https://www.youtube.com/watch?v=9If-K9R3Ka4&t=13s

Where Are All The Hidden Dimensions?

Kde jsou všechny skryté dimenze?

History of the Universe

856 tis. odběratelů

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--- Written by Joseph Conlon Professor of Theoretical Physics, University of Oxford Author, Why String Theory? https://www.amazon.com/Why-String-The... Edited and Narrated by David Kelly Thumbnail Art by Ettore Mazza Huge thanks to Oliver Knill for the use of his Calabi-Yau imagery, and Jeff Bryant for his. Footage from Videoblocks, Artgrid. Footage of galaxies from NASA Goddard. Image Credits: Democritus By Didier Descouens - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index... Aspen Centre for Physics By Éamonn Ó Muirí - Flickr: The Aspen Center for Physics, CC BY 2.0, https://commons.wikimedia.org/w/index... Silesia By derivative work: Dunmerr (talk) - Wroclaw_1.jpg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index... String theory SriVrushank(1840372), CC BY-SA 4.0 https://creativecommons.org/licenses/..., via Wikimedia Commons String theory t duality calculations Andrius.v, CC BY 3.0 https://creativecommons.org/licenses/..., via Wikimedia Commons Mobius Strip By 09glasgow09 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index... By Alex P. Kok - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index... Klein bottle By Tttrung - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index... Roman surface By en:user:A13ean - Transferred from en.wikipedia to Commons by Keyi., CC BY-SA 2.5, https://commons.wikimedia.org/w/index... Calabi Yau Manifold By The original uploader was Lunch at English Wikipedia. - Transferred from en.wikipedia to Commons by Lunch. This diagram was created with Mathematica., CC BY-SA 2.5, https://commons.wikimedia.org/w/index... Quintic By The original uploader was Floriang at German Wikipedia. - Transferred from de.wikipedia to Commons by Trockennasenaffe using CommonsHelper. This diagram was created with Mathematica., CC BY-SA 3.0, https://commons.wikimedia.org/w/index... Plant cells By Des_Callaghan - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index... 00:00 Introduction 04:15 The Fifth Dimension 10:03 A Theory of Strings 16:30 Visualizing The Invisible (Calabi-yau Manifolds) 22:31 Where Are The Hidden Dimensions? 33:01 Hunting For Evidence At The Beginning Of Time.

He who does not have a mustache is not a scientist...

0:02
(01)- Fame, glory, riches and acclaim… For those whose dream it is to be recognised in their own lifetime, fundamental physics is not the best choice of career. Over two thousand years ago, the Greek philosopher Democritus speculated that matter, instead of arising from combinations of earth, air, fire and water, was built from tiny indivisible constituents called atoms. These atoms would be small, fundamental and indestructible, and he hypothesised that such atoms would be the basic ingredients of all the objects and all the matter that we see around us.This was called the atomic hypothesis. In time, this did turn out to be true – but not until sixty generations after Democritus had died at the end of his long and full life, and his own atoms had been laid to rest within the warm sun-baked Mediterranean soil. More recently, in 1783 the English clergyman-scientist John Michell was thinking about the implications of Newton’s laws of forces and Newton’s theories of gravity, when they were applied to the corpuscular theory of light. Michell conceived of bodies which could be sufficiently dense and sufficiently massive that the escape velocity from their surface would be even greater than the speed of light itself. In this case, Michell theorised, even light itself would be unable to escape, and these objects would be highly massive but totally dark. He named them ‘Dark stars’. Michell’s idea was clever, correct and revolutionary – and so far ahead of his time that it would be entirely forgotten for two centuries. It was only in the 1970s, at a time when the first astrophysical Black Holes were being discovered, that his work was remembered again. Atoms as matter’s building blocks, and black holes as compact astrophysical objects – two ideas first conceived of centuries before they were widely acknowledged to be true. To this we can, perhaps, add a further, even more revolutionary idea. An idea first suggested by Theodor Kaluza in the early 1920s, an idea mused on by Einstein himself, but still argued about today. This is the idea that there are extra, as yet undiscovered, dimensions to space. Additional, hidden, directions beyond up and down, across, x y and z. Directions we have never yet been able to perceive. But what would this mean? Where would such dimensions exist - and what would they look like? And how would we – ever – be able to detect them? This video has been kindly sponsored by Babbel. Einstein spoke German, Curie spoke French, Dirac was English. Groundbreaking physics is an international effort, and that was only in 1927. Today, our world is more multilingual and global than ever - so being multilingual is hugely helpful. It's a simple, fun way to learn the basics and more - Babbel starts you straight from the beginning with conversational tools it's focused on helping you communicate, not solve grammar puzzles - its lessons having been designed by real teachers with real life experience, not algorithms or AI It even has a podcast

section - I have personally found podcasts an amazing way to improve my Spanish, and Babbel has lots of different fun ways to help you absorb the language in a natural, native way. So click on the link to get up 65% off your subscription, and start learning one of 14 languages available. Thanks to Babbel for supporting educational content on YouTube. The Fifth Dimension This story starts in 1916, in the midst of the largest and bloodiest war the world had ever seen. While the meat grinder of the Somme ate up the youth of Europe, the thoughts of Albert Einstein were on higher and more eternal matters. For the last ten years, Einstein had been attempting to extend his Special Theory of Relativity, developed in 1905, to include gravity. After many false starts, he finally succeeded, and formulated his General Theory of Relativity. This turned gravity – the force we have all been familiar with since we were babies – into geometry, the curved geometry of four spacetime dimensions. It was a beautiful theory – but a hard one to understand. The mathematics was unfamiliar, the physics seemed obscure and any possible experimental consequences seemed few and far away. One of the physicists grappling with this new and remarkable theory of Einstein was Theodor Kaluza. Kaluza had been born into a vanished society – Silesia, as a part of Prussia under the German Imperial Kaiser. He grew up in the cultured university city of Konigsberg, where his father was an academic, drinking long and deep from the intellectual values of traditions of German-speaking Europe and its great universities. The places and society he grew up have now utterly vanished or changed – Silesia has long since been part of Poland, while

