https://www.youtube.com/watch?v=SN8nTQiWOYY&t=1060s

What If Space And Time Are NOT Real?

Co když prostor a čas NEJSOU skutečné?

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Graydon Goss Frederic Simon Dmitri McGuiness John Robinson Jim Hudson Alex Gan David Barnholdt David Neal John Funai Bradley Jenkins Daniel Stříbrný Cody Brumfield Thomas Dougherty King Zeckendorff Dan Warren Patrick Sutton John Griffith Dean Faulk

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(01)- Thank you to Brilliant for supporting PBS. Physics progresses by breaking our intuitions, but we are now at a point where further progress may require us to do away with the most intuitive and seemingly fundamental concepts of all—space and time themselves. Physics came into its modern form as a description of how objects move through space and time. They are the stage on which physics plays out. But that stage begins to fall apart on the tiniest scales and the largest energies, and physics falls apart with it. Many believe that the only way to make physics whole again is to break what may be our most powerful intuition yet. In our minds, space and time seem pretty fundamental, but that primacy may not extend beyond our minds. In many of the new theories that are pushing the edge of physics, spacetime at its elementary level is not what we think it is. We're going to explore the "realness" of space and time over a few upcoming episodes. We'll ask: Do our minds hold a faithful representation of something real out there, and if not, why do we think about space and time the way we do? And if space and time aren't fundamental, what is? What do space and time emerge from? But today we're taking the first step by exploring how the notion of absolute space and time in physics came about in the first place, and how that notion is beginning to fall apart. We have this sense of space as an extended emptiness - a volume waiting to be filled with matter - a regular, continuous, mappable … space, in which everything that exists is embedded. Meanwhile time is the continuous rolling of future into past through the present, all governed by the same unstoppable clock. But this idea of space and time as having an existence "out there", independent of its contents, became cemented in popular intuition relatively recently, at the same time that they became cemented in physics. However humans have been arguing over the reality or the fundamentalness of the dimensions for millenia. We can summarise the two main conceptions of spacetime as either relational—space as a network of positional relationships of objects —or absolute—a real entity that
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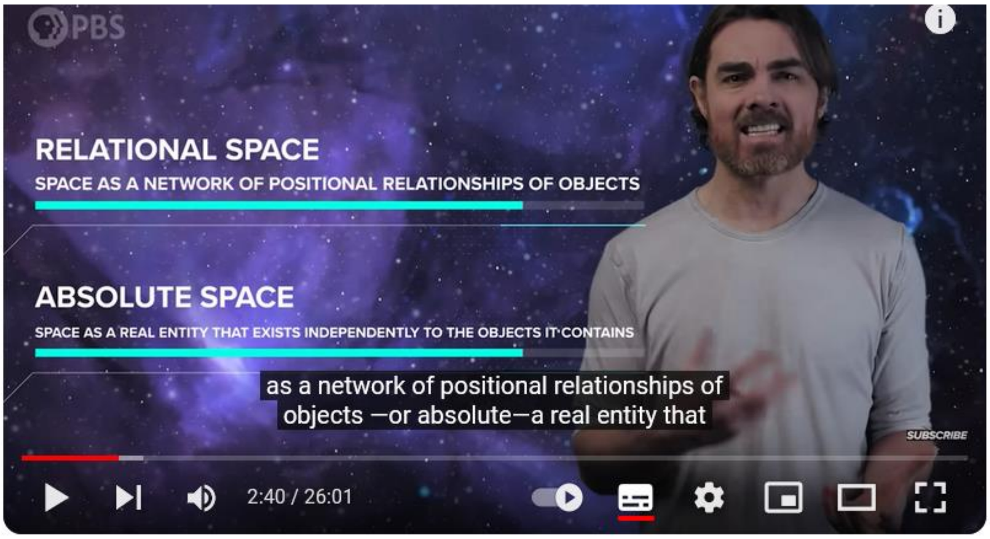

What If Space And Time Are NOT Real?

exists independently of objects, and rather, contains the objects. The latter seems to have emerged only relatively recently. Let's start with the ancients. They certainly thought a lot about space—after all, they had maps and they invented geometry. But the geometries of Euclid and Pythagorus and others didn't need the notion of space as an absolute entity—they were relational. For example, a triangle is defined by the relative lengths of its sides and its …………………………………………………………………………………………………..

(01)- Thank you to Brilliant for supporting PBS. Physics progresses by breaking our intuitions, but we are now at a point where further progress may require us to do away with the most intuitive and seemingly fundamental concepts of all—space and time themselves. Physics came into its modern form as a description of how objects move through space and time. They are the stage on which physics plays out. But that stage begins to fall apart on the tiniest scales and the largest energies, and physics falls apart with it. Many believe that the only way to make physics whole again is to break what may be our most powerful intuition yet. In our minds, space and time seem pretty fundamental, but that primacy may not extend beyond our minds. In many of the new theories that are pushing the edge of physics, spacetime at its elementary level is not what we think it is. We're going to explore the "realness" of space and time over a few upcoming episodes. We'll ask: Do our minds hold a faithful representation of something real out there, and if not, why do we think about space and time the way we do? And if space and time aren't fundamental, what is?
What makes space and time? But today we take the first step by examining how the concept of absolute space and time in physics came about in the first place, and how this concept begins to break down. We have this sense of space as an extended void – a volume waiting to be filled with matter – a regular, continuous, mappable…space in which everything that exists is embedded. Meanwhile, time is the continuous scrolling of the future into the past through the present, Not even **Matt O'Dowd** has yet understood that "time does not run for us, but we run for it", we run "through time", i.e. we move (and not only us, everything material) along time dimensions and thus "produce" flow - the passage of time. Space-time is only a stoic artifact of being, it is a yarn, it is a grid, it is a 3+3D network. And also the flow of the passage of time is "produced" by "unpacking = straightening" the curvature of the "crumpled" 3+3D space-time. In the macro world we have localities with different curvature of dimensions and therefore the flow of time is different at different potential levels from material bodies (even a galaxy can be considered a "body" with a higher curvature of dimensions than the "surrounding environment"... all controlled by the same unstoppable clock . Clocks=clocks=ticking mechanizmos are stoppable, but time = the flow of /material point/ is not stoppable. But this idea of space and time as an existence "out there", independent of its content, has become established in popular intuition relatively recently, at the same time that it was established in physics. However, for millennia people have argued about the reality or fundamentality of space-time. of objects - or as an absolute - as a real entity that exists independently of objects and rather contains objects. The latter appears to have appeared relatively recently. They certainly thought a lot about the universe - after all, they had maps. But the geometries of Euclid and Pythagoras and others did not need the concept of space as an absolute entity - they were relational. For example, a triangle is defined by the relative lengths of its sides and its

