, the more I have started to feel that the deeper you dig, the more this physical “stuff” starts looking like an illusion, as its fundamental core nature appears to be nothing but information and structure... “mathematics”, if you wish. After all, particles are excitations of the corresponding quantum fields (which are not “physical” in the traditional meaning of the term), or they can be defined, in modern particle physics, as "elements of an irreducible representation of the corresponding symmetry group".
And, after all, what does the word “physical” mean ? Is it what it can be perceived by our limited sensory organs ? Well, I think that this old-fashioned concept of "physical world" has been made obsolete for quite some time.

Moreover, the author compellingly and beautifully explains that we DISCOVER such structures fully describing reality, we do NOT invent them – all we invent is the NOTATION for describing such structures. A structure is defined as a set of abstract entities with a set of relations between them, whereby the only properties of these entities are those embodied by the relations between them: and it is clear to the author, from the latest developments in science in the last 90 years, that the properties of nature stem not from properties of its ultimate building blocks, but from the RELATIONS between such building blocks - and I find myself in substantial agreement with this view.

The author, after discussing the point that the fundamental properties of reality appear to be mathematical, addresses the relationship between such mathematical structures describing reality, and reality itself. What is such relationship ? Is such relationship an isomorphism, or is it an identity? In other words, is mathematics the language of nature, or IS IT nature itself ? Here, the author thesis is that, if two structures are “equivalent” (where equivalence is defined as the existence of a one-to-one relationship between the two structures, preserving all relations), they are the same and they describe the one and the same thing. The author's conclusion is: “this means that if some mathematical equations completely describe both our external physical reality and a mathematical structure, then our external physical reality and the mathematical structure are one and the same”. Here the author, disappointingly, does not really develop this

crucial point in any satisfactory detail: he refers to the work (a master thesis) done by a certain Marius Cohen (page 280 of the book), and this is all we have. Not enough, and I was left profoundly dissatisfied here - I will try and retrieve Marius Cohen's work, but that such a crucial point was not developed in more detail remain a weakness of this book, in my opinion.

But overall his points are very compelling, beautifully addressed and explained, and fascinating – a real intellectual challenge to our everyday perspective of reality.

There is so much to discuss here in relation to this book - I feel I could write a book on this book, as there are so many different interesting themes and fascinating points discussed by the author.
Just as an example, the author beautifully highlights how fundamental the property of “symmetry” is in the characterisation of mathematical structures and of reality. Also, the author addresses the issues raised by the concept of “infinity” and by incompleteness (as raised by Godel), elaborating, as a response to such issues, his initial “Mathematic Universe Hypothesis” into a "Computable Universe Hypothesis" (CUH), which posits that all COMPUTABLE mathematical structures exist. Fascinating, I must say.

Where I disagree with him however is in his own enthusiasm for the Multiverse interpretation of Quantum Mechanics (Level III Multiverse in his book) - I found his treatment of this specific issue quite weak, and the author also makes the mistake (unfortunately still common) of interpreting Bell's inequality experimental results as ruling out hidden variables – this is not correct – what has been ruled out is the existence of hidden LOCAL variables, so alternative interpretations (in particular, the de Broglie-Bohm theory, which I personally find quite attractive, and which elegantly tries to address the measurement problem), are still not ruled out. I realize though that this particular interpretation sits in a minority position, and many do not agree with it at all.

Overall, it is a great book, challenging, rich and fascinating. It even explores, with fascinating insights, hard problems such as the nature of consciousness, the issue of the potential future "singularity", and our place and our meaning in the Universe.

To finish, I would have loved a more quantitative treatment of some of the items discussed in the book (at least in areas such as quantum mechanics and symmetry) but I guess this is part of the current commercially-driven trend of dumbing down the maths in order to enlarge the potential audience (and therefore the potential customer base) - this is (together with the couple of other shortcomings I highlighted above) why I could not give this otherwise great book a full 5 star rating.