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(01)- Sláva, sláva, bohatství a uznání… Pro ty, jejichž snem je být uznán za jejich života, není základní fyzika tou nejlepší volbou kariéry. Před více než dvěma tisíci lety řecký filozof Democritus spekuloval, že hmota místo toho, aby vznikla kombinací země, vzduchu, ohně a vody, byla postavena z malých nedělitelných složek zvaných atomy. Tyto atomy by byly malé, základní a nezničitelné a on předpokládal, že takové atomy budou základními složkami všech objektů a veškeré hmoty, kterou kolem sebe vidíme. Tomu se říkalo atomová hypotéza. Časem se to ukázalo jako pravda – ale až po šedesáti generacích poté, co Democritus na konci svého dlouhého a plného života zemřel a jeho vlastní atomy byly uloženy k odpočinku v teplé, sluncem rozpálené středomořské půdě. Nedávno, v roce 1783, anglický duchovní a vědec **John Michell** přemýšlel o důsledcích Newtonových zákonů sil a Newtonových teorií gravitace, když byly aplikovány na korpuskulární teorii světla. Michell si představoval tělesa, která by mohla být dostatečně hustá a dostatečně masivní, aby úniková rychlost z jejich povrchu byla dokonce větší než rychlost samotného světla. V tomto případě, teoretizoval Michell, by ani samotné světlo nemohlo uniknout a tyto objekty by byly vysoce masivní, ale zcela tmavé. Pojmenoval je „Temné hvězdy“. Michellův nápad byl chytrý, správný a revoluční – a tak daleko před svou dobou, že by byl na dvě století zcela zapomenut. Teprve v 70. letech 20. století, v době, kdy byly objeveny první astrofyzikální černé díry, se jeho dílo znovu připomnělo. Atomy jako stavební kameny hmoty a černé díry jako kompaktní astrofyzikální objekty – dvě myšlenky, které se poprvé objevily po staletí předtím, než byly široce uznány za pravdivé. K tomu můžeme snad přidat další, ještě revolučnější myšlenku. Myšlenka, kterou poprvé navrhl **Theodor Kaluza** na počátku 20. let 20. století, myšlenka, o níž přemýšlel sám Einstein, ale dodnes se o ní vedou spory. To je myšlenka, že prostor má další, dosud neobjevené, dimenze. Další, skryté, směry za nahoru a dolů, napříč, x y a z. Směry, které jsme ještě nikdy nebyli schopni vnímat. Ale co by to znamenalo? Kde by takové dimenze existovaly – a jak by vypadaly? A jak bychom je – kdy – mohli odhalit? Toto video bylo laskavě sponzorováno společností Babbel. Einstein mluvil německy, Curie francouzsky, Dirac byl Angličan. Průkopnická fyzika je mezinárodním úsilím, a to teprve v roce 1927. Dnes je náš svět vícejazyčný a globálnější než kdy jindy – takže být vícejazyčný je nesmírně užitečné. Je to jednoduchý, zábavný způsob, jak se naučit základy a ještě mnohem víc – Babbel vás od začátku rovnou začne konverzačními nástroji, zaměřuje se na pomoc při komunikaci, ne na řešení gramatických hádanek – jeho lekce byly navrženy skutečnými učiteli se zkušenostmi z reálného života, nikoli algoritmy nebo AI. Má dokonce sekci podcastů – osobně jsem zjistil, že podcasty jsou úžasným způsobem, jak zlepšit svou španělštinu, a Babbel má spoustu různých zábavných způsobů, jak vám pomoci vstřebat jazyk přirozeným, nativním způsobem. Klikněte tedy na odkaz a získejte 65% slevu na předplatné a začněte se učit jeden ze 14 dostupných jazyků. Děkujeme Babbel za podporu vzdělávacího obsahu na YouTube. Pátá dimenze. Tento příběh začíná v roce 1916, uprostřed největší a nejkrvavější války, jakou kdy svět viděl. Zatímco mlýnek na maso Somme požíral evropskou mládež, myšlenky Alberta Einsteina se týkaly vyšších a věčných záležitostí. Posledních deset let se Einstein pokoušel rozšířit svou Speciální teorii relativity, vyvinutou v roce 1905, o gravitaci. Po mnoha chybných začátcích se mu to nakonec podařilo a zformuloval svou Obecnou teorii relativity. To změnilo gravitaci – sílu, kterou všichni známe už od dětství – v geometrii, zakřivenou geometrii **čtyř** prostoročasových dimenzí. Byla to krásná teorie – ale těžko pochopitelná. Myslím nakonec, že pochopitelnější bude **geometrie 3+3 dimenzionálního časoprostoru…** → I think in the end that the geometry of 3+3 dimensional space-time will be more understandable... Matematika byla neznámá, fyzika se zdála nejasná a jakékoli možné experimentální důsledky se zdály být velmi vzdálené. Jedním z fyziků, kteří se potýkali s touto novou a pozoruhodnou teorií Einsteina, byl **Theodor Kaluza**. Kaluza se narodil do zaniklé společnosti – Slezska, jako součást Pruska za německého císařského císaře. Vyrůstal v kultivovaném univerzitním městě Königsberg, kde byl jeho otec akademikem a dlouho a hluboce pil z intelektuálních hodnot tradic německy mluvící Evropy a jejích velkých univerzit. Místa a společnost, na které vyrostl, nyní zcela zmizela nebo se změnila – Slezsko je již dávno součástí Polska, zatímco

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(02)- Konigsberg has become Kaliningrad, host port of the Baltic Fleet of the Russian Navy. His ideas, however, remain. While thinking about Einstein’s equations, Kaluza asked himself a striking question According to Einstein, geometry was dynamical and central to the physics of gravity. So – what would happen if Einstein’s equations were instead written out for five spacetime dimensions (four space dimensions, and one time dimension) instead of the conventional three space dimensions and one time dimension? At first sight, this idea seems silly – or at least, a topic suitable only for a mathematician with no interest in the real world. In the world we live in, there are three directions (or dimensions) to space – not two and not four, but three. So, while it may be an interesting academic exercise to think about Einstein’s equations in four spatial dimensions, it – surely! - cannot be of any relevance to the actual physical world that we live in. Surely not indeed – unless, Kaluza argued, the extra dimension was so small as to render it unobservable. In this case, the spatial geometry would consist of three large spatial dimensions and one small one. And so Kaluza wrote down Einstein's equations of general relativity for such a space – and solved them. The result was striking. The equations separated themselves, allowed themselves to be re-written in a different way - and then they came back together with an entirely different structure – one that can be read as a purely three-dimensional set of equations, describing Einstein’s general relativity in three dimensions – plus the dynamics and interactions of an additional force that behaved in a very similar way to the electromagnetic force we are familiar with – plus again additional particles. Kaluza had found something stunning – gravity in four spatial dimensions, in a limit of one invisibly tiny extra dimension, was equivalent to gravity in three spatial dimensions plus an electromagnetic force. He published his result in the Proceedings of the Prussian Academy of Sciences, with the paper sponsored by Albert Einstein himself. This result was amazing. It was deep. It was striking – and almost no one cared, not then and not for decades afterwards. Instead, this was a time of destruction. In the depressing world of politics, the rich culture and science of 19th century Germany, which had hosted and nurtured many brilliant Jewish scholars from Einstein downwards, was being slowly destroyed and perverted by the ascent of the cancerous ideology of NS and with its doctrines of racial purity and Aryan supremacy. In the more exalted and eternal world of physics, destruction – creative and fruitful destruction – was also the order of the day. During the 1920s and 30s, the new and radically mysterious world of quantum mechanics was being discovered,The previous foundations of the subject were being dissolved, and in the whole history of physics, there has been no better time to be young – with time on your hands, the world at your feet and atoms in your brain. General relativity, meanwhile, may have been deep and it may have been important. It was not, however, as exciting. Even in three spatial dimensions, general relativity in the 1920s, 1930s or 1940s had limited contact with observation. Add in an unobserved and hypothetical extra fifth dimension to the mix – and why should anyone spend their time on this, rather than the magical and revolutionary world of quantum mechanics then opening up? And so, first for years, and then decades, and then for the better part of a century the possibility of extra dimensions was relegated to the backwaters of science.

A Theory of Strings Nestling among the Colorado Rockies is the mountain town of Aspen, an expensive and exclusive home, or second home, for those rich enough to afford a residence among the beautiful surroundings. But alongside the socially elevated houses is a centre for physics, where physicists gather to discuss current projects and deep ideas about various topical areas. In 1984 a conference was being held. Two of the physicists attending, Michael Green of Queen Mary and Westfield College, part of the University of London, and John Schwarz of the California Institute of Technology, were some of the few keeping the flame alive for extra dimensions. As thunder rolled outside, Green and Schwarz worked out and presented their solution to a problem that was widely believed to render extra dimensions physically impossible. And as the Green-Schwarz solution became widely known, extra dimensions rapidly became one of the hottest topics in theoretical physics. What had happened? For many decades, physicists had ignored the idea of extra dimensions in favour of other, more exciting, ideas. Starting in the 1970s, however, one obscure and oddball idea