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(02)- internal angles. You don't need a coordinate grid to define a triangle—which is good, because the ancient Greeks didn't have one. Sure, their maps had longitude and latitude, but they didn't have our own mathematical habit of gridding up empty space with x, y, and z axes. As such, they didn't tend to think of empty space as having its own independent existence. The idea of the coordinate grid came much, much later. Perhaps you've heard of the Cartesian coordinate system. x, y, and z axes, each at 90 degrees to the others and gridded up so that any point in space can be defined with three numbers - the value of the closest grid-mark on each of

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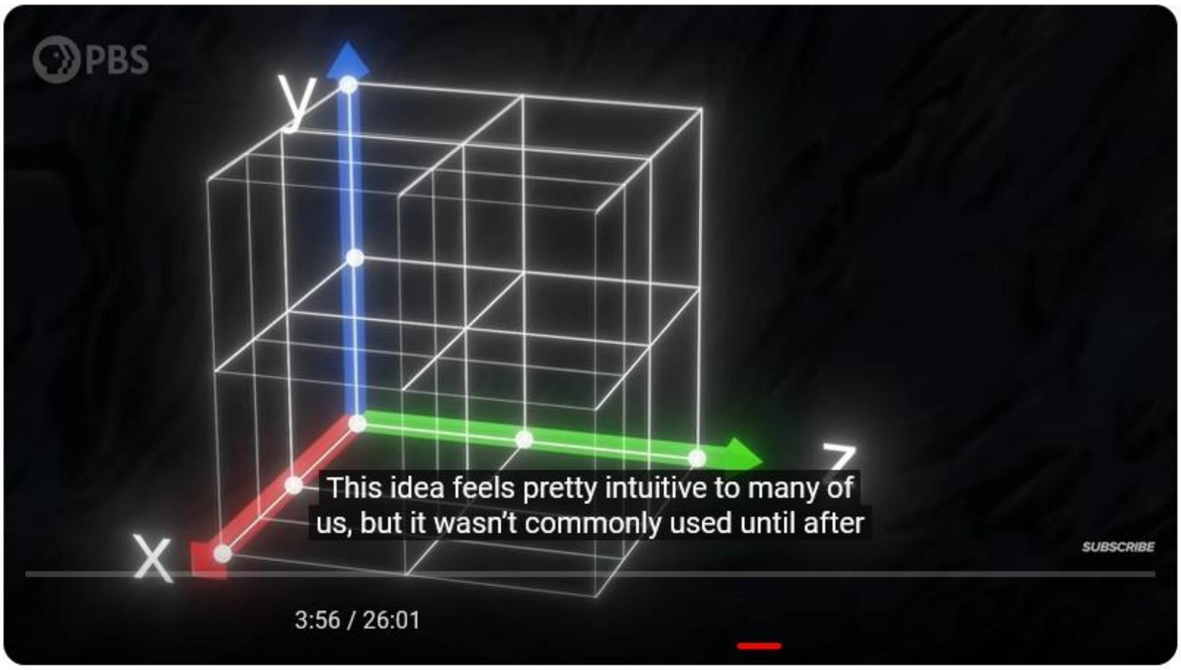

What If Space And Time Are NOT Real?

(03)- the axes. This idea feels pretty intuitive to many of us, but it wasn't commonly used until after 1637, when the French mathematician and philosopher Rene Descartes made it cool. With the coordinate system, it became possible to represent abstract numerical concepts in spatial terms—for example, by graphing an algebraic function. But it also gave us a tool for describing arbitrarily large and imaginary physical spaces—and this application would soon revolutionise all of physics. Regarding the actual nature of space, Descartes was firmly in the camp of philosophers like Plato, who didn't believe in empty space. Descartes said that space is only real as far as it defines the extension of objects and matter. But the invention of the first true mathematical coordinate system opened the door for a very, very different conception of space. And that new conception was almost entirely due to Isaac Newton. He gave us a set of equations that could, apparently, completely describe the motion of objects and how those motions change through the forces of their interactions.

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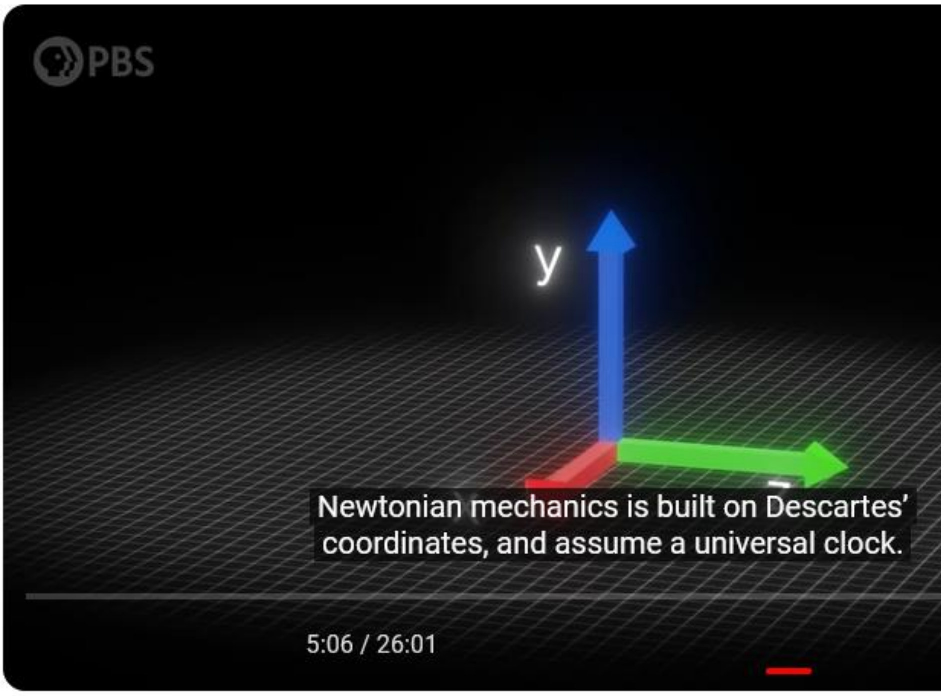
(03)- osy. Tato myšlenka se mnohým z nás zdá docela intuitivní, ale běžně se používala až po roce 1637, kdy ji francouzský matematik a filozof René Descartes učinil cool. Díky souřadnicovému systému bylo možné reprezentovat abstraktní numerické pojmy v prostorových termínech – například pomocí grafu algebraické funkce. Ale také nám poskytl nástroj pro popis libovolně velkých a imaginárních fyzických prostorů – a tato aplikace by brzy způsobila revoluci v celé fyzice. Pokud jde o skutečnou povahu prostoru, Descartes byl pevně v táboře filozofů jako Platón, kteří nevěřili v prázdný prostor. Descartes řekl, že prostor je skutečný pouze tehdy, pokud definuje rozšíření objektů a hmoty. Ale vynález prvního skutečného matematického souřadnicového systému otevřel dveře velmi, velmi odlišnému pojetí prostoru. A toto nové pojetí bylo téměř výhradně zásluhou Isaaca Newtona. Dal nám sadu rovnic, které by zjevně mohly zcela popsat pohyb objektů a to, jak se tyto pohyby mění prostřednictvím sil jejich interakcí.