Tara says

This book covers quite a bit of material, topics ranging from astronomy, cosmology, and quantum physics, to far more precarious stuff such as the level IV multiverse and the “Mathematical Universe Hypothesis,” which Tegmark champions rather emphatically. In the beginning of the book (page 13), he includes a helpful diagram that clearly states which chapters are considered “mainstream,” “controversial” and even “extremely controversial.” He’s very upfront about which parts of his book fall into which category, so I don’t believe we should fault him overmuch for being too speculative. I mean, in order for science to *work*, for it to explore radical new territory and discover equally radical new truths, radical new hypotheses are absolutely essential. Even, or perhaps especially, the ones that seem a little bananas. As Tegmark points out, it is *“amusing how strong the conformist herd mentality is among many physicists, given that we all pay lip*

service to thinking outside the box and challenging authority.”

After all, we don’t want to be like Mac on *It’s Always Sunny in Philadelphia* (best show ever!), slam science for barking up the wrong tree sometimes, and end up hating all the “stupid science bitches,” now do we?

Linda says

The human mind has constantly underestimated the size of our world and universe, while, at the same time, the human mind has constantly underestimated the chances of understanding it. Max Tegmark, one of the leading physicists in the world, explains theories about the universe and offer alternative conclusions which are considered controversial, but gain more and more acceptance and respect. He doesn't think the universe can be described by mathematics, he thinks it is mathematics. The smallest parts of the atom that we know of, the quarks, have no other quality than being mathematic. In the same way, the universe on the great scale seems to be symmetrical and consist of equations. The big and the small scales come together, and in the end, everything is mathematics.

Max Tegmark is a very interesting person, obviously very intelligent, interested in mysteries and the unexplainable, and has a great deal of open-minded imagination. That makes him a machine of ideas and theories about our universe. His determination is impressive. When he finds an obstacle, he writes a new computer program to be able to analyze data, or builds a groundbreaking kind of telescope - an omniscope, involving a method called 21 cm cosmology - to be able to continue his research.

This book brings out the physicist in you. Tegmark mixes equations and explanations with the big, existential questions. Sometimes the book is on the verge of philosophy, which only makes physics more beautiful. What are we, really? What makes us aware of everything and ourselves? Do we exist or are we just Boltzmann brains? (A self aware entity, existing due to fluctuations in space, according to quantum mechanics). What is reality? Is time an illusion? In which universe do we live? What does the world really look like? How accurate is our view when we depend on photons? (In the dark, we see nothing. Different materials absorb different light waves and the colour we see seems to be the one not absorbed. Much of the reality is hidden from us, like other dimensions).

This is some of the themes discussed in the book.
* Time is a fascinating dimension, belonging to the four dimensions of our universe. The speed of time moves differently depending on the whereabouts of the observer. Near a black hole, it goes faster. We are able to see almost 14 billion years back in time, when viewing the cosmic radiation created 400 000 years after the Big Bang.
* Hydrogen gives off radio waves with a wavelength of 21 centimeters. Since the waves reaches earth are stretched out by the expending universe, the length of them reveals how far away they come from. Since distance is a factor of time, that also reveals how old they are. It's called 21 cm tomography. It's a current scientific activity and physicists around the world are trying to track the signal from the places farthest away.
* Without three dimensions and time, woven together in a cosmic fabric of spacetime, life wouldn't exist, but according to Tegmark, we are not unique. Because of his theory about multiple universes, everything that can happen, will happen somewhere.
* According to Tegmark, there are universes on four levels. Our universe is on the first level, and is represented by how far we are able to see, or the light that has reached us in 14 billion years. Beyond that,

there are other universes that we can't see. The universes on level two are a consequence of a great expansion happening before Big Bang, called the inflation theory. These universes have different physical rules depending on inflation and early fluctuations. Universes on level three are coming from quantum physics. Universes on level four are made of every mathematical structure there is. Every equation happens somewhere, and imagination is the limit.
* According to quantum physics, there are endless copies of you that have your memories and think they are you. When you gamble, somewhere one of you win, and one of you loose. There are no luck, there are only different outcomes. When you feel immortal, it means the number of you have diminished. When you feel lucky, the number of you have increased.

In one chapter, the apocalypse is discussed and five alternatives for the universe apocalypse are introduced. They are called Big Chill, Big Crunch, Big Rip, Big Snap and Death Bubbels. The theories have to do with the expanding or eventual compressing of the universe. When considering an apocalypse within a billion years, Tegmark thinks the sun is the big threat. He almost dismisses the idea of an invasion from intelligent life in our galaxy, since the probability of a planet with intelligent life existing within our galaxy, considering the immense size of the rest of the universe, is almost non-existent. (In the same way, one could argue that mankind will not live for billion years. The probability of us being born so early in that kind of time-line is very small). Many planets are inhabitable, but are still not inhabited. Many planets are older than earth, and if there were intelligent life somewhere in our galaxy, some of them would probably already have colonized the universe. Or, perhaps they already have?