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(02)- Königsberg became Kaliningrad, the host port of the Russian Navy's Baltic Fleet. However, his ideas remain. In thinking about Einstein's equations, Kaluza asked himself a striking question: According to Einstein, geometry was dynamic and central to the physics of gravity. So - **what would happen if** Einstein's equations were instead written for five space-time dimensions (four spatial dimensions and one temporal dimension) instead of the conventional three spatial dimensions and one temporal dimension? At first glance, the idea seems silly – or at least a topic suitable only for a mathematician with no interest in the real world. In the world we live in, there are three directions (or dimensions) to space – not two

and not four, but three. So, while it may be an interesting academic exercise to think about Einstein's equations in four spatial dimensions, it is – sure! - can have no meaning for the actual physical world in which we live. Certainly not - unless, Kaluza argued, the extra dimension was so small as to be unobservable. In this case, the **spatial geometry would consist of three large spatial dimensions and one small one**. And so Kaluza wrote down Einstein's equations of general relativity for such a space—and solved them. The result was startling. The equations separated themselves, got rewritten in a different way—and then came back together with a completely different structure—one that can be read as a purely three-dimensional set of equations describing Einstein's general relativity in three dimensions—plus the dynamics and interactions of an additional force that behaved in a very similar way to the electromagnetic force we know - plus another particle again. >Kaluza found something astonishing< – gravity in four spatial dimensions, in the limit of one extra invisibly small dimension, was equivalent to gravity in three spatial dimensions plus the electromagnetic force. =He published his result in the Proceedings of the Prussian Academy of Sciences, with the paper sponsored by Albert Einstein himself. This result was amazing. It was deep. It was startling - **but almost nobody cared**, Just like nobody cares about the amazing HDV today not then and for decades afterwards. I have been offering my HDV on the Internet for 23 years. Instead, it was a time of doom. In the depressed world of politics, the rich culture and science of 19th century Germany, which hosted and nurtured many great Jewish scholars from Einstein on down, was slowly being destroyed and perverted by the rise of the cancerous ideology of the NS and its doctrines of racial purity and Aryan superiority. Today, once again, there is supremacy compounded by indifference... as all sorts of crazy ideas are published if the author has friends in the review sheet In the nobler and eternal world of physics, destruction - creative and fruitful destruction - was also the order of the day. Λ During the twenties and thirties, a new and radically mysterious world of **quantum mechanics** was discovered, http://www.hypothesis-of-universe.com/docs/eng/eng_203.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_124.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_108.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_089.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_084.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_047.pdf ;
the subject's previous foundations were dissolving, and there had never been a better time in the history of physics to be young—over time. Your hands, the world at your feet and the atoms in your brain. General relativity, meanwhile, could be profound and could be important. It wasn't all that exciting though. Even in three spatial dimensions, general relativity had limited contact with observations in the 1920s, 1930s, or 1940s. Add an unobserved and hypothetical extra fifth dimension to the mix - and why should anyone spend time on that rather than the magical and revolutionary world of quantum mechanics opening up?
The spell has worn off. Why? Because string physicists built matter "from strings out of NOTHING". If they looked at my HDV, they would find out that HDV is also multidimensional, but the objects of elementary particle matter are built from the real physical dimensions of the two quantities "Length" and "Time". The bending of dimensions, i.e. the "packaging" of dimensions, is mass-forming. The microworld is linear compared to macroscopic gravity. And so, first for years and then decades and then for the better part of a century, the possibility of other dimensions was relegated to the backwaters of science. Like HDV. String theory. Nestled among the Colorado Rockies is the mountain town of Aspen, an

expensive and exclusive home or second home for those wealthy enough to afford living in a beautiful setting. But next to the socially elevated houses, it is a center of physics, where physicists meet to discuss current projects and deep ideas about various topical areas. A conference was held in 1984. I already had 3 years of work on HDV behind me. Two of the physicists present, **Michael Green** from Queen Mary and Westfield College, part of the University of London, and ***John Schwarz*** from the California Institute of Technology, were one of the few who kept the flame alive for the next dimensions. As thunder rolled outside, Green and Schwarz worked out and presented their solution to a problem that was widely believed >to make extra dimensions physically impossible<. And how the Green-Schwarz solution happened widely known, and how do you make a solution become widely known??, extra dimensions quickly became one of the hottest topics in theoretical physics. What happened? For many decades **physicists have ignored the idea of extra dimensions in favor of other, more exciting ideas**. The idea of HDV has not been noticed for 40 years!!! When will they finally notice?, where? (I'm almost 80 years old). Beginning in the 1970s, however, an obscure and strange idea was born

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(03)- appeared to require, for consistency, the existence of extra dimensions. This idea was string theory. String theory has a justified reputation as a difficult and complex subject. Its origins, though, come from one single problem. Take the equations that describe a one-dimensional object under tension – think a violin string or a cracking whip. Promote these equations to a relativistic limit, where the ends move at the speed of light itself. Finally, take the quantum mechanical version of these equations – and study them. Take strings – make them relativistic, make them quantum mechanical – and you have the subject known as string theory. When the ideas of string theory were first developed – by the Italian physicist Gabriele Veneziano in the revolutionary summer of 1968, against a background of protest, a summer filled with students who were both rioting and rutting – the ideas of string theory were thought of as a possible explanation for the behaviour of the strong force, which binds the nuclei of atoms together. Despite five years of intense work from 1968 to 1973, this idea did not succeed. There were two major problems: the particles the theory predicted did not match those actually found in experiments on strong interactions, and more abstractly the theory simply broke – probabilities failed to add up to one – if space did not have an additional six spatial dimensions beyond the three we already know. This meant that string theory, by the early 1970s, seemed destined for the rubbish bin of failed ideas. But for a small number of physicists – including Green and Schwarz – something nagged. Many things about the theory worked surprisingly well – there were odd and unexpected cancellations that looked too good to be simply a coincidence. Why were these happening? Maybe string theory was actually something else? Maybe using string theory to describe the strong force was a desperate attempt to force a square peg into a round hole? Maybe, just maybe, they and others whispered in hushed voices, string theory was actually the quantum theory of the gravitational force - the long awaited theory that underlies everything. Were the strings of string theory the fundamental components of the universe? The response was disinterest. Why care? Quantum gravity was obscure. String theory was obscure. Put the two together – and the number of people working on the topic was literally a handful. For this was the great age of the Standard Model, and new particles were discovered almost every year. String theory in mid- to -late 1970s physics was about as fashionable as powdered wigs and top hats. It also appeared to be facing insurmountable problems. Any versions of string theory

that tried to include the type of particle that make up the Standard Model appeared internally inconsistent: the probabilities in quantum mechanical computations, again, were failing to add up to one. What happened in rainy Aspen in 1984 was that Green and Schwarz found a way to solve this problem. The problem was one of what are called anomalies – for a whole host of calculations in the quantum theory, probabilities were not adding up to one. Every time this happened, the theory was marked as inconsistent. Green and Schwarz discovered a new, previously missed term in the calculations – and with this included, all these previous problems disappeared and the quantum theory was suddenly consistent again. Their result was – and is - called Green-Schwarz anomaly cancellation. As news of their result spread, string theory – a theory which required not one, not two, but six additional dimensions to space - became one of the most popular subjects in theoretical physics. It was a pivotal moment, and the thunderous storm outside echoed its import. The physics of extra dimensions, a subject that had previously scraped its existence on the fringes of respectability, was now the subject of an intellectual gold rush, as physicists flocked in to try and relate the physics of string theory, and its six extra dimensions, to the more familiar physics of four dimensions and the Standard Model. It had been proposed that the particles and forces of our world were born out of the different ways in which these fundamental strings could vibrate - and they needed ten dimensions to vibrate within, in order to fit our reality. The quest for quantum gravity - a theory of everything that had haunted Einstein on his deathbed - was once again the centre of attention.
Visualizing The Invisible (Calabi-yau Manifolds) "I was in San Diego with my wife one day [in 1984], looking out at the beautiful ocean," "The phone rang and it was my friends Andrew Strominger and Gary Horowitz. They were excited because string theorists were building up

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(03)- it seemed to require the existence of additional dimensions for consistency. This idea was string theory. String theory has a well-deserved reputation as a difficult and complex subject. Because she's unbelievable. Because it builds matter not "from dimensions", but builds its strings "from Nothing" and from them matter. *If these elegant physicists had noticed my HDV a long time ago and exchanged the "strings for dimensions" of physical quantities in their theory!!!, their theory and my idea would have been developed into a wonderful THEORY OF EVERYTHING long ago. Will someone be found and forward this HDV to physical celebrities (for viewing)?? Brian Greene, Schwarz, etc... However, its origin comes from a single problem. Take the equations that describe a one-dimensional object under tension—think of a violin string or the crack of a whip. Push these equations to the relativistic limit, where the ends move at the speed of light itself. Finally, take the quantum mechanical version of these equations - and study them. Take strings - make them relativistic, quantum mechanical - and you have a subject known as string theory. No. Take the 3+3 physical dimensions of two quantities (Length and Time) and add n+m extra mathematical dimensions and you have an elegant and simple notational technique for the new theory of matter and its interactions and forces in the macro world : http://www.hypothesis-of-universe.com/docs/aa/aa_112.pdf unusual question http://www.hypothesis-of-universe.com/docs/aa/aa_078.pdf variant notation technique http://www.hypothesis-of-universe.com/docs/eng/eng_096.pdf variant notation technique When there were ||thoughts|| string theory first developed - by the Italian physicist Gabriel Veneziano in the revolutionary summer of 1968, against the background of protests, a summer full of students rioting and rioting, the ideas of string theory were considered as a possible explanation for the behavior of the strong force that binds the nuclei of atoms together. After five years of intensive work between 1968 and 1973 **this idea failed**. There were two main problems: the particles the theory predicted did not match those actually found in strong-interaction experiments, and more abstractly, the theory simply broke down—the probabilities failed to add up to one—unless space had six more spatial dimensions. Three we already know. This meant that **string theory seemed destined for the dustbin of failed ideas in the early 1970s**.