What If Space And Time Are NOT Real?

(04)- Newtonian mechanics is built on Descartes' coordinates, and assume a universal clock. Those mehcanics proved wildly successful— revolutionary, really. So much so that many, including Newton, began to see the foundational building blocks of the mechanics—the coordinate of space and time—as in some way physically real. Newton himself insisted that space is absolute; it exists completely independently of any objects within it. The empty volume implied by the Cartesian grid is a thing in itself. And according to Newton time is also absolute. From Aristotle to Descartes, “time” was mostly understood as a counting of events. But In Newton’s view, there’s a single universal clock that keeps the same time for all observers--time passes “by itself ”, even in the absence of any change. Newton also believed that there was an absolute notion of stillness. Like, a master frame of reference whose x, y, and z axes are unmoving, and if your position was fixed relative to those axes then you were truly still. This is contrary to the ideas of Galileo a century prior, who showed us that velocity is relative—the speed you measure for another traveller depends on your own speed. The laws of physics are the same in any non-accelerating, or inertial frame, and so all such frames are equal. While Newton accepted the mathematical consequences of Galilean relativity, he thought the difficulty we had in defining a preferred inertial frame was a limitation of the human mind, not of the universe. The success of Newtonian mechanics elevated the notion of the realness of space and time in everyone’s minds. But there was one prominent naysayer. Newton had a nemesis. Or maybe it was Newton who was the nemesis to this guy. Ok, he shared a mutually nemetical relationship with the German mathematician Gottfried Wilhelm Leibniz. Their most famous rivalry was over the discovery of calculus, which they figured out independently—with Leibniz probably getting to it first. Newton however accused him of plagiarism, and being by far the most powerful scientist of his day, secured the credit for himself. But another point of contention between these two was on the nature of space and time. Leibniz did not accept Newton’s assertion that these dimensions were in some sense real and independent of anything in them. Instead, he thought that both space and time were relational. What does that even mean? Well, it means that objects exist, but they don’t live in a 3- or any other dimensional space. Rather, what we think of spatial separation is a quality of the objects themselves—or rather of the connection between them. Exactly why Leibnitz thought this and rejected Newton is a whole thing, that we don’t have time to get into right now. Instead, let me try to give you a sense of what it could mean for space to be encoded in objects or in their relationships, rather than existing independently to those objects. Let’s start by imagining only one dimension of space, represented as a line. This is a Newtonian space, where every point represents an absolute position in a 1-D universe. We can put some particles in the universe. The position of each in space is defined by - well, its position in space—whatever grid mark it’s next to if we add a coordinate system. The particles might have intrinsic or internal properties—say, mass, electric charge, etc., but their position isn’t a quantity that’s intrinsic to the particle. In Leibniz’s view there is no space, so we get rid of the line. The particles still exist, but they aren’t anywhere. They’re sort of just bundles of properties with no size or location. Space doesn’t exist so maybe we should place these particles on top of each other, but then again if location is meaningless we might as well separate them so we can see them. Let’s add a new property to each particle that we’ll call X. X is what we call a degree of freedom—something about the particle that can take on different values, and it can change. Other degrees of freedom could be energy and phase and spin and so on. X behaves in a particular way. For example, it can change freely. If it’s changing, then it keeps changing at the same rate and in the same direction. Now these particles have no idea about each other's existence, except in a special circumstance. For example, If two particles have values of X that are close to each other then those X values influence each other, changing the rate at which the dials turn. Maybe they want to try to be more similar, or maybe they try to be more different. If we were to represent these X values with position on a number line - an x-axis - then the behaviour of the particles looks just like particles moving around in space and attracting or repelling each other only when they're …………………………………………………………………………………………………

(04)- Newtonian mechanics is built on Descartes' coordinates and assumes a universal clock. These mechanicals have proven to be very successful – truly revolutionary. So much so that many, including Newton, came to see the basic building blocks of mechanics—coordinate space and time—as somehow physically real. Newton himself insisted that space is absolute; it exists completely independently of any objects in it. And this is how I say in my words, that 3+3D space-time is stoic, infinite, flat as a yarn, a net, a grid, flat in which "float" (after the big-bang chaotically "infinitely warped" dimensions, or cocoons wrapped in localities, coiled (not in strings, out of thin air), packages of matter, elements of matter... which then combine into conglomerates of very complex matter, from chemistry to biology to DNA. The empty volume implied by the Cartesian grid is a thing By itself. And according to Newton, time is also absolute. But the one that begins to unfold or the one along which the element of matter or even the "cursor" begins to move is already "running as the flow of time". … From Aristotle to Descartes, "time" was mostly understood as counting events. O.K. But according to Newton, there are only universal **clocks** that keep the same time the same rate of passage of time is set to a "prescribed" ticking rate for all observers - time flows "on its own", yes, but Newton did not yet recognize that there could be other rates of time flow and that in the colossal universe there is an unfolding of the dimensions of space-time, which leads "in this locality" (solar system) to a certain rate that does not change in the long term. The devil knows what the pace of time was after the birth of the solar system.?
a to i bez jakékoli změny. Newton také věřil, že existuje absolutní pojem klidu. Jako hlavní referenční soustava, jejíž osy x, y a z se nepohybují, a pokud byla vaše poloha vzhledem k těmto osám pevná, pak jste byli skutečně nehybní. To je v rozporu s myšlenkami Galilea před stoletím, který nám ukázal, že rychlost je relativní – rychlost, kterou naměříte jinému cestujícímu, závisí na vaší vlastní rychlosti. Fyzikální zákony jsou stejné v jakémkoli nezrychlujícím se nebo inerciálním rámci, a proto jsou si všechny takové rámce rovny. Zatímco Newton akceptoval matematické důsledky Galileovy relativity, myslel si, že potíže, které jsme měli při definování preferované inerciální soustavy, jsou omezením lidské mysli, nikoli vesmíru. Úspěch newtonovské mechaniky povýšil představu o reálnosti prostoru a času v myslích každého. Ale byl tu jeden prominentní odpůrce. Newton měl nepřítele. Nebo to možná byl Newton, kdo byl nepřítelem toho chlapa. Dobře, sdílel oboustranně negativní vztah s německým matematikem **Gottfriedem Wilhelmem Leibnizem.** Jejich nejslavnější rivalita spočívala v objevu kalkulu, na který přišli nezávisle – přičemž Leibniz se k němu pravděpodobně dostal jako první. Newton ho však obvinil z plagiátorství a tím, že je zdaleka nejmocnějším vědcem své doby, si zajistil uznání. Ale další bod sporu mezi těmito dvěma byl o povaze prostoru a času. Leibniz nepřijal Newtonovo tvrzení, že tyto dimenze byly v jistém smyslu skutečné a nezávislé na čemkoli v nich. Místo toho si myslel, že prostor i čas jsou vztahové. Co to vůbec znamená? Znamená to, že předměty existují, ale nežijí ve 3- nebo jiném rozměrném prostoru. To, co si myslíme o prostorové separaci, je spíše kvalita objektů samotných – nebo spíše spojení mezi nimi. Přesně to, proč si to Leibnitz myslel a odmítl Newtona, je celá věc, kterou teď nemáme čas rozebírat. Místo toho se vám pokusím nastínit, co by pro prostor mohlo znamenat, že je zakódován v objektech nebo v jejich vztazích, místo aby existoval nezávisle na těchto objektech. Začněme tím, že si představíme pouze jeden