In the near future, however, the existential risks are the biggest threat, considering nuclear weapons and the fact that we eventually might build an intelligent computer, which earns some egoistical person much money and leaves the rest of the world in poverty. The artificial intelligence might be well beyond ourselves, and learn how to evolve without us, which makes us superfluous and ultimately might lead to our extinction. We should be grateful to what we have and not waste it. We should be able to save ourselves and our planet with knowledge. Tegmark thinks that scientists have failed to educate people and have to improve their information distribution. Many people still think that mankind is only 10000 years old, and in 2012, twelve people were burned to death for witchcraft in Haiti. The lack of knowledge is dangerous and certain companies strive to maintain ignorance to profit.

Despite his successful career, Max Tegmark seems to be a very modest and humble man, fully aware of the risks of theories, and that research has turned out to be wrong before. That is why he has an open mind. His attitude and love for his work, his collegues and previous scientists is admiring. Perhaps scientists have to really love their work, be their work, to succeed. Often, they work day and night, struggling with their thesis and experiments, to be able to finally reach a conclusion.

Tegmark's view of the world is fascinating and very inspiring. He mentions facts that are very romantic, almost like poetry. Gold is produced when a star dies in a supernova explosion so violent and rare that, during a fraction of a second, it releases about the same amount of energy as every other star in our observable universe, together. The world needs school teachers like that. The only criticism might be the sometimes fast deductions in his arguments. It would have been nice with a few more sentences with distinct explanations about the consistency in some of the chapters.

The gigant distances, mystery, beauty and elegance of the universe often make us feel small and insignificant. We are not. First, we have a big decision to make. During our lifetime, the future of our planet is most likely to be decided, according to the book, and we will be remembered for it in the future. Second, as Tegmark so delicately puts it, the universe – which is a true art - is only beautiful because a conscious being can perceive it. We are probably the only intelligent beings in our galaxy, and if we weren't here, the

beauty of the universe would be a waste of space. Instead of thinking the universe is giving meaning to us, we should think that we are giving meaning to the universe.

Wes says

Dr. Max Tegmark's "Our Mathematical Universe: My Quest for the Ultimate Nature of Reality" is an awe-inspiring journey into the "weirdness" that is reality (Tegmark's phrase). Forget everything you think you know about the place we inhabit; through engaging and friendly prose, Tegmark shows that seeing and believing are often wrong and that reality is something beyond our strangest dreams. If seeing the world (universe) as a grand landscape of seeming impossibilities sounds enjoyable, then this book is for you. Buckle up, strap in, and prepare to explore regions of reality that are almost beyond conception.

The book leads with a brief history of our understanding of the universe and our place in it – from earth as the center of the universe through big bang cosmology. The key point Tegmark makes is that each time we are able to perceive more of the universe, we are stunned by the size and scope of the cosmos. Put another way, our understanding of the universe has increased at intervals and with breathtaking realizations. Throughout the book, Tegmark boldly extrapolates mathematical predictions to counteract humanity's tendency toward chronic underestimation.

For example, a particularly bold section focuses on our cosmic origins. Specifically, Tegmark explains Alan Guth's model of how the universe grew since the big bang by "inflationary cosmology" or "inflationary growth." Inflationary growth solves a number of problems in physics and has been allegedly confirmed by recent gravity wave detections (BICEP2 project). Tegmark's characteristic bold extrapolation begins when he discusses the full implications of inflation, and this is where the book gets really fun. Inflation predicts that we inhabit an infinite space with infinite matter contained in a finite volume and created in a finite time. A truly infinite space with infinite matter implies that somewhere at an incomprehensibly far distance away, matter is arranged as an exact copy of earth – with an identical history – with an identical you – reading this very review – right at this very moment. Of course there would be many more "near copies" of you, many more than the exact copies, but there are exact copies nonetheless. As such, inflation predicts "parallel universes," where there are infinitely many exact copies of you. As crazy as this idea sounds, this isn't kooky crackpot science; this appears to be the cosmos we inhabit based on our most advanced models. Tegmark calculates that your nearest doppelganger is 10 to the power 10 to the power 115 meters away. Say hello to your doppelganger that is saying hello to you at this very moment.