But for a small number of physicists—including Green and Schwarz—something annoying. Many things worked surprisingly well in this theory - there were strange and unexpected cancellations that seemed too good to be mere coincidence. Why did this happen? Maybe string theory was actually something else? Perhaps the use of string theory to describe the strong force was a desperate attempt to fit a square peg into a round hole? Maybe, just maybe, quietly and others whispered that string theory was actually the quantum theory of gravity - the long-awaited theory that underlies everything. Were the strings of string theory the fundamental component of the universe? The answer was disinterest. Dtto HDV. Why care? Quantum gravity was obscure. String theory was unclear. Put them together - and the number of people working on the subject was literally a handful. There were even fewer for HDV → myself.And that was the great age of the Standard Model and new particles were discovered almost every year. String theory was about as fashionable as powdered wigs and top hats in mid-to-late 1970s physics. He also seemed to be facing insurmountable problems. What kind? It was a fable about a hen and a rooster… Any versions of string theory that attempted to include the type of particle that made up the Standard Model seemed internally inconsistent: the probabilities in quantum mechanical calculations again failed to sum to one. **It was in rainy Aspen in 1984 that Green and Schwarz found a way to solve this problem**. Oh, o… The problem was one of what is called an anomaly - for a whole series of calculations in quantum theory, the probabilities were not equal to one. I don't understand the calculations in String Theory, but I have one idea: ***Principle of alternating symmetries with asymmetries*** http://www.hypothesis-of-universe.com/docs/eng/eng_008.jpg ; http://www.hypothesis-of-universe.com/docs/aa/aa_041.pdf ; http://www.hypothesis-of-universe.com/docs/aa/aa_013.pdf ; Each time this happened, the theory was called inconsistent. **Green and Schwarz** discovered a new, previously missed term in the calculations - and with that all these previous problems disappeared and quantum theory was suddenly consistent again. Their result was - and is - called the cancellation of the Green-Schwarz anomaly. As news of their result spread, string theory—a theory that required not one, not two, but six extra dimensions for the universe—became one of the most popular subjects in theoretical physics. If nature were only and only symmetrical, nothing would happen, move, develop, the universe would be inert... This is the principle of alternating symmetries with asymmetries in a sequence of states, (since the big-bang today), ... while the laws of conservation - symmetry only apply as "stop-states" of continuous changes (likewise, asymmetries also apply as stop-states). I started thinking about it a long time ago. And on of the Internet are published in modifications already in 2004 and 2005,

…zde → http://www.hypothesis-of-universe.com/docs/aa/aa_004.pdf
a zde → http://www.hypothesis-of-universe.com/docs/aa/aa_002.pdf
a zde → http://www.hypothesis-of-universe.com/docs/aa/aa_008.pdf
a zde → http://www.hypothesis-of-universe.com/docs/aa/aa_013.pdf

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It was a pivotal moment, and the storm outside reflected its significance. Physics of Extra Dimensions, a subject that had previously scraped its existence on the edge of respectability, was now the subject of an intellectual gold rush as physicists flocked to try to relate the physics of string theory and its six other dimensions to the more familiar physics of the four dimensions and standard model. It was suggested that the particles and forces of our world were born from the various ways these fundamental strings could vibrate - and needed ten dimensions to vibrate within to match our reality. The search for quantum gravity—the theory of everything that haunted Einstein on his deathbed—was once again in the spotlight. Visualizing The Invisible (Calabi-yau Manifolds) “One day I was in San Diego with my wife [in 1984] looking at the beautiful ocean,” “The phone rang and it was my friends **Andrew Strominger and Gary Horowitz**. Excited because string theorists grew

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(04)- models of the Universe and needed to know whether [Calabi-Yau] manifolds really existed. I was happy to confirm that they did." Mobius Strips. Klein bottles. Roman Surfaces. They are complex, mind-boggling, difficult to comprehend - but still geometries. And so it goes with the almost impossible to visualise extra six dimensions of string theory. Geometry as a subject goes back over two thousand years – Pythagoras’s theorem, Euclid’s textbook, circles, parallel lines, infinite planes…it is one of the oldest subjects in mathematics. And so we can ask: what possible shape could these tiny six extra dimensions take? Would they be built up from simpler and more familiar ingredients, such as straight lines, circles and ellipses? Or might they rather be radically unfamiliar objects with strange and unusual topologies, One of the most interesting, and most studied, examples of possible geometric shapes for the six extra dimensions are what are called Calabi-Yau manifolds, named after the Italian-American mathematician Eugenio Calabi and the Chinese geometer Shing-Tung Yau. These spaces had already attracted interest from mathematicians because of their beautiful complex geometry – ‘complex’ here as in complex numbers such as i - the sum of a real and imaginary number.They are not easy to visualise and are topologically complex - a typical Calabi-Yau has hundreds and hundreds of the higher-dimensional equivalents of ‘holes’. Mathematically they are a marvel - but why have these manifolds been studied so mucwithin physics? Why did early string theorists choose these bizarre geometries to fold up the extra six dimensions? One reason is that the geometry of these spaces automatically satisfies the equations of Einstein's theory of gravity, general relativity. The equations of general relativity are restrictions on the allowed forms for the curvature of spacetime. These equations are one of the deepest and most powerful ideas in all of physics, and so they are expected to be true not just in the 4-dimensional world that we inhabit but also within any deeper frameworks that would extend our known laws - and this includes ideas such as string theory. And these Calabi-Yau geometries fit the bill. But that is not all. Einstein's equations are classical. They do not include any quantum physics. Often, there are solutions to classical equations which are destroyed the moment quantum effects are turned on. The quantum lead to uncontrolled, almost infinite, amounts of extra energy that act as a wrecking ball on the simple classical solution that was started. To avoid this wrecking ball, classical solutions and theories of quantum gravity need something extra – a form of extra protection, extra symmetry, that will act as a shield against these quantum effects. Calabi-Yau geometries have this extra protection which follows from their equations. It is called supersymmetry, a form of extra symmetry that is especially good at taming the most dangerous effects of quantum physics. In brief, supersymmetry roughly ensures the quantum effects split into two parts, both catastrophic, both almost infinite – but with opposite sign so that they precisely and totally cancel each other out. However, supersymmetry is still only a conjectured symmetry, and it may or may not be a part of the true theory of the world. When physicists started getting interested in Calabi-Yaus in the mid 1980s, only a small number of examples were known. It was dreamed that this small number might then turn into a semi-unique path, leading from the ten dimensions of string theory directly to the Standard Model. Scientists dared to dream - was this about to become one of the greatest moments in all of physics? Not quite. The number of such Calabi-Yau spaces just kept growing and growing.Their names sound deliciously exotic: 'the quintic hypersurface in CP4' or 'the mirror quintic'. Now billions upon billions of such geometries are known, and instead of being enumerated manually by a lone mathematician scribbling across sheets of paper, impersonal silicon spits them out by the microsecond. And so we are left with an incredibly complex and elegant theory - but also a problem. The world in which we live is not - at first glance - ten dimensional. Were these extra dimensions to exist, physicists believe they would be everywhere in four dimensional space, but extremely small - some estimates putting them at more than a quadrillion times smaller than an atom. So how could we ever know, or prove what form these extra dimensions actually take if they are too small to be observed? And indeed more fundamentally - what does it even mean to talk about extra dimensions that we cannot see? Where Are The Hidden Dimensions? What does it mean to see something? There is an anecdote about the famous and charismatic physicist Richard Feynman – although as with all good anecdotes, it may not be fully true. Feynman – the