rozměr prostoru, znázorněný jako čára. Toto je newtonovský prostor, kde každý bod představuje absolutní pozici v 1-D vesmíru.
We can put some particles into space. The position of each one in space is defined - that is, by its position in space - regardless of the grid mark it is next to if we add a coordinate system. **Particles can have** intrinsic or intrinsic **properties - say mass**, notably that **for the first time** I hear some scientist say - as I'm still writing - that weight is a property. (!) electric charge, etc., but their position is not a quantity intrinsic to the particle. There is no place in Leibniz's view, so we get rid of the line. The particles still exist, but they are nowhere. They are just parcels of real estate with no size or location. Space doesn't exist, so maybe we should place these particles on top of each other, but if the placement doesn't make sense, we can also separate them to see them. Let's add a new property to each particle, which we'll call X. X is what we call a degree of freedom freedom - something about the particle that can take on different values and change. Other degrees of freedom can be energy and phase and spin and so on. X behaves in a certain way. For example, it can change arbitrarily. If it changes, then it keeps changing at the same rate and in the same direction. Now these particles have no idea of mutual existence, except in special circumstances. For example, if two particles have X values that are close to each other, then those X values interact and change the speed of the dials. Maybe they want to be more alike, or maybe they're trying to be more different. If we were to represent these values of X by a position on a number axis—the x-axis—then the behavior of the particles looks like particles moving through space, attracting or repelling each other only when they are
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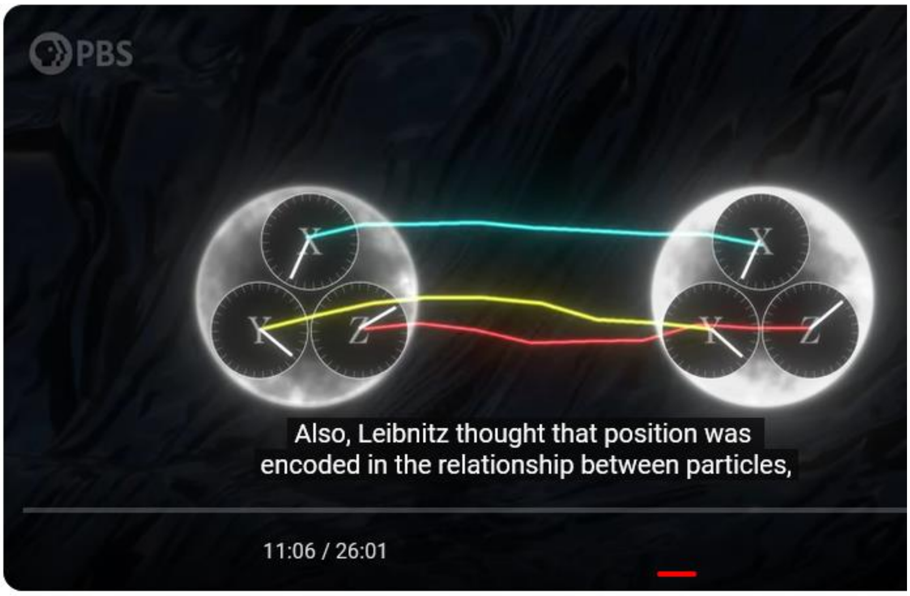
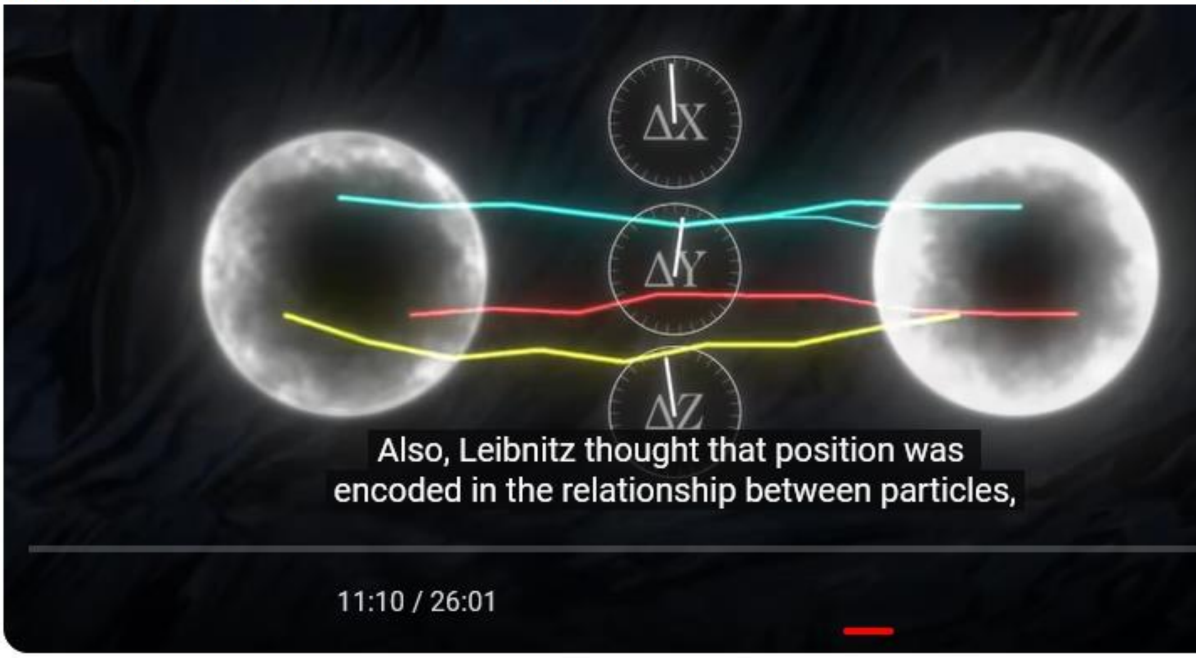
(05)- close together. We can't tell the difference between particles moving in space versus space-like behaviour emerging from a degree of freedom within the particles. This thought experiment isn't explicitly what Leibniz described, nor is it how things should really be to explain a universe like our own. For one thing, we need 3 spatial dimensions, not one. X, Y, & Z would all have to be close to each other for particles to interact.