This is one of many ideas that show how odd reality truly might be. Reality on our "scale" is intuitive because our brains developed to deal with problems on the scale of biological life. But if we zoom way out or zoom way in, what we find can be described in no other way than just plain "weird." That, to me, is a lot of fun. Life and the universe is a Lewis Carroll-esque landscape of seeming impossibilities and counterintuitive realities that are simply awe-inspiring.

Tegmark's bold extrapolation and continued expositions on physical weirdness continues through what he terms a four level "multiverse:" levels of the universe that exist but are unreachable. The Level One multiverse is predicted by inflation and contains you and your doppelganger, etc.; the Level Two multiverse is areas of space where fundamental natural constants are different due to fluctuations at the big bang (example: parts of space with 7 dimensions, sub atomic charges are different, etc.); the Level Three multiverse is predicted by Hugh Everett's "many worlds" interpretation of quantum mechanics; and the Level Four multiverse is predicted by Tegmark's "Mathematical Universe Hypothesis" ("MUH").

Tegmark's personal and most controversial theory is the MUH. The MUH theorizes that the universe is not only described by mathematics, but that it *is* mathematics, specifically, a mathematical structure. Tegmark asserts that sub-atomic “particles,” (say, an electron) are described solely by their mathematical characteristics and relationships. As such, an electron is not really a particle at all – but simply a mathematical object whose relationships are governed by various mathematical features (a number representing charge, lepton number, etc.). We give the electron a “particle” designation because it is intuitive, but in reality there is nothing there but mathematics. So at its most basic, the universe is an elaborate structure of mathematical relationships between entities whose sole characteristics are mathematical ones. Electrons, quarks, photons, molecules, our bodies and minds, solar systems, galaxies, etc., are mathematical objects that move and dance according to their mathematical properties. If you’re having trouble believing this one, don’t worry, the theory remains highly controversial. But I think you get the idea: reality is mathematics.

The MUH tells us that the multiverse is something akin to a DVD – it has always existed and will always exist with the information content contained therein. That means that in a sense, you, a self-aware mathematical substructure, have always existed and will always exist. You experience time as flowing subjectively as you process mathematical relationships between and among other mathematical substructures, including the mathematical substructure that makes up your physical self. Put another way, your reality model as a self-aware substructure observes mathematical relationships that change according to other mathematical relationships. Without an observer, these relationships are essentially timeless, have always existed and will always exist. Time subjectively appears fleeting and irreversible because our reality model is governed by mathematical relationships. But in reality, you have always and will always exist mathematically, on repeat, forever.

If this notion holds true, then it has important philosophical implications something akin to Schopenhauer and Nietzsche’s idea of “eternal recurrence.” Philosophers have tackled the question of infinity and some have deduced that in infinite space and time our physical selves occur repeatedly through “eternal recurrence.” This idea is summed up in the following quotation by Nietzsche: “And then you will find every pain and every pleasure, every friend and every enemy, every hope and every error, every blade of grass and every ray of sunshine once more . . . the whole fabric of things which make up your life. This ring [universe] in which you are but a grain will glitter afresh forever.”

My personal takeaway from the MUH is to simply live a happy life and live the life you want to live. Our intuition tells us that we only get one chance – so we should be doing this anyway – but this one chance may be the life you are destined to repeat forever and ever.

I should conclude by saying that many of Tegmark’s ideas are controversial and that we shouldn’t necessarily take what authority figures say as true, even when such figures are so clearly brilliant. Still, the journey through the mind of one of the most renowned scientists today is nothing short of exceptional, even if taken with a grain of salt.

P.S. There is also a small chance that our entire universe is a computer simulation being run by an ultra-intelligent entity. Tegmark suggests we all continue to do new and interesting things lest we risk deletion.