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(04)- models of the universe and needed to know if [Calabi-Yau] manifolds really exist. I was happy to confirm that it did." Mobius Strips. Klein bottles. Roman surfaces. They are complex, overwhelming, difficult to understand - but geometry nonetheless. And so it is almost impossible to imagine the other six dimensions of the string. The theory as a subject goes back over two thousand years to of the past - Pythagorean theorem, Euclid's textbook, circles, parallels, infinite planes...it is one of the oldest subjects in mathematics, so we can ask what shape this little six could have. They would be made of simpler and more familiar ingredients, such as straight lines lines, circles and ellipses, or could they be rather radically unknown objects with strange and unusual topologies, one of the most interesting and most studied examples of the possible geometric shapes for the six other dimensions are the so-called **Calabi-Yau manifolds**, named after the Italian- to the American mathematician Eugenio Calabi and the Chinese geometer Shing-Tung Yau These spaces have already attracted the interest of mathematicians because of their beautiful complex geometry – here “complex” as in complex numbers such as i – the sum of a real and an imaginary number. They are not easy to visualize and are topologically complex - **a typical Calabi -Yau has hundreds and hundreds of higher-dimensional equivalents of 'holes'**. http://www.hypothesis-of-universe.com/docs/eb/eb_002.pdf ; http://www.hypothesis-of-universe.com/index.php?nav=eb ; Mathematically they are a marvel - but why have these manifolds been so studied in physics? http://www.hypothesis-of-universe.com/docs/eb/eb_004.pdf ; http://www.hypothesis-of-universe.com/docs/eng/eng_096.pdf Why did the early string theorists choose these bizarre geometries to make up the extra six dimensions? http://www.hypothesis-of-universe.com/index.php?nav=eb ; One reason is that the geometry of these spaces automatically satisfies the equations of Einstein's theory of gravity, general relativity. The equations of general relativity are a limitation of the allowed forms of space-time curvature. These equations are one of the most profound and powerful ideas in all of physics, and are therefore expected to hold true not only in the 4-dimensional world we inhabit, but also in any deeper frameworks that would extend our known laws - and this includes ideas that such as string theory. And these Calabi-Yau geometries correspond to that. But that's not all. Einstein's equations are classical. They do not involve any quantum physics. There are often solutions to classical equations that are destroyed the moment quantum effects are turned on. A quantum lead to an uncontrolled, almost infinite amount of extra energy that acts as a wrecking ball on the simple classical solution that was initiated. To avoid this wrecking ball, classical solutions and quantum gravity theory need something extra - a form of special protection, an extra symmetry to act as a shield against these quantum effects. Calabi-Yau geometries have this extra protection that follows from their equations. It's called supersymmetry, a form of extraordinary symmetry that's especially good at taming the most dangerous effects of quantum physics. In short, supersymmetry roughly ensures that quantum effects split into two parts, both catastrophic, both nearly infinite—but of opposite sign, so they exactly and totally cancel each other out.

However, supersymmetry is still only a hypothetical symmetry and may or may not be part of a real theory of the world. When physicists became interested in Calabi-Yaus in the mid-1980s, only a small number of examples were known. The dream was that this small number could then be transformed into a semi-unique path leading from the ten dimensions of string theory directly to the Standard Model. Scientists dared to dream - was this to become one of the greatest moments in all of physics? Not quite. The number of such Calabi-Yau spaces kept growing and growing. Their names sound deliciously exotic: "quintic hypersurface in CP4" or "the mirror quintic". Billions and billions of such geometries are now known, and instead of being calculated by hand by a lone mathematician scribbling across sheets of paper, impersonal silicon spits them out in microseconds. And so we're left with an incredibly complex and elegant theory—but also a problem. The world we live in is not – at first glance – ten-dimensional. If these extra dimensions did exist, physicists believe they would be everywhere in four-dimensional space, but extremely small—more than a quadrillion times smaller than an atom, according to some estimates. So how could we ever know or prove what form these extra dimensions actually take if they are too small to observe? And more fundamentally - what does it even mean to talk about other dimensions that we cannot see?

Where are the hidden dimensions? They are in matter. http://www.hypothesis-of-universe.com/docs/eng/eng_012.jpg What does it mean to see something? There is an anecdote about the famous and charismatic physicist Richard Feynman - although, as with all good anecdotes, it may not be entirely true. Feynman - the one

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(05)- story goes – was conducting a PhD viva, the verbal examination for a student who had just submitted a thesis in theoretical physics. The student's thesis was on quantum gravity, and he had undertaken many long and intricate mathematical calculations. Feynman, however, was concerned that in this process the student had lost himself in mathematics and forgotten his physics. Feynman started asking questions about physical scales, physical sizes, physical properties. What, Feynman asked, was the wavelength of visible light? 'I don't know' – said the student. 'Perhaps a metre?'. Feynman got up from the examiner's chair and walked towards the student. 'Do I', he said in his New York drawl 'look blurry to you?'The reason we can see each other, and recognise the fine structure of each other's faces, is that the wavelength of visible light is a bit smaller than a micrometre, or a millionth of a metre. Any objects much bigger than a micrometer do not blur when viewed in visible light, and so visible light allows us to resolve objects down to these lengths. Objects smaller than this, however, cannot be seen with visible light. Atoms exist. They are, as Democritus said, part of the natural world. However, being one thousand times smaller than visible light, it is simply impossible for them to be seen using visible light. This simply lacks the necessary structure to resolve them. X-rays are another matter – but for most of our existence, humans did not have access to controlled sources of X-rays. Even if we cannot see individual atoms, we can still feel their effects. Every time we touch anything with our hands, or sit down on a chair, we feel the effects of atoms.The fact that, when we sit down, we do not carry on plunging through the seat of the chair is because of the summed effect of billions upon billions upon billions of atoms, and the electric interactions between them. When we sit down, the entire earth is pulling on us downwards, using the force of gravity. What resists this pull is an electric repulsion that occurs as the matter that is us tries to pass through the matter that is the chair – and this repulsion originates from the atoms making up both, even though we cannot directly discern individual atoms. So for atoms, we can feel their effects, even if we cannot directly resolve them. What would be the analogue for extra dimensions? If there is a secret geometry to space at the very smallest distances, what effects could this have at larger distances on those unable to resolve the extra dimensions? To understand this, it is worthwhile to consider what a dimension is. We are all familiar with three dimensions – these are the directions we move in, the way we label the positions of objects. There is one dimension of up and down, and two for moving horizontally. We can think of dimensions as the number of labels you have to give to say where an object is, in the way that coordinates on a two-dimensional sheet of paper allow you to locate any individual point on that paper. But what about four spatial dimensions – or five, or nine? Who can actually visualise what is meant by nine spatial dimensions? Where else can we go in our mind beyond up and down and North/South/East/West? It is hard even to conceive of what extra spatial dimensions would mean. There is no way to make this perfectly intuitive, but we can meet our intuition part of the way. One way to have a sense of this is to imagine an insect walking on a plant vine - a vine both long and thin. An ant - or any other insect - can walk along the vine – either forward or backwards. The surface of the vine certainly has two dimensions – zooming in with a powerful microscope, we would see the surface made up of many cells, stretching off in all directions. But the insect, small though it is, is still too large to treat the vine as having more just one linear dimension. In truth, the surface of the vine has two dimensions – but to a big enough insect, there is effectively only a single dimension. As for the ant, so – perhaps – for us. If extra dimensions are small enough, we (and all our technology) are simply too big and too clunky to resolve them. The fundamental strings of string theory would be small enough to make use of them, but without tools to resolve structure at sufficiently small distances, we cannot sense that they are present.Imagine trying to build an intricate Lego model or knit fine filigree lace – but while wearing boxing gloves. Impossible! Without tools that probe such smaller distances, any structure on these distances is simply inaccessible. But could there still be phenomena – like the bottom on the chair – where extra dimensions could manifest their effects, even if we cannot discern their full structure? Yes. Particles. Physicists unable to resolve the full structure of extra