(05)- blízko sebe. Nedokážeme rozeznat rozdíl mezi částicemi pohybujícími se v prostoru a chováním podobným prostoru vycházejícímu z určitého stupně volnosti v částicích. Tento myšlenkový experiment není výslovně tím, co popsal Leibniz, ani to není to, jak by věci měly skutečně být, aby vysvětlily vesmír, jako je ten náš. Pro jednu věc potřebujeme 3 prostorové rozměry, ne jeden. X, Y a Z by musely být všechny blízko sebe, aby částice interagovaly.



What If Space And Time Are NOT Real?



What If Space And Time Are NOT Real?

(06)- Also, Leibnitz thought that position was encoded in the relationship between particles, not in the objects themselves. He gave his elementary particles names - monads - which among other things had rudimentary consciousness, and that space emerged from their first-person perspectives of each other. But we don't actually need those extra qualities--the idea of particles with interacting, internal degrees of freedom illustrates how space can emerge from the relationships between elements that are themselves not in space. So that's Leibnitz on space. He disagreed with Newton on time in a similar way, believing it to be a measure of the change intrinsic to each element, rather than a cosmic clock that kept the universe in sync. Of course Newton was the undisputed boss of science back then, and so his preference for absolute space and time won over the physicists, and ultimately found its way into the popular

imagination. But who was really right? Are objects in space and moving through time, or are space and time somehow in objects and
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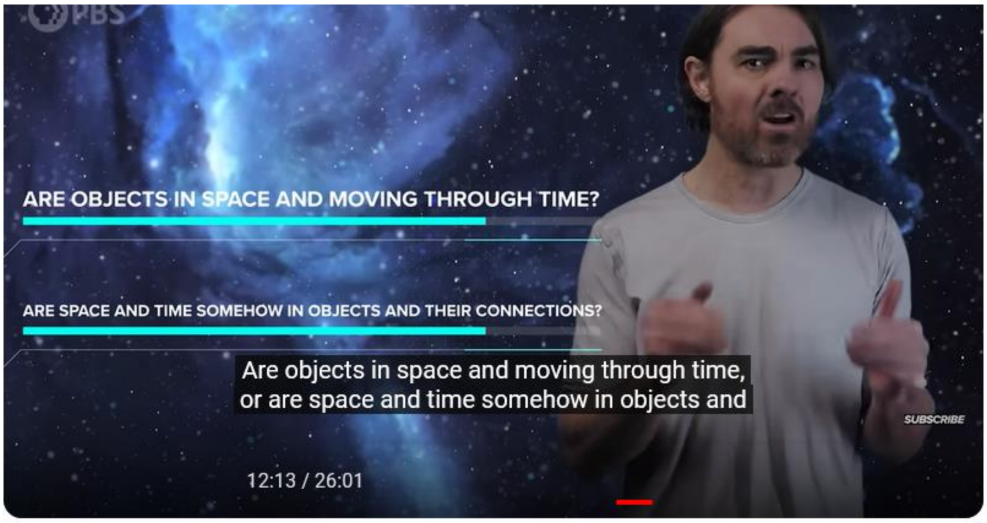
(06)- Leibnitz also thought that position is encoded in the relationship between particles, not in the objects themselves. He gave names to his elementary particles – monads – which, among other things, had basic consciousness and this space emerged from their first-person perspective on each other. But we don't really need these extra properties - the idea of particles with interacting internal degrees of freedom illustrates how space can emerge from relationships between elements that are not themselves in space. So that's Leibnitz in space. In a similar way, he disagreed with Newton about time, believing that it was time the rate of change inherent in each element, rather than a cosmic clock that kept the universe in sync. Thus neither Newton nor Leibnitz had yet considered, as I did, that the "ticking" of time, the passing of time, is essentially the "unwrapping" of the curvature of the crooked 3+3 dimensions. It makes me so uneasy… Newton was, of course, the undisputed boss of science at the time, and so his preferences for absolute space and time won out over physicists and eventually found their way into the popular imagination. But who was really right? **Are objects in space and move through time, or are space and time somehow in objects** , both (!) and this is my HDV…, mass objects are built = made of 3+3 dimensions np, so they are, yes , space and time are "in objects, within" as they are not, when they are built of them http://www.hypothesis-of-universe.com/index.php?nav=e And at the same time objects = matter "floats, floats" through curved space-time and maybe even this curved space-time (that's the 4 fields) still floats in the basic flat 3+3D space-time **a**
12:14



What If Space And Time Are NOT Real?

(07)- their connections? Are the dimensions absolute or relational? The big next development seemed to support Newton. Over the 19th century, our understanding of the phenomena of electricity and magnetism converged, revealing the existence of something called the electromagnetic field. A field is just some property that can take on a numerical value at all points in space. For example, temperature is a field defined in the air around you. It’s emergent from the properties of the air particles. But the electromagnetic field doesn’t need particles. For the first time, it seemed that a field could be a property of space itself. So, surely if space can have properties, then space must objectively exist. And more intrinsic properties emerged with the development of quantum mechanics—for example, space was shown to have a sort of energy even in the absence of particles—so-called vacuum energy. However, if we really want to decide whether space and time are real—to judge between Leibnitz and Newton—we need the ultimate arbiter. We need the greatest expert of space and time that ever lived—and that's Albert Einstein. We've talked about Einstein's special and general theories of relativity many times before. Let's just go over what the theory changed about our notions of the dimensions. With special relativity, the separation of 3-D space and 1-D time ended. They became 4-D spacetime. Einstein showed that our motion through space and our motion through time are linked. A clock moving relative to you ticks slower from your perspective. And then with general relativity we see that the presence of mass and energy stretch and warp both space and time. This causes straight line trajectories that we expect on a Cartesian grid to become curved, and the apparent change in an object's path in the presence of mass is Einstein's explanation of gravity. Relativity overturned some of Newton's notions about absolute space and time: that they are independent entities, that there's a universal clock for time, and that there's some sort of ultimate, rigid coordinate system for space. But what did these mean for the central question of this episode: what about the realness of space and time? Actually, spacetime in Einstein's universe kind of feels even more substantial than before. It's like a fabric that can be warped. It can hold energy. It can even propagate waves—gravitational waves. Einstein showed that empty space has properties, so it must be real, right? Well, maybe - but Einstein's view is really a radical departure from Newton's—to the extent that Einstein even called himself a Leibnizian. Newton believed in space as an underlying stage on which the particles and the fields danced. But Einstein insisted that no such background existed—and that's because to him, space and the gravitational field are the same thing. This field is not painted on top of a coordinate system; rather, the coordinate system is a quality of the field. Absent this field there is nothing. So all of this landed Einstein somewhere between Leibniz and Newton. He believed that there is an extended structure "out there" that can hold objects and on which distances and durations can be defined, but it's not absolute and fundamental in the way that Newton thought. According to Einstein, Descartes was right, and so was Plato: there's no such thing as empty space. To quote Einstein, "there is no space empty of field" So is Einstein the last word on the matter? Far from it. We know that general relativity breaks down on very small scales—smaller than around 10^-35 meters, which is the Planck length. There it comes into hopeless conflict with quantum mechanics, and it becomes impossible to meaningfully define shorter distances. Just as it's meaningless to define durations shorter than the Planck time. This conflict between Einstein's theory and quantum mechanics is one of the major challenges and inspirations for progressing to the next level of physics. And essentially all of the possible paths forward force us to rethink our understanding of the dimensions—whether multiplying their number as in string theory, or by having them emerge from elements that, themselves, do not exist within space—such as in loop quantum gravity, which we've discussed, or the cellular automata of Wolframs physics project, or in the entanglements between elements on a holographic horizon, or from Arkani-Hamed's amplituhedron among others.. If any of these latter are true, then Leibniz may have been onto something; space exists in the relationships between some sort of elementary… something, not as an absolute and physically real fabric. Leibniz also had another controversial idea: he thought that space was in our minds. This isn't the same as saying that reality is in our minds—it's not even the same as saying that space doesn't exist. Rather, Leibniz felt that whatever it is that's out there that behaves like space only gains the