John Gribbin says

Our Mathematical Universe
by
Max Tegmark

Max Tegmark, a physics professor at MIT, is a leading proponent of the idea of the multiverse, familiar to many as the “parallel worlds” of science fiction, but taken increasingly seriously by sober scientific theorists. Several variations on the theme tell us that there must be an infinite number of versions of our Universe (capital “U”), other universes (small “u”), some indistinguishable from our own, some with minor differences, many with significant differences. separated from us in space or time. But Tegmark is careful not to frighten his readers by making such seemingly outrageous claims at the start of his book. Instead, he leads us gently by the hand through the traditional story of our place in the Universe, from the Sun and Solar System outwards, before wading into deeper waters.

Even this familiar story is enlivened by the author’s personal touch, with anecdotes from his childhood and early life in research. So by the time he gets to the tricky bit, he feels like an old and trustworthy friend. This is just as well, because things get very tricky indeed.

The first step into deep water is the easiest. If space is infinite, our visible Universe can be regarded as a bubble within that infinite space, analogous to the bubble of visibility surrounding a person walking through a fog. It is possible to calculate the number of particles (neutrons, protons and the like) in that bubble, and to calculate the number of ways they could be arranged. This is an enormous number, but, crucially, it is not infinite. So in infinite space, there must be other bubbles -- other universes -- with exactly the same arrangement of particles as in our Universe. This is the Type I multiverse, and it is almost common sense.

The Type II multiverse is only slightly more complicated. It takes on board the currently-favoured idea of inflation, which explains the present appearance of our Universe as resulting from an epoch of very rapid expansion at the time of the Big Bang. Each universe is an inflating bubble within some kind of superspace. But it is the Type III multiverse that is familiar from science fiction.

This is where quantum physics comes in to the story, with Schrödinger’s famous “dead and alive cat” and the idea that every time the world is faced with a choice of possibilities at the quantum level it splits to allow all possible developments. In fact, no “splitting” is required, and it is equally valid, as Schrödinger himself pointed out, to think of all quantum possibilities existing alongside each other “all the time”, whatever that means in this context.

Let me spell that out. In the famous thought experiment, a (purely hypothetical) cat is trapped in a box with a quantum device that ensures that it has a 50:50 chance of being dead or alive. When the box is opened, one possibility is realised. The “splitting” idea says that at that moment the Universe divides in two, one universe with a dead cat and one with a live cat. The “parallel” idea says that there are always two universes, each initially with a cat in the same situation, in one of which the cat dies while in the other it lives, with no splitting involved. “Parallel universes,” says Tegmark, “are not a theory, but a prediction of certain theories.” All of this is allowed -- some would say, required -- by the known law of physics, or as Tegmark prefers, the known laws of mathematics. As Galileo said, nature is “a book written in the language of mathematics”. But Tegmark isn’t finished yet, He goes on (farther than most physicists would) to consider the Type IV multiverse, in which different universes are governed by different laws of mathematics. This leads on to speculation about the nature of reality and our place in it, the future of life and the future of the Universe. All a far cry from early chapters on our place in the Universe, and discussion of the sizes of planets and stars, but somehow a natural development, thanks to Tegmark’s gift for storytelling, from those beginnings. As he says, “physics is the ultimate intellectual adventure”; this is a great place to join in that adventure.

John Gribbin is a Visiting Fellow in Astronomy

at the University of Sussex
and author of In Search of the Multiverse (Penguin)

Ints says

P?d?j? laik? mani s?k nom?kt iekš?jie p?rmetumi. Ja paskat?s uz izlas?to, san?k, ka mani las?šanas paradumi p?d?jo piecu gadu laik? ir kardin?li main?jušies. Esmu gandr?z piln?b? p?rg?jis uz fantastikas un fant?zijas žanru. Popul?rzin?tnisk?s gr?matas tiek pamestas nov?rt?. No vienas puses – cik reizes vari las?t vienu un to pašu. Beig?s jau bija non?cis pie t?, ka par tematu (vismaz v?sturisko aspektu) es zinu lab?k par autoru. Popul?rzin?tnisk?s gr?matas es p?rku joproj?m, bet ar las?šanu neveicas tik labi k? v?l?tos. Š? ar gaid?ja savu k?rtu jau no maija.

Š?s gr?matas galvenais uzdevums ir ?tri iepaz?stin?t las?t?ju ar m?sdienu kosmolo?ijas pamatiem, nedaudz apst?st?t svar?g?ko kvantu fizik? un tad pier?d?t, ka paties?b? m?su visums ir matem?tiska strukt?ra ar vis?m no t? izrietošaj?m sek?m. Gr?mat? izlas?tais garant?ti laiku pa laikam noraus jumtu un liks aizdom?ties par m?su vietu pasaul?, agr?k vai v?l?k piespiežot las?t?ju padoties multiversu vilin?jumam.