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(05)- story goes - he was conducting a PhD viva, an oral exam for a student who had just handed in a thesis in theoretical physics. The student's paper was on quantum gravity and he performed many long and complex mathematical calculations. However, Feynman worried that in the process the student got lost in mathematics and forgot about physics. Feynman began to ask about physical scales, physical quantities, physical properties. What was the wavelength of visible light, Feynman asked? "I don't know," said the student. 'Perhaps a meter?' Feynman got up from the examiner's chair and walked over to the student. “I feel like a blur,” he said in his New York drawing? “The reason we can see each other and recognize the fine structure of each other's faces is because the wavelength of visible light is slightly smaller than a micrometer or a millionth of a meter. No objects much larger than a micrometer are out of focus when viewed in visible light, so visible light allows us to resolve objects at these lengths. However, objects smaller than this cannot be seen in visible light. Atoms exist. They are, as Democritus said, part of the natural world. However, since they are thousands of times smaller than visible light, it is simply impossible to see them using visible light. It simply lacks the necessary structure to resolve them. X-rays are another matter - but for most of our existence, humans have not had access to controlled sources of X-rays. Even though we cannot see the individual atoms, we can still feel their effects. Every time we touch anything with our hands or sit in a chair, we feel the effects of atoms. The fact that we don't fall over the seat of a chair when we sit down is due to the cumulative effect of billions upon billions of atoms and the electrical interactions between them. When we sit down, the entire Earth pulls us down with the force of gravity. What resists this pull is the electrical repulsion that occurs when the matter that is us tries to pass through the matter that is the chair—and that repulsion comes from the atoms that make up both, even though we cannot directly discern the individual atoms. So with atoms we can feel their effects even though we can't resolve them directly. What would be the analog for extra dimensions? If there is a secret geometry of the universe at the very smallest distances, what effects might it have at greater distances on those unable to discern other dimensions? To understand this, it's worth considering **what a dimension is**. We are all familiar with three dimensions - they are the directions in which we move, the way we mark the positions of objects. There is one dimension for up and down and two for horizontal movement. We can think of dimensions as the number of labels you have to enter to tell where an object is located, the way coordinates on a two-dimensional sheet of paper allow you to locate any single point on that paper. But what about four spatial dimensions—or five, or nine? Who can actually imagine what is

meant by nine spatial dimensions? I. They are "mathematical dimensions" hidden in a package of n-dimensions inside matter.
http://www.hypothesis-of-universe.com/docs/eb/eb_057.jpg ; http://www.hypothesis-of-universe.com/docs/eb/eb_058.pdf ; http://www.hypothesis-of-universe.com/docs/eb/eb_073.pdf ; Where else can we go in our mind beyond up and down and north/south/east/west? It is difficult to even imagine what additional spatial dimensions would mean. There is no way to make it perfectly intuitive, but we can partially meet our intuition. One way to understand this is to imagine an insect walking on a plant - a vine long and thin. An ant - or any other insect - can walk along a creeper - forwards or backwards. The surface of the vine certainly has two dimensions - by zooming in with a powerful microscope, we would see a surface made up of many cells, extending in all directions. But the insect, though small, is still too large to treat the vine as more than just one linear dimension. In reality, the surface of a vine has two dimensions – but for a sufficiently large insect, there is essentially only one dimension. Both for the ants and - perhaps - for us. If the additional dimensions are small enough, we (and all our technology) are simply too big and too clumsy to solve them. The fundamental strings of string theory would be small enough to use, but without tools to resolve the structure at small enough distances we can't sense that they are present. Imagine trying to build an intricate Lego model or knit delicate filigree lace – but while wearing boxing gloves. Impossible! Without instruments that sense such smaller distances, any structure at these distances is simply inaccessible. But could there still be phenomena—like the bottom on a chair—where other dimensions could exert their effects even if we can't discern their full structure? Yes. Particle. Physicists are unable to resolve the entire structure of the extra

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(06)- dimensions are only sensitive to gross features. It is not that there can be no information, but the information is limited – a bit like trying to describe one's daily life using a vocabulary limited to a hundred words. We could say something – but think how much would be left out! At energies far, far below those capable of directly resolving the intrinsic structure of the extra dimensions, the mathematics of general relativity tells us that the surviving residue of the extra dimension would be particles. If we blur the ability to perceive extra dimensions, then before reaching nothing at all, the last thing we would be left with would be particles. This is a statement of the mathematics, and it also follows from the mathematics that the number, type and interaction of these particles would reflect the geometry, and topology, of the extra dimensions. Although there may always be exceptions, it is generally true that the more complex the topology of the extra dimensions, the larger the number of such particles that would survive. These particles would be the minimal quantum excitation of the extra-dimensional geometry. In theories of extra dimensions, they are to the extra dimensions a bit like what the photon is to light and electromagnetism – the minimal quantum lump, quantum excitation that is left. These particles would be legacies of a higher dimensional theory of gravity, when viewed from a lower dimension. And so, this leaves us with questions. What are these legacy particles? Can we observe them? If they exist, and are generic features of theories with extra-dimensions, surely we should be able to detect them? To begin with lets focus our discussion on the most interesting and most generic types of such particle, called a modulus. Modulus particles – in their plural, moduli – originate from describing the size and shape of extra dimensions. fully trapped within the extra dimensions. Why, then, can we not just try and observe moduli by making them in particle colliders such as the CERN Large Hadron Collider? Why not just smash particles together at high enough energy, in order to make moduli and thereby discover them? This, after all, is a long-established approach for making and discovering new particles. The problem with this approach lies in the origin of moduli from extra-dimensional modes of the graviton. Such moduli behave like gravity – and gravity is, by far, by far, by far, intrinsically the weakest of all the forces. Gravity is such an incredibly weak force that when you put your little finger inside a key ring, and lift up the ring and its keys, you are able to pull the ring up against the gravitational pull of the entire Earth. This shows just how extraordinarily weak are the interactions of the gravitational force compared to any of the electrostatic effects used by our bodies and muscles. The gravitational force is therefore far, far too weak to be probed directly at any particle collider. Particles whose interactions are, at least morally, gravitational ones, could never be produced even by an LHC running at full intensity from the time of Stonehenge to now. Their interactions are much weaker even than neutrinos – which famously can pass through the entire Earth without interacting with any of the matter in the way. So – what can we do? Perhaps extra dimensions and moduli may exist, but perhaps we can never observe them? If a collider can never make such particles, or reach the energies required to resolve extra dimensions, would they always exist as some form of inaccessible other shadow world which we could never actually detect? But this is not yet the time to indulge our worst fears. It is true that, interacting so weakly, moduli would be very hard to make in the first place. However this has a positive counterpart – once they have been made, moduli would also live for a long time. The weaker the interactions, the harder it is for a particle to decay. Particles which interact via the strong force are easily made – but they typically decay in a lifetime much less than a billionth of a billionth of a second, whereas equivalent particles whose only interactions were at gravitational strength could have lifetimes measured in years. But to make them, we would need extreme conditions. And the most extreme conditions in the history of the universe occurred in its first moments. Hunting For Evidence At The Beginning Of Time In the beginning it is believed, if not known for absolute certainty – that the universe underwent a period of cosmological inflation. Its size grew both rapidly and exponentially in an extremely short period of time. It is hard to overstate the rapidity of this growth - indeed in the inflationary epoch alone, the universe is believed to have doubled its size approximately eighty times. Within a time period shorter than it would take light to cross from one end of an atomic nucleus to another, a