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(07)- their connection? Are dimensions absolute or relational? Well, here's a question. I am definitely saddened that scientists do not want to investigate my visions, are silent, or rather lean against me. Why? Another major development seemed to favor Newton. During the 19th century, our understanding of the phenomena of electricity and magnetism converged and revealed the existence of something called an electromagnetic field. **Field** is just some property, O.K. curvature cp such that it has not yet exceeded the "(s)packing" of dimensions into cocoons = packages = a ball of elementary particles (then into conglomerates, chemistry, biology, DNA), that is **field**... which can acquire numerical values at all points in space. For example, temperature is a field defined in the air around you. This results from the properties of air particles. But the electromagnetic field does not need particles. OK it is a state of curvature that has not exceeded the limits for packing "dimensions into matter"… For the first time, it seemed that field might be a property of space itself. So if space can have properties, then space must objectively exist. And other intrinsic properties appeared with the development of quantum mechanics - for example, it turned out that the universe has a certain kind of energy even in the absence of particles - the so-called **vacuum energy**. Yes, I have been talking about this for several years too, eg http://www.hypothesis-of-universe.com/docs/eng/eng_130.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_032.pdf ; and I propose "for the existence of dark energy" that it may be energy emerging emergently from a boiling vacuum on Planck scales. The boiling vacuum is matter-forming, every warping of dimensions is matter-forming. http://www.hypothesis-of-universe.com/docs/eng/eng_078.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_167.pdf ; But if we really want to decide whether space and time are real—to judge between Leibnitz and Newton—we need a final arbiter. HDV. We need the greatest expert on space and time who ever lived - and that's Albert Einstein. http://www.hypothesis-of-universe.com/docs/aa/aa_336.pdf We have talked about Einstein's special and general theories of relativity many times. Let's just review what this theory has changed about our ideas about dimensions. With special relativity, the separation of 3-D space and 1-D time ended. They became 4D spacetime. Unfortunately, it is not enough. Scientists Overlook My Vision of 3+3D Spacetime… http://www.hypothesis-of-universe.com/docs/aa/aa_080.pdf ; http://www.hypothesis-of-universe.com/docs/aa/aa_055.pdf ; Einstein showed that our movement through space and our movement through time are connected. A clock that moves relative to you ticks more slowly from your perspective. And then with general relativity we see that the presence of matter and energy stretches and warps both space and time. This causes the straight trajectories we expect on a Cartesian grid to curve, and an apparent change in the path of the object in curved space-time (hence the basic Observer observes, at home in the projectile, that the rocket (an object in non-uniform motion) rotates..., leading to to explain why there is no dilation on the rocket, the commander of the rocket does not observe it, only we-the Observer in the basic frame fit to rest observe it... in the presence of matter is Einstein's explanation of gravity. Relativity overturned some of Newton's ideas about absolute space and time: that they are independent entities, that there is a universal clock for time, and that there is some kind of finite, fixed coordinate system for space.But what did this mean for the central question of this episode: what about the reality of space and time?In reality, spacetime in Einstein's universe still seems to be more substantial than before. It's like a substance that can be twisted. HDV in pale pink. It can even propagate waves. Einstein showed that empty space has properties, right? Well, maybe - but Einstein's view is actually a radical departure from Newton's - to the point that Einstein even called himself a Leibnizian. Newton believed in space as the fundamental stage on which particles and fields dance.

But Einstein insisted that there was no such background—because for him space and the gravitational field were the same thing. This field is not drawn on a coordinate system; rather, the coordinate system is a field quality. Without this field, there is nothing. So all of this landed Einstein somewhere between Leibniz and Newton. He believed that there was an extended structure "out there" that could hold objects and on which distances and durations could be defined, but it was not absolute and fundamental in the way Newton thought. According to Einstein, Descartes was right and so was Plato: there is no such thing as empty space. To quote Einstein, "there is no space empty field" So is Einstein the last word on the matter? Far from it. We know that general relativity breaks down on very small scales - smaller than about 10^-35 meters, which is the Planck length. O.K. There it runs into a hopeless conflict with quantum mechanics and it is impossible to meaningfully define shorter distances. Just as it makes no sense to define a duration shorter than the Planck time. This conflict between Einstein's theory and quantum mechanics is one of the main challenges and inspirations for progressing to the next level of physics. And basically **all possible ways forward force us to rethink our understanding of dimensions** - either by multiplying their number as in string theory, or by emerging from elements that do not exist in space by themselves - such as loop quantum gravity , which we talked about, or the cellular automata of the Wolframs Physics Project, or in the entanglement between the elements on the holographic horizon, or from the Arkani-Hamed Amplituhedron, among others. If any of this is true, then Leibniz may have been on to something; space exists in relations between some kind of elemental ... something, not as an absolute and physically real substance. **Leibniz also had another controversial idea**. And lucky that his surrounding physics community were intelligent, wise people compared to today, when a lot of mudr-pudras (wannabe physicists, educated people) are not ashamed to spit and insult laymen to shit, idiots, ***** with well-thought-out ideas : he thought think that space is in our minds. This is not the same as saying that reality is in our minds - it is not even the same as saying that space does not exist. Rather, Leibniz felt that whatever it is out there that behaves like space is just gaining