Nav jau t?, ka gr?matas par multiversiem b?tu retums, bet tik skaidri un saprotami uzrakst?ta gad?s reti. Ja man k?ds tagad pras?tu gr?matu par zin?tnes v?sturi un iesp?jamo n?kotni, es bez šaub?šan?s vi?am dotu šo. Ja ar? neko daudz vair?k, tad vismaz iem?c?sies patst?v?gi noteikt Zemes diametru. Ta?u nevajag satraukties, autors savus secin?jumus b?v? uz stipriem pamatiem, un las?t?jam tiek pav?st?tas visas galven?s nianses. Ja esi baigais popul?rzin?tnisko gr?matu las?t?js, tad vari pirm?s sešas noda?as izlaist. Es gan to nerekomend?tu, jo taj?s ir atrodama noz?m?ga pievienot? v?rt?ba. Proti, autors daudz nodarbojies ar eksperimentu datu apstr?di. Parasti autori pav?sta par teoriju nemaz neiedzi?inoties, k? tika apstr?d?ti eksperimenta laik? ieg?tie dati, un k?d?? tieši š? interpret?cija ir vislab?k?. Autors par šo bieži aizmirsto teoriju pier?d?šanas aspektu raksta visai daudz un ar entuziasmu.

Visp?r visa gr?mat? j?tams ar? pats autors – vi?a karjera un dz?ve. Vi?š nekautr?jas st?st?t par savu zin?tnieka dz?vi, par to k? vi?am dažreiz ir izdevies atkl?t jau atkl?tas lietas. Par to cik v?lies vi?š juties uzzinot, ka tas nav nekas jauns, un par to, cik š?das vilšan?s ir vajadz?gas, ja v?lies k??t par ?stu zin?tnieku. Dom?jams, ka vi?a gr?matas pusaudžu las?t?jus var?tu nosv?rt par labu fizikas stud?šanai. Šaj? gr?mat?, lasot par daž?du probl?mu matem?tiskajiem mode?iem, tie tiek pasniegti tik saistoš? veid?, ka š?iet, ka viss ir saprotams bez ?pašas piep?les.

Centr?lais temats ir multiversi. Visp?r izš?ir veselus ?etrus to veidus. Vi?i visi izriet k? sekas no jau pier?d?t?m fizikas teorij?m. Un ar pier?d?jumiem ir t?, ka tu nevari izv?l?ties tikai t?s sekas, kuras tev ir pie?emamas. Vai nu ?em visu vai neko. Tad nu las?t?js var uzzin?t, ka gad?jum?, ja tu vienu br?di attopies k? vec?kais plan?tas iedz?vot?js, tad tev b?tu pr?t?gi pie?emt, ka eksist? treš? l?me?a multiversi. Savuk?rt, ja pie?em, ka m?su visuma infl?cijas teorija atbilst paties?bai, tad ?oti, ?oti t?lu, kaut kur eksist? identiska Zemes kopija ar visiem t?s iedz?vot?ju un t?du pašu v?sturi. Un visi iesp?jamie starpst?vok?i un katrs no tiem bezgal?gi daudz?s kopij?s. Ar bezgal?bas tieš?m ir pr?tam neaptveramas.

Un paš?s beig?s autors izvirza savu teoriju, ka visu visumu pamat? ir matem?tiskas strukt?ras, kas vari? no vienk?rš?m l?dz sarež??t?m. Iesp?jams, ka Hilberta telpa ir pieb?zta pilna ar visdaž?d?kaj?m konfigur?cij?m. Un m?su Visums ir t?ds tikai t?d??, ka t?da ir viena no bezgal?gi daudzaj?m matem?tiskaj?m strukt?r?m ar vis?m sav?m simetrij?m.

Lieku 10 no 10 ball?m. Noteikti iesaku izlas?t visiem, pat ja l?dz šim neesi par fiziku un kosmolo?iju interes?jies tik cik melns aiz naga. Izlasi, nenož?losi, pav?rs jaunus zin?šanu apv?rš?us un spriedumi k? b?tu,

ja b?tu izskat?sies daudz saprotam?ki. Galvenais uzzin?siet, ka p?rbaud?t vai las?t?js paties?b? nav “Bolcma?a smadzenes”.