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(06)- dimensions are only sensitive to rough features. It doesn't mean that there can't be any information, but the information is limited - a bit like trying to describe your daily life using a vocabulary limited to a hundred words. We could say something - but think how much would be left out! At energies far, far below those capable of directly resolving the internal structure of extra dimensions, the mathematics of general relativity tells us that the surviving remnant of the extra dimension would be particles. If we blur the ability to perceive extra dimensions, then before we achieve anything at all, the last thing we would have left would be particles. This is a statement of mathematics, and it also follows from mathematics that the number, type and interactions of these particles would reflect the geometry and topology of the extra dimensions. While there can always be exceptions, in general the more complex the topology of the extra dimensions, the greater the number of such particles that would survive. These particles would be the minimal quantum excitation of extradimensional geometry. However, these physicists forgot about the extra dimensions of time. They also exist (!) and I am building this wonderful pyramid of elementary particles from them… http://www.hypothesis-of-universe.com/docs/ea/ea_006.pdf ; http://www.hypothesis-of-universe.com/docs/ea/ea_013.pdf ; In extradimensional theories, they are a bit like what a photon is to light and electromagnetism - a **minimum quantum lump**, a quantum excitation that remains to extradimensions. Viewed from a lower dimension, these particles would be a legacy of a higher dimensional theory of gravity. And so it raises questions for us. What are these legacy particles? Can we observe them? If they exist and are general features of theories with extra-dimensions, surely we should be able to detect them? We will not reveal extra dimensions, they are not physical, but only "mathematical abstracts". I solved the construction of ||all|| of elementary particles (even those that are not normally found in nature), from the number of 9+9 dimensions, of which 3+3 physical dimensions!!! http://www.hypothesis-of-universe.com/docs/ea/ea_006.pdf ; To begin with, let us focus our discussion on the most interesting and general types of such particles, called moduli. Modulus particles—in their plural, moduli—come from describing the size and shape of particular dimensions. Fully trapped in extra dimensions. So why can't we just try to observe modules by creating them in particle accelerators like the CERN Large Hadron Collider? Why not just smash the particles together at high enough energy to form modules and thus discover them? This is, after all, a long-established approach to the production and discovery of new particles. By breaking **elemental !!!** particles, we do not get new "elemental" particles, only shards = jets. The problem with this approach lies in the origin of the moduli from the extradimensional modes of the graviton. Such modules behave like gravity - and gravity is far, far, far, intrinsically the weakest of all forces. Gravity is such an incredibly weak force that if you put your little finger inside a key ring and lift the ring and its keys, you are able to pull the ring against the gravitational force of the entire Earth. This shows how extremely weak the interactions of the gravitational force are compared to any electrostatic effect that our bodies and muscles use. Therefore, the gravitational force is too weak to be studied directly at any particle accelerator. Particles whose interactions are, at least morally, gravitational, could never be produced even by the LHC running at full blast from Stonehenge to the present. Their interactions are much weaker than neutrinos - which are known to be able to pass through the entire Earth without interacting with any matter in their path. So – what can we do? Perhaps there may be other dimensions and modules, but perhaps we can never observe them? If a collider can never create such particles or reach the energies needed to resolve extra dimensions, would they always exist as some form of inaccessible other shadow world that we could never actually detect? But it is not yet time to indulge our worst fears. Admittedly, with such a weak interaction, it would be very difficult to create modules in the first place. However, this has a positive counterpart – once produced, the modules would also live for a long time. The weaker the interactions, the harder the particle decays. Particles that interact through the strong force are easily created—but typically decay in lifetimes of much less than a billionth of a billionth of a second, while equivalent particles whose only interaction was with gravity could have lifetimes measured in years. However, we would need extreme conditions to produce them. And the most extreme conditions in the history of the universe occurred in its earliest moments. Searching for evidence at the beginning of time. In the beginning it was believed, if not absolutely known, that the universe had gone through a period of cosmological inflation. Its size grew both rapidly and exponentially in an extremely short period of time. It is difficult to overestimate the rate of this growth – indeed, the universe is believed to have doubled in size approximately eighty times in the inflationary epoch alone. In less time than it would take light to travel from one end of an atomic nucleus to the other, a

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(07)- length corresponding to the size of that atomic nucleus would have grown to a size far larger than that of the earth. At the end of the inflationary epoch, the enormous energies present in the universe were transferred away from the energy of the inflation into particles: both making them, and flooding them with energy. At the immediate end of inflation, the result is an enormously energetic soup with, potentially, many different types of particles. And these energies present during inflation are associated with space and geometry itself. In Einstein's theory of relativity, geometry and gravity are almost one and the same – and moduli are the particle excitations of geometry, or at least of the geometry of the extra dimensions. If moduli do exist, when inflation ends and the inflationary energy is transferred to particles, it would be natural for at least some of this inflationary energy to be transferred to the moduli. These share in the post-inflationary bounty: they are made, they exist and they would form some part of the maelstrom of particles in which the energy of the universe is deposited straight at the end of the inflationary epoch. And it is here that the long, long lifetimes of the moduli matter. Moduli would live much longer than other particles, and so if this scenario is true they would, in time, come to dominate the energy density of the universe. Eventually, for a moment, almost all the energy of the universe would be in the form of moduli. You can think of this a bit like a hammer striking a great bell. When first struck, the bell rings with the rich deep sound that comes from the many harmonics and overtones present in the bell resonating at once. But as time goes on, the higher harmonics decay and can no longer be heard. Several seconds after the original strike, the notes that remain are the longest-lasting harmonics. Likewise, in the early universe, the particles that live the longest are those that are left when all else has decayed. Estimates predict that a yoctosecond after the big bang most particles would have decayed - but that the moduli would last for nearly a full microsecond. A relative eternity. By itself, this may not seem that significant. Energy is conserved. When particles decay, their mass-energy does not disappear, but instead gets converted to other forms of energy, in particular relativistic particles such as photons, the quantised version of light. As our new universe expands, though, energy in the form of relativistic waves (such as photons) dissipates rapidly. The reason for this is something called the Doppler effect. This effect refers to how the pitch – or frequency – of waves change depending on whether the source of the wave is moving towards us or away from us. It is familiar from ambulance sirens. Although the siren itself operates at the same intrinsic note, when the ambulance is driving towards us we hear the note at a higher pitch and when the ambulance is driving away from us we hear the note at a lower pitch. How does this relate to an expanding universe? To an observer located at some point in an expanding universe, the expansion is like having everything move away from you. A continual growth in space itself means that every other point in the universe is, all the time, constantly moving further away. In these circumstances, all forms of relativistic wave energy feel the Doppler effect. As the universe is stretched, the wavelengths are stretched, and so the frequencies – the inverse of wavelength – all decrease. For light waves – that is, photons - the energy of the photon is directly proportional to frequency. As the universe expands, the frequency decreases, and the energy decreases. But for moduli, the same would not be true. Moduli would be heavy, and their energy is associated to their mass and not to their movement. The mass-energy of a modulus is all concentrated in the particle itself, rather than its motion. These heavy particles are not relativistic and simply remain where they are until they decay. While the universe expands, they stay right where they are, maintaining all their mass-energy until the point at which they eventually decay. Meanwhile, all the other particles, which have their mass-energy associated to their motion in the form of relativistic particle-waves, have all this energy dissipated away due to the Doppler effect. And so - if moduli do exist, it is likely that the universe went through a comparatively long phase just after inflation where its energy was dominantly in the form of the mass of moduli particles. For almost a microsecond right at the very start of the universe – the moduli had their day. They were everywhere, and they