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(08)- subjective feeling of depth, breadth, height, and distance when our brains try to organise objects that are separated by an altogether more abstract property. Kind of like how the subjective experience of red only exists when brains interpret a frequency of light. It's incredibly difficult to imagine a universe without space or time. The dimensions seem hardwired into our brains. Perhaps we need to break this preconception to move forward in physics. If so, we need to explore how and why our brains build our very convincingly spatial and temporal inner worlds. And we'll do that in an episode very soon, and perhaps get closer to figuring out whether we live in an absolute or a relational spacetime. Thank you to Brilliant for supporting PBS. Brilliant is an online learning platform for STEM with hands-on, interactive lessons. Brilliant is for curious learners, both young and old, professional and inexperienced. Brilliant courses teach you how to think (via interactive lessons and problem-solving activities/exercises.) and solve problems with interactive lessons in STEM.For example, Artificial neural networks learn by detecting patterns in huge amounts of information. Like your own brain, artificial neural nets are flexible, data-processing machines

that make predictions and decisions. In fact, the best ones outperform humans at tasks like chess and cancer diagnoses. In this course, you'll dissect the internal machinery of artificial neural nets through hands-on experimentation, not hairy mathematics. You'll develop intuition about the kinds of problems they are suited to solve, and by the end you'll be ready to dive into the algorithms, or build one for yourself.To learn more about Brilliant, go to brilliant.org/spacetime Today we're looking at your comments from the last two episodes. There was the one about how Earth really moves through the universe, and then the one about how the nucleus is held together by meson exchange. Starting with the motion of the Earth. Matt Thomas asks, when we put together all of our motion through the universe, how fast are we moving relative to the CMB? And what effect does that motion have on our experience of time? The answer is that we're moving at 368km/s relative to the CMB. This isn't unusual—most things in the universe have some relative velocity like this. But you're right that there should be a time dilation relative to the CMB. Let's assume the frame of reference of the stuff of the Earth has on average been moving at that speed over the history of the universe. Less time has passed in that reference frame compared to the rest frame of the CMB—the Big Bang was more recent for our hypothetical moving frame. I figured it out—the difference is about 10,000 years. Pretty tiny compared to the age of the universe. Karl Sheffield asks what is in front of our path around the Galaxy? Well, immediately in front: the interstellar medium. The Sun's heliosphere—a bubble containing its outward-flowing solar wind and magnetic field—is plowing its way through very low-density gas and dust grains. There are also bigger things that we can't see easily—bits of rock or ice like oumuamua that were ejected from other star systems. There will be ejected planets, brown dwarfs, black holes and other stellar remnants. In terms of stuff we can see—well we're heading in the direction of the star Vega, but Vega is also orbiting the galaxy and so we're not going to collide. That said, we do occasionally get close enough to a star or stellar remnant to mess with orbits in our system, with the main danger being an increase in inner-solar system comets. That's more likely when we're passing through the disk and especially in a spiral arm. It'll be millions of years before that happens again. Moving on to the episode on the strong nuclear force. Fensox asks whether Hideki Yukawa eventually got the recognition he deserves for discovery of the strong and weak forces. He did. He got the 1949 Nobel Prize for predicting the existence of the pi meson. And his name is all over the standard model—the Yukawa interaction governs the strong force part of the standard model Lagrangian as well the Higgs coupling termSeveral people asked how it is that the exchange of virtual particles can cause particles to be attracted. After all, in the analogy of particles throwing balls at each other, it seems that the exchange of momentum should only push them apart. The short answer is that the balls analogy is a pretty limited one, and even the notion of virtual particles is something of a metaphor.What's really happening is that the quantum fields between and around the particles are disturbed in a way that can be approximated as
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(08)- subjektivní pocit hloubky, šířky, výšky a vzdálenosti, když se náš mozek snaží uspořádat objekty, které jsou odděleny zcela abstraktnější vlastností. Něco jako, jak subjektivní zkušenost s červenou existuje pouze tehdy, když mozek interpretuje frekvenci světla. Je neuvěřitelně těžké si představit vesmír bez prostoru a času. Zdá se, že rozměry jsou pevně zapojené do našich mozků. Možná potřebujeme prolomit tento předsudek, abychom se posunuli ve fyzice kupředu. Pokud ano, musíme prozkoumat, jak a proč naše mozky staví naše velmi přesvědčivě prostorové a časové vnitřní světy. A to uděláme v epizodě velmi brzy a možná se přiblížíme k tomu, abychom zjistili, zda žijeme v absolutním nebo vztahovém časoprostoru. Děkujeme společnosti Brilliant za podporu PBS. Brilliant je online výuková platforma pro STEM s praktickými interaktivními lekcemi. Brilliant je pro zvídavé studenty, mladé i staré, profesionální i nezkušené. Brilantní kurzy vás naučí myslet (prostřednictvím interaktivních lekcí a aktivit/cvičení k řešení problémů) a řešit problémy pomocí interaktivních lekcí STEM. Například umělé neuronové sítě se učí detekcí vzorců v obrovském množství informací. Stejně jako váš vlastní mozek jsou umělé neuronové sítě flexibilní stroje na zpracování dat, které provádějí předpovědi a rozhodnutí. Ve skutečnosti ti nejlepší předčí lidi v úkolech, jako jsou šachy a diagnózy rakoviny. V tomto kurzu rozeberete vnitřní mašinérii umělých neuronových sítí prostřednictvím praktického experimentování, nikoli chlupaté matematiky. Rozvíjíte intuici o druzích problémů, které jsou vhodné k řešení, a na konci budete připraveni ponořit se do algoritmů nebo si jeden vytvořit pro sebe. Chcete-li se o Brilliant dozvědět více, přejděte na brilant.org/spacetime Dnes se podíváme na vaše komentáře z posledních dvou epizod. Byl tam ten o tom, jak se Země skutečně pohybuje vesmírem, a pak ten o tom, jak jádro drží pohromadě výměnou mezonů. Počínaje pohybem Země. Matt Thomas se ptá, když dáme dohromady veškerý náš pohyb vesmírem, jak rychle se pohybujeme vzhledem k CMB? A jaký vliv má tento pohyb na naši zkušenost s časem? Odpověď je, že se pohybujeme rychlostí 368 km/s vzhledem k CMB. To není neobvyklé – většina věcí ve vesmíru má nějakou relativní rychlost, jako je tato. Ale máte pravdu, že by mělo dojít k časové dilataci vzhledem k CMB. Předpokládejme, že referenční rámec hmoty Země se v průběhu historie vesmíru pohyboval v průměru touto rychlostí. V tomto referenčním rámci uplynulo méně času ve srovnání se zbývajícím rámcem CMB – Velký třesk byl pro náš hypotetický pohyblivý rámec novější. Přišel jsem na to – rozdíl je asi 10 000 let. Docela maličké ve srovnání s věkem vesmíru. Karl Sheffield se ptá, co je před naší cestou kolem Galaxie? No, hned vpředu: mezihvězdné médium. Sluneční heliosféra – bublina obsahující jeho ven proudící sluneční vítr a magnetické pole – si razí cestu skrz zrna plynu a prachu s velmi nízkou hustotou. Existují také větší věci, které nemůžeme snadno vidět – kousky skály nebo ledu jako oumuamua, které byly vyvrženy z jiných hvězdných systémů. Budou zde vyvržené planety, hnědí trpaslíci, černé díry a další pozůstatky hvězd. Pokud jde o věci, které můžeme vidět – míříme směrem k hvězdě Vega, ale Vega také obíhá galaxii, takže se nesrazíme. To znamená, že se občas dostaneme dostatečně blízko ke hvězdě nebo pozůstatku hvězdy, abychom si popletli oběžné dráhy v naší soustavě, přičemž hlavním nebezpečím je nárůst komet ve vnitřní sluneční soustavě. To je pravděpodobnější, když procházíme diskem a zejména ve spirálovém rameni. Než se to stane znovu, uplynou miliony let. Přejdeme k epizodě o silné jaderné síle. Fensox se ptá, zda Hideki Yukawa nakonec získal uznání, které si zaslouží za objev silných a slabých sil. Udělal to. V roce 1949 dostal Nobelovu cenu za předpověď existence pí mezonu. A jeho jméno je po celém standardním modelu – interakce Yukawa řídí silnou silovou část standardního modelu Lagrangian a také termín Higgsovy vazby Několik lidí se ptalo, jak je možné, že výměna virtuálních částic může způsobit přitahování částic. Ostatně v analogii částic házejících po sobě koule se zdá, že výměna hybnosti by je měla pouze od sebe odtlačit. Krátká odpověď je, že analogie kuliček je dost omezená a dokonce i pojem virtuálních částic je něco jako metafora. Ve skutečnosti se děje to, že kvantová pole mezi částicemi a kolem nich jsou narušena způsobem, který lze přiblížit jako