David says

The first half of this book is a review of modern physics on the macro and micro scales. The second half of this book is a discussion of the author's speculation, that the universe is a mathematical structure. Max Tegmark is quite clear--he is not saying that the universe is *described* by mathematics, but that the universe *is* mathematics. He calls this the "Mathematical Universe Hypothesis", or "MUH" for short.

Tegmark asserts that this idea is a testable, falsifiable hypothesis. I did not find the experimental test, but perhaps I simply missed it. To be perfectly frank, I don't even understand his reasoning.

The last chapter of the book switches gears entirely, and discusses the existential threats to human survival. Things like asteroid collisions, eventual expansion of the sun, and so on. Then the book describes the two most immediate threats to human existence. The first is a nuclear war. And the second is--are you sitting down for this?--the singularity, where artificial intelligence takes over the world.

I didn't read this book--I listened to the audiobook, read by Rob Shapiro. He did an excellent job, giving the narration an aura of authenticity. It's just too bad that the content of the book is not as good as the narration.

Mohamed al-Jamri says

This is Max Tegmark's first and only book so far. In the book, Max who likes to be called Mad Max proposes a really "mad" theory of everything called the "mathematical universe hypothesis" in which he argues that the ultimate nature of reality is mathematics. He also argues strongly for the multiverse idea, making it somewhat plausible.

The book is written with a mostly smooth and easy to understand narrative style that is often combined with inspirational quotations. It is from books like this that I get the feeling to want to do physics instead of medicine, even though I'm few weeks/months away from final year examinations. The author takes us through his personal quest for the ultimate nature of reality in which you'll see Einstein and Darwin next to Plato and Pythagoras.

The book is divided into three parts: physics of the big and small, mathematics as reality and philosophical reflections. The first chapters are the most beautiful in the book; I got immersed in them just like I do in an Orwell novel.

We are told about the ancient Greek scientists Eratosthenes and Aristarchus and their scientific discoveries made form limited observations. How just looking at a specter of a star can tell us so much information about it. He also asks 16 deep questions such as what is space, what is the curvature of the universe, how can triangles be more or less than 180 degrees, how did galaxies, atoms and elements form and what we don't know yet. He then continues with the history of scientific discoveries, going through Copernicus, Galileo, Giordano Bruno, Kepler, Newton, Hubble, Freidman and others.

A recurring theme is that of not taking one's theory seriously and to its full consequences. We see multiple scientists making the same mistake through the ages. He explains the inflation theory, which is the current mainstream theory to explain the Bang in the Big Bang. Here he makes the same point made by Hawking and Krauss in their recent books, that from a quantum vacuum we can get so much mass without breaking the law of conservation of energy. He calls it a galactic Ponzi scheme in which we borrow indefinitely from gravity.

Then he moves from the mainstream to purse the multiverse idea, which is enjoying much more support by physicists than it did decades ago when it was in the realm of science fiction only. He divides the multiverse into four levels and explains them. He maintains that while the multiverse is not testable/falsifiable, it is still science, because it's not a theory in it self, but a prediction of a testable theory; infinite inflation and quantum physics. He is critical of the Copenhagen interpretation of quantum physics and supports a Cosmological interpretation that is similar to the Many-worlds interpretation.

After that he reaches the Mathematical Universe Hypothesis which supports a level four multiverse, in which there is an infinite number of universes with their own set of fundamental laws of physics. The hypothesis states that mathematical structures are eternal and unchanging. They don't exist in time and space, rather space and time exist in some of them. The flow of time, creation and destruction are illusions, since change is an illusion. Mathematical existence = physical existence. He states and argues that this hypothesis is very simple and is testable/falsifiable.

In the last chapter, Tegmark tackles the future of the universe and how it could end. He talks about the existential threats to life on Earth from outside and inside, nature and human. He spends some time talking about artificial intelligence, the importance of education, the meaning of life and extraterrestrial intelligence.

The first parts of the book are absolutely amazing. I'd have given it 5 stars if it didn't contain some boring and hard to understand parts in the middle. Nevertheless, the book is really good and I recommend it.