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(07)- a length corresponding to the size of this atomic nucleus would grow to a size much larger than the size of the Earth. At the end of the inflationary epoch, the vast energies present in the universe were transferred away from the energy of inflation into particles: as they created them, they flooded them with energy. At the immediate end of inflation, the result is an enormously energetic soup with potentially many different types of particles. And these energies present during inflation are associated with space and geometry itself. In Einstein's theory of relativity, geometry and gravity are almost one and the same - and moduli are particle excitations of geometry, or at least geometry of extra dimensions. If the modules exist when inflation ends and the inflationary energy is transferred to the particles, it would be natural for at least some of that inflationary energy to be transferred to the modules. These participate in the post-inflationary reward: they are made, exist, and would form some part of the vortex of particles in which the energy of the universe is stored right at the end of the inflationary epoch. And this is where the long, long life of the modules matters. Modules would live much longer than other particles, and so if this scenario is true, they would eventually dominate the energy density of the universe. Eventually, for a moment, almost all the energy of the universe would be in the form of modules. You can think of it a bit like a hammer hitting a big bell. At the first strike, the bell rings with a rich, deep sound that comes from the many harmonics and overtones present in the bell resonating at once. But as time passes, the higher harmonics fade and are no longer audible. A few seconds after the original beat, the notes that remain are the longest lasting harmonics. Similarly, in the early universe, the particles that live the longest are the ones left when everything else has decayed. Estimates predict that within a yoctosecond of the big bang, most of the particles would have disintegrated - but the modules would have lasted almost a full microsecond. Relative eternity. In itself, this may not seem that significant. Energy is saved. When particles decay, their mass energy does not disappear, but is instead converted into other forms of energy, particularly relativistic particles such as photons, a quantized version of light. As our new universe expands, energy in the form of relativistic waves (such as photons) dissipates rapidly. The reason for this is something called the Doppler effect. This effect refers to how the height – or frequency – of waves changes depending on whether the source of the wave is moving towards us or away from us. It is known from ambulance sirens. Although the siren itself operates on the same internal tone, when the ambulance is coming towards us we hear a higher pitched tone and when the ambulance is coming away from us we hear a lower pitched tone. How does this relate to the expanding universe? To an observer at some point in the expanding universe, the expansion is like everything moving away from you. The constant expansion of the universe itself means that every other point in the universe is constantly moving away. Under these circumstances, all forms of relativistic wave energy experience the Doppler effect. As the universe stretches, the wavelengths stretch, so the frequencies—the inverse of the wavelength—all decrease. For light waves – i.e. photons – the energy of the photon is directly proportional to the frequency. As the universe expands, the frequency decreases and the energy decreases. But the same would not be true for modules. Modules would be heavy and their energy is associated with their mass and not their motion. The mass-energy of the module is all concentrated in the particle itself, rather than in its motion. These heavy particles are not relativistic and simply stay where they are until they decay. As the universe expands, they stay where they are, retaining all their material energy until the point where they eventually disintegrate. Meanwhile, all other particles whose mass energy is associated with their motion in the form of relativistic particle waves have all that energy dissipated due to the Doppler effect. And so - if moduli exist, it is likely that the universe went through a fairly long phase just after inflation when its energy was dominantly in the form of particle moduli mass. For almost a microsecond at the very beginning of the universe - modules had their day. They were everywhere and they

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(08)- dominated - almost all the energy of the universe in the form of quantum excitations of extra dimensions. Were this to be true, such an epoch would change detecting moduli – the extremely weakly interacting imprint of extra dimensions – from the outer realms of the impossible into a more conventional hard physics problem. So - how? How could we detect evidence for this microsecond of moduli dominance? The answer could lie in their eventual decay. Even though their gravitational-strength interactions give them longer lives than other particles, moduli do eventually decay, their mass-energy draining away into relativistic Standard Model particles, the Hot Big Bang of the early universe….and also, potentially, non-Standard Model particles. Gravity is universal, and loves everything. One example of such non-Standard Model particles – believed but not known to exist – are axions. If a modulus particle were to decay to two axions, they would each receive half the mass-energy of the modulus and then proceed through space at close to the speed of light. Axions are light, effectively massless and also interact very weakly. Though not predicted to be quite as weakly interacting as moduli, their interactions are weak enough that any axions produced this way in the early universe would free-stream from then to now. Decays of moduli could therefore have produced a permanent cosmic background of relativistic axions streaming through the universe. This would be hard to detect - one analogous weakly interacting universe-wide particle bath is the cosmic neutrino background, which despite there being an estimated 300 or more of in every cubic centimetre, scientists across the globe still struggle to detect one or two of each year across multiple experiments. But it would not be impossible. Within large magnetic fields, axions have a chance – a small chance, but a chance – of converting into photons. Such a universal cosmic background of axions, originating from the physics of moduli, the quantum excitations of extra dimensions, may then – in principle – be detected by converting the axions into photons within magnetic fields. Careful observations with better and larger telescopes, looking at what is apparently nothing through magnetic fields, may in the future possibly give evidence that the early universe was once filled with moduli, the quantum excitations of extra dimensions. Possibly – in the future. Answers may not forever be out of reach. And so, just as Einstein's theory of gravity is barely a hundred years old, the prospect that it actually originates in more than four dimensions is almost exactly a hundred years old. The idea remains tantalising, but still theoretical. Perhaps extra dimensions really exist, and the only reason we are not able to perceive them is that we are too large and clunky to appreciate they are there, trying in vain

to count sand grains wearing boxing gloves. Were they to exist, they would be everywhere, present at every single point in space and time - beautifully wrapped up miniature geometry awaiting the right microscope to discern their beauty – and their physics. Perhaps, some day, somehow, we may know for certain whether or not they are out there,
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and whether space itself is much larger, richer, and stranger - than we ever dreamed.

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(08)- dominates - almost all the energy of the universe in the form of quantum excitations of extra dimensions. If true, such an epoch would turn detection pods—the extremely weakly interacting imprint of extra dimensions—from the outer realms of the impossible into a more conventional hard physics problem. So - how? How might we uncover evidence for this microsecond of dominance modules? The answer could lie in their possible decomposition. Although their gravitational interaction gives them longer lifetimes than other particles, the modules eventually decay and their mass-energy drains into relativistic particles of the Standard Model, the hot big bang of the early universe… and potentially non-Standard Model particles as well. Gravity is universal and loves everything. One example of such non-standard model particles – believed but not known to exist – are axions. If the module particle were to decay into two axions, each would receive half the mass energy of the module and then proceed through space at speeds close to the speed of light. Axions are light, effectively immaterial, and also interact very weakly. Although they are not predicted to be as weakly interacting as modules, their interactions are weak enough that any axions formed in this way in the early universe could flow freely from then to the present. Thus, module decays may have created a permanent cosmic background of relativistic axions streaming through space. That would be hard to detect—one analogous pool of weakly interacting particles throughout the universe is the cosmic neutrino background, which, despite an estimated 300 or more for every cubic centimeter, scientists worldwide still struggle to detect one or two every few years experiments. But it wouldn't be impossible. Within large magnetic fields, axions have a chance—a small chance, but a chance—to transform into photons. Such a universal cosmic background of axions, originating from the physics of modules, quantum excitations of extra dimensions, can then – in principle – be detected by converting axions into photons within magnetic fields. Careful observations with better and larger telescopes, looking at what is clearly nothing beyond magnetic fields, may in the future >perhaps provide evidence that the early universe was once filled with modules, quantum excitations of extradimensions<. Maybe - in the future. The answers don't have to be out of reach forever. And so, just as Einstein's theory of gravity is barely a century old, the prospect that it actually comes from more than four dimensions is almost exactly a century old. The idea remains exciting, but still theoretical. Maybe extra dimensions really exist and the only reason we are unable to perceive them is because that extra dimensions above 3+3D are mathematical dimensions **with extra curvature** and are the building blocks of elementary particles of matter… we are too big and clumsy to realize they are there, and we try in vain to count the grains of sand in our boxing gloves. If they existed they would be everywhere, and they are, they are in matter … http://www.hypothesis-of-universe.com/index.php?nav=e present at every single point in space and of time – beautifully packaged miniature geometries yes, they are packages, balls of crooked dimensions = elementary particles http://www.hypothesis-of-universe.com/docs/ec/ec_047.pdf ; http://www.hypothesis-of-universe.com/docs/c/c_455.jpg ; http://www.hypothesis-of-universe.com/docs/c/c_427.gif ; http://www.hypothesis-of-universe.com/docs/c/c_426.jpg ; http://www.hypothesis-of-universe.com/docs/c/c_421.gif ; waiting for the right microscope to discern their beauty—and their physics. Maybe one day, somehow, we can know for sure whether or not they are out there,

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and whether space itself is far greater, richer, and stranger—than we ever dreamed.

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