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(09)- the work of many virtual particles. But those virtual particles don't simply originate at particle one and travel in a straight line to particle two. They can originate in a wide region governed by the uncertainty principle, including on the opposite side of particle two. They can also have any mass, including complex masses. All of this enables the virtual particles to transfer momentum in a way that pulls the particles together instead of apart. But really, these particles are a mathematical fiction to describe field behavior. No balls are being thrown. Feelincrispy points out that I could easily just make something up and %99.9 of you would have no idea. I don't know if I agree with that, but otherwise I have no comment. sleekweasel asks how the island of stability works, given that if a nucleus grows too big, its mesons can't hold it together. To remind everyone —the island of stability is a region of the periodic table of very large nuclei that is theoretically more stable than the current heavy end of the table that we've discovered at this point. Actually, I don't really know the details of this. But fortunately Gareth Dean jumped in to the comment section to answer, so I'm just going to read that. He says: Nuclei aren't just blobs of particles, they have 'nuclear shells'. When these are empty the few particles in them are far apart and cannot exchange mesons. When they are full, lots of particles are packed close and can bind strongly. 'Islands of stability' are places where the shells are full, binding is strong and the nucleus is more stable. Regarding my use of the labradoodle to illustrate the amount of force between adjacent protons in an atomic nucleus. Many of you expressed interest in using labradoodles as some sort of standard unit of measurement. This is a little impractical because we'd need to use the mean weight of a statistically large number of labradoodles. But I personally volunteer to run the NIST labradoodle standards facility to make sure those very good boys and girls get all their standard treats and pets. Many of you also pointed out that a universe without labradoodles is not a universe they'd want to live in. Also agreed. Which brings us to Steve. Steve sees the elimination of the strong nuclear force and with it the elimination of all chemistry, biology and life, as a promising way to rid the world of labradoodles. Steve, you've identified yourself as labradoodle-foe, and your name has been passed to a secret elite team at the NIST labradoodle
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standards facility. They'll be watching you. In fact all labradoodles will be watching you.
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(09)- práce mnoha virtuálních částic. Ale tyto virtuální částice jednoduše nepocházejí z částice jedna a necestují po přímce k částici dvě. Mohou vznikat v široké oblasti, která se řídí principem neurčitosti, a to i na opačné straně částice dvě. Mohou mít také libovolnou hmotnost, včetně komplexních hmotností. To vše umožňuje virtuálním částicím přenášet hybnost způsobem, který částice stahuje k sobě, nikoli od sebe. Ale ve skutečnosti jsou tyto částice matematickou fikcí k popisu chování pole. Nehází se žádné koule. Feelincrispy poukazuje na to, že bych si mohl snadno něco vymyslet a %99,9 z vás by o tom nemělo tušení. Nevím, jestli s tím souhlasím, ale jinak nemám komentář. sleekweasel se ptá, jak funguje ostrov stability, vzhledem k tomu, že pokud se jádro příliš zvětší, jeho mezony ho nemohou udržet pohromadě. Abychom všem připomněli – ostrov stability je oblastí periodické tabulky velmi velkých jader, která je teoreticky stabilnější než současný těžký konec tabulky, který jsme v tomto bodě objevili. Popravdě, podrobnosti o tom opravdu neznám. Ale naštěstí Gareth Dean skočil do sekce komentářů, aby odpověděl, takže si to přečtu. Říká: Jádra nejsou jen kapky částic, mají „jaderné obaly“. Když jsou prázdné, těch pár částic v nich je daleko od sebe a nemohou si vyměňovat mezony. Když jsou plné, spousta

částic je zabaleno blízko a mohou se silně vázat. „Ostrovy stability“ jsou místa, kde jsou skořápky plné, vazba je pevná a jádro stabilnější. Pokud jde o mé použití labradoodle k ilustraci velikosti síly mezi sousedními protony v atomovém jádru. Mnoho z vás projevilo zájem o použití labradoodles jako nějaké standardní jednotky měření. To je trochu nepraktické, protože bychom museli použít průměrnou hmotnost statisticky velkého počtu labradoodlů. Ale já osobně dobrovolně provozuji zařízení pro standardy labradoodle NIST, abych zajistil, že tito velmi dobří chlapci a dívky dostanou všechny své standardní pamlsky a domácí mazlíčky. Mnoho z vás také poukázalo na to, že vesmír bez labradoodles není vesmír, ve kterém by chtěli žít. Souhlasím také. Což nás přivádí ke Stevovi. Steve vidí likvidaci silné jaderné síly a s ní i likvidaci veškeré chemie, biologie a života jako slibný způsob, jak zbavit svět labradoodlů. Steve, identifikoval jsi se jako nepřítel labradoodle a tvé jméno bylo předáno tajnému elitnímu týmu v NIST labradoodle
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standardní zařízení. Budou vás sledovat. Ve skutečnosti vás budou všichni labradoodlové sledovat.
JN, 27.08.2024
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Píši o temné hmotě, moje web-odkazy
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http://www.hypothesis-of-universe.com/docs/aa/aa_077.pdf křivení dimenzí kde se bere TE

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